About the configuration guides

The configuration guides describe the software features for the following switch series:

- S5120V2-LI.
- S3100V3-SI.
- S5110V2.
- S5110V2-SI.
- S5000V3-EI.
- S5000V5-EI.
- S5000E-X.
- S5000X-EI.
- S5130S-LI.
- S5120V3-LI.
- S5120V3-SI.
- MS4320V2.
- MS4320V3.
- MS4320.
- MS4300V2.
- MS4200.
- WS5810-WiNet.
- WS5820-WiNet.
- WAS6000.

The guides guide you through the software configuration procedures and provide configuration examples to help you apply the software features to different network scenarios.

Configuration guide	Content
Fundamentals Configuration Guide	Covers information about using the command line interface, logging in to and setting up the device, and using the basic management features. This guide includes: • CLI (command line interface overview and how to use the CLI). • RBAC. • Logging in to the device (login methods such as Telnet, and user interface configuration and access control). • FTP and TFTP. • File system management. • Configuration file management. • Software upgrade. • Device management. • Tcl. • Python. • Automatic configuration. • License management.
Virtual Technologies Configuration Guide	Covers Intelligent Resilient Framework (IRF) technology, which provides data center class availability and scalability.

Configuration guide	Content
	IRF creates a large virtual device from multiple devices. The IRF member devices work in 1:N redundancy and appear as one unit in the network. IRF improves management efficiency and streamlines network topology. It is suitable for highly reliable enterprise networks and data centers.
Layer 2—LAN Switching Configuration Guide	Covers Layer 2 technologies and features used on a LAN switched network, such as VLAN technology, port isolation, and spanning tree. You can use these features to divide broadcast domains, remove Layer 2 loops, isolate users within a VLAN, re-mark VLAN tags, or implement VLAN VPNs over the Internet. This guide includes: • Ethernet interface. • Loopback, null, and inloopback interfaces. • Bulk interface configuration. • MAC address table and MAC Information. • Ethernet link aggregation. • Port isolation. • Spanning tree. • Loop detection. • VLAN (including VLAN, private VLAN, and voice VLAN). • MVRP. • QinQ. • VLAN mapping. • LLDP. • L2PT. • PPPoE relay.
Layer 3—IP Services Configuration Guide	Covers IP addressing (including static and dynamic IPv4 and IPv6 address assignment), network performance optimization, and ARP. This guide includes: • ARP (including gratuitous ARP, proxy ARP, ARP snooping, and ARP direct route advertisement). • IP addressing. • DHCP (including DHCP overview, DHCP server, DHCP relay agent, DHCP client, DHCP snooping, and BOOTP client). • DNS. • Basic IP forwarding. • Fast forwarding. • IP performance optimization. • UDP helper. • IPv6 basics. • DHCPv6 (including DHCPv6 overview, DHCPv6 server, DHCPv6 relay agent, DHCPv6 client, and DHCPv6 snooping). • IPv6 fast forwarding. • HTTP redirect.
Layer 3—IP Routing Configuration Guide	Covers the routing technologies for IPv4 and IPv6 networks of different sizes, route filtering, route control, and policy-based routing. This guide includes: • Basic IP routing. • Static routing. • Default route. • RIP. • OSPF.

Configuration guide	Content
	• Policy-based routing. • IPv6 static routing. • RIPng. • OSPFv3. • IPv6 policy-based routing. • Routing policy.
IP Multicast Configuration Guide	Covers Layer 2 IPv4 multicast protocols (including IGMP snooping, PIM snooping, and multicast VLAN) and Layer 2 IPv6 multicast protocols (including MLD snooping, IPv6 PIM snooping, and IPv6 multicast VLAN). This guide includes: • Multicast overview. • IGMP snooping. • PIM snooping. • Multicast VLAN. • MLD snooping. • IPv6 PIM snooping. • IPv6 multicast VLAN.
ACL and QoS Configuration Guide	Covers information about classifying traffic with ACLs, and allocating network resources and managing congestions with QoS technologies to improve network performance and network use efficiency. You can use ACLs to help feature modules (such as QoS and IP routing) classify or filter traffic. This guide includes: • ACL. • QoS (including QoS overview, QoS policy, priority mapping, traffic policing, GTS and rate limit, congestion management, traffic filtering, priority marking, nesting, traffic redirecting, global CAR, class-based accounting, and appendixes). • Data buffer. • Time range.
Security Configuration Guide	Covers security features. The major security features available on the switch include: identity authentication (AAA and PKI), access security (802.1X, MAC authentication, and port security), secure management (SSH), SSL, and attack protection (IP source guard and ARP attack protection). This guide includes: • AAA. • 802.1X. • MAC authentication. • Portal authentication. • Web authentication. • Triple authentication. • Port security. • User profile. • Password control. • Public key management. • PKI. • IPsec (including IPsec, IKE, and IKEv2). • SSH. • SSL. • Attack detection and prevention.

Configuration guide	Content
	• TCP attack prevention. • IP source guard. • ARP attack protection. • ND attack defense. • SAVI. • MFF. • Crypto engine. • FIPS. • 802.1X client.
High Availability Configuration Guide	Covers high availability technologies and features available on the switch for failure detection and failover. Failure detection technologies focus on fault detection and isolation. Failover technologies focus on network recovery. This guide includes: • Ethernet OAM. • CFD. • DLDP. • RRPP. • ERPS. • Smart Link. • Monitor Link. • VRRP. • BFD. • Track. • Loopback MAC SWAP.
Network Management and Monitoring Configuration Guide	Covers features that help you manage and monitor your network, for example, manage system events, collect traffic statistics, sample packets, assess network performance, and test network connectivity. This guide includes: • System maintenance and debugging (ping, tracert, and system debugging). • NQA. • NTP and SNTP. • PoE. • SNMP. • RMON. • NETCONF. • CWMP. • EAA. • Process monitoring and maintenance. • Mirroring (including both port and traffic mirroring). • sFlow. • Information center. • VCF fabric. • Cloud connection. • SmartMC. • WiNet.
Telemetry Configuration Guide	Covers gRPC fundamentals and configuration.
OpenFlow Configuration Guide	Covers the application scenarios, fundamentals, and configuration of OpenFlow.

Configuration guide	Content
Acronyms	Lists the significant acronyms in the configuration guides.

Fundamentals Configuration Guide

This command reference is applicable to the following switches and software versions:

H3C S5120V2-LI switch series (Release 6308P01 and later)
H3C S3100V3-SI switch series (Release 6309P01 and later)
H3C S5110V2 switch series (Release 6310 and later)
H3C S5110V2-SI switch series (Release 6310 and later)
H3C S5000V3-EI switch series (Release 6310 and later)
H3C S5000V5-EI switch series (Release 6319P01 and later)
H3C S5000E-X switch series (Release 6310 and later)
H3C S5130S-LI switch series (Release 6310 and later)
H3C MS4320V2 switch series (Release 6308P01 and later)
H3C MS4320 switch series (Release 6308P01 and later)
H3C MS4300V2 switch series (Release 6308P01 and later)
H3C MS4200 switch series (Release 6310 and later)
H3C WS5810-WiNet switch series (Release 6308P01 and later)
H3C WS5820-WiNet switch series (Release 6308P01 and later)
H3C WAS6000 switch series (Release 6308P01 and later)
H3C S5000X-EI switch series (Release 6329 and later)
H3C MS4320V3 switch series (Release 6329 and later)
H3C S5120V3-SI switch series (Release 6329 and later)
H3C S5120V3-LI switch series (Release 6329 and later)

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http://www.h3c.com

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Preface

This configuration guide describes features and tasks that help you get started with the device, including:

This preface includes the following topics about the documentation:

Audience

This documentation is intended for:

- Network planners.
- Field technical support and servicing engineers.
- Network administrators.

Conventions

The following information describes the conventions used in the documentation.

Command conventions

Convention	Description
Boldface	**Bold** text represents commands and keywords that you enter literally as shown.
Italic	*Italic* text represents arguments that you replace with actual values.
[ ]	Square brackets enclose syntax choices (keywords or arguments) that are optional.
{ x | y | ... }	Braces enclose a set of required syntax choices separated by vertical bars, from which you select one.
[x | y | ...]	Square brackets enclose a set of optional syntax choices separated by vertical bars, from which you select one or none.
{ x | y | ... } *	Asterisk marked braces enclose a set of required syntax choices separated by vertical bars, from which you select a minimum of one.
[x | y | ...] *	Asterisk marked square brackets enclose optional syntax choices separated by vertical bars, from which you select one choice, multiple choices, or none.
&<1-n>	The argument or keyword and argument combination before the ampersand (&) sign can be entered 1 to n times.
#	A line that starts with a pound (#) sign is comments.

GUI conventions

Convention	Description
Boldface	Window names, button names, field names, and menu items are in Boldface. For example, the **New User** window opens; click **OK**.
>	Multi-level menus are separated by angle brackets. For example, **File** > **Create** > **Folder**.

Symbols

Convention	Description
WARNING!	An alert that calls attention to important information that if not understood or followed can result in personal injury.
CAUTION:	An alert that calls attention to important information that if not understood or followed can result in data loss, data corruption, or damage to hardware or software.
IMPORTANT:	An alert that calls attention to essential information.
NOTE:	An alert that contains additional or supplementary information.
TIP:	An alert that provides helpful information.

Network topology icons

Convention	Description
	Represents a generic network device, such as a router, switch, or firewall.
	Represents a routing-capable device, such as a router or Layer 3 switch.
	Represents a generic switch, such as a Layer 2 or Layer 3 switch, or a router that supports Layer 2 forwarding and other Layer 2 features.
	Represents an access controller, a unified wired-WLAN module, or the access controller engine on a unified wired-WLAN switch.
	Represents an access point.
	Represents a wireless terminator unit.
	Represents a wireless terminator.
	Represents a mesh access point.
	Represents omnidirectional signals.
	Represents directional signals.
	Represents a security product, such as a firewall, UTM, multiservice security gateway, or load balancing device.
	Represents a security module, such as a firewall, load balancing, NetStream, SSL VPN, IPS, or ACG module.

Examples provided in this document

Examples in this document might use devices that differ from your device in hardware model, configuration, or software version. It is normal that the port numbers, sample output, screenshots, and other information in the examples differ from what you have on your device.

Documentation feedback

You can e-mail your comments about product documentation to info@h3c.com.

We appreciate your comments.

Contents

Using the CLI

About the CLI

At the command-line interface (CLI), you can enter text commands to configure, manage, and monitor the device.

You can use different methods to log in to the CLI. For example, you can log in through the console port or Telnet. For more information about login methods, see "Login overview."

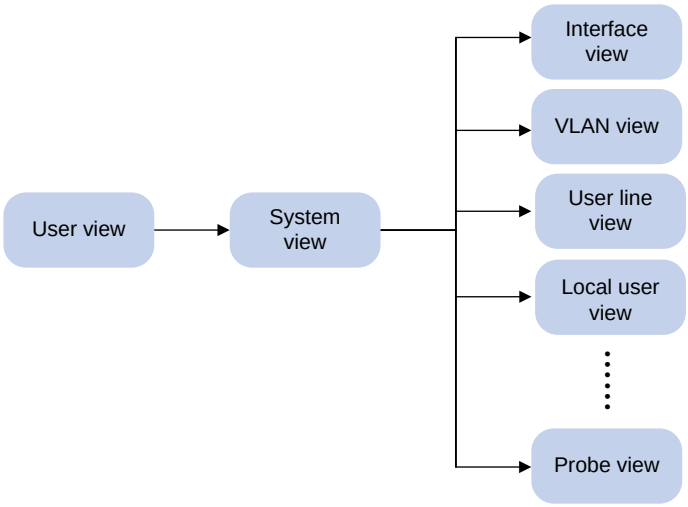
Using CLI views

About CLI views

Commands are grouped in different views by feature. To use a command, you must enter its view.

CLI views are hierarchically organized, as shown in Figure 1. Each view has a unique prompt, from which you can identify where you are and what you can do. For example, the prompt [Sysname-vlan100] shows that you are in VLAN 100 view and can configure attributes for that VLAN.

Figure 1 CLI views



You are placed in user view immediately after you log in to the CLI.

In user view, you can perform the following tasks:

- Perform basic operations including display, debug, file management, FTP, Telnet, clock setting, and reboot.
- Enter system view.

In system view, you can perform the following tasks:

- Configure settings that affect the device as a whole, such as the daylight saving time, banners, and hotkeys.
- Enter feature views.

  For example, you can perform the following tasks:
  - Enter interface view to configure interface parameters.

- Enter VLAN view to add ports to the VLAN.
- Enter user line view to configure login user attributes.

A feature view might have child views. For example, NQA operation view has the child view HTTP operation view.

- Enter probe view by using the **probe** command.

  The probe view provides display, debugging, and maintenance commands, which are mainly used by developers and testers for system fault diagnosis and system operation monitoring.

CAUTION:

Use the commands in probe view under the guidance of engineers to avoid system exceptions caused by incorrect operations.

For more information about the commands in probe view, see the probe commands manual for each feature.

To display all commands available in a view, enter a question mark (?) at the view prompt.

Entering system view from user view

To enter system view from user view, execute the following command:

system-view

Returning to the upper-level view from a view

Restrictions and guidelines

Executing the **quit** command in user view terminates your connection to the device.

To return from public key view to system view, you must use the **peer-public-key end** command.

Procedure

To return to the upper-level view from a view, execute the following command:

quit

Returning to user view

About returning to user view

This feature enables you to return to user view from any view by performing a single operation, eliminating the requirement to execute the **quit** command multiple times.

Procedure

To return directly to user view from any other view (except the Tcl configuration view and Python shell), use one of the following methods:

- Execute the **return** command in any view.
- Press **Ctrl+Z** in any view.

To return to user view from Tcl configuration view, execute the **tclquit** command in Tcl configuration view.

To return to user view from the Python shell, execute the **exit()** command in the Python shell.

Accessing the CLI online help

The CLI online help is context sensitive. Enter a question mark at any prompt or in any position of a command to display all available options.

To access the CLI online help, use one of the following methods:

- Enter a question mark at a view prompt to display the first keyword of every command available in the view. For example:

```
<Sysname> ?
User view commands:
  archive             Archive configuration
  arp                 Address Resolution Protocol (ARP) module
  backup              Backup the startup configuration file to a TFTP server
  boot-loader         Software image file management
...
```

- Enter a space and a question mark after a command keyword to display all available keywords and arguments.
  - If the question mark is in the place of a keyword, the CLI displays all possible keywords, each with a brief description. For example:

```
<Sysname> terminal ?
  debugging  Enable to display debugging logs on the current terminal
  logging    Display logs on the current terminal
  monitor    Enable to display logs on the current terminal
```

  - If the question mark is in the place of an argument, the CLI displays the description for the argument. For example:

```
<Sysname> system-view
[Sysname] interface vlan-interface ?
  <1-4094>  Vlan-interface interface number
[Sysname] interface vlan-interface 1 ?
  <cr>
[Sysname] interface vlan-interface 1
```

    <1-4094> is the value range for the argument. **<cr>** indicates that the command is complete and you can press **Enter** to execute the command.

- Enter an incomplete keyword string followed by a question mark to display all keywords starting with that string. The CLI also displays the descriptions for the keywords. For example:

```
<Sysname> f?
  fdisk    Partition a storage medium
  fixdisk   Check and repair a storage medium
  format    Format a storage medium
  free      Release a connection
  ftp       Open an FTP connection
<Sysname> display ftp?
  ftp         FTP module
  ftp-server  FTP server information
  ftp-user    FTP user information
```

Using the undo form of a command

Most configuration commands have an **undo** form for the following tasks:

- Canceling a configuration.
- Restoring the default.
- Disabling a feature.

For example, the **info-center enable** command enables the information center. The **undo info-center enable** command disables the information center.

Entering a command

When you enter a command, you can perform the following tasks:

- Use keys or hotkeys to edit the command line.
- Use abbreviated keywords or keyword aliases.

Editing a command line

To edit a command line, use the keys listed in Table 1 or the hotkeys listed in Table 4. When you are finished, you can press **Enter** to execute the command.

The command edit buffer can contain a maximum of 511 characters. If the total length of a command line exceeds the limit after you press **Tab** to complete the last keyword or argument, the system does not complete the keyword.

Table 1 Command line editing keys

Keys	Function
Common keys	If the edit buffer is not full, pressing a common key inserts a character at the cursor and moves the cursor to the right. The edit buffer can store up to 511 characters. Unless the buffer is full, all common characters that you enter before pressing **Enter** are saved in the edit buffer.
Backspace	Deletes the character to the left of the cursor and moves the cursor back one character.
Left arrow key (←)	Moves the cursor one character to the left.
Right arrow key (→)	Moves the cursor one character to the right.
Up arrow key (↑)	Displays the previous command in the command history buffer.
Down arrow key (↓)	Displays the next command in the command history buffer.
Tab	If you press **Tab** after typing part of a keyword, the system automatically completes the keyword. • If a unique match is found, the system displays the complete keyword. • If there is more than one match, press **Tab** multiple times to pick the keyword you want to enter. • If there is no match, the system does not modify what you entered but displays it again in the next line.

The device supports the following special commands:

- #—Used by the system in a configuration file as separators for adjacent sections.
- **version**—Used by the system in a configuration file to indicate the software version information. For example, **version 7.1. xxx**, **Release xxx**.

These commands are special because of the following reasons:

- These commands are not intended for you to use at the CLI.

- You can enter the **#** command in any view or the **version** command in system view, or enter any values for them. For example, you can enter **# abc** or **version abc**. However, the settings do not take effect.
- The device does not provide any online help information for these commands.

Entering a text or string type value for an argument

A text type argument value can contain any characters except question marks (?).

A string type argument value can contain any printable characters except question marks (?).

- To include a quotation mark (") or backward slash (\) in a string type argument value, prefix the character with an escape key (\), for example, \" and \\.
- To include a blank space in a string type argument value, enclose the value in quotation marks, for example, "my device".

A specific argument might have more requirements. For more information, see the relevant command reference.

To enter a printable character, you can enter the character or its ASCII code in the range of 32 to 126.

Entering an interface type

You can enter an interface type in one of the following formats:

- Full spelling of the interface type.
- An abbreviation that uniquely identifies the interface type.
- Acronym of the interface type.

For a command line, all interface types are case insensitive. Table 2 shows the full spellings and acronyms of interface types.

For example, to use the **interface** command to enter the view of interface GigabitEthernet 1/0/1, you can enter the command line in the following formats:

- **interface gigabitethernet 1/0/1**
- **interface g 1/0/1**
- **interface ge 1/0/1**

Spaces between the interface types and interfaces are not required.

Table 2 Full spellings and acronyms of interface types

Full spelling	Acronym
Bridge-Aggregation	BAGG
Ethernet	Eth
GigabitEthernet	GE
InLoopBack	InLoop
LoopBack	Loop
M-Ethernet	ME
NULL	NULL
Ten-GigabitEthernet	XGE
Vlan-interface	Vlan-int

Abbreviating commands

You can enter a command line quickly by entering incomplete keywords that uniquely identify the complete command. In user view, for example, commands starting with an **s** include **startup saved-configuration** and **system-view**. To enter the command **system-view**, you need to type only **sy**. To enter the command **startup saved-configuration**, type **st s**.

You can also press **Tab** to complete an incomplete keyword.

Configuring and using command aliases

About command aliases

You can configure one or more aliases for a command or the starting keywords of commands. Then, you can use the aliases to execute the command or commands. If the command or commands have **undo** forms, you can also use the aliases to execute the **undo** command or commands.

For example, if you configure the **shiprt** alias for **display ip routing-table**, you can enter **shiprt** to execute the **display ip routing-table** command. If you configure the **ship** alias for **display ip**, you can use **ship** to execute all commands starting with **display ip**, including:

- Enter **ship routing-table** to execute the **display ip routing-table** command.
- Enter **ship interface** to execute the **display ip interface** command.

The device provides a set of system-defined command aliases, as listed in Table 3.

Table 3 System-defined command aliases

Command alias	Command or command keyword
access-list	**acl**
end	**return**
erase	**delete**
exit	**quit**
hostname	**sysname**
logging	**info-center**
no	**undo**
show	**display**
write	**save**

Restrictions and guidelines

A command alias can be used only as the first keyword of a command or the second keyword of the **undo** form of a command.

After you successfully execute a command by using an alias, the system saves the command, instead of the alias, to the running configuration.

The command string can include up to nine parameters. Each parameter starts with the dollar sign ($) and a sequence number in the range of 1 to 9. For example, you can configure the alias **shinc** for the **display ip $1 | include $2** command. Then, to execute the **display ip routing-table | include Static** command, you need to enter only **shinc routing-table Static**.

To use an alias for a command that has parameters, you must specify a value for each parameter. If you fail to do so, the system informs you that the command is incomplete and displays the command string represented by the alias.

System-defined command aliases cannot be deleted.

Procedure

1. Enter system view.
   system-view
2. Configure a command alias.
   alias *alias command*
   By default, the device has a set of command aliases, as listed in Table 3.
3. (Optional.) Display command aliases.
   display alias [*alias*]
   This command is available in any view.

Configuring and using hotkeys

About hotkeys

The device supports a set of hotkeys. Pressing a hotkey executes the command or function assigned to the hotkey. Table 4 shows the hotkeys and their default definitions. You can configure all the hotkeys except **Ctrl+]**.

If a hotkey is also defined by the terminal software you are using to interact with the device, you can reconfigure the hotkey or remove the hotkey.

Restrictions and guidelines

A hotkey can correspond to only one command or function. If you assign multiple commands or functions to the same hotkey, the most recently assigned command or function takes effect.

A command or function can be assigned to multiple hotkeys. You can use any of the hotkeys to execute the command or function.

If a hotkey is also defined by the terminal software you are using to interact with the device, the terminal software definition takes effect.

Procedure

1. Enter system view.
   system-view
2. Assign a command to a hotkey.
   hotkey *hotkey* { *command* | **function** *function* | **none** }
   Table 4 shows the default definitions for the hotkeys.
3. (Optional.) Display hotkeys.
   display hotkey
   This command is available in any view.

Table 4 Default definitions for hotkeys

Hotkey	Function or command
Ctrl+A	**move_the_cursor_to_the_beginning_of_the_line**: Moves the cursor to the beginning of a line.
Ctrl+B	**move_the_cursor_one_character_to_the_left**: Moves the cursor one character to the left.

Hotkey	Function or command
Ctrl+C	**stop_the_current_command**: Stops the current command.
Ctrl+D	**erase_the_character_at_the_cursor**: Deletes the character at the cursor.
Ctrl+E	**move_the_cursor_to_the_end_of_the_line**: Moves the cursor to the end of a line.
Ctrl+F	**move_the_cursor_one_character_to_the_right**: Moves the cursor one character to the right.
Ctrl+G	**`display current-configuration`**: Display the running configuration.
Ctrl+H	**erase_the_character_to_the_left_of_the_cursor**: Deletes the character to the left of the cursor.
Ctrl+L	**`display ip routing-table`**: Display the IPv4 routing table information.
Ctrl+N	**display_the_next_command_in_the_history_buffer**: Displays the next command in the history buffer.
Ctrl+O	**`undo debugging all`**: Disable all debugging functions.
Ctrl+P	**display_the_previous_command_in_the_history_buffer**: Displays the previous command in the history buffer.
Ctrl+R	**redisplay_the_current_line**: Redisplays the current line.
Ctrl+T	N/A
Ctrl+U	N/A
Ctrl+W	**delete_the_word_to_the_left_of_the_cursor**: Deletes the word to the left of the cursor.
Ctrl+X	**delete_all_characters_from_the_beginning_of_the_line_to_the_cursor**: Deletes all characters to the left of the cursor.
Ctrl+Y	**delete_all_characters_from_the_cursor_to_the_end_of_the_line**: Deletes all characters from the cursor to the end of the line.
Ctrl+Z	**return_to_the_User_View**: Returns to user view.
Ctrl+]	**kill_incoming_connection_or_redirect_connection**: Terminates the current connection.
Esc+B	**move_the_cursor_back_one_word**: Moves the cursor back one word.
Esc+D	**delete_all_characters_from_the_cursor_to_the_end_of_the_word**: Deletes all characters from the cursor to the end of the word.
Esc+F	**move_the_cursor_forward_one_word**: Moves the cursor forward one word.

Enabling redisplaying entered-but-not-submitted commands

About redisplaying entered-but-not-submitted commands

Your input might be interrupted by system information output. If redisplaying entered-but-not-submitted commands is enabled, the system redisplays your input after finishing the output. You can then continue entering the command line.

Procedure

1. Enter system view.

   `system-view`
2. Enable redisplaying entered-but-not-submitted commands.

`info-center synchronous`

By default, the system does not redisplay entered-but-not-submitted commands.

For more information about this command, see *Network Management and Monitoring Command Reference*.

Understanding command-line syntax error messages

After you press **Enter** to submit a command, the command line interpreter examines the command syntax.

- If the command passes syntax check, the CLI executes the command.
- If the command fails syntax check, the CLI displays an error message.

Table 5 Common command-line syntax error messages

Syntax error message	Cause
% Unrecognized command found at '^' position.	The keyword in the marked position is invalid.
% Incomplete command found at '^' position.	One or more required keywords or arguments are missing.
% Ambiguous command found at '^' position.	The entered character sequence matches more than one command.
% Too many parameters found at '^' position.	The entered character sequence contains excessive keywords or arguments.
% Wrong parameter found at '^' position.	The argument in the marked position is invalid.

Using the command history feature

About command history buffers

The system automatically saves commands successfully executed by a login user to the following two command history buffers:

- Command history buffer for the user line.
- Command history buffer for all user lines.

Table 6 Comparison between the two types of command history buffers

Item	Command history buffer for a user line	Command history buffer for all user lines
Which commands are saved in the buffer?	Commands successfully executed by the current user of the user line.	Commands successfully executed by all login users.
Can commands in the buffer be displayed?	Yes.	Yes.
Can commands in the buffer be recalled?	Yes.	No.

Item	Command history buffer for a user line	Command history buffer for all user lines
Are buffered commands cleared when the user logs out?	Yes.	No.
Is the buffer size adjustable?	Yes.	No. The buffer size is fixed at 1024.

Command buffering rules

The system follows these rules when buffering commands:

- If you use incomplete keywords when entering a command, the system buffers the command in the exact form that you used.
- If you use an alias when entering a command, the system transforms the alias to the represented command or command keywords before buffering the command.
- If you enter a command in the same format multiple times in succession, the system buffers the command only once. If you enter a command in different formats multiple times, the system buffers each command format. For example, **`display cu`** and **`display current-configuration`** are buffered as two entries but successive repetitions of **`display cu`** create only one entry.
- To buffer a new command when a buffer is full, the system deletes the oldest command entry in the buffer.

Managing and using the command history buffers

Displaying the commands in command history buffers

To display the commands in command history buffers, execute the following commands in any view:

- Display the commands in command history buffers for a user line.
  `display history-command`
- Display the commands in command history buffers for all user lines.
  `display history-command all`

Recalling commands in the command history buffer for a user line

Use up and down arrow keys to navigate to the command and press **Enter**.

Setting the size of the command history buffer for a user line

Use the **`history-command max-size`** command in user line or user line class view. For more information, see *Fundamentals Command Reference*.

Repeating commands in the command history buffer for a user line

About repeating commands in the command history buffer for a user line

You can recall and execute commands in the command history buffer for the current user line multiple times.

Restrictions and guidelines

The **repeat** command is available in any view. However, to repeat a command, you must first enter the view for the command. To repeat multiple commands, you must first enter the view for the first command.

The **repeat** command executes commands in the order they were executed.

The system waits for your interaction when it repeats an interactive command.

Procedure

To repeat commands in the command history buffer for the current user line, execute the following command:

repeat [*number*] [**count** *times*] [**delay** *seconds*]

Controlling the CLI output

This section describes the CLI output control features that help you identify the desired output.

Pausing between screens of output

About pausing between screens of output

The device can automatically pause after displaying a specific number of lines if the output is too long to fit on one screen. At a pause, the device displays **----more----**. You can use the keys described in Table 7 to display more information or stop the display.

You can also disable pausing between screens of output for the current session. Then, all output is displayed at one time and the screen is refreshed continuously until the final screen is displayed.

Table 7 Output controlling keys

Keys	Function
Space	Displays the next screen.
Enter	Displays the next line.
Ctrl+C	Stops the display and cancels the command execution.
<PageUp>	Displays the previous page.
<PageDown>	Displays the next page.

Disabling pausing between screens of output

To disable pausing between screens of output, execute the following command in user view:

screen-length disable

The default depends on the settings of the **screen-length** command in user line view. The following are the default settings for the **screen-length** command:

- Pausing between screens of output is enabled.
- The maximum number of lines to be displayed at a time is 24.

For more information about the **screen-length** command, see *Fundamentals Command Reference*.

This command is a one-time command and takes effect only for the current CLI session.

Numbering each output line from a display command

About display command output line numbering

For easy identification, you can use the **| by-linenum** option to display a number for each output line from a **display** command.

Each line number is displayed as a 5-character string and might be followed by a colon (:) or hyphen (-). If you specify both **| by-linenum** and **| begin** *regular-expression* for a **display** command, a hyphen is displayed for all lines that do not match the regular expression.

Procedure

To number each output line from a **display** command, execute the following command in any view:

display *command* **| by-linenum**

Example

Display information about VLAN 999, numbering each output line.

```
<Sysname> display vlan 999 | by-linenum
    1:  VLAN ID: 999
    2:  VLAN type: Static
    3:  Route interface: Configured
    4:  IPv4 address: 192.168.2.1
    5:  IPv4 subnet mask: 255.255.255.0
    6:  Description: For LAN Access
    7:  Name: VLAN 0999
    8:  Tagged ports:   None
    9:  Untagged ports: None
```

Filtering the output from a display command

About display command output filtering

You can use the [**|** [**by-linenum**] { **begin** | **exclude** | **include** } *regular-expression*]&<1-128> option to filter the output from a **display** command.

- You can use the option to specify a maximum of 128 filter conditions. The system displays only output lines that meet all the conditions.
- **by-linenum**—Displays a number before each output line. You need to specify this keyword in only one filter condition.
- **begin**—Displays the first line matching the specified regular expression and all subsequent lines.
- **exclude**—Displays all lines not matching the specified regular expression.
- **include**—Displays all lines matching the specified regular expression.
- *regular-expression*—A case-sensitive string of 1 to 256 characters, which can contain the special characters described in Table 8.

Table 8 Special characters supported in a regular expression

Characters	Meaning	Examples
^	Matches the beginning of a line.	"^u" matches all lines beginning with "u". A line beginning with "Au" is not matched.
$	Matches the end of a line.	"u$" matches all lines ending with "u". A line

Characters	Meaning	Examples
		ending with "uA" is not matched.
. (period)	Matches any single character.	".s" matches "as" and "bs".
*	Matches the preceding character or string zero, one, or multiple times.	"zo*" matches "z" and "zoo", and "(zo)*" matches "zo" and "zozo".
+	Matches the preceding character or string one or multiple times.	"zo+" matches "zo" and "zoo", but not "z".
|	Matches the preceding or succeeding string.	"def|int" matches a line containing "def" or "int".
( )	Matches the string in the parentheses, usually used together with the plus sign (+) or asterisk sign (*).	"(123A)" matches "123A". "408(12)+" matches "40812" and "408121212", but not "408".
\N	Matches the preceding strings in parentheses, with the *Nth* string repeated once.	"(string)\1" matches a string containing "stringstring". "(string1)(string2)\2" matches a string containing "string1string2string2". "(string1)(string2)\1\2" matches a string containing " string1string2string1string2".
[ ]	Matches a single character in the brackets.	"[16A]" matches a string containing 1, 6, or A; "[1-36A]" matches a string containing 1, 2, 3, 6, or A (- is a hyphen). To match the character "]", put it immediately after "[", for example, []abc]. There is no such limit on "[".
[^]	Matches a single character that is not in the brackets.	"[^16A]" matches a string that contains one or more characters except for 1, 6, or A, such as "abc". A match can also contain 1, 6, or A (such as "m16"), but it cannot contain these three characters only (such as 1, 16, or 16A).
{n}	Matches the preceding character *n* times. The number *n* must be a nonnegative integer.	"o{2}" matches "food", but not "Bob".
{n,}	Matches the preceding character *n* times or more. The number *n* must be a nonnegative integer.	"o{2,}" matches "foooood", but not "Bob".
{n,m}	Matches the preceding character *n* to *m* times or more. The numbers *n* and *m* must be nonnegative integers and *n* cannot be greater than *m*.	" o{1,3}" matches "fod", "food", and "foooood", but not "fd".
\<	Matches a string that starts with the pattern following \<. A string that contains the pattern is also a match if the characters preceding the pattern are not digits, letters, or underscores.	"\<do" matches "domain" and "doa".
\>	Matches a string that ends with the pattern preceding \>. A string that contains the pattern is also a match if the characters following the pattern are not digits, letters, or underscores.	"do\>" matches "undo" and "cdo".
\b	Matches a word that starts with the pattern following \b or ends with the	"er\b" matches "never", but not "verb" or "erase".

Characters	Meaning	Examples
	pattern preceding \b.	"\ber" matches "erase", but not "verb" or "never".
\B	Matches a word that contains the pattern but does not start or end with the pattern.	"er\B" matches "verb", but not "never" or "erase".
\w	Same as [A-Za-z0-9_], matches a digit, letter, or underscore.	"v\w" matches "vlan" and "service".
\W	Same as [^A-Za-z0-9_], matches a character that is not a digit, letter, or underscore.	"\Wa" matches "-a", but not "2a" or "ba".
\	Escape character. If a special character listed in this table follows \, the specific meaning of the character is removed.	"\\" matches a string containing "\", "\^" matches a string containing "^", and "\\b" matches a string containing "\b".

Restrictions and guidelines

The required filtering time increases with the complexity of the regular expression. To abort the filtering process, press **Ctrl+C**.

Examples

Display the running configuration, starting from the first configuration line that contains **line**.

```
<Sysname> display current-configuration | begin line
line class aux
 user-role network-admin
#
line class vty
 user-role network-operator
#
line aux 0
 user-role network-admin
#
line vty 0 63
 authentication-mode none
 user-role network-admin
 user-role network-operator
#
...
```

Display brief information about interfaces in up state.

```
<Sysname> display interface brief | exclude DOWN
Brief information on interfaces in route mode:
Link: ADM - administratively down; Stby - standby
Protocol: (s) - spoofing
Interface            Link Protocol Primary IP      Description
InLoop0              UP   UP(s)    --
NULL0                UP   UP(s)    --
Vlan1                UP   UP       192.168.1.83

Brief information on interfaces in bridge mode:
Link: ADM - administratively down; Stby - standby
```

```
Speed: (a) - auto
Duplex: (a)/A - auto; H - half; F - full
Type: A - access; T - trunk; H - hybrid
Interface            Link Speed    Duplex Type PVID Description
GE1/0/1              UP   1000M(a) F(a)  A    1
```

Display SNMP-related running configuration lines.

```
<Sysname> display current-configuration | include snmp
snmp-agent
 snmp-agent community write private
 snmp-agent community read public
 snmp-agent sys-info version all
 snmp-agent target-host trap address udp-domain 192.168.1.26 params securityname public
```

Display log entries in the log buffer that contain both **SHELL** and **VTY**.

```
<Sysname> display logbuffer | include SHELL | include VTY
%Sep  6 10:38:12:320 2018 Sysname SHELL/5/SHELL_LOGIN: VTY logged in from 169.254.100.171.
%Sep  6 10:52:32:576 2018 Sysname SHELL/5/SHELL_LOGOUT: VTY logged out from
169.254.100.171.
%Sep  6 16:03:27:100 2018 Sysname SHELL/5/SHELL_LOGIN: VTY logged in from 169.254.100.171.
%Sep  6 16:44:18:113 2018 Sysname SHELL/5/SHELL_LOGOUT: VTY logged out from
169.254.100.171.
```

Saving the output from a display command to a file

About display command output saving

A **display** command shows certain configuration and operation information of the device. Its output might vary over time or with user configuration or operation. You can save the output to a file for future retrieval or troubleshooting.

Use one of the following methods to save the output from a **display** command:

- Save the output to a separate file. Use this method if you want to use one file for a single **display** command.
- Append the output to the end of a file. Use this method if you want to use one file for multiple **display** commands.

Procedure

To save the output from a **display** command to a file, use one of the following commands in any view:

- Save the output from a **display** command to a separate file.

  display *command* **>** *filename*
- Append the output from a **display** command to the end of a file.

  display *command* **>>** *filename*

Examples

Save the VLAN 1 settings to a separate file named **vlan.txt**.

```
<Sysname> display vlan 1 > vlan.txt
```

Verify that the VLAN 1 settings are saved to the file **vlan.txt**.

```
<Sysname> more vlan.txt
VLAN ID: 1
 VLAN type: Static
```

```
 Route interface: Not configured
 Description: VLAN 0001
 Name: VLAN 0001
 Tagged ports:   None
 Untagged ports: None
```

Append the VLAN 999 settings to the end of the file **vlan.txt**.

```
<Sysname> display vlan 999 >> vlan.txt
```

Verify that the VLAN 999 settings are appended to the end of the file **vlan.txt**.

```
<Sysname> more vlan.txt
VLAN ID: 1
 VLAN type: Static
 Route interface: Not configured
 Description: VLAN 0001
 Name: VLAN 0001
 Tagged ports:   None
 Untagged ports: None

 VLAN ID: 999
 VLAN type: Static
 Route interface: Configured
 IP address: 192.168.2.1
 Subnet mask: 255.255.255.0
 Description: For LAN Access
 Name: VLAN 0999
 Tagged ports:   None
 Untagged ports: None
```

Viewing and managing the output from a display command effectively

You can use the following methods in combination to filter and manage the output from a **`display`** command:

- Numbering each output line from a display command
- Filtering the output from a display command
- Saving the output from a display command to a file

Procedure

To use multiple measures to view and manage the output from a **`display`** command effectively, execute the following command in any view:

`display` *`command`* [**`|`** [**`by-linenum`**] { **`begin`** | **`exclude`** | **`include`** } *`regular-expression`*]&<1-128> [**`>`** *`filename`* | **`>>`** *`filename`*]

Examples

Save the running configuration to a separate file named **test.txt**, with each line numbered.

```
<Sysname> display current-configuration | by-linenum > test.txt
```

Append lines including **snmp** in the running configuration to the file **test.txt**.

```
<Sysname> display current-configuration | include snmp >> test.txt
```

Display the first line that begins with **user-group** in the running configuration and all the following lines.

```
<Sysname> display current-configuration | by-linenum begin user-group
  114:  user-group system
  115-  #
  116-  return
```

// The colon (:) following a line number indicates that the line contains the string user-group. The hyphen (-) following a line number indicates that the line does not contain the string **user-group**.

Contents

Configuring RBAC

About RBAC

Role-based access control (RBAC) controls access permissions of users based on user roles.

RBAC assigns access permissions to user roles that are created for different job functions. Users are given permission to access a set of items and resources based on the users' user roles. Separating permissions from users enables simple permission authorization management.

Permission assignment

Use the following methods to assign permissions to a user role:

- Define a set of rules to determine accessible or inaccessible items for the user role. (See "User role rules.")
- Configure resource access policies to specify which resources are accessible to the user role. (See "Resource access policies.")

To use a command related to a system resource, a user role must have access to both the command and the resource.

For example, a user role has access to the **vlan** command and access only to VLAN 10. When the user role is assigned, you can use the **vlan** command to create VLAN 10 and enter its view. However, you cannot create any other VLANs. If the user role has access to VLAN 10 but does not have access to the **vlan** command, you cannot use the command to enter the view of VLAN 10.

When a user logs in to the device with any user role and enters **<?>** in a view, help information is displayed for the system-defined command aliases in the view. However, the user might not have the permission to access the command aliases. Whether the user can access the command aliases depends on the user role's permission to the commands corresponding to the aliases. For information about command aliases, see "Using the CLI."

A user that logs in to the device with any user role has access to the **system-view**, **quit**, and **exit** commands.

User role rules

User role rules permit or deny access to the items, including commands, Web pages, XML elements, or MIB nodes. You can define the following types of rules for different access control granularities:

- **Command rule**—Controls access to a command or a set of commands that match a regular expression.
- **Feature rule**—Controls access to the commands of a feature by command type.
- **Feature group rule**—Controls access to the commands of features in a feature group by command type.
- **Web menu rule**—Controls access to Web pages used for configuring the device. These Web pages are called Web menus.
- **XML element rule**—Controls access to XML elements used for configuring the device.
- **OID rule**—Controls SNMP access to a MIB node and its child nodes. An OID is a dotted numeric string that uniquely identifies the path from the root node to a leaf node.

The items (commands, Web menus, XML elements, and MIB nodes) are controlled based on the following types:

- **Read**—Items that display configuration and maintenance information. For example, the **display** commands and the **dir** command.

- **Write**—Items that configure the features in the system. For example, the **info-center enable** command and the **debugging** command.
- **Execute**—Items that execute specific functions. For example, the **ping** command and the **ftp** command.

A user role can access the set of permitted items specified in the user role rules. The user role rules include predefined (identified by sys-*n*) and user-defined user role rules. For more information about the user role rule priority, see "Configuring user role rules."

Resource access policies

Resource access policies control access of a user role to system resources and include the following types:

- **Interface policy**—Controls access to interfaces.
- **VLAN policy**—Controls access to VLANs.

Resource access policies do not control access to the interface or VLAN options in the **display** commands. You can specify these options in the **display** commands if the options are permitted by any user role rule.

Predefined user roles

The system provides predefined user roles. These user roles have access to all system resources. However, their access permissions differ, as shown in Table 1.

Among all of the predefined user roles, only network-admin and level-15 can create, modify, and delete local users and local user groups. The other user roles can only modify their own passwords if they have permissions to configure local users and local user groups.

The access permissions of the level-0 to level-14 user roles can be modified through user role rules and resource access policies. However, you cannot make changes on the predefined access permissions of these user roles. For example, you cannot change the access permission of these user roles to the **display history-command all** command.

Table 1 Predefined roles and permissions matrix

User role name	Permissions
network-admin	Accesses all features and resources in the system, except for the **display security-logfile summary**, **info-center security-logfile directory**, and **security-logfile save** commands.
network-operator	• Accesses the **display** commands for features and resources in the system. To display all accessible commands of the user role, use the **display role** command. • Enables local authentication login users to change their own passwords. • Accesses the command used for entering XML view. • Accesses all read-type Web menu items. • Accesses all read-type XML elements. • Accesses all read-type MIB nodes.
level-*n* (*n* = 0 to 15)	• **level-0**—Has access to commands including **ping**, **tracert**, **ssh2**, **telnet**, and **super**. Level-0 access rights are configurable. • **level-1**—Has access to the **display** commands of features and resources in the system. The **level-1** user role also has all access rights of the level-0 user role. Level-1 access rights are configurable. • **level-2 to level-8, and level-10 to level-14**—Have no access rights by default. Access rights are configurable.

User role name	Permissions

	• **level-9**—Has access to most of the features and resources in the system. If you are logged in with a local user account that has a level-9 user role, you can change the password in the local user account. The following are the major features and commands that the level-9 user role cannot access:
	  ○ RBAC non-debugging commands.
	  ○ Local users.
	  ○ File management.
	  ○ Device management.
	  ○ The **`display history-command all`** command.
	• **level-15**—Has the same rights as network-admin.

security-audit	Security log manager. The user role has the following access rights to security log files: • Accesses the commands for displaying and maintaining security log files (for example, the **`dir`**, **`display security-logfile summary`**, and **`more`** commands). • Accesses the commands for managing security log files and security log file system (for example, the **`info-center security-logfile directory`**, **`mkdir`**, and **`security-logfile save`** commands). For more information about security log management, see *Network Management and Monitoring Configuration Guide*. For more information about file system management, see "Managing file systems." **IMPORTANT:** Only the security-audit user role has access to security log files. You cannot assign the security-audit user role to non-AAA authentication users.

User role assignment

You assign access rights to a user by assigning a minimum of one user role. The user can use the collection of items and resources accessible to all user roles assigned to the user. For example, you can access any interface to use the **`qos apply policy`** command if you are assigned the following user roles:

- User role A denies access to the **`qos apply policy`** command and permits access only to interface GigabitEthernet 1/0/1.
- User role B permits access to the **`qos apply policy`** command and all interfaces.

Depending on the authentication method, user role assignment has the following methods:

- **AAA authorization**—If scheme authentication is used, the AAA module handles user role assignment.
  - If the user passes local authorization, the device assigns the user roles specified in the local user account.
  - If the user passes remote authorization, the remote AAA server assigns the user roles specified on the server. The AAA server can be a RADIUS or HWTACACS server.
- **Non-AAA authorization**—When the user accesses the device without authentication or by passing password authentication on a user line, the device assigns user roles specified on the user line. This method also applies to SSH clients that use publickey or password-publickey authentication. User roles assigned to these SSH clients are specified in their respective device management user accounts.

For more information about AAA and SSH, see *Security Configuration Guide*. For more information about user lines, see "Login overview" and "Configuring CLI login."

FIPS compliance

The device supports the FIPS mode that complies with NIST FIPS 140-2 requirements. Support for features, commands, and parameters might differ in FIPS mode and non-FIPS mode. For more information about FIPS mode, see *Security Configuration Guide*.

RBAC tasks at a glance

To configure RBAC, perform the following tasks:

1. Creating a user role
2. Configuring user role rules
3. (Optional.) Configuring a feature group
4. Configuring resource access policies
   - Configuring the user role interface policy
   - Configuring the user role VLAN policy
5. Assigning user roles
   - Enabling the default user role feature
   - Assigning user roles to remote AAA authentication users
   - Assigning user roles to local AAA authentication users
   - Assigning user roles to non-AAA authentication users on user lines
6. Configuring temporary user role authorization
   a. Setting the authentication mode for temporary user role authorization
   b. Specifying the default target user role for temporary user role authorization
   c. Setting an authentication password for temporary user role authorization
   d. (Optional.) Automatically obtaining the login username for temporary user role authorization
   e. Obtaining temporary user role authorization

Creating a user role

About user role creation

In addition to the predefined user roles, you can create a maximum of 64 custom user roles for granular access control.

Procedure

1. Enter system view.
   `system-view`
2. Create a user role and enter its view.
   `role name` *`role-name`*
   By default, the system has the following predefined user roles:
   - network-admin.
   - network-operator.
   - level-*n* (where *n* equals an integer in the range of 0 to 15).
   - security-audit.

Among these user roles, only the permissions and descriptions of the level-0 to level-14 user roles are configurable.

3. (Optional.) Configure a description for the user role.

   description *text*

   By default, a user role does not have a description.

Configuring user role rules

About user role rules

You can configure user role rules to permit or deny the access of a user role to specific commands, Web pages, XML elements, and MIB nodes.

The following guidelines apply to non-OID rules:

- If two user-defined rules of the same type conflict, the rule with the higher ID takes effect. For example, a user role can use the **tracert** command but not the **ping** command if the user role contains rules configured by using the following commands:
  - **rule** *1* **permit command** *ping*
  - **rule** *2* **permit command** *tracert*
  - **rule** *3* **deny command** *ping*
- If a predefined user role rule and a user-defined user role rule conflict, the user-defined user role rule takes effect.

The following guidelines apply to OID rules:

- The system compares an OID with the OIDs specified in user role rules, and it uses the longest match principle to select a rule for the OID. For example, a user role cannot access the MIB node with OID 1.3.6.1.4.1.25506.141.3.0.1 if the user role contains rules configured by using the following commands:
  - **rule** *1* **permit read write oid** *1.3.6*
  - **rule** *2* **deny read write oid** *1.3.6.1.4.1*
  - **rule** *3* **permit read write oid** *1.3.6.1.4*
- If the same OID is specified in multiple rules, the rule with the higher ID takes effect. For example, a user role can access the MIB node with OID 1.3.6.1.4.1.25506.141.3.0.1 if the user role contains rules configured by using the following commands:
  - **rule** *1* **permit read write oid** *1.3.6*
  - **rule** *2* **deny read write oid** *1.3.6.1.4.1*
  - **rule** *3* **permit read write oid** *1.3.6.1.4.1*

Restrictions and guidelines

- Only the network-admin and level-15 user roles have access to the following commands:
  - The **display history-command all** command.
  - All commands that start with the **display role**, **reboot**, **startup saved-configuration**, and **undo startup saved-configuration** keywords.
  - All commands that start with the **role**, **undo role**, **super**, **undo super**, **password-recovery**, and **undo password-recovery** keywords in system view.
  - All commands that start with the **snmp-agent community**, **undo snmp-agent community**, **snmp-agent usm-user**, **undo snmp-agent usm-user**, **snmp-agent group**, and **undo snmp-agent group** keywords in system view.
  - All commands that start with the **user-role**, **undo user-role**, **authentication-mode**, **undo authentication-mode**, **set authentication**

password, and **undo set authentication password** keywords in user line view or user line class view.

- All commands that start with the **user-role** and **undo user-role** keywords in schedule view or in CLI-defined policy view.

- You can configure a maximum of 256 user-defined rules for a user role. The total number of user-defined user role rules cannot exceed 1024.
- Any rule modification, addition, or removal for a user role takes effect only on users who are logged in with the user role after the change.

Procedure

1. Enter system view.

   system-view
2. Enter user role view.

   role name *role-name*
3. Configure rules for the user role. Choose the options to configure as needed:
   - Configure a command rule.

     rule *number* { **deny** | **permit** } **command** *command-string*
   - Configure a feature rule.

     rule *number* { **deny** | **permit** } { **execute** | **read** | **write** } * **feature** [*feature-name*]
   - Configure a feature group rule.

     rule *number* { **deny** | **permit** } { **execute** | **read** | **write** } * **feature-group** *feature-group-name*

     A feature group rule takes effect only after the feature group is created.
   - Configure a Web menu rule.

     rule *number* { **deny** | **permit** } { **execute** | **read** | **write** } * **web-menu** [*web-string*]
   - Configure an XML element rule.

     rule *number* { **deny** | **permit** } { **execute** | **read** | **write** } * **xml-element** [*xml-string*]
   - Configure an OID rule.

     rule *number* { **deny** | **permit** } { **execute** | **read** | **write** } * **oid** *oid-string*

Configuring a feature group

About feature groups

Use feature groups to bulk assign command access permissions to sets of features. In addition to the predefined feature groups, you can create a maximum of 64 custom feature groups and assign a feature to multiple feature groups.

Procedure

1. Enter system view.

   system-view
2. Create a feature group and enter its view.

   role feature-group name *feature-group-name*

   By default, the system has the following predefined feature groups, which cannot be deleted or modified:

- **L2**—Includes all Layer 2 commands.
- **L3**—Includes all Layer 3 commands.

3. Add a feature to the feature group.

   feature *feature-name*

   By default, a feature group does not have any feature.

Configuring resource access policies

About resource access policies

Every user role has one interface policy and VLAN policy. By default, these policies permit a user role to access any system resources. You can configure the policies of a user-defined user role or a predefined level-*n* user role to limit its access to any resources.

Restrictions and guidelines for resource access policy configuration

The policy configuration takes effect only on users who are logged in with the user role after the configuration.

Configuring the user role interface policy

1. Enter system view.

   system-view

2. Enter user role view.

   role name *role-name*

3. Enter user role interface policy view.

   interface policy deny

   By default, the interface policy of the user role permits access to all interfaces.

CAUTION:

This command denies the access of the user role to any interfaces if you do not specify accessible interfaces by using the **permit interface** command.

4. (Optional.) Specify a list of interfaces accessible to the user role.

   permit interface *interface-list*

   By default, no accessible interfaces are configured in user role interface policy view.

   Repeat this step to add multiple accessible interfaces.

Configuring the user role VLAN policy

1. Enter system view.

   system-view

2. Enter user role view.

   role name *role-name*

3. Enter user role VLAN policy view.

vlan policy deny

By default, the VLAN policy of the user role permits access to all VLANs.

CAUTION:

This command denies the access of the user role to any VLANs if you do not specify accessible VLANs by using the **permit vlan** command.

4. (Optional.) Specify a list of VLANs accessible to the user role.

   permit vlan *vlan-id-list*

   By default, no accessible VLANs are configured in user role VLAN policy view.

   Repeat this step to add multiple accessible VLANs.

Assigning user roles

Restrictions and guidelines for user role assignment

To control user access to the system, you must assign a minimum of one user role. Make sure a minimum of one user role among the user roles assigned by the server exists on the device.

Enabling the default user role feature

About the default user role feature

The default user role feature assigns the default user role to AAA-authenticated users if the authentication server (local or remote) does not assign any user roles to the users. These users are allowed to access the system with the default user role.

You can specify any user role existing in the system as the default user role.

Procedure

1. Enter system view.

   system-view

2. Enable the default user role feature.

   role default-role enable [*role-name*]

   By default, the default user role feature is disabled.

   If you do not use the **authorization-attribute user role** command to assign user roles to local users, you must enable the default user role feature. For information about the **authorization-attribute user role** command, see AAA commands in *Security Command Reference*.

Assigning user roles to remote AAA authentication users

For remote AAA authentication users, user roles are configured on the remote authentication server. For information about configuring user roles for RADIUS users, see the RADIUS server documentation. For HWTACACS users, the role configuration must use the **roles="***role-1 role-2 … role-n***"** format, where user roles are space separated. For example, configure **roles="level-0 level-1 level-2"** to assign level-0, level-1, and level-2 to an HWTACACS user.

If the AAA server assigns the security-audit user role and other user roles to the same user, only the security-audit user role takes effect.

Assigning user roles to local AAA authentication users

About user role assignment to local AAA authentication users

Configure user roles for local AAA authentication users in their local user accounts. For information about AAA and local user configuration, see AAA configuration in *Security Configuration Guide*.

Restrictions and guidelines

- Every local user has a default user role. If this default user role is not suitable, remove it.
- If a local user is the only user with the security-audit user role, the user cannot be deleted.
- The security-audit user role is mutually exclusive with other user roles.
  - When you assign the security-audit user role to a local user, the system requests confirmation to remove all the other user roles from the user.
  - When you assign the other user roles to a local user who has the security-audit user role, the system requests confirmation to remove the security-audit role from the user.
- You can assign a maximum of 64 user roles to a local user.

Procedure

1. Enter system view.

   system-view
2. Create a local user and enter its view.

   local-user *user-name* **class** { **manage** | **network** }
3. Assign a user role to the local user.

   authorization-attribute user-role *role-name*

   By default, the network-operator user role is assigned to local users created by a network-admin or level-15 user.

Assigning user roles to non-AAA authentication users on user lines

About user role assignment to non-AAA authentication users

Specify user roles for the following two types of login users on the user lines:

- Non-SSH users that use password authentication or no authentication.
- SSH clients that use publickey or password-publickey authentication. User roles assigned to these SSH clients are specified in their respective device management user accounts.

For more information about user lines, see "Login overview" and "Configuring CLI login." For more information about SSH, see *Security Configuration Guide*.

Restrictions and guidelines

- You can assign a maximum of 64 user roles to a non-AAA authentication user on a user line.
- You cannot assign the security-audit user role to non-AAA authentication users on user lines.

Procedure

1. Enter system view.

   system-view
2. Enter user line view or user line class view.
   - Enter user line view.

line { *first-num1* [*last-num1*] | { **aux** | **vty** } *first-num2* [*last-num2*] }

- Enter user line class view.

  line class { **aux** | **vty** }

For information about the priority order and application scope of the settings in user line view and user line class view, see "Configuring CLI login."

3. Specify a user role on the user line.

   user-role *role-name*

   By default, the network-admin user role is specified on the AUX user line, and the network-operator user role is specified on any other user line.

Configuring temporary user role authorization

About temporary user role authorization

Temporary user role authorization allows you to obtain another user role without reconnecting to the device. This feature is useful when you want to use a user role temporarily to configure a feature.

Temporary user role authorization is effective only on the current login. This feature does not change the user role settings in the user account that you have been logged in with. The next time you are logged in with the user account, the original user role settings take effect.

To enable a user to obtain another user role without reconnecting to the device, you must configure user role authentication. Table 2 describes the available authentication modes and configuration requirements.

Table 2 User role authentication modes

Keywords	Authentication mode	Description
local	Local password authentication only (local-only)	The device uses the locally configured password for authentication. If no local password is configured for a user role in this mode, an AUX user can obtain the user role by either entering a string or not entering anything.
scheme	Remote AAA authentication through HWTACACS or RADIUS (remote-only)	The device sends the username and password to the HWTACACS or RADIUS server for remote authentication. To use this mode, you must perform the following configuration tasks: • Configure the required HWTACACS or RADIUS scheme, and configure the ISP domain to use the scheme for the user. For more information, see *Security Configuration Guide*. • Add the user account and password on the HWTACACS or RADIUS server.
local scheme	Local password authentication first, and then remote AAA authentication (local-then-remote)	Local password authentication is performed first. If no local password is configured for the user role in this mode: • The device performs remote AAA authentication for VTY users. • An AUX user can obtain another user role by either entering a string or not entering anything.

Keywords	Authentication mode	Description
scheme local	Remote AAA authentication first, and then local password authentication (remote-then-local)	Remote AAA authentication is performed first. Local password authentication is performed in either of the following situations: • The HWTACACS or RADIUS server does not respond. • The remote AAA configuration on the device is invalid.

Restrictions and guidelines for temporary user role authorization

If HWTACACS authentication is used, the following rules apply:

- If the device is not enabled to automatically obtain the login username as the authentication username, you must enter a username to request role authentication.
- The device sends the username to the server in the *username or username@domain-name* format. Whether the domain name is included in the username depends on the **user-name-format** command in the HWTACACS scheme.
- To obtain a level-*n* user role, the user account on the server must have the target user role level or a level higher than the target user role. A user account that obtains the level-*n* user role can obtain any user role among level-0 through level-*n*.
- To obtain a non-level-*n* user role, make sure the user account on the server meets the following requirements:
  - The account has a user privilege level.
  - The HWTACACS custom attribute is configured for the account in the form of **allowed-roles="***role***"**. The variable *role* represents the target user role.

If RADIUS authentication is used, the following rules apply:

- The device does not use the username you enter or the automatically obtained login username to request user role authentication. It uses a username in the **$enab*n*$** format. The variable *n* represents a user role level, and a domain name is not included in the username. You can always pass user role authentication when the password is correct.
- To obtain a level-*n* user role, you must create a user account for the level-*n* user role in the **$enabn$** format on the RADIUS server. The variable *n* represents the target user role level. For example, to obtain the level-3 user role, you can enter any username. The device uses the username **$enab3$** to request user role authentication from the server.
- To obtain a non-level-*n* user role, you must perform the following tasks:
  - Create a user account named **$enab0$** on the server.
  - Configure the cisco-av-pair attribute for the account in the form of **allowed-roles="***role***"**. The variable *role* represents the target user role.

The device selects an authentication domain for user role authentication in the following order:

1. The ISP domain included in the entered username.
2. The default ISP domain.

If you execute the **quit** command after obtaining user role authorization, you are logged out of the device.

Setting the authentication mode for temporary user role authorization

1. Enter system view.
   system-view
2. Set the authentication mode.
   super authentication-mode { **local** | **scheme** } *
   By default, local-only authentication applies.

Specifying the default target user role for temporary user role authorization

1. Enter system view.
   system-view
2. Specify the default target user role for temporary user role authorization.
   super default role *role-name*
   By default, the default target user role is network-admin.

Setting an authentication password for temporary user role authorization

About authentication passwords

Authentication passwords are required only for local password authentication.

Procedure

1. Enter system view.
   system-view
2. Set a local authentication password for a user role.
   In non-FIPS mode:
   super password [**role** *role-name*] [{ **hash** | **simple** } *string*]
   In FIPS mode:
   super password [**role** *role-name*]
   By default, no password is set.
   If you do not specify the **role** *role-name* option, the command sets a password for the default target user role.

Automatically obtaining the login username for temporary user role authorization

About automatic obtaining of the login username for temporary user role authorization

This feature is applicable only to the login from a user line that uses scheme authentication, which requires a username for login. This feature enables the device to automatically obtain the login username when the login user requests a temporary user role authorization from a remote authentication server.

Restrictions and guidelines

If the user was logged in from a user line that uses password authentication or no authentication, the device cannot obtain the login username. The request for temporary user role authorization from a remote authentication server will fail.

This feature does not take effect on local password authentication for temporary user role authorization.

Procedure

1. Enter system view.

   system-view

2. Enable the device to automatically obtain the login username when a login user requests temporary user role authorization from a remote authentication server.

   super use-login-username

   By default, the device prompts for a username when a login user requests temporary user role authorization from a remote authentication server.

Obtaining temporary user role authorization

Restrictions and guidelines

The operation of obtaining temporary user role authorization fails after three consecutive unsuccessful authentication attempts.

You might fail to switch to a non-level-*n* user role if both of the following conditions exist:

- User role switching authentication is performed in the same ISP domain as the current login user.
- User role switching authentication uses a different AAA method than the login authorization method configured for the ISP domain.

To resolve this issue, make sure the AAA methods configured by using the **authentication super** command are consistent with those configured by using the **authorization login** command for the ISP domain.

For more information about AAA, see *Security Configuration Guide*.

Prerequisites

Before you obtain temporary user role authorization, make sure the current user account has the permission to execute the **super** command to obtain temporary user role authorization.

Procedure

To obtain the temporary authorization to use a user role, execute the following command in user view:

super [*role-name*]

If you do not specify the *role-name* argument, you obtain the default target user role for temporary user role authorization.

Display and maintenance commands for RBAC

Execute **display** commands in any view.

Task	Command
Display user role information.	**display role** [**name** *role-name*]

Task	Command
Display user role feature information.	**display role feature** [**name** *feature-name* | **verbose**]
Display user role feature group information.	**display role feature-group** [**name** *feature-group-name*] [**verbose**]

RBAC configuration examples

Example: Configuring RBAC for local AAA authentication users

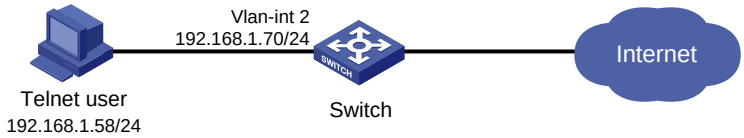
Network configuration

As shown in Figure 1, the switch performs local AAA authentication for the Telnet user. The user account for the Telnet user is **user1@bbb**, which is assigned user role **role1**.

Configure **role1** to have the following permissions:

- Execute the read commands of any feature.
- Access VLANs 10 to 20. Access to any other VLANs is denied.

Figure 1 Network diagram



Procedure

Assign an IP address to VLAN-interface 2 (the interface connected to the Telnet user).

```
<Switch> system-view
[Switch] interface vlan-interface 2
[Switch-Vlan-interface2] ip address 192.168.1.70 255.255.255.0
[Switch-Vlan-interface2] quit
```

Enable the Telnet server.

```
[Switch] telnet server enable
```

Enable scheme authentication on the user lines for Telnet users.

```
[Switch] line vty 0 63
[Switch-line-vty0-63] authentication-mode scheme
[Switch-line-vty0-63] quit
```

Enable local authentication and authorization for ISP domain **bbb**.

```
[Switch] domain bbb
[Switch-isp-bbb] authentication login local
[Switch-isp-bbb] authorization login local
[Switch-isp-bbb] quit
```

Create a user role named **role1**.

```
[Switch] role name role1
```

Configure rule 1 to permit the user role to access the read commands of all features.

```
[Switch-role-role1] rule 1 permit read feature
```

Configure rule 2 to permit the user role to create VLANs and access commands in VLAN view.

```
[Switch-role-role1] rule 2 permit command system-view ; vlan *
```

Change the VLAN policy to permit the user role to configure only VLANs 10 to 20.

```
[Switch-role-role1] vlan policy deny
[Switch-role-role1-vlanpolicy] permit vlan 10 to 20
[Switch-role-role1-vlanpolicy] quit
[Switch-role-role1] quit
```

Create a device management user named **user1** and enter local user view.

```
[Switch] local-user user1 class manage
```

Set a plaintext password of **123456TESTplat&!** for the user.

```
[Switch-luser-manage-user1] password simple 123456TESTplat&!
```

Set the service type to **Telnet**.

```
[Switch-luser-manage-user1] service-type telnet
```

Assign **role1** to the user.

```
[Switch-luser-manage-user1] authorization-attribute user-role role1
```

Remove the default user role (**network-operator**) from the user. This operation ensures that the user has only the permissions of **role1**.

```
[Switch-luser-manage-user1] undo authorization-attribute user-role network-operator
[Switch-luser-manage-user1] quit
```

Verifying the configuration

Telnet to the switch, and enter the username and password to access the switch. (Details not shown.)

Verify that you can create VLANs 10 to 20. This example uses VLAN 10.

```
<Switch> system-view
[Switch] vlan 10
[Switch-vlan10] quit
```

Verify that you cannot create any VLAN other than VLANs 10 to 20. This example uses VLAN 30.

```
[Switch] vlan 30
Permission denied.
```

Verify that you can use all read commands of any feature. This example uses **`display clock`**.

```
[Switch] display clock
09:31:56.258 UTC Sun 01/01/2017
[Switch] quit
```

Verify that you cannot use the write or execute commands of any feature.

```
<Switch> debugging role all
Permission denied.
<Switch> ping 192.168.1.58
Permission denied.
```

Example: Configuring RBAC for RADIUS authentication users

Network configuration

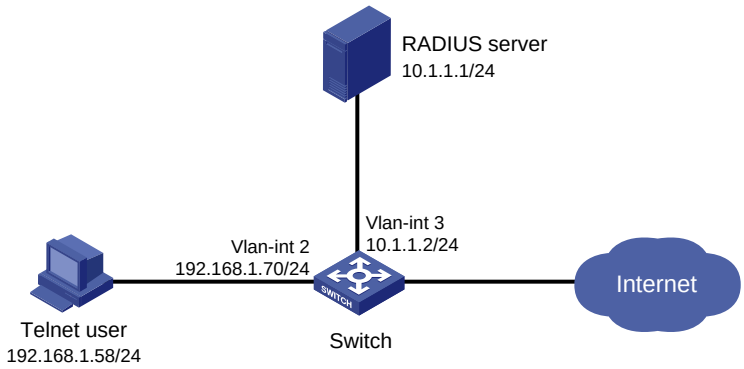
As shown in Figure 2, the switch uses the FreeRADIUS server to provide AAA service for login users, including the Telnet user. The user account for the Telnet user is **hello@bbb**, which is assigned user role **role2**.

User role **role2** has the following permissions:

- Use all commands in ISP domain view.
- Use the read and write commands of the **arp** and **radius** features.
- Cannot access the read commands of the **acl** feature.
- Configure VLANs 1 to 20 and interfaces GigabitEthernet 1/0/1 to GigabitEthernet 1/0/4. Access to any other VLANs and interfaces is denied.

The switch and the FreeRADIUS server use a shared key of **expert** and authentication port **1812**. The switch delivers usernames with their domain names to the server.

Figure 2 Network diagram



Procedure

Make sure the settings on the switch and the RADIUS server match.

1. Configure the switch:

Assign VLAN-interface 2 an IP address from the same subnet as the Telnet user.

```
<Switch> system-view
[Switch] interface vlan-interface 2
[Switch-Vlan-interface2] ip address 192.168.1.70 255.255.255.0
[Switch-Vlan-interface2] quit
```

Assign VLAN-interface 3 an IP address from the same subnet as the RADIUS server.

```
[Switch] interface vlan-interface 3
[Switch-Vlan-interface3] ip address 10.1.1.2 255.255.255.0
[Switch-Vlan-interface3] quit
```

Enable the Telnet server.

```
[Switch] telnet server enable
```

Enable scheme authentication on the user lines for Telnet users.

```
[Switch] line vty 0 63
[Switch-line-vty0-63] authentication-mode scheme
[Switch-line-vty0-63] quit
```

Create RADIUS scheme **rad** and enter RADIUS scheme view.

```
[Switch] radius scheme rad
```

Specify the primary server address and the service port in the scheme.

```
[Switch-radius-rad] primary authentication 10.1.1.1 1812
```

Set the shared key to **expert** in the scheme for the switch to authenticate to the server.

```
[Switch-radius-rad] key authentication simple expert
[Switch-radius-rad] quit
```

Specify scheme **rad** as the authentication and authorization schemes for ISP domain **bbb**, and configure the ISP domain to not perform accounting for login users.

IMPORTANT:

Because RADIUS user authorization information is piggybacked in authentication responses, the authentication and authorization methods must use the same RADIUS scheme.

```
[Switch] domain bbb
[Switch-isp-bbb] authentication login radius-scheme rad
[Switch-isp-bbb] authorization login radius-scheme rad
[Switch-isp-bbb] accounting login none
[Switch-isp-bbb] quit
```

Create feature group **fgroup1**.

```
[Switch] role feature-group name fgroup1
```

Add the **arp** and **radius** features to the feature group.

```
[Switch-featuregrp-fgroup1] feature arp
[Switch-featuregrp-fgroup1] feature radius
[Switch-featuregrp-fgroup1] quit
```

Create user role **role2**.

```
[Switch] role name role2
```

Configure rule 1 to permit the user role to use all commands available in ISP domain view.

```
[Switch-role-role2] rule 1 permit command system-view ; domain *
```

Configure rule 2 to permit the user role to use the read and write commands of all features in **fgroup1**.

```
[Switch-role-role2] rule 2 permit read write feature-group fgroup1
```

Configure rule 3 to disable access to the read commands of the **acl** feature.

```
[Switch-role-role2] rule 3 deny read feature acl
```

Configure rule 4 to permit the user role to create VLANs and use all commands available in VLAN view.

```
[Switch-role-role2] rule 4 permit command system-view ; vlan *
```

Configure rule 5 to permit the user role to enter interface view and use all commands available in interface view.

```
[Switch-role-role2] rule 5 permit command system-view ; interface *
```

Configure the user role VLAN policy to disable configuration of any VLAN except VLANs 1 to 20.

```
[Switch-role-role2] vlan policy deny
[Switch-role-role2-vlanpolicy] permit vlan 1 to 20
[Switch-role-role2-vlanpolicy] quit
```

Configure the user role interface policy to disable configuration of any interface except GigabitEthernet 1/0/1 to GigabitEthernet 1/0/4.

```
[Switch-role-role2] interface policy deny
```

```
[Switch-role-role2-ifpolicy] permit interface gigabitethernet 1/0/1 to
gigabitethernet 1/0/4
[Switch-role-role2-ifpolicy] quit
[Switch-role-role2] quit
```

2. Configure the RADIUS server:

   # Add either of the user role attributes to the dictionary file of the FreeRADIUS server.

   ```
   Cisco-AVPair = "shell:roles=\"role2\""
   Cisco-AVPair = "shell:roles*\"role2\""
   ```

   # Configure the settings required for the FreeRADIUS server to communicate with the switch. (Details not shown.)

Verifying the configuration

Telnet to the switch, and enter the username and password to access the switch. (Details not shown.)

Verify that you can use all commands available in ISP domain view.

```
<Switch> system-view
[Switch] domain abc
[Switch-isp-abc] authentication login radius-scheme abc
[Switch-isp-abc] quit
```

Verify that you can use all read and write commands of the **radius** and **arp** features. This example uses **radius**.

```
[Switch] radius scheme rad
[Switch-radius-rad] primary authentication 2.2.2.2
[Switch-radius-rad] display radius scheme rad
...
```

Verify that you cannot configure any VLAN except VLANs 1 to 20. This example uses VLAN 10 and VLAN 30.

```
[Switch] vlan 10
[Switch-vlan10] quit
[Switch] vlan 30
Permission denied.
```

Verify that you cannot configure any interface except GigabitEthernet 1/0/1 to GigabitEthernet 1/0/4. This example uses GigabitEthernet 1/0/2 and GigabitEthernet 1/0/5.

```
[Switch] vlan 10
[Switch-vlan10] port gigabitethernet 1/0/2
[Switch-vlan10] port gigabitethernet 1/0/5
Permission denied.
```

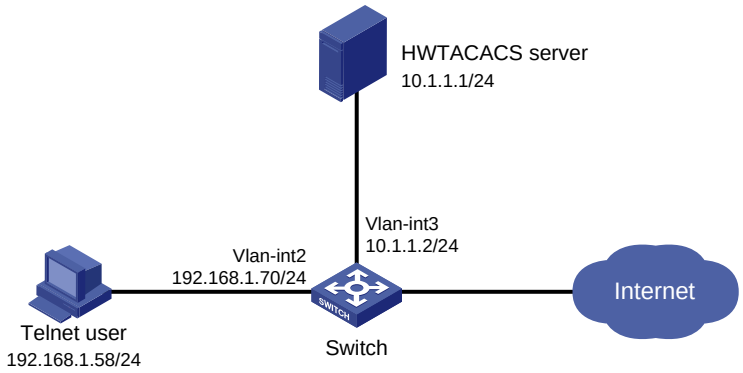
Example: Configuring RBAC temporary user role authorization (HWTACACS authentication)

Network configuration

As shown in Figure 3, the switch uses HWTACACS authentication for login users, including the Telnet user. The user account for the Telnet user is **test@bbb**, which is assigned user role **level-0**.

Configure the remote-then-local authentication mode for temporary user role authorization. The switch uses the HWTACACS server to provide authentication for changing the user role among **level-0** through **level-3** or changing the user role to **network-admin**. If the AAA configuration is invalid or the HWTACACS server does not respond, the switch performs local authentication.

Figure 3 Network diagram



Procedure

1. Configure the switch:

   # Assign an IP address to VLAN-interface 2 (the interface connected to the Telnet user).

   ```
   <Switch> system-view
   [Switch] interface vlan-interface 2
   [Switch-Vlan-interface2] ip address 192.168.1.70 255.255.255.0
   [Switch-Vlan-interface2] quit
   ```

   # Assign an IP address to VLAN-interface 3 (the interface connected to the HWTACACS server).

   ```
   [Switch] interface vlan-interface 3
   [Switch-Vlan-interface3] ip address 10.1.1.2 255.255.255.0
   [Switch-Vlan-interface3] quit
   ```

   # Enable the Telnet server.

   ```
   [Switch] telnet server enable
   ```

   # Enable scheme authentication on the user lines for Telnet users.

   ```
   [Switch] line vty 0 63
   [Switch-line-vty0-63] authentication-mode scheme
   [Switch-line-vty0-63] quit
   ```

   # Enable remote-then-local authentication for temporary user role authorization.

   ```
   [Switch] super authentication-mode scheme local
   ```

   # Create an HWTACACS scheme named **hwtac** and enter HWTACACS scheme view.

   ```
   [Switch] hwtacacs scheme hwtac
   ```

   # Specify the primary authentication server address and the service port in the scheme.

   ```
   [Switch-hwtacacs-hwtac] primary authentication 10.1.1.1 49
   ```

   # Specify the primary authorization server address and the service port in the scheme.

   ```
   [Switch-hwtacacs-hwtac] primary authorization 10.1.1.1 49
   ```

   # Set the shared key to **expert** in the scheme for the switch to authenticate to the authentication server.

   ```
   [Switch-hwtacacs-hwtac] key authentication simple expert
   ```

   # Set the shared key to **expert** in the scheme for the switch to authenticate to the authorization server.

   ```
   [Switch-hwtacacs-hwtac] key authorization simple expert
   ```

   # Exclude ISP domain names from the usernames sent to the HWTACACS server.

   ```
   [Switch-hwtacacs-hwtac] user-name-format without-domain
   [Switch-hwtacacs-hwtac] quit
   ```

Create ISP domain **bbb** and enter ISP domain view.

```
[Switch] domain bbb
```

Configure ISP domain **bbb** to use HWTACACS scheme **hwtac** for login user authentication.

```
[Switch-isp-bbb] authentication login hwtacacs-scheme hwtac
```

Configure ISP domain **bbb** to use HWTACACS scheme **hwtac** for login user authorization.

```
[Switch-isp-bbb] authorization login hwtacacs-scheme hwtac
```

Configure ISP domain **bbb** to not perform accounting for login users.

```
[Switch-isp-bbb] accounting login none
```

Apply HWTACACS scheme **hwtac** to the ISP domain for user role authentication.

```
[Switch-isp-bbb] authentication super hwtacacs-scheme hwtac
[Switch-isp-bbb] quit
```

Set the local authentication password to **654321TESTplat&!** for user role **level-3**.

```
[Switch] super password role level-3 simple 654321TESTplat&!
```

Set the local authentication password to **654321TESTplat&!** for user role **network-admin**.

```
[Switch] super password role network-admin simple 654321TESTplat&!
[Switch] quit
```

2. Configure the HWTACACS server:

This example uses ACSv4.0.

This example only provides the key configuration steps. For more information about configuring a HWTACACS server, see the server documentation.

a. Access the **User Setup** page.

b. Add a user account named **test** and set its password to **123456TESTplat&!**. (Details not shown.)

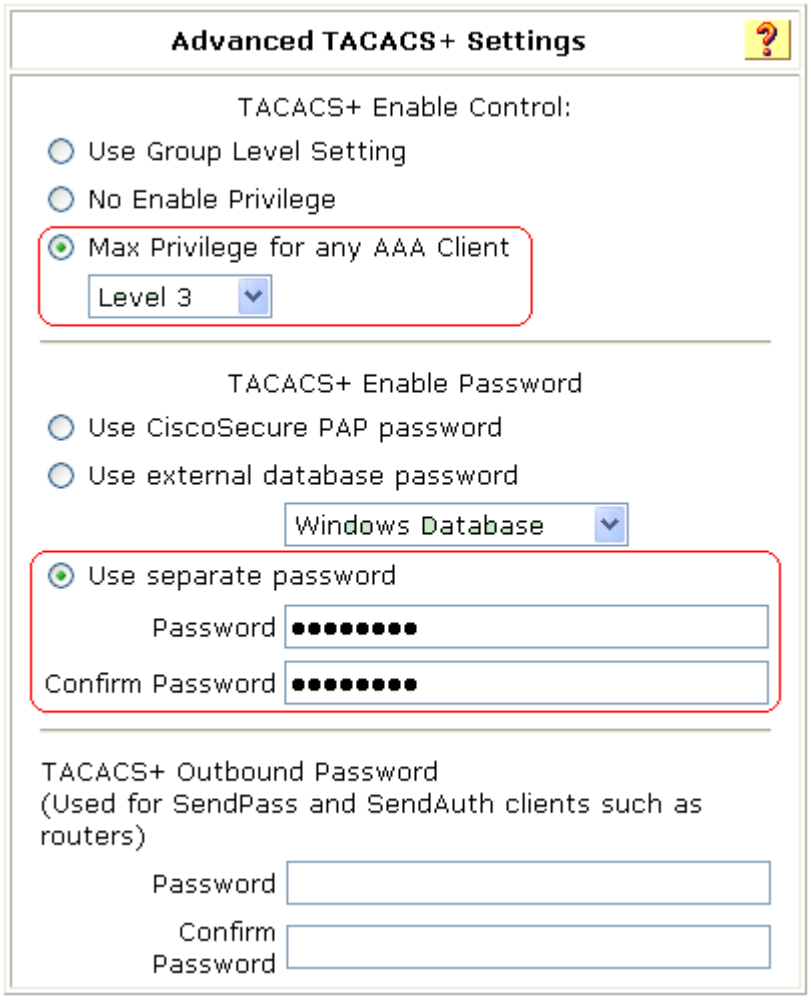
c. In the **Advanced TACACS+ Settings** area, configure the following parameters:

- Select **Level 3** for the **Max Privilege for any AAA Client** option.

  If the target user role is only **network-admin** for temporary user role authorization, you can select any level for the option.

- Select the **Use separate password** option, and specify **enabpass** as the password.

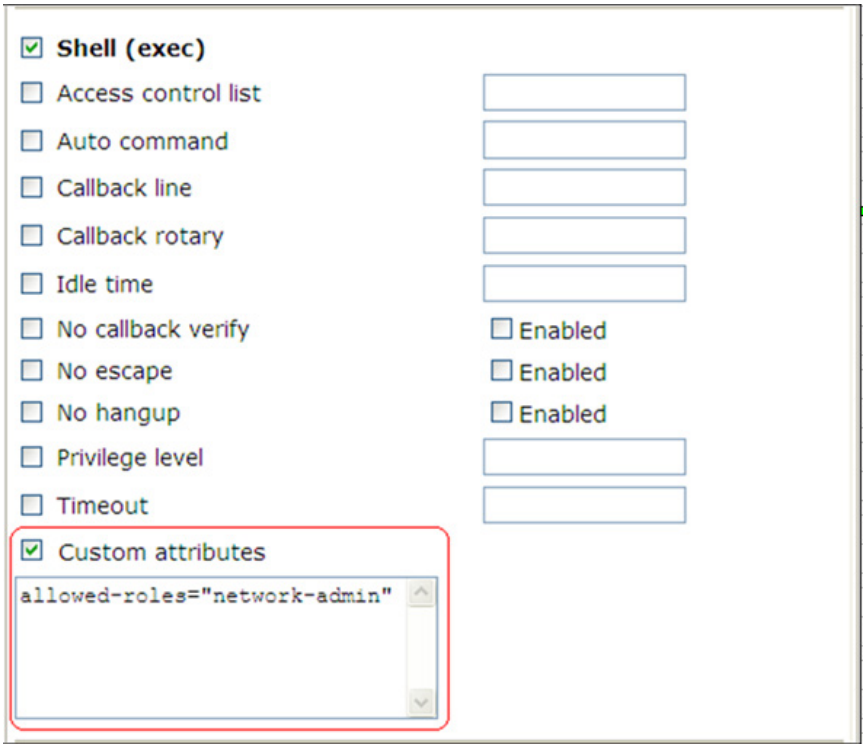
Figure 4 Configuring advanced TACACS+ settings



d. Select **Shell (exec)** and **Custom attributes**, and enter **allowed-roles="network-admin"** in the **Custom attributes** field.

Use a blank space to separate the allowed roles.

Figure 5 Configuring custom attributes for the Telnet user



Verifying the configuration

1. Telnet to the switch, and enter username **test@bbb** and password **123456TESTplat&!** to access the switch. Verify that you have access to diagnostic commands.

```
<Switch> telnet 192.168.1.70
Trying 192.168.1.70 ...
Press CTRL+K to abort
Connected to 192.168.1.70 ...
******************************************************************************
* Copyright (c) 2004-2017 New H3C Technologies Co., Ltd. All rights reserved.*
* Without the owner's prior written consent,                                 *
* no decompiling or reverse-engineering shall be allowed.                    *
******************************************************************************

login: test@bbb
Password:
<Switch>?
User view commands:
  ping         Ping function
  quit         Exit from current command view
  ssh2         Establish a secure shell client connection
  super        Switch to a user role
  system-view  Enter the System View
  telnet       Establish a telnet connection
  tracert      Tracert function

<Switch>
```

2. Verify that you can obtain the level-3 user role:

   # Use the super password to obtain the level-3 user role. When the system prompts for a username and password, enter username **test@bbb** and password **enabpass**.

   ```
   <Switch> super level-3
   Username: test@bbb
   Password:
   ```

   The following output shows that you have obtained the level-3 user role.

   ```
   User privilege role is level-3, and only those commands that authorized to the role can be used.
   ```

   # If the ACS server does not respond, enter local authentication password **654321TESTplat&!** at the prompt.

   ```
   Invalid configuration or no response from the authentication server.
   Change authentication mode to local.
   Password:
   User privilege role is level-3, and only those commands that authorized to the role can be used.
   ```

   The output shows that you have obtained the level-3 user role.

3. Use the method in step 2 to verify that you can obtain the level-0, level-1, level-2, and network-admin user roles. (Details not shown.)

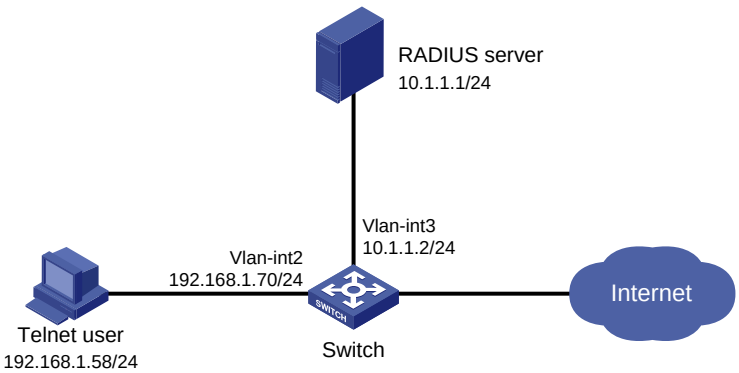
Example: Configuring RBAC temporary user role authorization (RADIUS authentication)

Network configuration

As shown in Figure 6, the switch uses RADIUS authentication for login users, including the Telnet user. The user account for the Telnet user is **test@bbb**, which is assigned user role **level-0**.

Configure the remote-then-local authentication mode for temporary user role authorization. The switch uses the RADIUS server to provide authentication for the **network-admin** user role. If the AAA configuration is invalid or the RADIUS server does not respond, the switch performs local authentication.

Figure 6 Network diagram



Procedure

1. Configure the switch:

   # Assign an IP address to VLAN-interface 2 (the interface connected to the Telnet user).

   ```
   <Switch> system-view
   [Switch] interface vlan-interface 2
   ```

```
[Switch-Vlan-interface2] ip address 192.168.1.70 255.255.255.0
[Switch-Vlan-interface2] quit
```

Assign an IP address to VLAN-interface 3 (the interface connected to the RADIUS server).

```
[Switch] interface vlan-interface 3
[Switch-Vlan-interface3] ip address 10.1.1.2 255.255.255.0
[Switch-Vlan-interface3] quit
```

Enable the Telnet server.

```
[Switch] telnet server enable
```

Enable scheme authentication on the user lines for Telnet users.

```
[Switch] line vty 0 15
[Switch-line-vty0-15] authentication-mode scheme
[Switch-line-vty0-15] quit
```

Enable remote-then-local authentication for temporary user role authorization.

```
[Switch] super authentication-mode scheme local
```

Create RADIUS scheme **radius** and enter RADIUS scheme view.

```
[Switch] radius scheme radius
```

Specify the primary authentication server address and the shared key in the scheme for secure communication between the switch and the server.

```
[Switch-radius-radius] primary authentication 10.1.1.1 key simple expert
```

Exclude ISP domain names from the usernames sent to the RADIUS server.

```
[Switch-radius-radius] user-name-format without-domain
[Switch-radius-radius] quit
```

Create ISP domain **bbb** and enter ISP domain view.

```
[Switch] domain bbb
```

Configure ISP domain **bbb** to use RADIUS scheme **radius** for login user authentication.

```
[Switch-isp-bbb] authentication login radius-scheme radius
```

Configure ISP domain **bbb** to use RADIUS scheme **radius** for login user authorization.

```
[Switch-isp-bbb] authorization login radius-scheme radius
```

Configure ISP domain **bbb** to not perform accounting for login users.

```
[Switch-isp-bbb] accounting login none
```

Apply RADIUS scheme **radius** to the ISP domain for user role authentication.

```
[Switch-isp-bbb] authentication super radius-scheme radius
[Switch-isp-bbb] quit
```

Set the local authentication password to **abcdef654321** for user role **network-admin**.

```
[Switch] super password role network-admin simple abcdef654321
[Switch] quit
```

2. Configure the RADIUS server:

This example uses ACSv4.2.

This example only provides the key configuration steps. For more information about configuring a RADIUS server, see the server documentation.

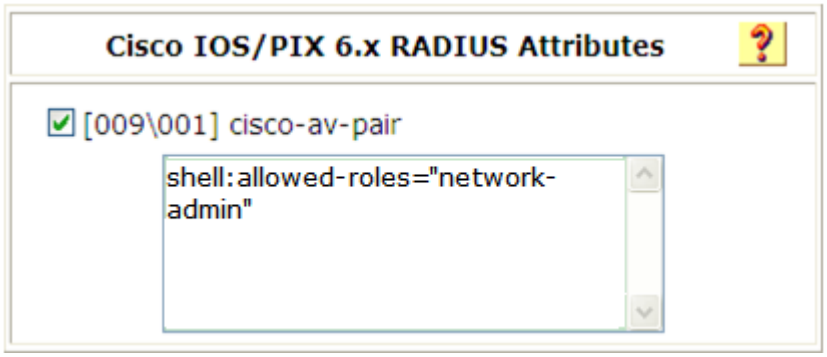
a. Add a Telnet user account for login authentication. Set the username to **test@bbb** and the password to **123456TESTplat&!**. (Details not shown.)

b. Add a user account for temporary user role authorization. Set the username to **$enab0$** and the password to **123456**. (Details not shown.)

c. Access the **Cisco IOS/PIX 6.x RADIUS Attributes** page.

d. Configure the **cisco-av-pair** attribute, as shown in Figure 7.

Figure 7 Configuring the cisco-av-pair attribute



Verifying the configuration

1. Telnet to the switch, and enter username **test@bbb** and password **123456TESTplat&!** to access the switch. Verify that you have access to diagnostic commands.

```
<Switch> telnet 192.168.1.70
Trying 192.168.1.70 ...
Press CTRL+K to abort
Connected to 192.168.1.70 ...
******************************************************************************
* Copyright (c) 2004-2017 New H3C Technologies Co., Ltd. All rights reserved.*
* Without the owner's prior written consent,                                 *
* no decompiling or reverse-engineering shall be allowed.                    *
******************************************************************************

login: test@bbb
Password:
<Switch>?
User view commands:
  ping         Ping function
  quit         Exit from current command view
  ssh2         Establish a secure shell client connection
  super        Switch to a user role
  system-view  Enter the System View
  telnet       Establish a telnet connection
  tracert      Tracert function

<switch>
```

2. Verify that you can obtain the network-admin user role:

   # Use the super password to obtain the network-admin user role. When the system prompts for a username and password, enter username **test@bbb** and password **123456**.

```
<Switch> super network-admin
Username: test@bbb
Password:
```

   The following output shows that you have obtained the network-admin user role.

```
User privilege role is network-admin, and only those commands that authorized to the role can be used.
```

If the ACS server does not respond, enter local authentication password **abcdef654321** at the prompt.

```
Invalid configuration or no response from the authentication server.
Change authentication mode to local.
Password:
User privilege role is network-admin, and only those commands that authorized to the role can be used.
```

The output shows that you have obtained the network-admin user role.

Troubleshooting RBAC

This section describes several typical RBAC issues and their solutions.

Local users have more access permissions than intended

Symptom

A local user can use more commands than should be permitted by the assigned user roles.

Analysis

The local user might have been assigned to user roles without your knowledge. For example, the local user is automatically assigned the default user role when you create the user.

Solution

To resolve the issue:

1. Use the **`display local-user`** command to examine the local user accounts for undesirable user roles, and remove them.
2. If the issue persists, contact H3C Support.

Login attempts by RADIUS users always fail

Symptom

Attempts by a RADIUS user to log in to the network access device always fail, even though the following conditions exist:

- The network access device and the RADIUS server can communicate with one another.
- All AAA settings are correct.

Analysis

RBAC requires that a login user have a minimum of one user role. If the RADIUS server does not authorize the login user to use any user role, the user cannot log in to the device.

Solution

To resolve the issue:

1. Use one of the following methods:
   - Configure the **`role default-role enable`** command. A RADIUS user can log in with the default user role when no user role is assigned by the RADIUS server.
   - Add the user role authorization attributes on the RADIUS server.
2. If the issue persists, contact H3C Support.

Contents

Login overview

The device supports the following types of login methods:

- **CLI login**—At the CLI, you can enter text commands to configure and manage the device.

  To log in to the CLI, you can use one of the following methods:

  - Connect to the console port.
  - Connect to the USB port.
  - Use Telnet.
  - Use SSH.
- **Web login**—Through the Web interface, you can configure and manage the device visually.
- **SNMP access**—You can run SNMP on an NMS to access the device MIB, and perform Get and Set operations to configure and manage the device.
- **RESTful access**—You can use RESTful API operations to configure and manage the device.

The first time you access the device, the available login methods vary by device model.

- For the following switch series, you can log in to the device through the console port or USB port, or the Web interface unless the device is automatically configured at startup:
  - S5000V3-EI.
  - S5000V5-EI.
  - S5000E-X.
  - S5000X-EI.
  - WS5810-WiNet.
  - WS5820-WiNet.
  - WAS6000.

  Before the first Web login, obtain the management IP address, username, and password on the device. Then, run a Web browser, enter the management IP address in the address bar, and press **Enter** to access the Web interface for device login.
- For the other switch series, you can only log in to the CLI through the console port or USB port unless the device is automatically configured at startup.

The default authentication mode for console login is as follows:

- On the S5000V3-EI, S5000V5-EI, S5000E-X, S5000X-EI, and WAS6000 switch series, the default setting varies by startup configuration.
  - If the device starts up with factory defaults, scheme authentication is enabled. The username and password are required, which can be obtained on the device.
  - If the device starts up with the initial configuration, authentication is disabled.
- On the other switch series, authentication is disabled.

For more information about the initial configuration and factory defaults, see "Managing configuration files."

After login, you can change console login parameters or configure other access methods.

The device supports the FIPS mode that complies with NIST FIPS 140-2 requirements. Support for features, commands, and parameters might differ in FIPS mode and non-FIPS mode. For more information about FIPS mode, see *Security Configuration Guide*.

Telnet, HTTP-based Web login, and HTTP-based RESTful access are not supported in FIPS mode.

Using the console port for the first device access

About using the console port for the first device access

Console login is the fundamental login method.

Prerequisites

To log in through the console port, prepare a console terminal, for example, a PC. Make sure the console terminal has a terminal emulation program, such as HyperTerminal or PuTTY. For information about how to use terminal emulation programs, see the programs' user guides.

Procedure

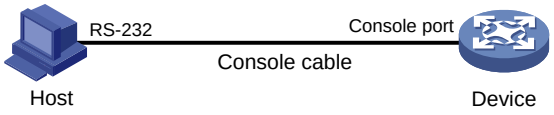
1. Turn off the PC.

   The serial ports on PCs do not support hot swapping. Before connecting a cable to or disconnecting a cable from a serial port on a PC, you must turn off the PC.
2. Find the console cable shipped with the device and connect the DB-9 female connector of the console cable to the serial port of the PC.
3. Identify the console port of the device carefully and connect the RJ-45 connector of the console cable to the console port.

IMPORTANT:

To connect a PC to an operating device, first connect the PC end. To disconnect a PC from an operating device, first disconnect the device end.

Figure 1 Connecting a terminal to the console port



4. Turn on the PC.
5. On the PC, launch the terminal emulation program, and create a connection that uses the serial port connected to the device. Set the port properties so the port properties match the following console port default settings:
   - **Bits per second**—9600 bps.
   - **Flow control**—None.
   - **Parity**—None.
   - **Stop bits**—1.
   - **Data bits**—8.
6. Power on the device. The method to enter the CLI varies by device model.
   - For the S5000V3-EI, S5000V5-EI, S5000E-X, S5000X-EI, and WAS6000 switch series, enter the username and password as prompted.
   - For the other switch series, press **Enter**.

   The user view prompt appears. You can enter commands to configure or manage the device. To get help, enter a question mark (?).

Configuring CLI login

About CLI login

The device uses user lines (also called user interfaces) to manage CLI sessions and monitor user behavior. For a user line, you can configure access control settings, including the login authentication method and user roles.

User lines

User line types

The device supports the types of user lines listed in Table 1. Different user lines require different login methods.

Table 1 CLI login method and user line matrix

User line	Login method
AUX line	Console port.
USB line	USB port.
Virtual type terminal (VTY) line	Telnet or SSH.

User line numbering

A user line has an absolute number and a relative number.

An absolute number uniquely identifies a user line among all user lines. The user lines are numbered starting from 0 and incrementing by 1, in the sequence of AUX, VTY, and USB lines. You can use the **`display line`** command without any parameters to view supported user lines and their absolute numbers.

A relative number uniquely identifies a user line among all user lines of the same type. The number format is *user line type* + *number*. All types of user lines are numbered starting from 0 and incrementing by 1. For example, the first VTY line is VTY 0.

User line assignment

The device assigns user lines to CLI login users depending on their login methods, as shown in Table 1. When a user logs in, the device checks the idle user lines for the login method, and assigns the lowest numbered user line to the user. For example, if VTY 0 and VTY 3 are idle when a user Telnets to the device, the device assigns VTY 0 to the user.

Each user line can be assigned only to one user at a time. If no user line is available, a CLI login attempt will be rejected.

Login authentication modes

You can configure login authentication to prevent illegal access to the device CLI.

In non-FIPS mode, the device supports the following login authentication modes:

- **None**—Disables authentication. This mode allows access without authentication and is insecure.
- **Password**—Requires password authentication. A user must provide the correct password at login.

- **Scheme**—Uses the AAA module to provide local or remote login authentication. A user must provide the correct username and password at login.

In FIPS mode, the device supports only the scheme authentication mode.

Different login authentication modes require different user line configurations, as shown in Table 2.

Table 2 Configuration required for different login authentication modes

Authentication mode	Configuration tasks
None	Set the authentication mode to none.
Password	**1.** Set the authentication mode to password. **2.** Set a password.
Scheme	**1.** Set the authentication mode to scheme. **2.** Configure login authentication methods in ISP domain view. For more information, see *Security Configuration Guide*.

User roles

A user is assigned user roles at login. The user roles control the commands available for the user. For more information about user roles, see "Configuring RBAC."

The device assigns user roles based on the login authentication mode and user type.

- In none or password authentication mode, the device assigns the user roles specified for the user line.
- In scheme authentication mode, the device uses the following rules to assign user roles:
  - For an SSH login user who uses publickey or password-publickey authentication, the device assigns the user roles specified for the local device management user with the same name.
  - For other users, the device assigns user roles according to the user role configuration of the AAA module. If the AAA server does not assign any user roles and the default user role feature is disabled, a remote AAA authentication user cannot log in.

FIPS compliance

The device supports the FIPS mode that complies with NIST FIPS 140-2 requirements. Support for features, commands, and parameters might differ in FIPS mode and non-FIPS mode. For more information about FIPS mode, see *Security Configuration Guide*.

Telnet login is not supported in FIPS mode.

Restrictions and guidelines: CLI login configuration

For commands that are available in both user line view and user line class view, the following rules apply:

- A setting in user line view applies only to the user line. A setting in user line class view applies to all user lines of the class.
- A non-default setting in either view takes precedence over the default setting in the other view. A non-default setting in user line view takes precedence over the non-default setting in user line class view.
- A setting in user line class view takes effect only on users who log in after the setting is made. It does not affect users who are already online when the setting is made.

Configuring console or USB login

About console and USB login

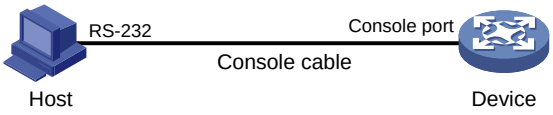
You can connect a terminal to the console port of the device to log in and manage the device, as shown in Figure 2. For information about the login procedure, see "Using the console port for the first device access."

You can also log in to the device through the USB port by completing the following tasks:

1. Connect a bluetooth modem to the USB port of the device.
2. Use a mobile terminal to establish a connection to the bluetooth modem.

After logging in to the device, you can use the application on the mobile terminal to manage the device.

Figure 2 Logging in through the console port



The default settings for console login is as follows:

- On the S5000V3-EI, S5000V5-EI, S5000E-X, S5000X-EI, and WAS6000 switch series, the default setting varies by startup configuration.
  - If the device starts up with factory defaults, scheme authentication is enabled.
  - If the device starts up with the initial configuration, authentication is disabled.

  The user role is network-admin for a console user.
- On the other switch series, authentication is disabled. The user role is network-admin for a console user.

For more information about the initial configuration and factory defaults, see "Managing configuration files."

By default, USB login is enabled and does not require authentication. The default user role is network-admin for a USB user.

To improve device security, configure password or scheme authentication immediately after you log in to the device for the first time.

Restrictions and guidelines

A console or USB login configuration change takes effect only for users who log in after the change is made. It does not affect users who are already online when the change is made.

In FIPS mode, the device supports only scheme authentication. You cannot disable authentication or configure password authentication.

Console and USB login configuration tasks at a glance

To configure console or USB login, perform the following tasks:

1. Configuring console or USB login authentication
   - Disabling authentication for console or USB login
   - Configuring password authentication for console or USB login
   - Configuring scheme authentication for console or USB login

2. (Optional.) Configuring common console or USB login settings

Configuring console or USB login authentication

Disabling authentication for console or USB login

1. Enter system view.
   system-view
2. Enter AUX/USB line view or class view.
   - Enter AUX or USB line view.
     line { **aux** | **usb** } *first-number* [*last-number*]
   - Enter AUX or USB line class view.
     line class { **aux** | **usb** }
3. Disable authentication.
   authentication-mode none

   The default authentication mode for console login is as follows:
   - On the S5000V3-EI, S5000V5-EI, S5000E-X, S5000X-EI, and WAS6000 switch series, the default setting varies by startup configuration.
     - If the device starts up with factory defaults, scheme authentication is enabled.
     - If the device starts up with the initial configuration, authentication is disabled.
   - On the other switch series, authentication is disabled.

   For more information about the initial configuration and factory defaults, see "Managing configuration files."

   CAUTION:
   When authentication is disabled, users can log in to the device through the line or line class without authentication. For security purpose, disable authentication with caution.
4. Assign a user role.
   user-role *role-name*

   By default, a console or USB user is assigned the **network-admin** user role.

Configuring password authentication for console or USB login

1. Enter system view.
   system-view
2. Enter AUX/USB line view or class view.
   - Enter AUX or USB line view.
     line { **aux** | **usb** } *first-number* [*last-number*]
   - Enter AUX or USB class view.
     line class { **aux** | **usb** }
3. Enable password authentication.
   authentication-mode password

   The default authentication mode for console login is as follows:
   - On the S5000V3-EI, S5000V5-EI, S5000E-X, S5000X-EI, and WAS6000 switch series, the default setting varies by startup configuration.
     - If the device starts up with factory defaults, scheme authentication is enabled.
     - If the device starts up with the initial configuration, authentication is disabled.

- On the other switch series, authentication is disabled.

For more information about the initial configuration and factory defaults, see "Managing configuration files."

4. Set a password.

   set authentication password { **hash** | **simple** } *password*

   By default, no password is set.

5. Assign a user role.

   user-role *role-name*

   By default, a console or USB user is assigned the **network-admin** user role.

Configuring scheme authentication for console or USB login

1. Enter system view.

   system-view

2. Enter AUX/USB line view or class view.
   - Enter AUX or USB line view.

     line { **aux** | **usb** } *first-number* [*last-number*]
   - Enter AUX or USB line class view.

     line class { **aux** | **usb** }

3. Enable scheme authentication.

   In non-FIPS mode:

   authentication-mode scheme

   The default authentication mode for console login is as follows:
   - On the S5000V3-EI, S5000V5-EI, S5000E-X, S5000X-EI, and WAS6000 switch series, the default setting varies by startup configuration.
     - If the device starts up with factory defaults, scheme authentication is enabled.
     - If the device starts up with the initial configuration, authentication is disabled.
   - On the other switch series, authentication is disabled.

   For more information about the initial configuration and factory defaults, see "Managing configuration files."

   In FIPS mode:

   authentication-mode scheme

   By default, scheme authentication is enabled.

CAUTION:

When you enable scheme authentication, make sure an authentication user account is available. If no authentication user account is available, you cannot log in to the device through the line or line class at the next time.

4. Configure user authentication parameters in ISP domain view.

   To use local authentication, configure a local user and set the relevant attributes. To use remote authentication, configure a RADIUS, LDAP, or HWTACACS scheme. For more information, see AAA in *Security Configuration Guide*.

Configuring common console or USB login settings

Restrictions and guidelines

Some common console or USB login settings take effect immediately and can interrupt the current session. Use a login method different from console or USB login to log in to the device before you change console or USB login settings.

After you change console or USB login settings, adjust the settings on the configuration terminal accordingly for a successful login.

Procedure

1. Enter system view.

   system-view

2. Enter AUX/USB line view or class view.
   - Enter AUX/USB line view.

     line { **aux** | **usb** } *first-number* [*last-number*]
   - Enter AUX or USB line class view.

     line class { **aux** | **usb** }

3. Configure transmission parameters.
   - Set the transmission rate.

     speed *speed-value*

     By default, the transmission rate is 9600 bps.

     This command is not available in user line class view.
   - Specify the parity mode.

     parity { **even** | **mark** | **none** | **odd** | **space** }

     By default, a user line does not use parity.

     This command is not available in user line class view.
   - Configure flow control.

     flow-control { **hardware** | **none** | **software** }

     By default, the device does not perform flow control.

     This command is not available in user line class view.
   - Specify the number of data bits for a character.

     databits { **5** | **6** | **7** | **8** }

     The default is 8.

     This command is not available in user line class view.

Parameter	Description
7	Uses standard ASCII characters.
8	Uses extended ASCII characters.
5 and **6**	Available only for modem dial-in.

   - Specify the number of stop bits for a character.

     stopbits { **1** | **1.5** | **2** }

     The default is 1.

     Stop bits indicate the end of a character. The more the stop bits, the slower the transmission.

This command is not available in user line class view.

4. Configure terminal attributes.
   - Enable the terminal service.

     shell

     Be default, the terminal service is enabled on all user lines.

     The **undo shell** command is not available in AUX line view.
   - Specify the terminal display type.

     terminal type { **ansi** | **vt100** }

     By default, the terminal display type is ANSI.

     The device supports ANSI and VT100 terminal display types. As a best practice, specify VT100 type on both the device and the configuration terminal. You can also specify the ANSI type for both sides, but a display problem might occur if a command line has more than 80 characters.
   - Set the maximum number of lines of command output to send to the terminal at a time.

     screen-length *screen-length*

     By default, the device sends a maximum of 24 lines to the terminal at a time.

     To disable pausing between screens of output, set the value to 0.
   - Set the size for the command history buffer.

     history-command max-size *value*

     By default, the buffer size is 10. The buffer for a user line can save a maximum of 10 history commands.
   - Set the CLI connection idle-timeout timer.

     idle-timeout *minutes* [*seconds*]

     By default, the CLI connection idle-timeout timer is 10 minutes.

     If no interaction occurs between the device and the user within the idle-timeout interval, the system automatically terminates the user connection on the user line.

     If you set the timeout timer to 0, the connection will not be aged out.
5. Specify the command to be automatically executed for login users on the lines.

   auto-execute command *command*

   By default, no command is specified for auto execution.

   CAUTION:

   Use this command with caution. If this command is used on a user line, users that log in to the device through this user line might fail to configure the system.

   The device will automatically execute the specified command when a user logs in through the user line, and close the user connection after the command is executed.

   This command is not available in AUX line view or AUX line class view.
6. Configure shortcut keys.
   - Specify the terminal session activation key.

     activation-key *character*

     By default, pressing **Enter** starts the terminal session.
   - Specify the escape key.

     escape-key { *character* | **default** }

     By default, pressing **Ctrl+C** terminates a command.
   - Set the user line locking key.

lock-key *key-string*

By default, no user line locking key is set.

Configuring Telnet login

About Telnet login

The device can act as a Telnet server to allow Telnet login, or as a Telnet client to Telnet to other devices.

Restrictions and guidelines

Telnet login is not supported in FIPS mode. For more information about FIPS mode, see *Security Configuration Guide*.

A Telnet login configuration change takes effect only for users who log in after the change is made. It does not affect users who are already online when the change is made.

Configuring the device as a Telnet server

Telnet server configuration tasks at a glance

To configure the device as a Telnet server, perform the following tasks:

1. Enabling the Telnet server
2. Configuring Telnet login authentication
   - Disabling authentication for Telnet login
   - Configuring password authentication for Telnet login
   - Configuring scheme authentication for Telnet login
3. (Optional.) Configuring common Telnet server settings
4. (Optional.) Configuring common VTY line settings

Enabling the Telnet server

1. Enter system view.
   system-view
2. Enable the Telnet server.
   telnet server enable
   By default, the Telnet server is disabled.

Disabling authentication for Telnet login

1. Enter system view.
   system-view
2. Enter VTY line view or class view.
   - Enter VTY line view.
     line vty *first-number* [*last-number*]
   - Enter VTY line class view.
     line class vty
3. Disable authentication.
   authentication-mode none

By default, password authentication is enabled for Telnet login.

CAUTION:

When authentication is disabled, users can log in to the device through the line or line class without authentication. For security purpose, disable authentication with caution.

In VTY line view, this command is associated with the **protocol inbound** command. If one command has a non-default setting in VTY line view, the other command uses its setting in VTY line view, regardless of its setting in VTY line class view.

4. (Optional.) Assign a user role.

   user-role *role-name*

   By default, a VTY line user is assigned the **network-operator** user role.

Configuring password authentication for Telnet login

1. Enter system view.

   system-view

2. Enter VTY line view or class view.
   - Enter VTY line view.

     line vty *first-number* [*last-number*]
   - Enter VTY line class view.

     line class vty

3. Enable password authentication.

   authentication-mode password

   By default, password authentication is enabled for Telnet login.

CAUTION:

When you enable password authentication, you must also configure an authentication password for the line or line class. If no authentication password is configured, you cannot log in to the device through the line or line class at the next time.

In VTY line view, this command is associated with the **protocol inbound** command. If one command has a non-default setting in VTY line view, the other command uses its setting in VTY line view, regardless of its setting in VTY line class view.

4. Set a password.

   set authentication password { **hash** | **simple** } *password*

   By default, no password is set.

5. (Optional.) Assign a user role.

   user-role *role-name*

   By default, a VTY line user is assigned the **network-operator** user role.

Configuring scheme authentication for Telnet login

1. Enter system view.

   system-view

2. Enter VTY line view or class view.
   - Enter VTY line view.

     line vty *first-number* [*last-number*]
   - Enter VTY line class view.

     line class vty

3. Enable scheme authentication.

   authentication-mode scheme

   By default, password authentication is enabled for Telnet login.

   CAUTION:

   When you enable scheme authentication, make sure an authentication user account is available. If no authentication user account is available, you cannot log in to the device through the line or line class at the next time.

   In VTY line view, this command is associated with the **protocol inbound** command. If one command has a non-default setting in VTY line view, the other command uses its setting in VTY line view, regardless of its setting in VTY line class view.

4. Configure user authentication parameters in ISP domain view.

   To use local authentication, configure a local user and set the relevant attributes.

   To use remote authentication, configure a RADIUS, LDAP, or HWTACACS scheme. For more information, see AAA in *Security Configuration Guide*.

Configuring common Telnet server settings

1. Enter system view.

   system-view

2. Set the DSCP value for outgoing Telnet packets.

   IPv4:

   telnet server dscp *dscp-value*

   IPv6:

   telnet server ipv6 dscp *dscp-value*

   By default, the DSCP value is 48.

3. Specify the Telnet service port number.

   IPv4:

   telnet server port *port-number*

   IPv6:

   telnet server ipv6 port *port-number*

   By default, the Telnet service port number is 23.

4. Set the maximum number of concurrent Telnet users.

   aaa session-limit telnet *max-sessions*

   By default, the maximum number of concurrent Telnet users is 32.

   Changing this setting does not affect users who are currently online. If the new limit is less than the number of online Telnet users, no additional users can Telnet in until the number drops below the new limit.

   For more information about this command, see *Security Command Reference*.

Configuring common VTY line settings

1. Enter system view.

   system-view

2. Enter VTY line view or class view.

   - Enter VTY line view.

     line vty *first-number* [*last-number*]

   - Enter VTY line class view.

line class vty

3. Configure VTY terminal attributes.
   - Enable the terminal service.

     shell

     By default, the terminal service is enabled on all user lines.
   - Specify the terminal display type.

     terminal type { **ansi** | **vt100** }

     By default, the terminal display type is ANSI.
   - Set the maximum number of lines of command output to send to the terminal at a time.

     screen-length *screen-length*

     By default, the device sends a maximum of 24 lines to the terminal at a time.

     To disable pausing between screens of output, set the value to 0.
   - Set the size for the command history buffer.

     history-command max-size *value*

     By default, the buffer size is 10. The buffer for a user line can save a maximum of 10 history commands.
   - Set the CLI connection idle-timeout timer.

     idle-timeout *minutes* [*seconds*]

     By default, the CLI connection idle-timeout timer is 10 minutes.

     If no interaction occurs between the device and the user within the idle-timeout interval, the system automatically terminates the user connection on the user line.

     If you set the timeout timer to 0, the connection will not be aged out.
4. Specify the supported protocols.

   protocol inbound { **all** | **ssh** | **telnet** }

   By default, Telnet and SSH are supported.

   A protocol change takes effect only on users who log in after the setting is made. It does not affect users who are already online when the setting is made.

   In VTY line view, this command is associated with the **authentication-mode** command. If one command has a non-default setting in VTY line view, the other command uses its setting in VTY line view, regardless of its setting in VTY line class view.
5. Specify the command to be automatically executed for login users on the user lines.

   auto-execute command *command*

   By default, no command is specified for auto execution.

IMPORTANT:

Before you execute this command and save the configuration, make sure you can access the CLI to modify the configuration through other VTY lines or AUX lines.

For a VTY line, you can specify a command that is to be automatically executed when a user logs in. After executing the specified command, the system automatically disconnects the Telnet session.

6. Configure shortcut keys.
   - Specify the shortcut key for terminating a task.

     escape-key { *character* | **default** }

     The default setting is **Ctrl+C**.
   - Set the user line locking key.

lock-key *key-string*

By default, no user line locking key is set.

Using the device to log in to a Telnet server

About using the device to log in to a Telnet server

You can use the device as a Telnet client to log in to a Telnet server.

Figure 3 Telnetting from the device to a Telnet server

Prerequisites

Assign an IP address to the device and obtain the IP address of the Telnet server. If the device resides on a different subnet than the Telnet server, make sure the device and the Telnet server can reach each other.

Procedure

1. Enter system view.

   system-view

2. (Optional.) Specify the source IPv4 address or source interface for outgoing Telnet packets.

   telnet client source { **interface** *interface-type interface-number* | **ip** *ip-address* }

   By default, no source IPv4 address or source interface is specified. The device uses the primary IPv4 address of the output interface as the source address for outgoing Telnet packets.

3. Exit to user view.

   quit

4. Use the device to log in to a Telnet server.

   IPv4:

   telnet *remote-host* [*service-port*] [**source** { **interface** *interface-type interface-number* | **ip** *ip-address* } | **dscp** *dscp-value*] *

   IPv6:

   telnet ipv6 *remote-host* [**-i** *interface-type interface-number*] [*port-number*] [**source** { **interface** *interface-type interface-number* | **ipv6** *ipv6-address* } | **dscp** *dscp-value*] *

Configuring SSH login

About SSH login

SSH offers a secure remote login method. By providing encryption and strong authentication, it protects devices against attacks such as IP spoofing and plaintext password interception. For more information, see *Security Configuration Guide*.

The device can act as an SSH server to allow Telnet login, or as an SSH client to log in to an SSH server.

Configuring the device as an SSH server

About SSH server configuration procedure

This section provides the SSH server configuration procedure used when the SSH client authentication method is password. For more information about SSH and publickey authentication configuration, see *Security Configuration Guide*.

Procedure

1. Enter system view.

   system-view

2. Create local key pairs.

   In non-FIPS mode:

   public-key local create { **dsa** | **ecdsa** [**secp192r1** | **secp256r1** | **secp384r1** | **secp521r1**] | **rsa** } [**name** *key-name*]

   In FIPS mode:

   public-key local create { **dsa** | **ecdsa** [**secp256r1** | **secp384r1** | **secp521r1**] | **rsa** } [**name** *key-name*]

3. Enable the SSH server.

   ssh server enable

   By default, the SSH server is disabled.

4. (Optional.) Create an SSH user and specify the authentication mode.

   ssh user *username* **service-type stelnet authentication-type password**

5. Enter VTY line view or class view.

   - Enter VTY line view.

     line vty *first-number* [*last-number*]

   - Enter VTY line class view.

     line class vty

6. Enable scheme authentication.

   In non-FIPS mode:

   authentication-mode scheme

   By default, password authentication is enabled for VTY lines.

   In VTY line view, this command is associated with the **protocol inbound** command. If one command has a non-default setting in VTY line view, the other command uses its setting in VTY line view, regardless of its setting in VTY line class view.

   In FIPS mode:

   authentication-mode scheme

   By default, scheme authentication is enabled for VTY lines.

   In VTY line view, this command is associated with the **protocol inbound** command. If one command has a non-default setting in VTY line view, the other command uses its setting in VTY line view, regardless of its setting in VTY line class view.

   CAUTION:

   When you enable scheme authentication, make sure an authentication user account is available. If no authentication user account is available, you cannot log in to the device through the line or line class at the next time.

7. (Optional.) Specify the protocols for the user lines to support.

In non-FIPS mode:

protocol inbound { **all** | **ssh** | **telnet** }

By default, Telnet and SSH are supported.

A protocol change takes effect only on users who log in after the setting is made. It does not affect users who are already online when the setting is made.

In VTY line view, this command is associated with the **authentication-mode** command. If one command has a non-default setting in VTY line view, the other command uses its setting in VTY line view, regardless of its setting in VTY line class view.

In FIPS mode:

protocol inbound ssh

By default, SSH is supported.

A protocol change takes effect only on users who log in after the setting is made. It does not affect users who are already online when the setting is made.

In VTY line view, this command is associated with the **authentication-mode** command. If one command has a non-default setting in VTY line view, the other command uses its setting in VTY line view, regardless of its setting in VTY line class view.

8. (Optional.) Set the maximum number of concurrent SSH users.

   aaa session-limit ssh *max-sessions*

   By default, the maximum number of concurrent SSH users is 32.

   Changing this setting does not affect users who are currently online. If the new limit is less than the number of online SSH users, no additional SSH users can log in until the number drops below the new limit.

   For more information about this command, see *Security Command Reference*.

9. (Optional.) Configure common settings for VTY lines:

   a. Exit to system view.

      quit

   b. Configure common settings for VTY lines.

      See "Configuring common VTY line settings."

Using the device to log in to an SSH server

About using the device to log in to an SSH server

You can use the device as an SSH client to log in to an SSH server.

Figure 4 Logging in to an SSH server from the device

Prerequisites

Assign an IP address to the device and obtain the IP address of the SSH server. If the device resides on a different subnet than the SSH server, make sure the device and the SSH server can reach each other.

Procedure

To use the device to log in to an SSH server, execute one of the following commands in user view:

IPv4:

ssh2 *server*

IPv6:

ssh2 ipv6 *server*

To work with the SSH server, you might need to specify a set of parameters. For more information, see *Security Configuration Guide*.

Display and maintenance commands for CLI login

Execute **display** commands in any view.

Task	Command	Remarks
Display user line information.	**display line** [*num1* | { **aux** | **usb** | **vty** } *num2*] [**summary**]	N/A
Display the packet source setting for the Telnet client.	**display telnet client**	N/A
Display online CLI users.	**display users** [**all**]	N/A
Release a user line.	**free line** { *num1* | { **aux** | **usb** | **vty** } *num2* }	Multiple users can log in to the device to simultaneously configure the device. When necessary, you can execute this command to release some connections. You cannot use this command to release the connection you are using or a redirected Telnet connection. This command is available in user view.
Lock the current user line and set the password for unlocking the line.	**lock**	By default, the system does not lock any user lines. This command is not supported in FIPS mode. This command is available in user view.
Lock the current user line and enable unlocking authentication.	**lock reauthentication**	By default, the system does not lock any user lines or initiate reauthentication. To unlock the locked user line, you must press **Enter** and provide the login password to pass reauthentication. This command is available in any view.
Send messages to user lines.	**send** { **all** | *num1* | { **aux** | **usb** | **vty** } *num2* }	This command is available in user view.

Configuring Web login

About Web login

The device provides a built-in Web server that supports HTTP 1.0, HTTP 1.1, and HTTPS. You can use a Web browser to log in to and configure the device.

HTTPS uses SSL to ensure the integrity and security of data exchanged between the client and the server, and is more secure than HTTP. You can define a certificate-based access control policy to allow only legal clients to access the Web interface.

FIPS compliance

The device supports the FIPS mode that complies with NIST FIPS 140-2 requirements. Support for features, commands, and parameters might differ in FIPS mode and non-FIPS mode. For more information about FIPS mode, see *Security Configuration Guide*.

HTTP is not supported in FIPS mode.

Restrictions and guidelines: Web login configuration

To improve device security, the system automatically enables the HTTPS service when you enable the HTTP service. When the HTTP service is enabled, you cannot disable the HTTPS service.

Web login configuration tasks at a glance

To configure Web login, perform the following tasks:

1. Configuring Web login
   - Configuring HTTP login
   - Configuring HTTPS login
2. Configuring a Web login local user
3. Managing Web connections
4. Enabling Web operation logging

Prerequisites for Web login

Before logging in to the Web interface of the device, log in to the device by using any other method and assign an IP address to the device. Make sure the configuration terminal and the device can communicate over the IP network.

Configuring HTTP login

1. (Optional.) Specify a fixed verification code for Web login.
   `web captcha` *`verification-code`*

By default, no fixed verification code is specified. A Web user must enter the verification code displayed on the login page at login.

Execute this command in user view.

2. Enter system view.

   system-view

3. Enable the HTTP service.

   ip http enable

   The default is as follows:

   - On the S5000V3-EI, S5000V5-EI, S5000E-X, S5000X-EI, WS5810-WiNet, WS5820-WiNet, and WAS6000 switch series, the default setting varies by startup configuration.
     - If the device starts up with factory defaults, the HTTP service is enabled.
     - If the device starts up with the initial configuration, the HTTP service is disabled.
   - On the other switch series, the HTTP service is disabled.

   For more information about the initial configuration and factory defaults, see "Managing configuration files."

4. (Optional.) Specify the HTTP service port number.

   ip http port *port-number*

   The default HTTP service port number is 80.

Configuring HTTPS login

About HTTPS login

The device supports the following HTTPS login modes:

- **Simplified mode**—The device uses a self-signed certificate (a certificate that is generated and signed by the device itself) and the default SSL settings. The device operates in simplified mode after you enable HTTPS service on the device.
- **Secure mode**—The device uses a certificate signed by a CA and a set of user-defined security protection settings to ensure security. For the device to operate in secure mode, you must perform the following tasks:
  - Enable HTTPS service on the device.
  - Specify an SSL server policy for the service.
  - Configure PKI domain-related parameters.

Simplified mode is easy to configure but it is insecure. Secure mode is secure but it is complicated to configure.

For more information about SSL and PKI, see *Security Configuration Guide*.

Restrictions and guidelines

- To associate a different SSL server policy with the HTTPS service, you must perform the following tasks:
  - Disable the HTTP service and HTTPS service before you associate the new SSL server policy.
  - Enable the HTTP service and HTTPS service again after the association.

  If you fail to complete the required tasks, the new SSL server policy does not take effect.
- For the HTTP service to use its self-signed certificate after you associate an SSL server policy with the HTTPS service, you must follow these steps:

  a. Disable the HTTP service and HTTPS service.

b. Execute the **undo ip https ssl-server-policy** command to remove the existing SSL server policy association.

c. Enable the HTTP service and HTTPS service again.

- Enabling the HTTPS service triggers the SSL handshake negotiation process.
  - If the device has a local certificate, the SSL handshake negotiation succeeds and the HTTPS service starts up.
  - If the device does not have a local certificate, the certificate application process starts. Because the certificate application process takes a long time, the SSL handshake negotiation might fail and the HTTPS service might not be started. To solve the problem, execute the **ip https enable** command again until the HTTPS service is enabled.
- To use a certificate-based access control policy to control HTTPS access, you must perform the following tasks:
  - Execute the **client-verify enable** command in the SSL server policy that is associated with the HTTPS service.
  - Configure a minimum of one **permit** rule in the certificate-based access control policy.

  If you fail to complete the required tasks, HTTPS clients cannot log in.

Procedure

1. (Optional.) Specify a fixed verification code for Web login.

web captcha *verification-code*

By default, no fixed verification code is configured. A Web user must enter the verification code displayed on the login page at login.

2. Enter system view.

system-view

3. (Optional.) Apply policies to the HTTPS service.

- Apply an SSL server policy.

  ip https ssl-server-policy *policy-name*

  By default, no SSL server policy is associated. The HTTP service uses a self-signed certificate.
- Apply a certificate-based access control policy to control HTTPS access.

  ip https certificate access-control-policy *policy-name*

  By default, no certificate-based access control policy is applied.

  For more information about certificate-based access control policies, see PKI in *Security Configuration Guide*.

4. Enable the HTTPS service.

ip https enable

The default is as follows:

- On the S5000V3-EI, S5000V5-EI, S5000E-X, S5000X-EI, WS5810-WiNet, WS5820-WiNet, and WAS6000 switch series, the default setting varies by startup configuration.
  - If the device starts up with factory defaults, the HTTPS service is enabled.
  - If the device starts up with the initial configuration, the HTTPS service is disabled.
- On the other switch series, the HTTPS service is disabled.

For more information about the initial configuration and factory defaults, see "Managing configuration files."

5. (Optional.) Specify the HTTPS service port number.

ip https port *port-number*

The default HTTPS service port number is 443.

6. (Optional.) Set the HTTPS login authentication mode.

   web https-authorization mode { **auto** | **manual** }

   By default, manual authentication mode is used for HTTPS login.

Configuring a Web login local user

1. Enter system view.

   system-view

2. Create a local user and enter local user view.

   local-user *user-name* [**class manage**]

3. (Optional.) Configure a password for the local user.

   In non-FIPS mode:

   password [{ **hash** | **simple** } *password*]

   By default, no password is configured for a local user. The local user can pass authentication after entering the correct username and passing attribute checks.

   In FIPS mode:

   password

   By default, no password is configured for a local user. The local user cannot pass authentication.

4. Configure user attributes.

   - Assign a user role to the local user.

     authorization-attribute user-role *user-role*

     The default user role is network-operator for a Web user.

   - Specify the service type for the local user.

     service-type { **http** | **https** }

     By default, no service type is specified for a local user.

Managing Web connections

Setting the Web connection idle-timeout timer

1. Enter system view.

   system-view

2. Set the Web connection idle-timeout timer.

   web idle-timeout *minutes*

   By default, the Web connection idle-timeout timer is 10 minutes.

Specifying the maximum number of online HTTP or HTTPS users

1. Enter system view.

   system-view

2. Specify the maximum number of online HTTP or HTTPS users.

   aaa session-limit { **http** | **https** } *max-sessions*

   By default, the device supports a maximum number of 32 online HTTP users and 32 online HTTPS users.

   Changing this setting does not affect users who are currently online. If the new setting is less than the number of online HTTP or HTTPS users, no additional HTTP or HTTPS users can log

in until the number drops below the new limit. For more information about this command, see *Security Command Reference*.

Logging off Web users

To log off Web users, execute the following command in user view:

free web users { **all** | **user-id** *user-id* | **user-name** *user-name* }

Enabling Web operation logging

1. Enter system view.
   system-view
2. Enable Web operation logging.
   webui log enable
   By default, Web operation logging is disabled.

Display and maintenance commands for Web login

Execute **display** commands in any view.

Task	Command
Display HTTP service configuration and status information.	**display ip http**
Display HTTPS service configuration and status information.	**display ip https**
Display Web interface navigation tree information.	**display web menu** [**chinese**]
Display online Web users.	**display web users**

Web login configuration examples

Example: Configuring HTTP login

Network configuration

As shown in Figure 5, the PC and the device can communicate over the IP network.

Configure the device to allow the PC to log in by using HTTP.

Figure 5 Network diagram

Procedure

Create a local user named **admin**. Set the password to **hello12345**, the service type to HTTP, and the user role to network-admin.

```
[Sysname] local-user admin
```

```
[Sysname-luser-manage-admin] service-type http
[Sysname-luser-manage-admin] authorization-attribute user-role network-admin
[Sysname-luser-manage-admin] password simple hello12345
[Sysname-luser-manage-admin] quit
```

Enable HTTP.

```
[Sysname] ip http enable
```

Verifying the configuration

1. On the PC, run a Web browser and enter the IP address of the device in the address bar.
2. On the login page, enter the username, password, and verification code. Select **English** and click **Login**.

   After you pass authentication, the homepage appears and you can configure the device.

Example: Configuring HTTPS login

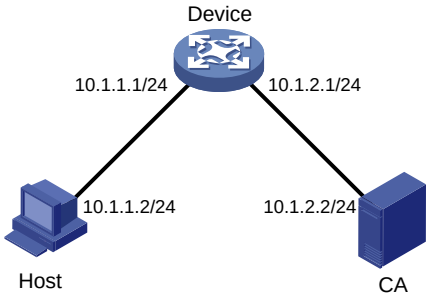
Network configuration

As shown in Figure 6, the host, device, and CA can communicate over the IP network.

Perform the following tasks to allow only authorized users to access the device's Web interface:

- Configure the device as the HTTPS server and request a certificate for the device.
- Configure the host as the HTTPS client and request a certificate for the host.

Figure 6 Network diagram



Procedure

In this example, the CA runs Windows Server and has the SCEP add-on installed.

1. Configure the device (HTTPS server):

   # Create PKI entity **en** and set entity parameters.

   ```
   <Device> system-view
   [Device] pki entity en
   [Device-pki-entity-en] common-name http-server1
   [Device-pki-entity-en] fqdn ssl.security.com
   [Device-pki-entity-en] quit
   ```

   # Create PKI domain **1** and set domain parameters.

   ```
   [Device] pki domain 1
   [Device-pki-domain-1] ca identifier new-ca
   [Device-pki-domain-1] certificate request url
   http://10.1.2.2/certsrv/mscep/mscep.dll
   [Device-pki-domain-1] certificate request from ra
   [Device-pki-domain-1] certificate request entity en
   ```

Configure the PKI domain to use the 1024-bit long RSA key pair **hostkey** for both signing and encryption.

```
[Device-pki-domain-1] public-key rsa general name hostkey length 1024
[Device-pki-domain-1] quit
```

Create RSA local key pairs.

```
[Device] public-key local create rsa
```

Retrieve the CA certificate.

```
[Device] pki retrieve-certificate domain 1 ca
```

Configure the device to request a local certificate through SCEP.

```
[Device] pki request-certificate domain 1
```

Create SSL server policy **myssl**. Specify PKI domain 1 for the SSL server policy, and enable certificate-based SSL client authentication.

```
[Device] ssl server-policy myssl
[Device-ssl-server-policy-myssl] pki-domain 1
[Device-ssl-server-policy-myssl] client-verify enable
[Device-ssl-server-policy-myssl] quit
```

Create certificate attribute group **mygroup1**. Configure a certificate attribute rule that matches statements with the **new-ca** string in the distinguished name of the subject name.

```
[Device] pki certificate attribute-group mygroup1
[Device-pki-cert-attribute-group-mygroup1] attribute 1 issuer-name dn ctn new-ca
[Device-pki-cert-attribute-group-mygroup1] quit
```

Create certificate-based access control policy **myacp**. Configure a certificate access control rule that uses the matching criteria in certificate attribute group **mygroup1**.

```
[Device] pki certificate access-control-policy myacp
[Device-pki-cert-acp-myacp] rule 1 permit mygroup1
[Device-pki-cert-acp-myacp] quit
```

Associate SSL server policy **myssl** with the HTTPS service.

```
[Device] ip https ssl-server-policy myssl
```

Use certificate-based access control policy **myacp** to control HTTPS access.

```
[Device] ip https certificate access-control-policy myacp
```

Enable the HTTPS service.

```
[Device] ip https enable
```

Create local user **usera**. Set the password to **hello12345**, the service type to HTTPS, and the user role to network-admin.

```
[Device] local-user usera
[Device-luser-usera] password simple hello12345
[Device-luser-usera] service-type https
[Device-luser-usera] authorization-attribute user-role network-admin
```

2. Configure the host (HTTPS client):

   # On the host, run a Web browser and enter **http://10.1.2.2/certsrv** in the address bar.

   # Request a certificate for the host as prompted.

Verifying the configuration

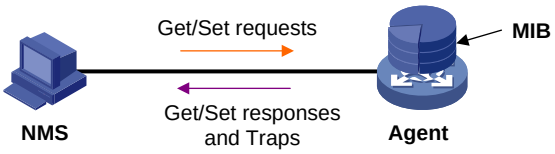
1. On the host, enter **https://10.1.1.1** in the Web browser's address bar, and select the certificate issued by **new-ca**.
2. When the Web login page appears, enter the username **usera** and password **hello12345** to log in to the Web interface.

For more information about PKI and SSL configuration commands and the **public-key local create rsa** command, see *Security Command Reference*.

Accessing the device through SNMP

You can run SNMP on an NMS to access the device MIB and perform Get and Set operations to configure and manage the device.

Figure 7 SNMP access diagram



For more information about SNMP, see *Network Management and Monitoring Configuration Guide*.

Configuring RESTful access

About RESTful access

The device provides the Representational State Transfer application programming interface (RESTful API). Based on this API, you can use programming languages such as Python, Ruby, or Java to write programs to perform the following tasks:

- Send RESTful requests to the device to pass authentication.
- Use RESTful API operations to configure and manage the device. RESTful API operations include Get, Put, Post, and Delete.

The device supports using HTTP or HTTPS to transfer RESTful packets.

FIPS compliance

The device supports the FIPS mode that complies with NIST FIPS 140-2 requirements. Support for features, commands, and parameters might differ in FIPS mode and non-FIPS mode. For more information about FIPS mode, see *Security Configuration Guide*.

RESTful access over HTTP is not supported in FIPS mode.

Configuring RESTful access over HTTP

1. Enter system view.
   system-view
2. Enable RESTful access over HTTP.
   restful http enable
   By default, RESTful access over HTTP is disabled.
3. Create a local user and enter local user view.
   local-user *user-name* [**class manage**]
4. Configure a password for the local user.
   password [{ **hash** | **simple** } *password*]
5. (Optional.) Assign a user role to the local user.
   authorization-attribute user-role *user-role*
   The default user role is network-operator for a RESTful access user.
6. Specify the HTTP service for the local user.
   service-type http
   By default, no service type is specified for a local user.

Configuring RESTful access over HTTPS

1. Enter system view.
   system-view
2. Enable RESTful access over HTTPS.
   restful https enable

By default, RESTful access over HTTPS is disabled.

3. Create a local user and enter local user view.
   local-user *user-name* [**class manage**]
4. Configure a password for the local user.
   In non-FIPS mode:
   password [{ **hash** | **simple** } *password*]
   In FIPS mode:
   password
5. (Optional.) Assign a user role to the local user.
   authorization-attribute user-role *user-role*
   The default user role is network-operator for a RESTful access user.
6. Specify the HTTPS service for the local user.
   service-type https
   By default, no service type is specified for a local user.

Controlling user access to the device

About login user access control

Use ACLs to prevent unauthorized access, and configure command authorization and accounting to monitor and control user behavior.

If an applied ACL does not exist or does not have any rules, no user login restriction is applied. If the ACL exists and has rules, only users permitted by the ACL can access the device.

For more information about ACLs, see *ACL and QoS Configuration Guide.*

FIPS compliance

The device supports the FIPS mode that complies with NIST FIPS 140-2 requirements. Support for features, commands, and parameters might differ in FIPS mode and non-FIPS mode. For more information about FIPS mode, see *Security Configuration Guide*.

Telnet and HTTP are not supported in FIPS mode.

Controlling Telnet and SSH logins

Controlling Telnet logins

1. Enter system view.

   system-view

2. Apply an ACL to control Telnet logins.

   IPv4:

   telnet server acl { *advanced-acl-number* | *basic-acl-number* | **mac** *mac-acl-number* }

   IPv6:

   telnet server ipv6 acl { **ipv6** { *advanced-acl-number* | *basic-acl-number* } | **mac** *mac-acl-number* }

   By default, no ACL is used to control Telnet logins.

3. (Optional.) Enable logging for Telnet login attempts that are denied by the Telnet login control ACL.

   telnet server acl-deny-log enable

   By default, logging is disabled for Telnet login attempts that are denied by the Telnet login control ACL.

Controlling SSH logins

1. Enter system view.

   system-view

2. Apply an ACL to control SSH logins.

   IPv4:

ssh server acl { *advanced-acl-number* | *basic-acl-number* | **mac** *mac-acl-number* }

IPv6:

ssh server ipv6 acl { **ipv6** { *advanced-acl-number* | *basic-acl-number* } | **mac** *mac-acl-number* }

By default, no ACL is used to control SSH logins.

3. (Optional.) Enable logging for SSH login attempts that are denied by the SSH login control ACL.

   ssh server acl-deny-log enable

   By default, logging is disabled for SSH login attempts that are denied by the SSH login control ACL.

   For more information about **ssh** commands, see *Security Command Reference*.

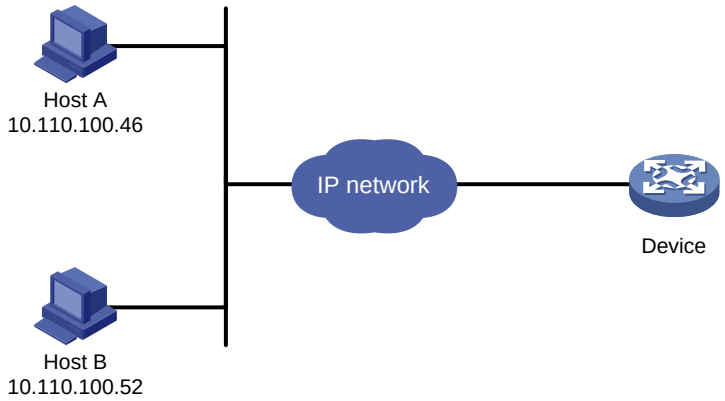
Example: Controlling Telnet login

Network configuration

As shown in Figure 8, the device is a Telnet server.

Configure the device to permit only Telnet packets sourced from Host A and Host B.

Figure 8 Network diagram



Procedure

Configure an ACL to permit packets sourced from Host A and Host B.

```
<Sysname> system-view
[Sysname] acl basic 2000 match-order config
[Sysname-acl-ipv4-basic-2000] rule 1 permit source 10.110.100.52 0
[Sysname-acl-ipv4-basic-2000] rule 2 permit source 10.110.100.46 0
[Sysname-acl-ipv4-basic-2000] quit
```

Apply the ACL to filter Telnet logins.

```
[Sysname] telnet server acl 2000
```

Controlling Web logins

Configuring source IP-based Web login control

1. Enter system view.

system-view

2. Apply a basic ACL to control Web logins.
   - Control HTTP logins.
     ip http acl { *acl-number* | **name** *acl-name* }
   - Control HTTPS logins.
     ip https acl { *acl-number* | **name** *acl-name* }

   By default, no ACL is applied to control Web logins.

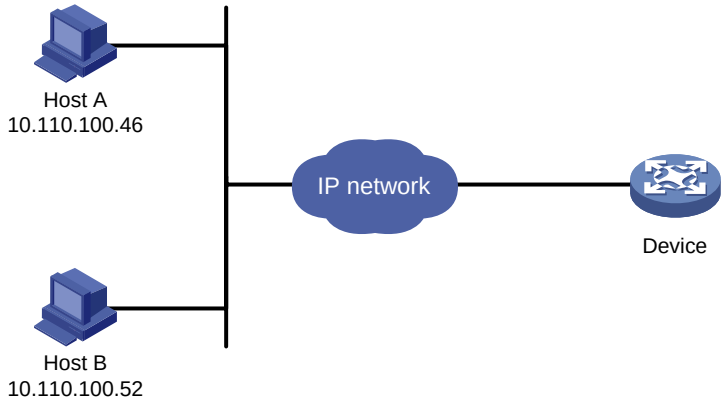
Example: Controlling Web login

Network configuration

As shown in Figure 9, the device is an HTTP server.

Configure the device to provide HTTP service only to Host B.

Figure 9 Network diagram



Procedure

Create an ACL and configure rule 1 to permit packets sourced from Host B.

```
<Sysname> system-view
[Sysname] acl basic 2030 match-order config
[Sysname-acl-ipv4-basic-2030] rule 1 permit source 10.110.100.52 0
```

Apply the ACL to the HTTP service so only a Web user on Host B can access the device.

```
[Sysname] ip http acl 2030
```

Controlling SNMP access

About SNMP access control

For information about SNMP access control, see SNMP in *Network Management and Monitoring Configuration Guide.*

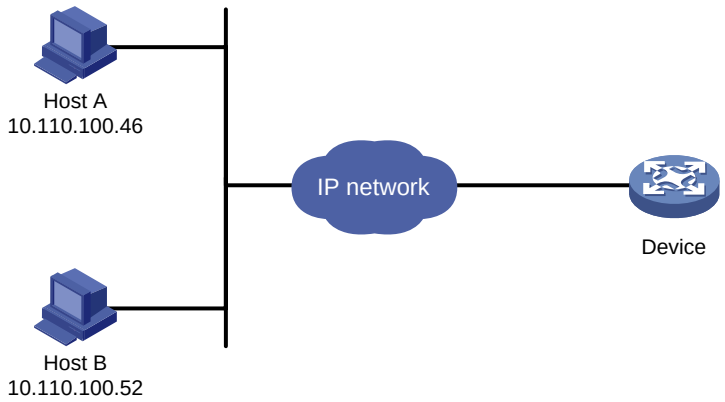
Example: Controlling SNMP access

Network configuration

As shown in Figure 10, the device is running SNMP.

Configure the device to allow Host A and Host B to access the device through SNMP.

Figure 10 Network diagram



Procedure

Create an ACL to permit packets sourced from Host A and Host B.

```
<Sysname> system-view
[Sysname] acl basic 2000 match-order config
[Sysname-acl-ipv4-basic-2000] rule 1 permit source 10.110.100.52 0
[Sysname-acl-ipv4-basic-2000] rule 2 permit source 10.110.100.46 0
[Sysname-acl-ipv4-basic-2000] quit
```

Associate the ACL with the SNMP community and the SNMP group.

```
[Sysname] snmp-agent community read aaa acl 2000
[Sysname] snmp-agent group v2c groupa acl 2000
[Sysname] snmp-agent usm-user v2c usera groupa acl 2000
```

Configuring command authorization

About command authorization

By default, commands available for a user depend only on the user's user roles. When the authentication mode is scheme, you can configure the command authorization feature to further control access to commands.

After you enable command authorization, a user can use only commands that are permitted by both the AAA scheme and user roles.

Restrictions and guidelines

The command authorization method can be different from the user login authorization method.

To make the command authorization feature take effect, you must configure a command authorization method in ISP domain view. For more information, see *Security Configuration Guide*.

Procedure

1. Enter system view.
   `system-view`

2. Enter user line view or user line class view.
   - Enter user line view.

     line { *first-number1* [*last-number1*] | { **aux** | **usb** | **vty** } *first-number2* [*last-number2*] }
   - Enter user line class view.

     line class { **aux** | **usb** | **vty** }

   A setting in user line view applies only to the user line. A setting in user line class view applies to all user lines of the class. A non-default setting in either view takes precedence over the default setting in the other view. A non-default setting in user line view takes precedence over the non-default setting in user line class view.

   A setting in user line class view takes effect only on users who log in after the setting is made. It does not affect users who are already online when the setting is made.
3. Enable scheme authentication.

   In non-FIPS mode:

   authentication-mode scheme

   By default, password authentication is enabled for VTY login.

   The default authentication mode for console login is as follows:
   - On the S5000V3-EI, S5000V5-EI, S5000E-X, S5000X-EI, and WAS6000 switch series:
     - If the device starts up with factory defaults, scheme authentication is enabled.
     - If the device starts up with the initial configuration, authentication is disabled.
   - On the other switch series, authentication is disabled.

   For more information about the initial configuration and factory defaults, see "Managing configuration files."

   In VTY line view, this command is associated with the **protocol inbound** command. If one command has a non-default setting in VTY line view, the other command uses its setting in VTY line view, regardless of its setting in VTY line class view.

   In FIPS mode:

   authentication-mode scheme

   By default, scheme authentication is enabled.

   In VTY line view, this command is associated with the **protocol inbound** command. If one command has a non-default setting in VTY line view, the other command uses its setting in VTY line view, regardless of its setting in VTY line class view.

CAUTION:

When you enable scheme authentication, make sure an authentication user account is available. If no authentication user account is available, you cannot log in to the device through the line or line class at the next time.

4. Enable command authorization.

   command authorization

   By default, command authorization is disabled, and the commands available for a user only depend on the user role.

   If the **command authorization** command is executed in user line class view, command authorization is enabled on all user lines in the class. You cannot execute the **undo command authorization** command in the view of a user line in the class.

Example: Configuring command authorization

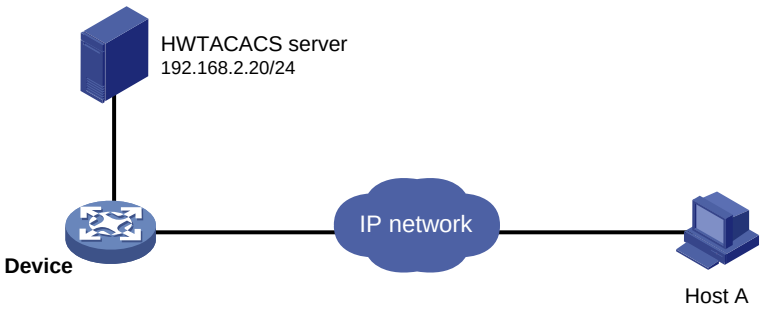
Network configuration

As shown in Figure 11, Host A needs to log in to the device to manage the device.

Configure the device to perform the following operations:

- Allow Host A to Telnet in after authentication.
- Use the HWTACACS server to control the commands that the user can execute.
- If the HWTACACS server is not available, use local authorization.

Figure 11 Network diagram



Procedure

Assign IP addresses to relevant interfaces. Make sure the device and the HWTACACS server can reach each other. Make sure the device and Host A can reach each other.

Enable the Telnet server.

```
<Device> system-view
[Device] telnet server enable
```

Enable scheme authentication for user lines VTY 0 through VTY 4.

```
[Device] line vty 0 4
[Device-line-vty0-4] authentication-mode scheme
```

Enable command authorization for the user lines.

```
[Device-line-vty0-4] command authorization
[Device-line-vty0-4] quit
```

Create HWTACACS scheme **tac**.

```
[Device] hwtacacs scheme tac
```

Configure the scheme to use the HWTACACS server at 192.168.2.20:49 for authentication and authorization.

```
[Device-hwtacacs-tac] primary authentication 192.168.2.20 49
[Device-hwtacacs-tac] primary authorization 192.168.2.20 49
```

Set the shared keys to **expert**.

```
[Device-hwtacacs-tac] key authentication simple expert
[Device-hwtacacs-tac] key authorization simple expert
```

Remove domain names from usernames sent to the HWTACACS server.

```
[Device-hwtacacs-tac] user-name-format without-domain
[Device-hwtacacs-tac] quit
```

Configure the system-defined domain (**system**).

```
[Device] domain system
```

Use HWTACACS scheme **tac** for login user authentication and command authorization. Use local authentication and local authorization as the backup method.

```
[Device-isp-system] authentication login hwtacacs-scheme tac local
[Device-isp-system] authorization command hwtacacs-scheme tac local
[Device-isp-system] quit
```

Create local user **monitor**. Set the simple password to **hello12345**, the service type to Telnet, and the default user role to level-1.

```
[Device] local-user monitor
[Device-luser-manage-monitor] password simple hello12345
[Device-luser-manage-monitor] service-type telnet
[Device-luser-manage-monitor] authorization-attribute user-role level-1
```

Configuring command accounting

About command accounting

Command accounting uses the HWTACACS server to record all executed commands to monitor user behavior on the device.

If command accounting is enabled but command authorization is not, every executed command is recorded. If both command accounting and command authorization are enabled, only authorized commands that are executed are recorded.

Restrictions and guidelines

The command accounting method can be the same as or different from the command authorization method and user login authorization method.

To make the command accounting feature take effect, you must configure a command accounting method in ISP domain view. For more information, see *Security Configuration Guide*.

Procedure

1. Enter system view.

   system-view

2. Enter user line view or user line class view.

   - Enter user line view.

     line { *first-number1* [*last-number1*] | { **aux** | **usb** |**vty** } *first-number2* [*last-number2*] }

   - Enter user line class view.

     line class { **aux** | **usb** |**vty** }

   A setting in user line view applies only to the user line. A setting in user line class view applies to all user lines of the class. A non-default setting in either view takes precedence over the default setting in the other view. A non-default setting in user line view takes precedence over the non-default setting in user line class view.

   A setting in user line class view takes effect only on users who log in after the setting is made. It does not affect users who are already online when the setting is made.

3. Enable scheme authentication.

   In non-FIPS mode:

   authentication-mode scheme

By default, password authentication is enabled for VTY login.

The default authentication mode for console login is as follows:

- On the S5000V3-EI, S5000V5-EI, S5000E-X, S5000X-EI, and WAS6000 switch series:
  - If the device starts up with factory defaults, scheme authentication is enabled.
  - If the device starts up with the initial configuration, authentication is disabled.
- On the other switch series, authentication is disabled.

For more information about the initial configuration and factory defaults, see "Managing configuration files."

In VTY line view, this command is associated with the **protocol inbound** command. If one command has a non-default setting in VTY line view, the other command uses its setting in VTY line view, regardless of its setting in VTY line class view.

In FIPS mode:

authentication-mode scheme

By default, scheme authentication is enabled.

In VTY line view, this command is associated with the **protocol inbound** command. If one command has a non-default setting in VTY line view, the other command uses its setting in VTY line view, regardless of its setting in VTY line class view.

CAUTION:

When you enable scheme authentication, make sure an authentication user account is available. If no authentication user account is available, you cannot log in to the device through the line or line class at the next time.

4. Enable command accounting.

   command accounting

   By default, command accounting is disabled. The accounting server does not record the commands executed by users.

   If the **command accounting** command is executed in user line class view, command accounting is enabled on all user lines in the class. You cannot execute the **undo command accounting** command in the view of a user line in the class.

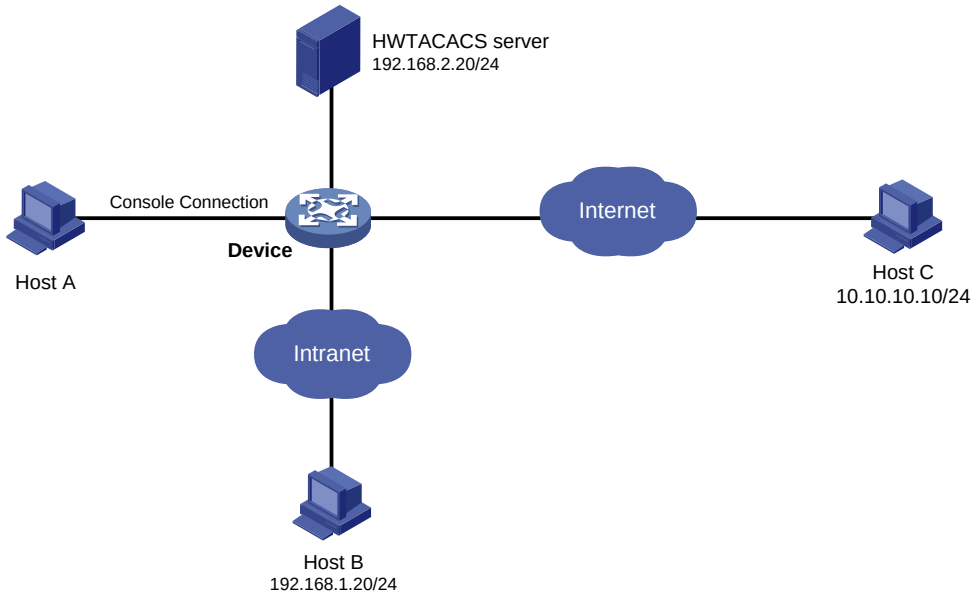
Example: Configuring command accounting

Network configuration

As shown in Figure 12, users need to log in to the device to manage the device.

Configure the device to send commands executed by users to the HWTACACS server to monitor and control user operations on the device.

Figure 12 Network diagram



Procedure

Enable the Telnet server.

```
<Device> system-view
[Device] telnet server enable
```

Enable command accounting for user line AUX 0.

```
[Device] line aux 0
[Device-line-aux0] command accounting
[Device-line-aux0] quit
```

Enable command accounting for user lines VTY 0 through VTY 63.

```
[Device] line vty 0 63
[Device-line-vty0-63] command accounting
[Device-line-vty0-63] quit
```

Create HWTACACS scheme **tac**.

```
[Device] hwtacacs scheme tac
```

Configure the scheme to use the HWTACACS server at 192.168.2.20:49 for accounting.

```
[Device-hwtacacs-tac] primary accounting 192.168.2.20 49
```

Set the shared key to **expert**.

```
[Device-hwtacacs-tac] key accounting simple expert
```

Remove domain names from usernames sent to the HWTACACS server.

```
[Device-hwtacacs-tac] user-name-format without-domain
[Device-hwtacacs-tac] quit
```

Configure the system-defined domain (**system**) to use the HWTACACS scheme for command accounting.

```
[Device] domain system
[Device-isp-system] accounting command hwtacacs-scheme tac
[Device-isp-system] quit
```

Contents

Configuring FTP

About FTP

File Transfer Protocol (FTP) is an application layer protocol for transferring files from one host to another over an IP network. It uses TCP port 20 to transfer data and TCP port 21 to transfer control commands.

FTP is based on the client/server model. The device can act as the FTP server or FTP client.

FTP file transfer modes

FTP supports the following transfer modes:

- **Binary mode**—Used to non-text files, such as **.app**, **.bin**, and **.btm** files.
- **ASCII mode**—Used to transfer text files, such as **.txt**, **.bat**, and **.cfg** files.

When the device acts as the FTP client, you can set the transfer mode (**binary** by default). When the device acts as the FTP server, the transfer mode is determined by the FTP client.

FTP operation modes

FTP can operate in either of the following modes:

- **Active mode (PORT)**—The FTP server initiates the TCP connection. This mode is not suitable when the FTP client is behind a firewall, for example, when the FTP client resides in a private network.
- **Passive mode (PASV)**—The FTP client initiates the TCP connection. This mode is not suitable when the server does not allow the client to use a random unprivileged port greater than 1024.

FTP operation mode varies depending on the FTP client program.

FIPS compliance

The device supports the FIPS mode that complies with NIST FIPS 140-2 requirements. Support for features, commands, and parameters might differ in FIPS mode and non-FIPS mode. For more information about FIPS mode, see *Security Configuration Guide*.

FTP is not supported in FIPS mode.

Using the device as an FTP server

To use the device as an FTP server, you must enable the FTP server and configure authentication and authorization on the device. Other commands are optional.

FTP server configuration tasks at a glance

To use the device as an FTP server, perform the following tasks:

1. Enabling the FTP server
2. Configuring client authentication and authorization
3. (Optional.) Configuring FTP server access control

4. (Optional.) Setting connection management parameters
5. (Optional.) Specifying an SSL server policy for SFTP connections
6. (Optional.) Setting the DSCP value for outgoing FTP packets
7. (Optional.) Manually releasing FTP connections

Enabling the FTP server

1. Enter system view.
   ```
   system-view
   ```
2. Enable the FTP server.
   ```
   ftp server enable
   ```
   By default, the FTP server is disabled.

Configuring client authentication and authorization

Perform this task on the FTP server to authenticate FTP clients and set the authorized directories that authenticated clients can access.

The following authentication modes are available:

- **Local authentication**—The device looks up the client's username and password in the local user account database. If a match is found, authentication succeeds.
- **Remote authentication**—The device sends the client's username and password to a remote authentication server for authentication. The user account is configured on the remote authentication server rather than the device.

The following authorization modes are available:

- **Local authorization**—The device assigns authorized directories to FTP clients based on the locally configured authorization attributes.
- **Remote authorization**—A remote authorization server assigns authorized directories on the device to FTP clients.

For more information about configuring authentication and authorization, see AAA in *Security Configuration Guide*.

Configuring FTP server access control

About FTP server access control

Use ACLs to prevent unauthorized access. If an applied ACL does not exist or does not have any rules, no user login restriction is applied. If the ACL exists and has rules, only FTP clients permitted by the ACL can access the device.

Restrictions and guidelines

This configuration takes effect only for FTP connections to be established. It does not affect existing FTP connections.

If you configure FTP server access control multiple times, the most recent configuration takes effect.

Procedure

1. Enter system view.
   ```
   system-view
   ```
2. Use an ACL to control access to the FTP server.

ftp server acl { *advanced-acl-number* | *basic-acl-number* | **ipv6** { *advanced-acl-number* | *basic-acl-number* } }

By default, no ACL is used for access control.

3. Enable logging for FTP login attempts that are denied by the FTP login control ACL.

ftp server acl-deny-log enable

By default, logging is disabled for FTP login attempts that are denied by the FTP login control ACL.

Setting connection management parameters

1. Enter system view.

system-view

2. Set the FTP connection idle-timeout timer.

ftp timeout *minutes*

By default, the FTP connection idle-timeout timer is 30 minutes.

If no data transfer occurs on an FTP connection before the idle-timeout timer expires, the FTP server closes the FTP connection.

3. Set the maximum number of concurrent FTP users.

aaa session-limit ftp *max-sessions*

By default, the maximum number of concurrent FTP users is 32.

Changing this setting does not affect users who are currently online. If the new limit is less than the number of online FTP users, no additional FTP users can log in until the number drops below the new limit. For more information about this command, see *Security Command Reference*.

Specifying an SSL server policy for SFTP connections

About specifying an SSL server policy for SFTP connections

After you associate an SSL server policy with the device, a client that supports SFTP will establish a secure connection to the device to ensure data security.

Procedure

1. Enter system view.

system-view

2. Associate an SSL server policy with the FTP server to ensure data security.

ftp server ssl-server-policy *policy-name*

By default, no SSL server policy is associated with the FTP server.

Setting the DSCP value for outgoing FTP packets

1. Enter system view.

system-view

2. Set the DSCP value for outgoing FTP packets.

IPv4:

ftp server dscp *dscp-value*

IPv6:

ftp server ipv6 dscp *dscp-value*

By default, the DSCP value is 0.

Manually releasing FTP connections

To manually release FTP connections, execute the following commands in user view:

- Release the FTP connection established by using a specific user account:
  free ftp user *username*
- Release the FTP connection to a specific IP address:
  free ftp user-ip [**ipv6**] *ip-address* [**port** *port*]

Display and maintenance commands for the FTP server

Execute **display** commands in any view.

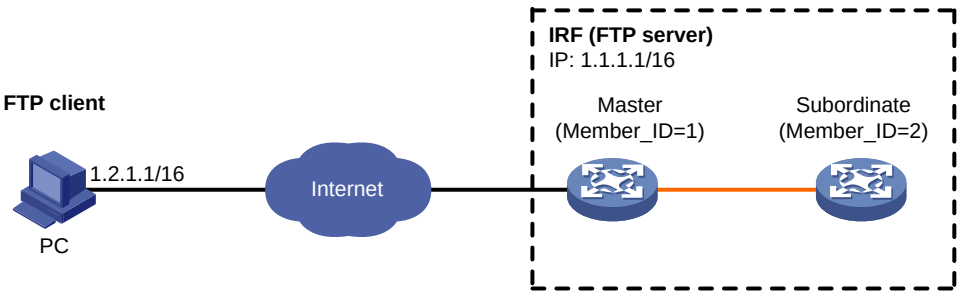
Task	Command
Display FTP server configuration and status information.	**display ftp-server**
Display detailed information about online FTP users.	**display ftp-user**

Example: Using the device as an FTP server

Network configuration

- Configure the IRF fabric as an FTP server.
- Create a local user account named **abc** on the FTP server. Set the password to **hello12345**.
- Use the user account to log in to the FTP server from the FTP client.
- Upload the **temp.bin** file from the FTP client to the FTP server.

Figure 1 Network diagram



Note: The orange line represents an IRF connection.

Procedure

1. Configure IP addresses as shown in Figure 1. Make sure the IRF fabric and the PC can reach each other. (Details not shown.)
2. Configure the FTP server:

   # Examine the storage space on the member devices. If the free space is insufficient, use the **delete/unreserved** *file* command to delete unused files. (Details not shown.)

   # Create a local user with username **abc** and password **hello12345**.

   ```
   <Sysname> system-view
   ```

```
[Sysname] local-user abc class manage
[Sysname-luser-manage-abc] password simple hello12345
```

Assign the **network-admin** user role to the user. Set the working directory to the root directory of the flash memory on the master. (To set the working directory to the root directory of the flash memory on the subordinate member, you must include the slot number in the directory path.)

```
[Sysname-luser-manage-abc] authorization-attribute user-role network-admin
work-directory flash:/
```

Assign the service type FTP to the user.

```
[Sysname-luser-manage-abc] service-type ftp
[Sysname-luser-manage-abc] quit
```

Enable the FTP server.

```
[Sysname] ftp server enable
[Sysname] quit
```

3. Perform FTP operations from the FTP client:

Log in to the FTP server at 1.1.1.1 using username **abc** and password **hello12345**.

```
c:\> ftp 1.1.1.1
Connected to 1.1.1.1.
220 FTP service ready.
User(1.1.1.1:(none)):abc
331 Password required for abc.
Password:
230 User logged in.
```

Use the ASCII mode to download configuration file **config.cfg** from the FTP server to the PC for backup.

```
ftp> ascii
200 TYPE is now ASCII
ftp> get config.cfg back-config.cfg
```

Use the binary mode to upload the **temp.bin** file from the PC to the root directory of the flash memory on the master.

```
ftp> binary
200 TYPE is now 8-bit binary
ftp> put temp.bin
```

Exit FTP.

```
ftp> bye
```

Using the device as an FTP client

FTP client configuration tasks at a glance

To use the device as an FTP server, perform the following tasks:

1. Establishing an FTP connection
2. (Optional.) Displaying command help information
3. (Optional.) Displaying directories and files on the FTP server
4. (Optional.) Managing directories on the FTP server
5. (Optional.) Working with files on the FTP server
6. (Optional.) Changing to another user account

7. (Optional.) Maintaining and troubleshooting the FTP connection
8. (Optional.) Terminating the FTP connection

Establishing an FTP connection

FTP connection establishment task list

To establish an FTP connection, perform the following tasks:

1. (Optional.) Specifying a source IP address for outgoing FTP packets
2. Establishing an FTP connection
3. Setting the FTP file transfer mode and operation mode

Restrictions and guidelines

The source IP address specified in the **ftp** command takes precedence over the one set by the **ftp client source** command.

The source IP address specified in the **ftp ipv6** command takes precedence over the one set by the **ftp client ipv6 source** command.

Specifying a source IP address for outgoing FTP packets

1. Enter system view.

   system-view

2. Specify a source IP address for outgoing FTP packets.

   IPv4:

   ftp client source { **interface** *interface-type interface-number* | **ip** *source-ip-address* }

   By default, no source IP address is specified. The device uses the primary IP address of the output interface as the source IP address.

   IPv6:

   ftp client ipv6 source { **interface** *interface-type interface-number* | **ipv6** *source-ipv6-address* }

   By default, no source IPv6 address is specified. The source address is automatically selected as defined in RFC 3484.

Establishing an FTP connection

- Log in to the FTP server from user view.

  IPv4:

  ftp [*ftp-server* [*service-port*] [**dscp** *dscp-value* | **source** { **interface** *interface-type interface-number* | **ip** *source-ip-address* } | **-d**] *]

  IPv6:

  ftp ipv6 [*ftp-server* [*service-port*] [**dscp** *dscp-value* | **source** { **interface** *interface-type interface-number* | **ipv6** *source-ipv6-address* } | **-d**] * [**-i** *interface-type interface-number*]]

- Log in to the FTP server from FTP client view.

  a. Enter FTP client view.

     ftp [**ipv6**]

  b. Log in to the FTP server.

     open *server-address* [*service-port*]

Setting the FTP file transfer mode and operation mode

1. Enter FTP client view from user view.
   ftp
2. Set the file transfer mode.
   - Set the file transfer mode to ASCII.
     ascii
   - Set the file transfer mode to binary.
     binary

   The default file transfer mode is binary.
3. Change the FTP operation mode.
   passive

   The default FTP operation mode is passive.

Displaying command help information

1. Enter FTP client view from user view.
   ftp
2. Display command help information.
   - **help** [*command-name*]
   - **?** [*command-name*]

Displaying directories and files on the FTP server

1. Enter FTP client view from user view.
   ftp
2. Display directories and files on the FTP server.
   - **dir** [*remotefile* [*localfile*]]
   - **ls** [*remotefile* [*localfile*]]

Managing directories on the FTP server

Prerequisites

Use the **dir** or **ls** command to display the directories and files on the FTP server.

Procedure

1. Enter FTP client view from user view.
   ftp
2. Manage directories on the FTP server.
   - Display the working directory that is being accessed on the FTP server.
     pwd
   - Change the working directory on the FTP server.
     cd { *directory* | **..** | **/** }
   - Return to the upper level directory on the FTP server.
     cdup
   - Create a directory on the FTP server.

mkdir *directory*

- Delete a directory from the remote FTP server.
  rmdir *directory*

> **CAUTION:**
> Delete a directory from the FTP server with caution. When you delete a directory from the FTP server, make sure the directory is no longer in use.

Managing directories on the FTP client

1. Enter FTP client view from user view.
   ftp
2. Display or change the local working directory of the FTP client.
   lcd [*directory* | */*]
   To upload a file, use this command to change to the directory where the file resides. Downloaded files are saved in the working directory.

Working with files on the FTP server

Prerequisites

Use the **dir** or **ls** command to display the directories and files on the FTP server.

Procedure

1. Enter FTP client view from user view.
   ftp
2. Work with files on the FTP server.
   - Delete a file from the FTP server permanently.
     delete *remotefile*

> **CAUTION:**
> Delete a file from the FTP server permanently with caution. When you delete a file from the FTP server permanently, make sure the file is no longer in use.

   This command requires that you have the delete right.
   - Rename a file.
     rename [*oldfilename* [*newfilename*]]
   - Upload a file to the FTP server.
     put *localfile* [*remotefile*]
   - Download a file from the FTP server.
     get *remotefile* [*localfile*]
   - Add the content of a file on the FTP client to a file on the FTP server.
     append *localfile* [*remotefile*]
   - Specify the retransmit marker.
     restart *marker*
     Use this command together with the **put**, **get**, or **append** command.
   - Update a local file.

newer *remotefile*

- Get the missing part of a file.
  reget *remotefile* [*localfile*]

Changing to another user account

About changing to another user account

After you log in to the FTP server, you can initiate an FTP authentication to change to a new account. By changing to a new account, you can get a different privilege without re-establishing the FTP connection.

Restrictions and guidelines

For successful account change, you must enter the new username and password correctly. A wrong username or password can cause the FTP connection to be disconnected.

Procedure

1. Enter FTP client view from user view.
   ftp
2. Initiate an FTP authentication on the current FTP connection.
   user *username* [*password*]

Maintaining and troubleshooting the FTP connection

About maintaining and troubleshooting the FTP connection

After you use the device to establish an FTP connection to the FTP server, use the commands in this section to locate and troubleshoot problems about the FTP connection.

Procedure

1. Enter FTP client view from user view.
   ftp
2. Maintain and troubleshoot the FTP connection.
   - Display FTP commands supported by the FTP server.
     rhelp
   - Display help information about an FTP command that is supported by the FTP server.
     rhelp *protocol-command*
   - Display FTP server status.
     rstatus
   - Display detailed information about a directory or file on the FTP server.
     rstatus *remotefile*
   - Display FTP connection status.
     status
   - Display the system information of the FTP server.
     system
   - Enable or disable FTP operation information display.
     verbose

     By default, this function is enabled.
   - Enable FTP client debugging.

debug

By default, FTP client debugging is disabled.

- Clear the reply information in the buffer.

  reset

Terminating the FTP connection

1. Enter FTP client view from user view.

   ftp
2. Terminate the connection.
   - Terminate the connection to the FTP server without exiting FTP client view.

     disconnect

     close
   - Terminate the connection to the FTP server and return to user view.

     bye

     quit

Display and maintenance commands for the FTP client

Execute the **display** command in any view.

Task	Command
Display source IP address information on the FTP client.	**display ftp client source**

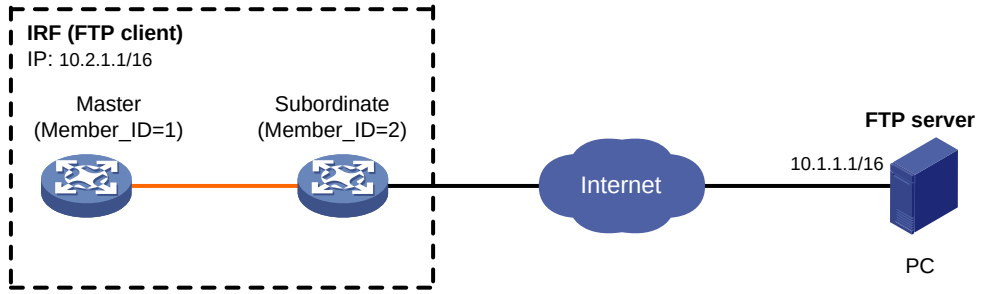
Example: Using the device as an FTP client

Network configuration

As shown in Figure 2, the PC is acting as an FTP server. A user account with username **abc** and password **hello12345** has been created on the PC.

- Use the IRF fabric as an FTP client to log in to the FTP server.
- Download the **temp.bin** file from the FTP server to the FTP client.

Figure 2 Network diagram



Note: The orange line represents an IRF connection.

Procedure

Configure IP addresses as shown in Figure 2. Make sure the IRF fabric and PC can reach each other. (Details not shown.)

Examine the storage space on the member devices. If the free space is insufficient, use the **delete/unreserved** *file* command to delete unused files. (Details not shown.)

Log in to the FTP server at 10.1.1.1 using username **abc** and password **hello12345**.

```
<Sysname> ftp 10.1.1.1
Press CTRL+C to abort.
Connected to 10.1.1.1 (10.1.1.1).
220 WFTPD 2.0 service (by Texas Imperial Software) ready for new user
User (10.1.1.1:(none)): abc
331 Give me your password, please
Password:
230 Logged in successfully
Remote system type is MSDOS.
ftp>
```

Set the file transfer mode to binary.

```
ftp> binary
200 TYPE is now 8-bit binary
```

Download the **temp.bin** file from the PC to the root directory of the flash memory on the master device.

```
ftp> get temp.bin
local: temp.bin remote: temp.bin
150 Connecting to port 47457
226 File successfully transferred
23951480 bytes received in 95.399 seconds (251.0 kbyte/s)
```

Download the **temp.bin** file from the PC to the root directory of the flash memory on the subordinate member (with member ID of 2).

```
ftp> get temp.bin slot2#flash:/temp.bin
```

Use the ASCII mode to upload configuration file **config.cfg** from the IRF fabric to the PC for backup.

```
ftp> ascii
200 TYPE is now ASCII
ftp> put config.cfg back-config.cfg
local: config.cfg remote: back-config.cfg
150 Connecting to port 47461
226 File successfully transferred
3494 bytes sent in 5.646 seconds (618.00 kbyte/s)
ftp> bye
221-Goodbye. You uploaded 2 and downloaded 2 kbytes.
221 Logout.
<Sysname>
```

Configuring TFTP

About TFTP

Trivial File Transfer Protocol (TFTP) is a simplified version of FTP for file transfer over secure reliable networks. TFTP uses UDP port 69 for data transmission. In contrast to TCP-based FTP, TFTP does not require authentication or complex message exchanges, and is easier to deploy. TFTP is suited for reliable network environments.

FIPS compliance

The device supports the FIPS mode that complies with NIST FIPS 140-2 requirements. Support for features, commands, and parameters might differ in FIPS mode and non-FIPS mode. For more information about FIPS mode, see *Security Configuration Guide*.

TFTP is not supported in FIPS mode.

Restrictions and guidelines: TFTP configuration

You can upload a file from the device to the TFTP server or download a file from the TFTP server to the device.

As a best practice to download a file, specify a nonexistent file name as the destination file name. If you download a file with a file name that exists in the target directory, the device deletes the existing file and saves the new one. If file download fails due to network disconnection or other reasons, the original file cannot be restored.

The device can act only as a TFTP client.

Configuring and using the IPv4 TFTP client

1. Enter system view.

   system-view

2. (Optional.) Use an ACL to control the client's access to TFTP servers.

   tftp-server acl *acl-number*

   By default, no ACL is used for access control.

3. Specify the source IP address for TFTP packets sent by the TFTP client.

   tftp client source { **interface** *interface-type interface-number* | **ip** *source-ip-address* }

   By default, no source IP address is specified. The device uses the primary IP address of the output interface as the source IP address.

4. Return to user view.

   quit

5. Download or upload a file in an IPv4 network.

   tftp *tftp-server* { **get** | **put** | **sget** } *source-filename* [*destination-filename*] [**dscp** *dscp-value* | **source** { **interface** *interface-type interface-number* | **ip** *source-ip-address* }] *

   The source IP address specified in this command takes precedence over the source IP address set by using the **tftp client source** command.

Configuring and using the IPv6 TFTP client

1. Enter system view.

   system-view

2. (Optional.) Use an ACL to control the client's access to TFTP servers.

   tftp-server ipv6 acl *ipv6-acl-number*

   By default, no ACL is used for access control.

3. Specify the source IPv6 address for TFTP packets sent by the TFTP client.

   tftp client ipv6 source { **interface** *interface-type interface-number* | **ipv6** *source-ipv6-address* }

   By default, no source IPv6 address is specified. The source address is automatically selected as defined in RFC 3484.

4. Return to user view.

   quit

5. Download or upload a file in an IPv6 network.

   tftp ipv6 *tftp-server* [**-i** *interface-type interface-number*] { **get** | **put** | **sget** } *source-filename* [*destination-filename*] [**dscp** *dscp-value* | **source** { **interface** *interface-type interface-number* | **ipv6** *source-ipv6-address* }] *

   The source IP address specified in this command takes precedence over the one set by the **tftp client ipv6 source** command.

Contents

Managing file systems

This chapter describes how to manage file systems.

About file system management

Storage media and file systems

The device supports both fixed (the flash memory) and hot swappable (USB disk) storage media.

- The fixed storage medium has one file system.
- The hot swappable storage media can be partitioned. Each unpartitioned storage medium has one file system. On a partitioned storage medium, each partition has one file system.

Storage medium and file system naming conventions

The file system on the flash memory has the same name as the flash memory. The name has the following parts:

- Storage medium type **flash**.
- Colon (:).

A USB disk name and the file system names share the following parts:

- Storage medium type **usb**.
- Sequence number, a lower-case English letter such as a, b, or c.
- Partition number, a digit that starts at 0 and increments by 1. If the storage medium is not partitioned, the system determines that the storage medium has one partition. (The storage medium name does not contain a partition number.)
- Colon (:).

For example, the first USB disk is named **usba:**, and the file system on the first partition of the first USB disk is named **usba0:**.

IMPORTANT:

File system names are case sensitive and must be entered in lower case.

File system location

To identify a file system on the master device, you do not need to specify the file system location. To identify a file system on a subordinate member device, you must specify the file system location in the **slot***n***#** format. The *n* argument represents the IRF member ID of the member device. For example, the location is **slot2#** for a file system that resides on member device 2.

IMPORTANT:

The file system location string is case sensitive and must be entered in lower case.

Default file system

You are working with the default file system by default after you log in. To specify a file or directory on the default file system, you do not need to specify the file system name. For example, you do not need to specify any location information if you want to save the running configuration to the root directory of the default file system.

To change the default file system, use the Boot ROM menu. For more information, see the software release notes.

Directories

Directories in a file system are structured in a tree form.

Root directory

The root directory is represented by a forwarding slash (/). For example, **flash:/** represents the root directory of the flash memory.

Working directory

The working directory is also called the current directory.

Directory naming conventions

When you specify a name for a directory, follow these conventions:

- A directory name can contain letters, digits, and special characters except for asterisks (*), vertical bars (|), forward slashes (/), backward slashes (\), question marks (?), left angle brackets (<), right angle brackets (>), quotation marks ("), and colons (:).
- A directory whose name starts with a dot character (.) is a hidden directory. To prevent the system from hiding a directory, make sure the directory name does not start with a dot character.

Commonly used directories

The device has some factory-default directories. The system automatically creates directories during operation. These directories include:

- **diagfile**—Stores diagnostic information files.
- **logfile**—Stores log files.
- **seclog**—Stores security log files.
- **versionInfo**—Stores software version information files.

Files

File naming conventions

When you specify a name for a file, follow these conventions:

- A file name can contain letters, digits, and special characters except for asterisks (*), vertical bars (|), forward slashes (/), backward slashes (\), question marks (?), left angle brackets (<), right angle brackets (>), quotation marks ("), and colons (:).
- A file whose name starts with a dot character (.) is a hidden file. To prevent the system from hiding a file, make sure the file name does not start with a dot character.

Common file types

The device is shipped with some files. The system automatically creates files during operation. The types of these files include:

- **.ipe file**—Compressed software image package file.
- **.bin file**—Software image file.
- **.cfg file**—Configuration file.
- **.mdb file**—Binary configuration file.
- **.log file**—Log file.

Specifying a directory name or file name

Specifying a directory name

To specify a directory, you can use the absolute path or a relative path. For example, the working directory is **flash:/**. To specify the **test2** directory in Figure 1, you can use the following methods:

- **flash:/test/test1/test2** (absolute path)
- **flash:/test/test1/test2/** (absolute path)
- **test/test1/test2** (relative path)
- **test/test1/test2/** (relative path)

Figure 1 Sample directory hierarchy

Specifying a file name

To specify a file, use the following methods:

- Enter the absolute path of the file and the file name in the format of *filesystem*I*directory1*I*directory2*I…I*directoryn*I*filename*, where *directoryn* is the directory in which the file resides.
- Enter the relative path of the file and the file name.

For example, the working directory is **flash:/**. The **samplefile.cfg** file is in the **test2** directory shown in Figure 1. To specify the file, you can use the following methods:

- **flash:/test/test1/test2/samplefile.cfg**
- **test/test1/test2/samplefile.cfg**

FIPS compliance

The device supports the FIPS mode that complies with NIST FIPS 140-2 requirements. Support for features, commands, and parameters might differ in FIPS mode and non-FIPS mode. For more information about FIPS mode, see *Security Configuration Guide*.

Restrictions and guidelines: File system management

To avoid file system corruption, do not perform the following tasks during file system management:

- Install or remove storage media.
- Perform a master/subordinate switchover.

If you remove a storage medium while a directory or file on the medium is being accessed, the device might not recognize the medium when you reinstall it. To reinstall this kind of storage medium, perform one of the following tasks:

- If you were accessing a directory on the storage medium, change the working directory.
- If you were accessing a file on the storage medium, close the file.
- If another administrator was accessing the storage medium, unmount all partitions on the storage medium.

Make sure a USB disk is not write protected before an operation that requires the write right on the disk.

You cannot access a storage medium that is being partitioned, or a file system that is being formatted or repaired.

Before managing file systems, directories, and files, make sure you know the possible impact.

Managing storage media and file systems

Partitioning a storage medium

About partitioning a storage medium

A storage medium can be divided into logical devices called partitions. Operations on one partition do not affect the other partitions.

Restrictions and guidelines

IMPORTANT:

Partitioning a storage medium clears all data on the medium.

The flash memory does not support partitioning.

Before partitioning a storage medium, perform the following tasks:

- Make sure no other users are accessing the medium.
- To partition a USB disk, make sure the disk is not write protected. If the disk is write protected, the partition operation will fail. To restore access to the USB disk, you must reinstall the disk or remount the file systems on the disk.

A partition must have a minimum of 32 MB of storage space.

The actual partition size and the specified partition size might have a difference of less than 5% of the storage medium's total size.

Prerequisites

Back up the files in the storage medium.

Procedure

To partition a storage medium, execute the following command in user view:

fdisk *medium* [*partition-number*]

To partition a storage medium evenly, specify the *partition-number* argument. To customize the sizes of partitions, do not specify the *partition-number* argument. The command will require you to specify a size for each partition.

Mounting or unmounting a file system

Restrictions and guidelines

You can mount or unmount only a file system that is on a hot-swappable storage medium.

You can unmount a file system only when no other users are accessing the file system.

To prevent a USB disk and the USB interface from being damaged, make sure the following requirements are met before unmounting file systems on the USB disk:

- The system has recognized the USB disk.
- The USB disk LED is not blinking.

Mounting a file system

To mount a file system, execute the following command in user view:

mount *filesystem*

File systems on a hot-swappable storage medium are automatically mounted when the storage medium is connected to the device. If the system cannot recognize a file system, you must mount the file system before you can access it.

Unmounting a file system

To unmount a file system, execute the following command in user view:

umount *filesystem*

To remove a hot-swappable storage medium from the device, you must first unmount all file systems on the storage medium to disconnect the medium from the device. Removing a connected hot-swappable storage medium might damage files on the storage medium or even the storage medium itself.

Formatting a file system

Restrictions and guidelines

You can format a file system only when no other users are accessing the file system.

Procedure

To format a file system, execute the following command in user view:

format *filesystem*

△ **CAUTION:**

Formatting a file system permanently deletes all files and directories in the file system. You cannot restore the deleted files or directories. If a startup configuration file exists in the file system, back up the file if necessary.

Repairing a file system

Restrictions and guidelines

If part of a file system is inaccessible, use this task to examine and repair the file system.

You can repair a file system only when no other users are accessing the file system.

Procedure

To repair a file system, execute the following command in user view:

fixdisk *filesystem*

Managing files and directories

Setting the operation mode for files and directories

About file and directory operation modes

The device supports the following operation modes:

- **alert**—The system prompts for confirmation when your operation might cause problems such as file corruption or data loss. This mode provides an opportunity for you to cancel a disruptive operation.
- **quiet**—The system does not prompt for confirmation when you perform a file or directory operation except the recycle bin emptying operation.

Procedure

1. Enter system view.

   system-view
2. Set the operation mode for files and directories.

   file prompt { **alert** | **quiet** }

   The default mode is alert.

Displaying file and directory information

To display file and directory information, execute the following command in user view:

dir [**/all**] [*file* | *directory* | **/all-filesystems**]

If multiple users perform file operations (for example, creating or deleting files or directories) at the same time, the output from this command might be incorrect.

Displaying the contents of a text file

To display the contents of a text file, execute the following command in user view:

more *file*

Displaying the working directory

To display the working directory, execute the following command in user view:

pwd

Changing the working directory

About changing the working directory

The default working directory is the root directory of the default file system on the master device.

Procedure

To change the working directory, execute the following command in user view:

cd { *directory* | **..** }

Creating a directory

To create a directory, execute the following command in user view:

mkdir *directory*

Renaming a file or directory

To rename a file or directory, execute the following command in user view:

rename { *source-file* | *source-directory* } { *dest-file* | *dest-directory* }

Copying a file

To copy a file, execute the command in user view.

In non-FIPS mode:

copy *source-file* { *dest-file* | *dest-directory* } [**source interface** *interface-type interface-number*]

In FIPS mode:

copy *source-file* {*dest-file* |*dest-directory*}

Moving a file

To move a file, execute the following command in user view:

move *source-file* {*dest-file* | *dest-directory*}

Deleting and restoring files

About deleting and restoring a file

You can delete a file permanently or move it to the recycle bin of the file system. A file moved to the recycle bin can be restored, but a permanently deleted file cannot.

Each file system has a recycle bin. A recycle bin is a directory named **.trash** in the root directory of the file system.

Restrictions and guidelines

Files in the recycle bin occupy storage space. To release the occupied storage space, delete files from the recycle bin.

To delete files from the recycle bin, use the **reset recycle-bin** command. If you use the **delete** command, the recycle bin might not be able to operate correctly.

To display files in a recycle bin, use one of the following methods:

- Access the root directory of the file system and execute the **dir /all .trash** command.
- Access the recycle bin directory of the file system and execute the **dir** command.

Deleting a file

To delete a file, execute one of the following commands in user view:

- Delete a file by moving it to the recycle bin.
  delete *file*
- Delete a file permanently.
  delete /unreserved *file*

CAUTION:
The **delete /unreserved** *file* command deletes a file permanently. The file cannot be restored.

- Delete files from the recycle bin.
  reset recycle-bin [**/force**]

CAUTION:

The files in a recycle bin can be restored by using the **undelete** command. If you delete a file from the recycle bin, that file cannot be restored. Before you delete files from a recycle bin, make sure the files are no longer in use.

Restoring a file

To restore a file from the recycle bin, execute the following command in user view:

undelete *file*

Deleting a directory

To delete a directory, execute the following command in user view:

rmdir *directory*

CAUTION:

To delete a directory, you must first delete all files and subdirectories in the directory permanently or move them to the recycle bin. If you move them to the recycle bin, executing the **rmdir** command to delete the directory will delete them permanently. Before you use the **rmdir** command to delete a directory, you must make sure the directory and its files and subdirectories are no longer in use.

Archiving files and directories

About archiving files and directories

You can archive files and directories to a single file for purposes such as file backup. The original files and directories still exist.

When you archive files and directories, you can choose to compress the archive files so the archive files use less storage space.

Procedure

To archive files and directories, execute the following command in user view:

tar create [**gz**] **archive-file** *dest-file* [**verbose**] **source** { *source-file* | *source-directory* }&<1-5>

Extracting files and directories

About extracting files and directories

Use this feature to extract files and directories from archive files.

Restrictions and guidelines

To specify the **screen** keyword for the **tar extract** command, first use the **tar list** command to identify the types of the archived files. As a best practice, specify the keyword only if all archived files are text files. Displaying the content of an archived non-text file that contains terminal control characters might result in garbled characters and even cause the terminal unable to operate correctly. To use the terminal again, you must close the current connection and log in to the device again.

Procedure

To extract files and directories, execute the following commands in user view:

1. (Optional.) Display archived files and directories.

tar list archive-file *file*

2. Extract files and directories.
   tar extract archive-file *file* [**verbose**] [**screen** | **to** *directory*]

Compressing a file

To compress a file, execute the following command in user view:

gzip *file*

Decompressing a file

To decompress a file, execute the following command in user view:

gunzip *file*

Calculating the file digest

About file digests

File digests are used to verify file integrity.

Procedure

To calculate the digest of a file, execute one of the following commands in user view:

- Use the SHA-256 algorithm.
  sha256sum *file*
- Use the MD5 algorithm.
  md5sum *file*

Executing a batch file

About batch file and batch file execution

A batch file contains a set of commands. Executing a batch file executes the commands in the file one by one.

Restrictions and guidelines

To execute a batch file on the device, create a batch file on a PC and load the batch file to the device.

As a best practice, try every command on the device to make sure the command line can be executed correctly before adding the command to a batch file. If a command is invalid or a condition for executing the command is not met, the command fails and the system continues to execute the next command.

When executing an interactive command in a batch file, the system uses the default inputs.

Procedure

1. Enter system view.
   system-view
2. Execute a batch file.
   execute *filename*

Contents

Managing configuration files

About configuration file management

You can manage configuration files from the CLI or the BootWare menu. The following information explains how to manage configuration files from the CLI.

A configuration file saves a set of commands for configuring software features on the device. You can save any configuration to a configuration file so the configuration can survive a reboot. You can also back up configuration files to a host for future use.

Configuration types

Initial configuration

Initial configuration is the collection of initial default settings for the configuration commands in software.

The device starts up with the initial configuration if you access the BootWare menu and select the **Skip Current System Configuration** option. In this situation, the device might also be described as starting up with empty configuration.

No commands are available to display the initial configuration. To view the initial default settings for the configuration commands, see the Default sections in the command references.

Factory defaults

Factory defaults are custom basic settings that came with the device. Factory defaults vary by device models and might differ from the initial default settings for the commands.

The device starts up with the factory defaults if no next-startup configuration files are available.

To display the factory defaults, use the **`display default-configuration`** command.

Startup configuration

The device uses startup configuration to configure software features during startup. After the device starts up, you can specify the configuration file to be loaded at the next startup. This configuration file is called the next-startup configuration file. The configuration file that has been loaded is called the current startup configuration file.

You can display the startup configuration by using one of the following methods:

- To display the contents of the current startup configuration file, execute the **`display current-configuration`** command before changing the configuration after the device reboots.
- To display the contents of the next-startup configuration file, use the **`display saved-configuration`** command.
- Use the **`display startup`** command to display names of the current startup configuration file and next-startup configuration files. Then, you can use the **`more`** command to display the contents of the specified startup configuration file.

Running configuration

The running configuration includes unchanged startup settings and new settings. The running configuration is stored in memory and is cleared at a device reboot or power off. To use the running configuration after a power cycling or reboot, save it to a configuration file.

To display the running configuration, use the **`display current-configuration`** command.

Configuration file types and file selection process at startup

When you save the configuration, the system saves the settings to a .cfg configuration file and to an .mdb file.

- A .cfg configuration file is a human-readable text file and its contents can be displayed by using the **more** command. Configuration files you specify for saving the configuration must use the .cfg extension.
- An .mdb file is a user-inaccessible binary file that has the same name as the .cfg file. The device loads an .mdb file faster than loading a .cfg file.

At startup, the device uses the following procedure to identify the configuration file to load:

1. The device searches for a valid .cfg next-startup configuration file. For more information about the file selection rules, see "Next-startup configuration file redundancy."
2. If a valid .cfg next-startup configuration file is found, the device searches for an .mdb file that has the same name and checksum as the .cfg file.
3. If a matching .mdb file is found, the device starts up with the .mdb file. If none is found, the device starts up with the .cfg file.

If no .cfg next-startup configuration files are available, the device starts up with the factory defaults.

Unless otherwise stated, the term "configuration file" in this document refers to a .cfg configuration file.

Next-startup configuration file redundancy

You can specify one main next-startup configuration file and one backup next-startup configuration file for redundancy.

At startup, the device tries to select the .cfg startup configuration in the following order:

1. The main next-startup configuration file.
2. The backup next-startup configuration file if the main next-startup configuration file does not exist or is corrupt.

If no next-startup configuration files are available, the device starts up with the factory defaults.

Configuration file content organization and format

IMPORTANT:

To run on the device, a configuration file must meet the content and format requirements. To ensure a successful configuration load, rollback, or restoration, use a configuration file created on the device. If you edit the configuration file, make sure all edits are compliant with the requirements.

A configuration file must meet the following requirements:

- All commands are saved in their complete form.
- No command lines contain invalid characters.

IMPORTANT:

Some command lines (for example, the **sysname** command) cannot contain question marks (?) or horizontal tabs (\t). If the system loads a configuration file that contains the **sysname abc??** command line at startup, the system will ignore the command line and use the default system name. If the system uses that configuration file to roll back or restore the configuration, the system name will not be rolled back or restored.

- Commands are sorted into sections by different command views, including system view, interface views, protocol views, and user line views.
- Two adjacent sections are separated by a pound sign (#).
- The configuration file ends with the word **return**.

The following is a sample configuration file excerpt:

```
#
local-user root class manage
 password hash
$h$6$Twd73mLrN8O2vvD5$Cz1vgdpR4KoTiRQNE9pg33gU14Br2p1VguczLSVyJLO2huV5Syx/LfDIf8ROLtV
ErJ/C31oq2rFtmNuyZf4STw==
 service-type ssh telnet terminal
 authorization-attribute user-role network-admin
 authorization-attribute user-role network-operator
#
interface Vlan-interface1
 ip address 192.168.1.84 255.255.255.0
#
```

Configuration rollback

Configuration rollback allows you to replace the running configuration with the configuration in a configuration file without rebooting the device. You can use this feature for the following purposes:

- Reverting to a previous configuration state.
- Adapting the running configuration to different network environments.

FIPS compliance

The device supports the FIPS mode that complies with NIST FIPS 140-2 requirements. Support for features, commands, and parameters might differ in FIPS mode and non-FIPS mode. For more information about FIPS mode, see *Security Configuration Guide*.

Enabling configuration encryption

About configuration encryption

Configuration encryption enables the device to encrypt a startup configuration file automatically when it saves the running configuration. All devices running Comware 7 software use the same private key or public key to encrypt configuration files.

Restrictions and guidelines

Any devices running Comware 7 software can decrypt the encrypted configuration files. To prevent an encrypted file from being decoded by unauthorized users, make sure the file is accessible only to authorized users.

You cannot use the **more** command to view the contents of an encrypted configuration file.

Procedure

1. Enter system view.

   system-view
2. Enable configuration encryption.

configuration encrypt { **private-key** | **public-key** }

By default, configuration encryption is disabled.

Disabling automatic system-wide next-startup configuration file operations

About automatic system-wide next-startup configuration file operations

By default, automatic system-wide next-startup configuration file operations are enabled. The system performs the following operations on all IRF subordinate devices in addition to the master device:

- Saves the running configuration to the next-startup configuration file on each member device when you execute the **save** [**safely**] [**backup** | **main**] [**force**] [**changed**] command.
- Deletes the next-startup configuration file on each member device when you execute the **reset saved-configuration** command.

If you disable automatic system-wide next-startup configuration file operations, the system saves the running configuration or deletes the next-startup configuration file only on the master device.

Automatic system-wide operations ensure start-up configuration file consistency between the master and subordinate devices. However, a system-wide operation takes more time than an operation performed only on the master device. In addition, the amount of time required to complete a system-wide configuration operation increases as the amount of configuration data grows.

If you are disabling automatic system-wide operations for faster configuration saving, be aware that the next-startup configuration files will be inconsistent between the master device and the subordinate devices.

Procedure

1. Enter system view.

   system-view

2. Disable automatic system-wide next-startup configuration file operations.

   undo standby auto-update config

   By default, next-startup configuration file operations are automatically synchronized across the entire system.

Saving the running configuration

About running configuration saving methods

When you save the running configuration to a .cfg configuration file, you can specify the file as a next-startup configuration file or not.

If you are specifying the file as a .cfg next-startup configuration file, use one of the following methods to save the configuration:

- **Fast mode**—Use the **save** command without the **safely** keyword. In this mode, the device directly overwrites the target next-startup configuration file. If a reboot or power failure occurs during this process, the next-startup configuration file is lost. You must specify a new startup configuration file after the device reboots (see "Specifying a next-startup configuration file").
- **Safe mode**—Use the **save** command with the **safely** keyword. Safe mode is slower than fast mode, but more secure. In safe mode, the system saves the configuration in a temporary file and starts overwriting the target next-startup configuration file after the save operation is complete. If a reboot or power failure occurs during the save operation, the next-startup

configuration file is still retained. Use the safe mode if the power source is not reliable or you are remotely configuring the device.

Restrictions and guidelines

To prevent the loss of next-startup configuration, make sure no one reboots or power cycles the device while the device is saving the running configuration.

When an IRF member device splits from the IRF fabric, its settings are retained in memory but removed from the running configuration on the IRF fabric. Saving the running configuration before the IRF fabric recovers will remove the member device's settings from the next-startup configuration file.

If you have saved the running configuration before the member device rejoins the IRF fabric, perform the following steps to restore the member device settings to the next-startup configuration file:

1. Resolve the split issue.
2. Reboot the member device to rejoin the IRF fabric.
3. After the member device rejoins the IRF fabric, execute the **display current-configuration** command to verify that the member device's settings have been restored from memory to the running configuration.
4. Save the running configuration to the next-startup configuration file on the IRF fabric.

IMPORTANT:

To ensure a successful configuration restoration, make sure the IRF fabric has not rebooted after the member device left.

By default, the **save** [**safely**] [**backup** | **main**] [**force**] [**changed**] command saves the configuration to all IRF member devices. To save the configuration only to the master device, disable automatic system-wide next-startup configuration file operations. For more information, see "Disabling automatic system-wide next-startup configuration file operations."

Procedure

To save the running configuration, perform one of the following tasks in any view:

- Save the running configuration to a configuration file without specifying the file as a next-startup configuration file.

  save *file-url* [**all** | **slot** *slot-number*]

- Save the running configuration to a configuration file in the root directory of the storage medium, and specify the file as a next-startup configuration file.

  save [**safely**] [**backup** | **main**] [**force**] [**changed**]

  As a best practice, specify the **safely** keyword for reliable configuration saving.

CAUTION:

Use the **save** command with caution. This command will overwrite the settings in the target configuration file. Carefully read the messages generated on the device when you use this command and make sure you fully understand the impact of this command when you execute it.

Comparing configurations for their differences

About configuration comparison

You can compare configuration files or compare a configuration file with the running configuration for their differences.

If you specify the next-startup configuration for a comparison, the system selects the next-startup configuration file to be compared with in the following order:

1. The main next-startup configuration file.
2. The backup next-startup configuration file if the main next-startup configuration file is unavailable.

If both configuration files are unavailable, the system displays a message indicating that no next-startup configuration files exist.

Procedure

To compare configurations for their differences, perform one of the following tasks in any view:

- Display the differences that a configuration file, the running configuration, or the next-startup configuration has as compared with the specified source configuration file.

  display diff configfile *file-name-s* { **configfile** *file-name-d* | **current-configuration** | **startup-configuration** }

- Display the differences that a configuration file or next-startup configuration has as compared with the running configuration.

  display diff current-configuration { **configfile** *file-name-d* | **startup-configuration** }

- Display the differences that a configuration file has as compared with the next-startup configuration.

  display diff startup-configuration configfile *file-name-d*

- Display the differences that the running configuration has as compared with the next-startup configuration.
  - Method 1:

    display diff startup-configuration current-configuration
  - Method 2:

    display current-configuration diff

Configuring configuration rollback

Configuration rollback tasks at a glance

To configure configuration rollback, perform the following tasks:

1. Setting configuration archive parameters
2. Archiving the running configuration
   - Enabling automatic configuration archiving
   - Manually archiving the running configuration
3. Rolling back configuration

Setting configuration archive parameters

About setting configuration archive parameters

Before archiving the running configuration, you must set a file directory and file name prefix for configuration archives.

The archive directory can be located on the local device or on a remote SCP server.

If you use local archiving, configuration archives are named in the format of *prefix_serial number***.cfg**, for example, **archive_1.cfg** and **archive_2.cfg**. The serial number is automatically assigned from 1 to 1000, increasing by 1. After the serial number reaches 1000, it restarts from 1.

If you change the file directory or file name prefix on the local device, the following events occur:

- The old configuration archives change to common configuration files.
- The configuration archive counter is reset. The serial number for new configuration archives starts at 1.
- The **display archive configuration** command no longer displays the old configuration archives.

The configuration archive counter does not restart when you delete configuration archives from the archive directory. However, if the device reboots after all configuration archives have been deleted, the configuration archive counter restarts. The serial number for new configuration archives starts at 1.

If you archive the running configuration to a remote SCP server, configuration archives are named in the format of *prefix_YYYYMMDD_HHMMSS***.cfg**, for example, **archive_20170526_203430.cfg**.

If you change the file directory or file name prefix on the remote SCP server, the **display archive configuration** command no longer displays the old configuration archives saved before the change.

Restrictions and guidelines for setting configuration archive parameters

Local archiving (the **archive configuration location** command) and remote archiving (the **archive configuration server** command) are mutually exclusive. You cannot use the two features at the same time.

IMPORTANT:

In FIPS mode, the device does not support archiving the running configuration to a remote SCP server.

With local configuration archiving, the system deletes the oldest archive to make room for the new archive after the maximum number of configuration archives is reached.

The maximum number of configuration archives on a remote SCP server depends on the SCP server setting and is not restricted by the **archive configuration max** command.

The **undo archive configuration location** command removes the local configuration archive directory and file name prefix settings, but it does not delete the configuration archives on the device. The command also performs the following operations:

- Disables both the manual and automatic configuration archiving features.
- Restores the default settings for the **archive configuration interval** and **archive configuration max** commands.
- Clears the configuration archive information displayed by using the **display archive configuration** command.

The **undo archive configuration server** command removes the remote configuration archive directory and file name prefix settings, but it does not delete the configuration archives on the server. The command also performs the following operations:

- Disables both the manual and automatic configuration archiving features.
- Restores the default setting for the **archive configuration interval** command.
- Clears the configuration archive information displayed by using the **display archive configuration** command.

Configuring local archiving parameters

1. Enter system view.

   system-view

2. Set the directory and file name prefix for archiving the running configuration to the local device.

   archive configuration location *directory* **filename-prefix** *filename-prefix*

   By default, no path or file name prefix is set for configuration archives on the device, and the system does not regularly save configuration.

   In an IRF fabric, the configuration archive directory must already exist on the master device and cannot include a member ID.

3. (Optional.) Set the maximum number of configuration archives.

   archive configuration max *file-number*

   The default number is 5.

   Change the setting depending on the amount of storage available on the device.

Configuring remote archiving parameters

1. Enter system view.

   system-view

2. Set the directory and file name prefix for archiving the running configuration on a remote SCP server.

   archive configuration server scp { *ipv4-address* | **ipv6** *ipv6-address* } [**port** *port-number*] [**directory** *directory*] **filename-prefix** *filename-prefix*

   By default, no path or file name prefix is set for archiving the running configuration to a remote SCP server.

3. Configure the username and password for accessing the remote SCP server:

   a. Configure the username.

      archive configuration server user *user-name*

      By default, no username is configured for accessing the SCP server.

   b. Configure the password.

      archive configuration server password { **cipher** | **simple** } *string*

      By default, no password is configured for accessing the SCP server.

   Make sure the username and password are the same as the SCP account settings on the SCP server.

Archiving the running configuration

About archiving the running configuration

The following are methods for archiving the running configuration:

- **Automatic configuration archiving**—The system automatically archives the running configuration at intervals as configured.
- **Manual configuration archiving**—You can disable automatic configuration archiving and manually archive the running configuration if the configuration will not be changed very often. You can also use this method before performing complicated configuration tasks. If the configuration attempt fails, you can use the archive for configuration recovery.

Restrictions and guidelines for archiving the running configuration

If you use local archiving, the configuration archive feature saves the running configuration only on the master device. To make sure the system can archive the running configuration after a master/subordinate switchover, create the configuration archive directory on all IRF members.

If a local archiving has started based on the existing archive parameters when an archive parameter is changed, the archive will still be retained in the old directory. However, the **display archive configuration** command will not display the record about this archiving.

When you modify parameters (for example, the username or password) for remote archiving, make sure the changes are consistent between the device and the server. A manual or automatic remote archiving will fail if it has started before you change the device and the server settings to be consistent.

Enabling automatic configuration archiving

1. Enter system view.

   system-view

2. Enable automatic configuration archiving and set the archiving interval.

   archive configuration interval *interval*

   By default, automatic configuration archiving is disabled.

Manually archiving the running configuration

Manually archive the running configuration in user view.

archive configuration

Rolling back configuration

About configuration rollback

The configuration rollback feature compares the running configuration against the specified replacement configuration file and handles configuration differences as follows:

- If a command in the running configuration is not in the replacement file, the rollback feature executes the **undo** form of the command.
- If a command in the replacement file is not in the running configuration, the rollback feature adds the command to the running configuration.
- If a command has different settings in the running configuration and the replacement file, the rollback feature replaces the running command setting with the setting in the replacement file.

Restrictions and guidelines

To ensure a successful rollback, do not perform a master/subordinate switchover while the system is rolling back the configuration.

The configuration rollback feature might fail to reconfigure some commands in the running configuration for one of the following reasons:

- A command cannot be undone because prefixing the **undo** keyword to the command does not result in a valid **undo** command. For example, if the **undo** form designed for the **A** [**B**] **C** command is **undo A C**, the configuration rollback feature cannot undo the **A B C** command. This is because the system does not recognize the **undo A B C** command.
- A command (for example, a hardware-dependent command) cannot be deleted, overwritten, or undone due to system restrictions.
- The commands in different views are dependent on each other.
- Commands or command settings that the device does not support cannot be added to the running configuration.

Make sure the replacement configuration file is created by using the configuration archive feature or the **save** command on the local device. If the configuration file is not created on the local device, make sure the command lines in the configuration file are fully compatible with the local device.

If the replacement configuration file is encrypted, make sure the device can decrypt it.

Procedure

1. Enter system view.

   system-view

2. Roll the running configuration back to the configuration defined by a configuration file.

   configuration replace file *filename*

CAUTION:

The configuration rollback feature replaces the running configuration with the configuration in a configuration file without rebooting the device. This operation will cause settings not in the replacement configuration file to be lost, which might cause service interruption. When you perform configuration rollback, make sure you fully understand its impact on your network.

The specified configuration file must be saved on the local system.

Configuring configuration commit delay

About configuration commit delay

This feature enables the system to automatically remove the settings you made during a configuration commit delay interval if you have not manually committed them.

You specify the configuration commit delay interval by using the configuration commit delay timer. The system creates a rollback point to record the configuration status when you start the configuration commit delay timer. The settings you made during the configuration commit delay interval takes effect immediately. However, these settings will be removed automatically if you have not manually committed them before the configuration commit delay timer expires. Then, the system returns to the configuration status when the configuration commit delay timer started.

This feature prevents a misconfiguration from causing the inability to access the device and is especially useful when you configure the device remotely.

Restrictions and guidelines

When you use this feature, follow these restrictions and guidelines:

- In a multi-user context, make sure no one else is configuring the device.
- To avoid unexpected errors, do not perform any operations during the configuration rollback.
- You can reconfigure the configuration commit delay timer before it expires to shorten or extend the commit delay interval. However, the rollback point will not change.
- The configuration commit delay feature is a one-time setting. The feature is disabled with the rollback point removed when the commit delay timer expires or after a manual commit operation is performed. To use this feature again, you must restart the timer.

Procedure

1. Enter system view.

   system-view

2. Enable the configuration commit delay feature and start the commit delay timer.

   configuration commit delay *delay-time*

3. (Optional.) Commit the settings configured after the commit delay timer started.

   configuration commit

Specifying a next-startup configuration file

Restrictions and guidelines

CAUTION:
Using the **undo startup saved-configuration** command can cause an IRF split after the IRF fabric or an IRF member reboots. When you execute this command, make sure you understand its impact on your network.

As a best practice, specify different files as the main and backup next-startup configuration files.

The **undo startup saved-configuration** command changes the attribute of the main or backup next-startup configuration file to NULL instead of deleting the file.

Prerequisites

In an IRF fabric, make sure the specified configuration file is valid and has been saved to the root directory of a storage medium on each member device. In addition, make sure the storage media are the same type across all IRF member devices.

Procedure

1. Specify a next-startup configuration file. Choose one of the following methods:
   - Execute the following command in user view to specify a next-startup configuration file:
     startup saved-configuration *cfgfile* [**backup** | **main**]
     By default, no next-startup configuration files are specified.
   - Execute the following command in any view to save the running configuration to a file and specify the file as a next-startup configuration file:
     save [**safely**] [**backup** | **main**] [**force**]
     For more information about this command, see "Saving the running configuration."

   If you do not specify the **backup** or **main** keyword, this command specifies the configuration file as the main next-startup configuration file.
2. (Optional.) Verify the configuration. Use one of the following commands in any view:
   - Display the names of the configuration files for this startup and the next startup.
     display startup
   - Display the contents of the configuration file for the next system startup.
     display saved-configuration

Backing up and restoring the main next-startup configuration file

About backing up and restoring the main next-startup configuration file

You can back up the main next-startup configuration file to a TFTP server or restore the main next-startup configuration file from a TFTP server.

Restrictions and guidelines for configuration backup and restoration

Configuration backup and restoration are not supported in FIPS mode.

Prerequisites for configuration backup and restoration

Before you back up or restore the main next-startup configuration file, perform the following tasks:

- Make sure the following requirements are met:
  - The server is reachable.
  - The server is enabled with TFTP service.
  - You have read and write permissions to the server.
- For configuration backup, use the **display startup** command to verify that the main next-startup configuration file has been specified in user view. If no next-startup configuration file has been specified or the specified configuration file does not exist, the backup operation will fail.

Backing up the main next-startup configuration file to a TFTP server

To back up the main next-startup configuration file to a TFTP server, execute the following command in user view:

backup startup-configuration to { *ipv4-server* | **ipv6** *ipv6-server* } [*dest-filename*]

Restoring the main next-startup configuration file from a TFTP server

1. Restore the main next-startup configuration file from a TFTP server in user view.

   restore startup-configuration from { *ipv4-server* | **ipv6** *ipv6-server* } *src-filename*
2. (Optional.) Verify that the specified configuration file has been set as the main next-startup configuration file. Use one of the following commands in any view:
   - Display the names of the configuration files for this startup and the next startup.

     display startup
   - Display the contents of the configuration file for the next system startup.

     display saved-configuration

Deleting a next-startup configuration file

About deleting a next-startup configuration file

You can perform this task to delete a next-startup configuration file.

If both the main and backup next-startup configuration files are deleted, the device uses the factory defaults at the next startup.

To delete a file that is set as both main and backup next-startup configuration files, you must execute both the **reset saved-configuration backup** command and the **reset saved-configuration main** command. Using only one of the commands removes the specified file attribute instead of deleting the file.

For example, if the **reset saved-configuration backup** command is executed, the backup next-startup configuration file setting is set to NULL. However, the file is still used as the main file. To delete the file, you must also execute the **reset saved-configuration main** command.

Restrictions and guidelines

CAUTION:

By default, this task permanently deletes a next-startup configuration file from all IRF member devices. To delete the configuration file only from the master device, disable automatic system-wide next-startup configuration file operations. For more information, see "Disabling automatic system-wide next-startup configuration file operations."

If you do not specify the **backup** or **main** keyword when you perform this task, the main next-startup configuration is deleted.

Procedure

To delete a next-startup configuration file, execute the following command in user view:

reset saved-configuration [**backup** | **main**]

Display and maintenance commands for configuration files

Execute **display** commands in any view and **reset** commands in user view.

Task	Command
Display configuration archive information.	**display archive configuration**
Display the running configuration.	**display current-configuration** [[**configuration** [*module-name*] | **interface** [*interface-type* [*interface-number*]]] [**all**] | **slot** *slot-number*]
Display the differences that the running configuration has as compared with the next-startup configuration.	**display current-configuration diff**
Display the factory defaults.	**display default-configuration**
Display the differences between configurations.	• **display diff configfile** *file-name-s* { **configfile** *file-name-d* | **current-configuration** | **startup-configuration** } • **display diff current-configuration** { **configfile** *file-name-d* | **startup-configuration** } • **display diff startup-configuration** { **configfile** *file-name-d* | **current-configuration** }

Task	Command
Display the contents of the configuration file for the next system startup.	**display saved-configuration**
Display the names of the configuration files for this startup and the next startup.	**display startup**
Display the valid configuration in the current view.	**display this** [**all**]
Delete next-startup configuration files.	**reset saved-configuration** [**backup** | **main**]

Contents

Upgrading software

About software upgrade

Software upgrade enables you to upgrade a software version, add new features, and fix software bugs. This chapter describes software types and release forms, compares software upgrade methods, and provides the procedures for upgrading software from the CLI.

Software types

The following software types are available:

- **BootWare image**—Also called the Boot ROM image. This image contains a basic segment and an extended segment.
  - The basic segment is the minimum code that bootstraps the system.
  - The extended segment enables hardware initialization and provides system management menus. When the device cannot start up correctly, you can use the menus to load software and the startup configuration file or manage files.

  Typically, the BootWare image is integrated into the Boot image to avoid software compatibility errors.
- **Comware image**—Includes the following image subcategories:
  - **Boot image**—A .bin file that contains the Linux operating system kernel. It provides process management, memory management, and file system management.
  - **System image**—A .bin file that contains the Comware kernel and standard features, including device management, interface management, configuration management, and routing.
  - **Feature image**—A .bin file that contains advanced or customized software features. You can purchase feature images as needed.
  - **Patch image**—A .bin file that is released for fixing bugs without rebooting the device. A patch image does not add or remove features.

    Patch images have the following types:

    - **Incremental patch images**—A new patch image can cover all, part, or none of the functions provided by an old patch image. A new patch image can coexist with an old patch image on the device only when the former covers none of the functions provided by the latter.
    - **Non-incremental patch images**—A new non-incremental patch image covers all functions provided by an old non-incremental patch image. Each boot, system, or feature image can have one non-incremental patch image, and these patch images can coexist on the device. The device uninstalls the old non-incremental patch image before installing a new non-incremental patch image.

    An incremental patch image and a non-incremental patch image can coexist on the device.

  Comware images that have been loaded are called current software images. Comware images specified to load at the next startup are called startup software images.

BootWare image, boot image, and system image are required for the device to operate.

You can install up to 32 .bin files on the device, including one boot image file, one system image file, and up to 30 feature and patch image files.

Software release forms

Software images are released in one of the following forms:

- Separate .bin files. You must verify compatibility between software images.
- As a whole in one .ipe package file. The images in an .ipe package file are compatible. The system decompresses the file automatically, loads the .bin images and sets them as startup software images.

NOTE:

Software image file names use the *model-comware version-im*age *type-release* format. This document uses **boot.bin** and **system.bin** as boot and system image file names.

Upgrade methods

Upgrade method	Software types	Remarks
Upgrading from the CLI by using the boot loader method	• BootWare image • Comware images (excluding incremental patches)	This method is disruptive. You must reboot the entire device to complete the upgrade.
Upgrading from the BootWare menu	• BootWare image • Comware images	Use this method when the device cannot start up correctly. To use this method, first connect to the console port and power cycle the device. Then, press **Ctrl+B** at prompt to access the BootWare menu. For more information about upgrading software from the BootWare menu, see the release notes for the software version. **IMPORTANT:** Use this method only when you do not have any other choice.

This chapter covers only upgrading software from the CLI by using the boot loader method.

Software image loading

Startup software images

To upgrade software, you must specify the upgrade files as the startup software images for the device to load at next startup. You can specify two lists of software images: one main and one backup. The device first loads the main startup software images. If the main startup software images are not available, the devices loads the backup startup software images.

Image loading process at startup

At startup, the device performs the following operations after loading and initializing BootWare:

1. Loads main images.
2. If any main image does not exist or is invalid, loads the backup images.
3. If any backup image does not exist or is invalid, the device cannot start up.

Restrictions and guidelines: Software upgrade

As a best practice, store the startup images in a fixed storage medium. If you store the startup images in a hot swappable storage medium, do not remove the hot swappable storage medium during the startup process.

Upgrading device software by using the boot loader method

Software upgrade tasks at a glance

To upgrade software, perform one of the following tasks:

1. Upgrade the IRF fabric:
   a. (Optional.) Preloading the BootWare image to BootWare

      If a BootWare upgrade is required, you can perform this task to shorten the subsequent upgrade time. This task helps reduce upgrade problems caused by unexpected power failure. If you skip this task, the device upgrades the BootWare automatically when it upgrades the startup software images.

   b. Specifying startup images and completing the upgrade
2. (Optional.) Synchronizing startup images from the master device to subordinate devices

   Perform this task when the startup images on subordinate devices are not the same version as those on the master device.

Prerequisites

1. Use the **display version** command to verify the current BootWare image version and startup software version.
2. Use the release notes for the upgrade software version to evaluate the upgrade impact on your network and verify the following items:
   - Software and hardware compatibility.
   - Version and size of the upgrade software.
   - Compatibility of the upgrade software with the current BootWare image and startup software image.
3. Use the **dir** command to verify that all IRF member devices have sufficient storage space for the upgrade images. If the storage space is not sufficient, delete unused files by using the **delete** command. For more information, see "Managing file systems."
4. Use FTP or TFTP to transfer the upgrade image file to the root directory of a file system. For more information about FTP and TFTP, see "Configuring FTP" or "Configuring TFTP." For more information about file systems, see "Managing file systems."

Preloading the BootWare image to BootWare

To load the upgrade BootWare image to the Normal area of BootWare, execute the following command in user view:

bootrom update file *file* **slot** *slot-number-list*

Specify the downloaded software image file for the *file* argument.

The new BootWare image takes effect at a reboot.

Specifying startup images and completing the upgrade

Perform the following steps in user view:

1. Specify main or backup startup images for all member devices.
   - Use an .ipe file:

     boot-loader file *ipe-filename* [**patch** *filename*&<1-16>] { **all** | **slot** *slot-number* } { **backup** | **main** }
   - Use .bin files:

     boot-loader file boot *filename* **system** *filename* [**feature** *filename*&<1-30>] [**patch** *filename*&<1-16>] { **all** | **slot** *slot-number* } { **backup** | **main** }

   As a best practice in a multichassis IRF fabric, specify the **all** keyword for the command. If you use the **slot** *slot-number* option to upgrade member devices one by one, version inconsistencies occur among the member devices during the upgrade.
2. Save the running configuration.

   save

   This step ensures that any configuration you have made can survive a reboot.
3. Reboot the IRF fabric.

   reboot
4. (Optional.) Verify the software image settings.

   display boot-loader [**slot** *slot-number*]

   Verify that the current software images are the same as the startup software images.

Synchronizing startup images from the master device to subordinate devices

About startup image synchronization

Perform this task when the startup images on subordinate devices are not the same version as those on the master device.

This task synchronizes startup images that are running on the master device to subordinate devices. If any of the startup images does not exist or is invalid, the synchronization fails.

The startup images synchronized to subordinate devices are set as main startup images, regardless of whether the source startup images are main or backup.

Restrictions and guidelines

If a patch installation has been performed on the master device, use the **install commit** command to update the set of main startup images on the master device before software synchronization. This command ensures startup image consistency between the master and subordinate devices.

Procedure

Perform the following steps in user view:

1. Synchronize startup images from the master to subordinate devices.

   boot-loader update { **all** | **slot** *slot-number* }
2. Reboot the subordinate devices.

   reboot slot *slot-number* [**force**]

Installing or uninstalling features and patches

About installing or uninstalling features and patches

You can install a new feature or patch image, or upgrade an existing feature image.

Restrictions and guidelines

To ensure a successful image installation or upgrade, do not reboot the device or perform a master/subordinate switchover during the image installation or upgrade.

After installing a feature image, you must log in to the device again to use the commands provided in the image.

Prerequisites

Use FTP or TFTP commands to transfer the image file to the default file system on the master device. You do not need to transfer or copy the image file to subordinate member devices. The system will automatically copy the image file to the subordinate members when you activate the images on them. For more information about FTP and TFTP, see "Configuring FTP" and "Configuring TFTP."

Installing or upgrading features

1. Activate features in the specified files.

   install activate feature *filename*&<1-30> **slot** *slot-number*

2. Commit the software change.

   install commit

   For the image changes to take effect after a reboot, you must perform a commit operation.

Installing patches

1. Activate patches in a file.

   install activate patch *filename* { **all** | **slot** *slot-number* }

   You can specify only one patch image file for this command at a time. However, you can execute this command multiple times to install multiple patch image files.

   The **install activate patch** *filename* **all** command installs the specified patch images on all hardware and the images can survive a reboot. You do not need to execute the **install commit** command for the installation.

2. Commit the software change.

   install commit

   Images run in memory immediately after they are activated. However, only patch images activated by using the **install activate patch** *filename* **all** command can survive a reboot. For other images to take effect after a reboot, you must execute this command to commit the software change.

Uninstalling features or patches

Restrictions and guidelines

After uninstalling a feature image, you must log in to the device again for the commands in the image to be removed.

Procedure

1. Deactivate the features or patches installed from an image file.

   install deactivate feature *filename*&<1-30> **slot** *slot-number*

   install deactivate patch *filename* { **all** | **slot** *slot-number* }

   You can specify only one patch image file for this command at a time. However, you can execute this command multiple times to deactivate multiple patch image files.

   Images deactivated by using the **install deactivate patch** *filename* **all** command do not run after a reboot. To prevent other deactivated images from running after a reboot, you must commit the software change by using the **install commit** command.

2. Commit the software change.

   install commit

   This step removes the image file from the startup image list but does not delete the image file from the default file system.

   The device will not load features and patches from the image files at startup.

Display and maintenance commands for software image settings

Execute **display** commands in any view.

Task	Command
Display current software images and startup software images.	**display boot-loader** [**slot** *slot-number*]

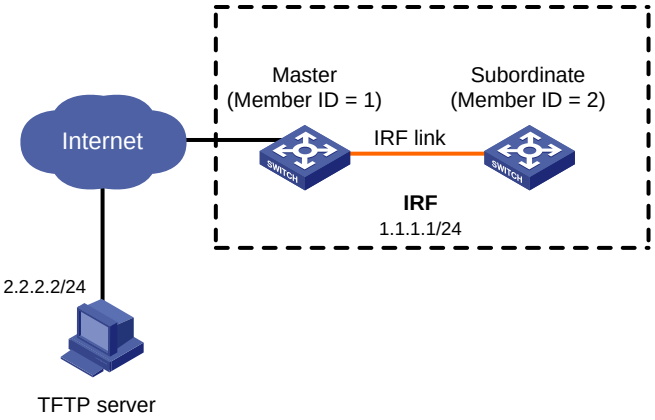
Software upgrade examples

Example: Upgrading device software

Network configuration

As shown in Figure 1, use the file **startup-a2105.ipe** to upgrade software images for the IRF fabric.

Figure 1 Network diagram



Procedure

Configure IP addresses and routes. Make sure the device and the TFTP server can reach each other. (Details not shown.)

Configure TFTP settings on both the device and the TFTP server. (Details not shown.)

Display information about the current software images.

```
<Sysname> display version
```

Back up the current software images.

```
<Sysname> copy boot.bin boot_backup.bin
<Sysname> copy system.bin system_backup.bin
```

Specify **boot_backup.bin** and **system_backup.bin** as the backup startup image files for all IRF member devices.

```
<Sysname> boot-loader file boot flash:/boot_backup.bin system flash:/system_backup.bin slot 1 backup
<Sysname> boot-loader file boot flash:/boot_backup.bin system flash:/system_backup.bin slot 2 backup
```

Use TFTP to download the **startup-a2105.ipe** image file from the TFTP server to the root directory of the flash memory on the master device.

```
<Sysname> tftp 2.2.2.2 get startup-a2105.ipe
```

Specify **startup-a2105.ipe** as the main startup image file for all IRF member devices.

```
<Sysname> boot-loader file flash:/startup-a2105.ipe slot 1 main
<Sysname> boot-loader file flash:/startup-a2105.ipe slot 2 main
```

Verify the startup image settings.

```
<Sysname> display boot-loader
```

Reboot the device to complete the upgrade.

```
<Sysname> reboot
```

Verify that the device is running the correct software.

```
<Sysname> display version
```

Contents

Managing the device

This chapter describes how to configure basic device parameters and manage the device.

Device management tasks at a glance

All device management tasks are optional. You can perform any of the tasks in any order.

- Configuring basic parameters
  - Configuring the device name
  - Configuring the system time
  - Enabling displaying the copyright statement
  - Configuring banners
- Configuring security parameters
  - Disabling password recovery capability
- Adjusting device capacities
  - Setting the port status detection timer
- Monitoring the device
  - Monitoring CPU usage
  - Setting memory alarm thresholds
  - Configuring disk usage monitoring
  - Setting the temperature alarm thresholds
- Managing resources
  - Configuring device poweroff alarming
  - Verifying and diagnosing transceiver modules
  - Configuring transceiver monitoring
  - Configuring transceiver anti-counterfeit
- Maintaining the device
  - Scheduling a task
  - Rebooting the device
  - Restoring the factory-default configuration

Configuring the device name

About the device name

A device name (also called hostname) identifies a device in a network and is used in CLI view prompts. For example, if the device name is **Sysname**, the user view prompt is <Sysname>.

Restrictions and guidelines

On an underlay network, the device uses the device name that you have configured for it. If you do not configure a device name for the device but automated underlay network deployment is enabled, the device uses the device name assigned by the VCF fabric feature. For more information about VCF fabric, see VCF fabric configuration in *Network Management and Monitoring Configuration Guide*.

Procedure

1. Enter system view.
   system-view
2. Configure the device name.
   sysname *sysname*
   By default, the device name is **H3C**.

Configuring the system time

About the system time

Correct system time is essential to network management and communication. Configure the system time correctly before you run the device on the network.

The device can use one of the following methods to obtain the system time:

- Uses the locally set system time, and then uses the clock signals generated by its built-in crystal oscillator to maintain the system time.
- Periodically obtains the UTC time from an NTP source, and uses the UTC time, time zone, and daylight saving time to calculate the system time. For more information about NTP, see *Network Management and Monitoring Configuration Guide*.

The system time calculated by using the UTC time from a time source is more precise.

Restrictions and guidelines for configuring the system time

After you execute the **clock protocol none** command, the **clock datetime** command determines the system time, whether or not the time zone or daylight saving time has been configured.

If you configure or change the time zone or daylight saving time after the device obtains the system time, the device recalculates the system time. To view the system time, use the **display clock** command.

System time configuration tasks at a glance

To configure the system time, perform the following tasks:

1. Configuring the system time
   Choose one of the following tasks:
   - Setting the system time at the CLI
   - Obtaining the UTC time through a time protocol
2. (Optional.) Setting the time zone
   Make sure each network device uses the time zone of the place where the device resides.
3. (Optional.) Setting the daylight saving time
   Make sure each network device uses the daylight saving time parameters of the place where the device resides.

Setting the system time at the CLI

1. Enter system view.

system-view

2. Configure the device to use the local system time.

   clock protocol none

   By default, the device uses the NTP time source.

   If you execute the **clock protocol** command multiple times, the most recent configuration takes effect.

3. Return to user view.

   quit

4. Set the local system time.

   clock datetime *time date*

   By default, the system time is UTC time 00:00:00 01/01/2013.

CAUTION:

This command changes the system time, which affects the execution of system time-related features (for example, scheduled tasks) and collaborative operations of the device with other devices (for example, log reporting and statistics collection). Before executing this command, make sure you fully understand its impact on your live network.

Obtaining the UTC time through a time protocol

1. Enter system view.

   system-view

2. Specify the system time source.

   clock protocol ntp

   By default, the device uses the NTP time source.

   If you execute this command multiple times, the most recent configuration takes effect.

3. Configure time protocol parameters.

   For more information about NTP configuration, see *Network Management and Monitoring Configuration Guide*.

Setting the time zone

1. Enter system view.

   system-view

2. Set the time zone.

   clock timezone *zone-name* { **add** | **minus** } *zone-offset*

   By default, the system uses the UTC time zone.

Setting the daylight saving time

1. Enter system view.

   system-view

2. Set the daylight saving time.

   clock summer-time *name start-time start-date end-time end-date add-time*

   By default, the daylight saving time is not set.

Enabling displaying the copyright statement

About copyright statement displaying

This feature enables the device to display the copyright statement in the following situations:

- When a Telnet or SSH user logs in.
- When a console user quits user view. This is because the device automatically tries to restart the user session.

If you disable displaying the copyright statement, the device does not display the copyright statement in any situations.

Procedure

1. Enter system view.

   `system-view`

2. Enable displaying the copyright statement.

   `copyright-info enable`

   By default, displaying the copyright statement is enabled.

Configuring banners

About banners

Banners are messages that the system displays when a user logs in.

The system supports the following banners:

- **Legal banner**—Appears after the copyright statement. To continue login, the user must enter **Y** or press **Enter**. To quit the process, the user must enter **N**. **Y** and **N** are case insensitive.
- **Message of the Day (MOTD) banner**—Appears after the legal banner and before the login banner.
- **Login banner**—Appears only when password or scheme authentication is configured.
- **Shell banner**—Appears when a user accesses user view.

The system displays the banners in the following order: legal banner, MOTD banner, login banner, and shell banner.

Banner input methods

You can configure a banner by using one of the following methods:

- Input the entire command line in a single line.

  The banner cannot contain carriage returns. The entire command line, including the command keywords, the banner, and the delimiters, can have a maximum of 511 characters. The delimiters for the banner can be any printable character but must be the same. You cannot press **Enter** before you input the end delimiter.

  For example, you can configure the shell banner "Have a nice day." as follows:

  ```
  <System> system-view
  [System] header shell %Have a nice day.%
  ```

- Input the command line in multiple lines.

  The banner can contain carriage returns. A carriage return is counted as two characters.

  To input a banner configuration command line in multiple lines, use one of the following methods:

- Press **Enter** after the final command keyword, type the banner, and end the final line with the delimiter character %. The banner plus the delimiter can have a maximum of 1999 characters.

  For example, you can configure the banner "Have a nice day." as follows:

  ```
  <System> system-view
  [System] header shell
  Please input banner content, and quit with the character '%'.
  Have a nice day.%
  ```

- After you type the final command keyword, type any printable character as the start delimiter for the banner and press **Enter**. Then, type the banner and end the final line with the same delimiter. The banner plus the end delimiter can have a maximum of 1999 characters.

  For example, you can configure the banner "Have a nice day." as follows:

  ```
  <System> system-view
  [System] header shell A
  Please input banner content, and quit with the character 'A'.
  Have a nice day.A
  ```

- After you type the final command keyword, type the start delimiter and part of the banner. Make sure the final character of the final string is different from the start delimiter. Then, press **Enter**, type the rest of the banner, and end the final line with the same delimiter. The banner plus the start and end delimiters can have a maximum of 2002 characters.

  For example, you can configure the banner "Have a nice day." as follows:

  ```
  <System> system-view
  [System] header shell AHave a nice day.
  Please input banner content, and quit with the character 'A'.
  A
  ```

Procedure

1. Enter system view.
   system-view
2. Configure the legal banner.
   header legal *text*
3. Configure the MOTD banner.
   header motd *text*
4. Configure the login banner.
   header login *text*
5. Configure the shell banner.
   header shell *text*

Disabling password recovery capability

About password recovery capability

Password recovery capability controls console user access to the device configuration and SDRAM from BootWare menus. For more information about BootWare menus, see the release notes.

If password recovery capability is enabled, a console user can access the device configuration without authentication to configure a new password.

If password recovery capability is disabled, console users must restore the factory-default configuration before they can configure new passwords. Restoring the factory-default configuration deletes the next-startup configuration files.

To enhance system security, disable password recovery capability.

Restrictions and guidelines

Procedure

1. Enter system view.
   system-view
2. Disable password recovery capability.
   undo password-recovery enable
   By default, password recovery capability is enabled.

Setting the port status detection timer

About the port status detection timer

The device starts a port status detection timer when a port is shut down by a protocol. Once the timer expires, the device brings up the port so the port status reflects the port's physical status.

Procedure

1. Enter system view.
   system-view
2. Set the port status detection timer.
   shutdown-interval *time*
   The default setting is 30 seconds.

Monitoring CPU usage

About CPU usage monitoring

To monitor CPU usage, the device performs the following operations:

- Samples CPU usage at 1-minute intervals, and compares the samples with CPU usage thresholds to identify the CPU usage status and send alarms or notifications accordingly.
- Samples and saves CPU usage at a configurable interval if CPU usage tracking is enabled. You can use the **display cpu-usage history** command to display the historical CPU usage statistics in a coordinate system.

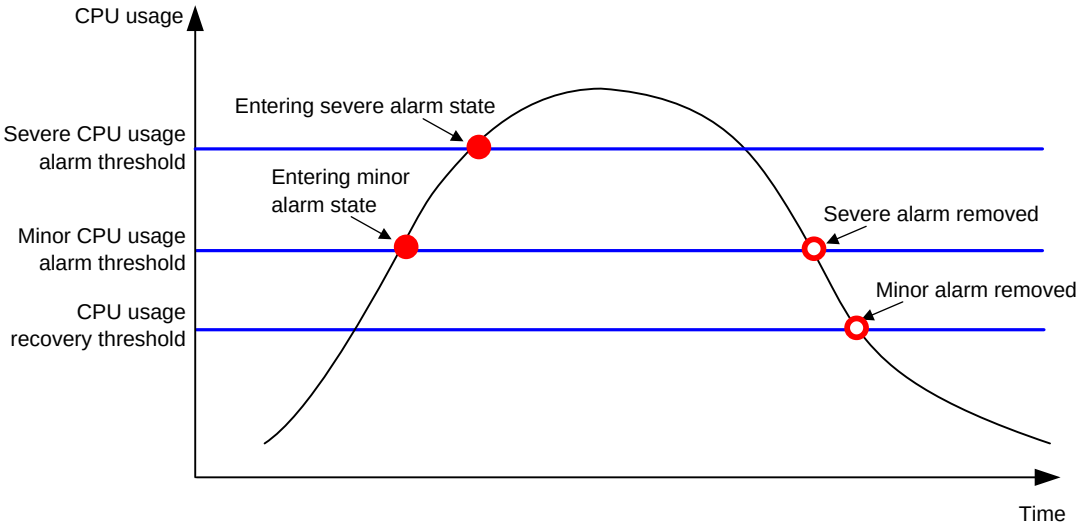
The device supports the following CPU usage thresholds:

- **Minor threshold**—If the CPU usage increases to or above the minor threshold but is less than the severe threshold, the CPU usage enters minor alarm state. The device sends minor alarms periodically until the CPU usage increases above the severe threshold or the minor alarm is removed.
- **Severe threshold**—If the CPU usage increases above the severe threshold, the CPU usage enters severe alarm state. The device sends severe alarms periodically until the severe alarm is removed.
- **Recovery threshold**—If the CPU usage decreases below the recovery threshold, the CPU usage enters recovered state. The device sends a recovery notification.

CPU usage alarms and notifications can be sent to NETCONF, SNMP, and the information center to be encapsulated as NETCONF events, SNMP traps and informs, and log messages. For more

information, see NETCONF, SNMP, and information center in *Network Management and Monitoring Configuration Guide*.

Figure 1 CPU alarms and alarm-removed notifications



Procedure

1. Enter system view.

   system-view

2. Set the CPU usage alarm thresholds.

   monitor cpu-usage threshold *severe-threshold* **minor-threshold** *minor-threshold* **recovery-threshold** *recovery-threshold* [**slot** *slot-number* [**cpu** *cpu-number*]]

   The default settings are as follows:

   - **Severe CPU usage alarm threshold**—99%.
   - **Minor CPU usage alarm threshold**—98%.
   - **CPU usage recovery threshold**—50%.

CAUTION:

If you set the severe CPU usage alarm threshold to a too low value, the device will reach the threshold easily. Normal services will be affected.

3. Set CPU usage alarm resending intervals.

   monitor resend cpu-usage { **minor-interval** *minor-interval* | **severe-interval** *severe-interval* } * [**slot** *slot-number* [**cpu** *cpu-number*]]

   By default, the minor alarm resending interval is 300 seconds and the severe alarm resending interval is 60 seconds.

4. Set the sampling interval for CPU usage tracking.

   monitor cpu-usage interval *interval* [**slot** *slot-number* [**cpu** *cpu-number*]]

   By default, the sampling interval for CPU usage tracking is 1 minute.

5. Enable CPU usage tracking.

   monitor cpu-usage enable [**slot** *slot-number* [**cpu** *cpu-number*]]

   By default, CPU usage tracking is enabled.

Setting memory alarm thresholds

About memory alarm thresholds

To ensure correct operation and improve memory efficiency, the system monitors the amount of free memory space in real time. If the amount of free memory space exceeds an alarm threshold, the system issues an alarm to affected service modules and processes.

(On devices that do not support low memory.) You can use the **display memory** command to display memory usage information.

(On devices that support low memory.) The system monitors only the amount of free low-memory space. You can use the **display memory** command to display memory usage information.

(On devices with slots that support low memory.) For slots that support low memory, the system monitors only the amount of free low-memory space. You can use the **display memory** command to display memory usage information. If the LowMem field is displayed for a slot, the slot supports low memory.

As shown in Table 1, the system supports the following free-memory thresholds:

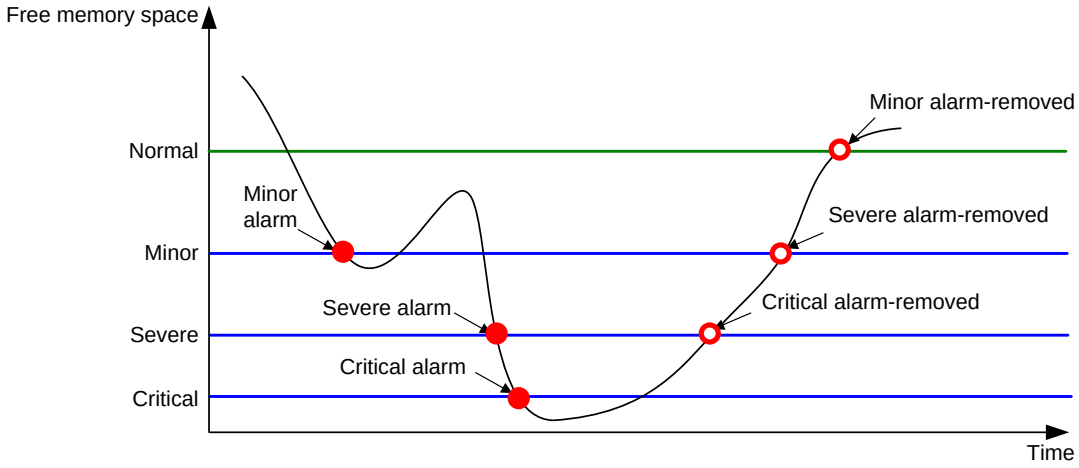
- Normal state threshold.
- Minor alarm threshold.
- Severe alarm threshold.
- Critical alarm threshold.

Table 1 Memory alarm notifications and memory alarm-removed notifications

Notification	Triggering condition	Remarks
Early-warning notification	The amount of free memory space decreases below the early-warning threshold.	After generating and sending an early-warning notification, the system does not generate and send any additional early-warning notifications until the early warning is removed.
Minor alarm notification	The amount of free memory space decreases below the minor alarm threshold.	After generating and sending a minor alarm notification, the system does not generate and send any additional minor alarm notifications until the minor alarm is removed.
Severe alarm notification	The amount of free memory space decreases below the severe alarm threshold.	After generating and sending a severe alarm notification, the system does not generate and send any additional severe alarm notifications until the severe alarm is removed.
Critical alarm notification	The amount of free memory space decreases below the critical alarm threshold.	After generating and sending a critical alarm notification, the system does not generate and send any additional critical alarm notifications until the critical alarm is removed.
Critical alarm-removed notification	The amount of free memory space increases above the severe alarm threshold.	N/A
Severe alarm-removed notification	The amount of free memory space increases above the minor alarm threshold.	N/A
Minor alarm-removed notification	The amount of free memory space increases above the	N/A

Notification	Triggering condition	Remarks
	normal state threshold.	
Early-warning-removed notification	The amount of free memory space increases above the sufficient-memory threshold.	N/A

Figure 2 Memory alarm notifications and alarm-removed notifications



Restrictions and guidelines

If a memory alarm occurs, delete unused configuration items or disable some features to increase the free memory space. Because the memory space is insufficient, some configuration items might not be able to be deleted.

Procedure

1. Enter system view.

   system-view

2. Set the memory usage threshold.

   memory-threshold [**slot** *slot-number* [**cpu** *cpu-number*]] **usage** *memory-threshold*

   By default, the memory usage threshold is 100%.

3. Set the free-memory thresholds.

   memory-threshold [**slot** *slot-number* [**cpu** *cpu-number*]] [**ratio**] **minor** *minor-value* **severe** *severe-value* **critical** *critical-value* **normal** *normal-value*

   The default settings are as follows:

   - **Minor alarm threshold**—60 MB.
   - **Severe alarm threshold**—56 MB.
   - **Critical alarm threshold**—52 MB.
   - **Normal state threshold**—64 MB.

4. Set memory depletion alarm resending intervals.

   monitor resend memory-threshold { **critical-interval** *critical-interval* | **minor-interval** *minor-interval* | **severe-interval** *severe-interval* } * [**slot** *slot-number* [**cpu** *cpu-number*]]

   The following are the default settings:

- **Minor alarm resending interval**—12 hours.
- **Severe alarm resending interval**—3 hours.
- **Critical alarm resending interval**—1 hour.

Configuring disk usage monitoring

About disk usage monitoring

This feature enables the device to periodically sample the usage of a disk and compare the usage with the threshold. If the disk usage exceeds the threshold, the device sends a high disk usage alarm to the NETCONF module. For more information about the NETCONF module, see *Network Management and Monitoring Configuration Guide*.

Software version and feature compatibility

This feature is available only Release 6348P01 and later.

Procedure

1. Enter system view.

   system-view
2. Set the disk usage sampling interval.

   monitor disk-usage interval *interval*

   By default, the disk usage sampling interval is 300 seconds.
3. Set the usage threshold for a disk.

   monitor disk-usage [**slot** *slot-number*] **disk** *disk-name* **threshold** *threshold-value*

   By default, the disk usage threshold is 95%.

Setting the temperature alarm thresholds

About temperature alarm thresholds

The device monitors its temperature based on the following thresholds:

- Low-temperature threshold.
- High-temperature warning threshold.
- High-temperature alarming threshold.

When the device temperature drops below the low-temperature threshold or reaches the high-temperature warning or alarming threshold, the device performs the following operations:

- Sends log messages and traps.
- Sets LEDs on the device panel.

Procedure

1. Enter system view.

   system-view
2. Configure the temperature alarm thresholds.

   temperature-limit slot *slot-number* **hotspot** *sensor-number lowlimit warninglimit* [*alarmlimit*]

   The defaults vary by temperature sensor model. To view the defaults, execute the **undo temperature-limit** and **display environment** commands in turn.

The high-temperature alarming threshold must be higher than the high-temperature warning threshold, and the high-temperature warning threshold must be higher than the low-temperature threshold.

Configuring device poweroff alarming

About device poweroff alarming

This feature enables the device to detect a device poweroff event and issue a poweroff alarm by sending SNMP notifications or log messages.

Hardware compatibility

This feature is supported only on the following devices:

- PoE devices and 52-port non-PoE devices.
- Devices that support hot-swappable power supplies.

Procedure

1. Enter system view.

   system-view

2. Specify the source interface for sending the poweroff alarm.

   dying-gasp source *interface-type* { *interface-number* | *interface-number.subnumber* }

   By default, no source interface is specified. On an IPv4 network, the device uses the primary IPv4 address of the output interface for the route to the destination host as the source address. On an IPv6 network, the device selects a source IPv6 address as defined in RFC 3484.

3. Configure SNMP notification destination host settings.

   dying-gasp host { *ip-address* | **ipv6** *ipv6-address* } **snmp-trap version** { **v1** | **v2c** } **securityname** *security-string*

   By default, no SNMP notification destination host settings are configured.

   You can configure the device to send poweroff alarm SNMP notifications to multiple destination hosts.

4. Configure log message destination host settings.

   dying-gasp host { *ip-address* | **ipv6** *ipv6-address* } **syslog**

   By default, no log message destination host settings are configured.

   You can configure the device to send the poweroff alarm log messages to multiple destination hosts.

Verifying and diagnosing transceiver modules

Verifying transceiver modules

About transceiver module verification

You can use one of the following methods to verify the genuineness of a transceiver module:

- Display the key parameters of a transceiver module, including its transceiver type, connector type, central wavelength of the transmit laser, transfer distance, and vendor name.
- Display its electronic label. The electronic label is a profile of the transceiver module and contains the permanent configuration, including the serial number, manufacturing date, and vendor name. The data was written to the transceiver module or the device's storage component during debugging or testing of the transceiver module or device.

The device regularly checks transceiver modules for their vendor names. If a transceiver module does not have a vendor name or the vendor name is not H3C, the device repeatedly outputs traps and log messages. For information about logging rules, see *Network Management and Monitoring Configuration Guide*.

Procedure

To verify transceiver modules, execute the following commands in any view:

- Display the key parameters of transceiver modules.
  display transceiver interface [*interface-type interface-number*]
- Display the electrical label information of transceiver modules.
  display transceiver manuinfo interface [*interface-type interface-number*]

Diagnosing transceiver modules

About transceiver module diagnosis

The device provides the alarm and digital diagnosis functions for transceiver modules. When a transceiver module fails or is not operating correctly, you can perform the following tasks:

- Check the alarms that exist on the transceiver module to identify the fault source.
- Examine the key parameters monitored by the digital diagnosis function, including the temperature, voltage, laser bias current, TX power, and RX power.

Procedure

To diagnose transceiver modules, execute the following commands in any view:

- Display transceiver alarms.
  display transceiver alarm interface [*interface-type interface-number*]
- Display the current values of the digital diagnosis parameters on transceiver modules.
  display transceiver diagnosis interface [*interface-type interface-number*]

Configuring transceiver monitoring

About transceiver monitoring

After transceiver monitoring is enabled, the device samples the parameters of transceiver modules periodically, including the input power and output power of transceiver modules. If a sampled value reaches the alarm threshold, the device generates a log to notify users.

Software version and feature compatibility

This feature is available only in Release 6343P08 and later.

Procedure

1. Enter system view.
   system-view
2. Set the transceiver monitoring interval.
   transceiver monitor interval *interval*
   By default, the transceiver monitoring interval is 600 seconds.
3. Enable transceiver monitoring.
   transceiver monitor enable

By default, transceiver monitoring is disabled.

Configuring transceiver anti-counterfeit

About transceiver anti-counterfeit

This feature automatically detects H3C transceiver modules.

- Upon detection of an H3C transceiver module, the system outputs a log that recommends the user to verify authenticity of the transceiver from the H3C official website www.h3c.com. Select **Support** > **H3C Product Anti-Counterfeit Query** from the website, and then enter the barcode of the transceiver module. To get the transceiver module barcode, see the label on the transceiver module or execute the **`display device manuinfo`** command.
- The system outputs a log upon detection of a possibly counterfeited H3C transceiver module to notify the user. The log contains information about which transceiver modules are possibly counterfeited. For an H3C transceiver counterfeit, the **`display transceiver diagnosis`** command does not display any information about it.

Software version and feature compatibility

This feature is supported only in Release 6342 and later.

Scheduling a task

About task scheduling

You can schedule the device to automatically execute a command or a set of commands without administrative interference.

You can configure a periodic schedule or a non-periodic schedule. A non-periodic schedule is not saved to the configuration file and is lost when the device reboots. A periodic schedule is saved to the startup configuration file and is automatically executed periodically.

Restrictions and guidelines

- The default system time is always restored at reboot. To make sure a task schedule can be executed as expected, reconfigure the system time or configure NTP after you reboot the device. For more information about NTP, see *Network Management and Monitoring Configuration Guide*.
- To assign a command (command A) to a job, you must first assign the job the command or commands for entering the view of command A.
- Make sure all commands in a schedule are compliant to the command syntax. The system does not check the syntax when you assign a command to a job.
- A schedule cannot contain any one of these commands: **`telnet`**, **`ftp`**, **`ssh2`**, and **`monitor process`**.
- A schedule does not support user interaction. If a command requires a yes or no answer, the system always assumes that a **Y** or **Yes** is entered. If a command requires a character string input, the system assumes that either the default character string (if any) or a null string is entered.
- A schedule is executed in the background, and no output (except for logs, traps, and debug information) is displayed for the schedule.

Procedure

1. Enter system view.
   system-view
2. Create a job.
   scheduler job *job-name*
3. Assign a command to the job.
   command *id command*

   By default, no command is assigned to a job.

   You can assign multiple commands to a job. A command with a smaller ID is executed first.
4. Exit to system view.
   quit
5. Create a schedule.
   scheduler schedule *schedule-name*
6. Assign a job to the schedule.
   job *job-name*

   By default, no job is assigned to a schedule.

   You can assign multiple jobs to a schedule. The jobs will be executed concurrently.
7. Assign user roles to the schedule.
   user-role *role-name*

   By default, a schedule has the user role of the schedule creator.

   You can assign a maximum of 64 user roles to a schedule. A command in a schedule can be executed if it is permitted by one or more user roles of the schedule.
8. Specify the execution time for the schedule.

   Choose one option as needed:

   - Execute the schedule at specific points of time.
     time at *time date*

     time once at *time* [**month-date** *month-day* | **week-day** *week-day*&<1-7>]
   - Execute the schedule after a period of time.
     time once delay *time*
   - Execute the schedule at the specified time on every specified day in a month or week.
     time repeating at *time* [**month-date** [*month-day* | **last**] | **week-day** *week-day*&<1-7>]
   - Execute the schedule periodically from the specified time on.
     time repeating [**at** *time* [*date*]] **interval** *interval*

   By default, no execution time is specified for a schedule.

   The **time** commands overwrite each other. The most recently executed command takes effect.
9. (Optional.) Set the schedule log file size limit.
   scheduler logfile size *value*

   By default, the schedule log file size limit is 16 KB.

   The schedule log file stores log messages for execution results of commands in jobs. After the limit is reached, the system deletes the oldest log messages to store the new log messages. If the remaining space of the log file is not enough for a single log message, the system truncates the message and does not store the extra part.

Example: Scheduling a task

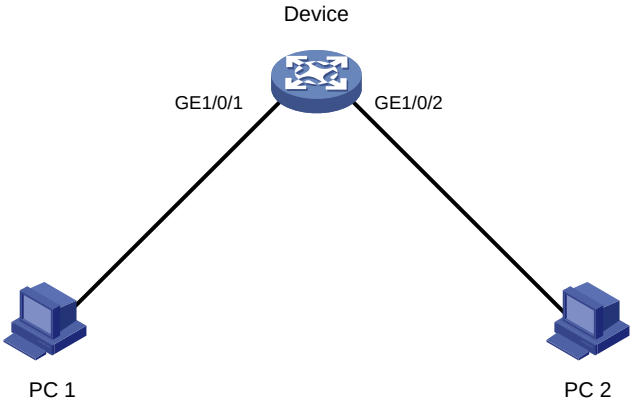
Network configuration

As shown in Figure 3, two interfaces of the device are connected to users.

To save energy, configure the device to perform the following operations:

- Enable the interfaces at 8:00 a.m. every Monday through Friday.
- Disable the interfaces at 18:00 every Monday through Friday.

Figure 3 Network diagram



Procedure

Enter system view.

```
<Sysname> system-view
```

Configure a job for disabling interface GigabitEthernet 1/0/1.

```
[Sysname] scheduler job shutdown-GigabitEthernet1/0/1
[Sysname-job-shutdown-GigabitEthernet1/0/1] command 1 system-view
[Sysname-job-shutdown-GigabitEthernet1/0/1] command 2 interface gigabitethernet 1/0/1
[Sysname-job-shutdown-GigabitEthernet1/0/1] command 3 shutdown
[Sysname-job-shutdown-GigabitEthernet1/0/1] quit
```

Configure a job for enabling interface GigabitEthernet 1/0/1.

```
[Sysname] scheduler job start-GigabitEthernet1/0/1
[Sysname-job-start-GigabitEthernet1/0/1] command 1 system-view
[Sysname-job-start-GigabitEthernet1/0/1] command 2 interface gigabitethernet 1/0/1
[Sysname-job-start-GigabitEthernet1/0/1] command 3 undo shutdown
[Sysname-job-start-GigabitEthernet1/0/1] quit
```

Configure a job for disabling interface GigabitEthernet 1/0/2.

```
[Sysname] scheduler job shutdown-GigabitEthernet1/0/2
[Sysname-job-shutdown-GigabitEthernet1/0/2] command 1 system-view
[Sysname-job-shutdown-GigabitEthernet1/0/2] command 2 interface gigabitethernet 1/0/2
[Sysname-job-shutdown-GigabitEthernet1/0/2] command 3 shutdown
[Sysname-job-shutdown-GigabitEthernet1/0/2] quit
```

Configure a job for enabling interface GigabitEthernet 1/0/2.

```
[Sysname] scheduler job start-GigabitEthernet1/0/2
[Sysname-job-start-GigabitEthernet1/0/2] command 1 system-view
[Sysname-job-start-GigabitEthernet1/0/2] command 2 interface gigabitethernet 1/0/2
```

```
[Sysname-job-start-GigabitEthernet1/0/2] command 3 undo shutdown
[Sysname-job-start-GigabitEthernet1/0/2] quit
```

Configure a periodic schedule for enabling the interfaces at 8:00 a.m. every Monday through Friday.

```
[Sysname] scheduler schedule START-pc1/pc2
[Sysname-schedule-START-pc1/pc2] job start-GigabitEthernet1/0/1
[Sysname-schedule-START-pc1/pc2] job start-GigabitEthernet1/0/2
[Sysname-schedule-START-pc1/pc2] time repeating at 8:00 week-day mon tue wed thu fri
[Sysname-schedule-START-pc1/pc2] quit
```

Configure a periodic schedule for disabling the interfaces at 18:00 every Monday through Friday.

```
[Sysname] scheduler schedule STOP-pc1/pc2
[Sysname-schedule-STOP-pc1/pc2] job shutdown-GigabitEthernet1/0/1
[Sysname-schedule-STOP-pc1/pc2] job shutdown-GigabitEthernet1/0/2
[Sysname-schedule-STOP-pc1/pc2] time repeating at 18:00 week-day mon tue wed thu fri
[Sysname-schedule-STOP-pc1/pc2] quit
```

Verifying the configuration

Display the configuration information of all jobs.

```
[Sysname] display scheduler job
Job name: shutdown-GigabitEthernet1/0/1
 system-view
 interface gigabitethernet 1/0/1
 shutdown

Job name: shutdown-GigabitEthernet1/0/2
 system-view
 interface gigabitethernet 1/0/2
 shutdown

Job name: start-GigabitEthernet1/0/1
 system-view
 interface gigabitethernet 1/0/1
 undo shutdown

Job name: start-GigabitEthernet1/0/2
 system-view
 interface gigabitethernet 1/0/2
 undo shutdown
```

Display the schedule information.

```
[Sysname] display scheduler schedule
Schedule name        : START-pc1/pc2
Schedule type        : Run on every Mon Tue Wed Thu Fri at 08:00:00
Start time           : Wed Sep 28 08:00:00 2011
Last execution time  : Wed Sep 28 08:00:00 2011
Last completion time : Wed Sep 28 08:00:03 2011
Execution counts     : 1
----------------------------------------------------------------------
Job name                                        Last execution status
```

```
start-GigabitEthernet1/0/1                                  Successful
start-GigabitEthernet1/0/2                                  Successful

Schedule name        : STOP-pc1/pc2
Schedule type        : Run on every Mon Tue Wed Thu Fri at 18:00:00
Start time           : Wed Sep 28 18:00:00 2011
Last execution time  : Wed Sep 28 18:00:00 2011
Last completion time : Wed Sep 28 18:00:01 2011
Execution counts     : 1
-------------------------------------------------------------------
Job name                                      Last execution status
shutdown-GigabitEthernet1/0/1                           Successful
shutdown-GigabitEthernet1/0/2                           Successful
```

Display schedule log information.

```
[Sysname] display scheduler logfile
Job name        : start-GigabitEthernet1/0/1
Schedule name   : START-pc1/pc2
Execution time  : Wed Sep 28 08:00:00 2011
Completion time : Wed Sep 28 08:00:02 2011
--------------------------------- Job output ---------------------------------
<Sysname>system-view
System View: return to User View with Ctrl+Z.
[Sysname]interface gigabitethernet 1/0/1
[Sysname-GigabitEthernet1/0/1]undo shutdown

Job name        : start-GigabitEthernet1/0/2
Schedule name   : START-pc1/pc2
Execution time  : Wed Sep 28 08:00:00 2011
Completion time : Wed Sep 28 08:00:02 2011
--------------------------------- Job output ---------------------------------
<Sysname>system-view
System View: return to User View with Ctrl+Z.
[Sysname]interface gigabitethernet 1/0/2
[Sysname-GigabitEthernet1/0/2]undo shutdown

Job name        : shutdown-GigabitEthernet1/0/1
Schedule name   : STOP-pc1/pc2
Execution time  : Wed Sep 28 18:00:00 2011
Completion time : Wed Sep 28 18:00:01 2011
--------------------------------- Job output ---------------------------------
<Sysname>system-view
System View: return to User View with Ctrl+Z.
[Sysname]interface gigabitethernet 1/0/1
[Sysname-GigabitEthernet1/0/1]shutdown

Job name        : shutdown-GigabitEthernet1/0/2
Schedule name   : STOP-pc1/pc2
Execution time  : Wed Sep 28 18:00:00 2011
```

```
Completion time : Wed Sep 28 18:00:01 2011
--------------------------------- Job output ---------------------------------
<Sysname>system-view
System View: return to User View with Ctrl+Z.
[Sysname]interface gigabitethernet 1/0/2
[Sysname-GigabitEthernet1/0/2]shutdown
```

Rebooting the device

About device reboot

The following device reboot methods are available:

- Schedule a reboot at the CLI, so the device automatically reboots at the specified time or after the specified period of time.
- Immediately reboot the device at the CLI.

  This method allows you to reboot the device remotely.

  During the reboot process, the device performs the following operations:

  a. Resets all of its chips.

  b. Uses the BootWare to verify the startup software package, decompress the package, and load the images.

  c. Initializes the system.
- Power off and then power on the device. This method might cause data loss, and is the least-preferred method.

Using the CLI, you can reboot the device from a remote host.

Restrictions and guidelines for device reboot

For data security, the device does not reboot while it is performing file operations.

Rebooting the device immediately at the CLI

Prerequisites

Perform the following steps in any view:

1. Verify that the next-startup configuration file is correctly specified.

`display startup`

For more information about the **`display startup`** command, see *Fundamentals Command Reference*.

2. Verify that the startup image files are correctly specified.

`display boot-loader`

If one main startup image file is damaged or does not exist, you must specify another main startup image file before rebooting the device.

For more information about the **`display boot-loader`** command, see *Fundamentals Command Reference*.

3. Save the running configuration to the next-startup configuration file.

`save`

To avoid configuration loss, save the running configuration before a reboot.

For more information about the **save** command, see *Fundamentals Command Reference*.

Procedure

To reboot the device immediately at the CLI, execute the following command in user view:

reboot [**slot** *slot-number*] [**force**]

CAUTION:

- A device reboot might cause service interruption. Before executing this command, make sure you fully understand its impact on your live network.
- Use the **force** keyword to reboot the device only when the system is faulty or fails to start up normally. A forced device reboots might cause file system damage. Before using the **force** keyword to reboot the device, make sure you understand its impact.

Scheduling a device reboot

Restrictions and guidelines

The automatic reboot configuration takes effect on all member devices. It will be canceled if a master/subordinate switchover occurs.

The device supports only one device reboot schedule. If you execute the **scheduler reboot** command multiple times, the most recent configuration takes effect.

Procedure

To schedule a reboot, execute one of the following commands in user view:

- **scheduler reboot at** *time* [*date*]
- **scheduler reboot delay** *time*

By default, no device reboot time is specified.

CAUTION:

This task enables the device to reboot at a scheduled time, which causes service interruption. Before configuring this task, make sure you fully understand its impact on your live network.

Restoring the factory-default configuration

About restoring the factory-default configuration

If you want to use the device in a different scenario or you cannot troubleshoot the device by using other methods, use this task to restore the factory-default configuration.

This task does not delete **.bin** files.

Restrictions and guidelines

This feature is disruptive.

Procedure

1. Execute the following command in user view to restore the factory-default configuration for the device:

   restore factory-default

2. Reboot the device.

   reboot

When the command prompts you to choose whether to save the running configuration, enter **N**. If you choose to save the running configuration, the device loads the saved configuration at startup.

CAUTION:

This command restores the device to the factory default settings. Before using this command, make sure you fully understand its impact on your live network.

Display and maintenance commands for device management configuration

Execute **display** commands in any view. Execute the **reset scheduler logfile** command in user view. Execute the **reset version-update-record** command in system view.

Task	Command
Display the system time, date, time zone, and daylight saving time.	**display clock**
Display the copyright statement.	**display copyright**
Display CPU usage statistics.	**display cpu-usage** [**summary**] [**slot** *slot-number* [**cpu** *cpu-number* [**core** { *core-number* | **all** }]]]
Display CPU usage monitoring settings.	**display cpu-usage configuration** [**slot** *slot-number* [**cpu** *cpu-number*]]
Display the historical CPU usage statistics in a coordinate system.	**display cpu-usage history** [**job** *job-id*] [**slot** *slot-number* [**cpu** *cpu-number*]]
Display hardware information.	**display device** [**flash** | **usb**] [**slot** *slot-number* | **verbose**]
Display electronic label information for the device.	**display device manuinfo** [**slot** *slot-number*]
Display electronic label information for a power supply.	**display device manuinfo slot** *slot-number* **power** *power-id*
Display or save operating information for features and hardware modules.	**display diagnostic-information** [**hardware** | **infrastructure** | **l2** | **l3** | **service**] [**key-info**] [*filename*]
Display poweroff alarm destination host settings.	**display dying-gasp host**
Display device temperature information.	**display environment** [**slot** *slot-number*]
Display the operating states of fan trays.	**display fan** [**slot** *slot-number* [*fan-id*]]
Display memory usage statistics.	**display memory** [**summary**] [**slot** *slot-number* [**cpu** *cpu-number*]]
Display memory alarm thresholds and statistics.	**display memory-threshold** [**slot**

Task	Command
	slot-number [**cpu** *cpu-number*]]
Display power supply information.	**display power** [**slot** *slot-number* [*power-id*]]
Display job configuration information.	**display scheduler job** [*job-name*]
Display job execution log information.	**display scheduler logfile**
Display the automatic reboot schedule.	**display scheduler reboot**
Display schedule information.	**display scheduler schedule** [*schedule-name*]
Display system stability and status information.	**display system stable state**
Display system version information.	**display version**
Display startup software image upgrade records.	**display version-update-record**
Clear job execution log information.	**reset scheduler logfile**
Clear startup software image upgrade records.	**reset version-update-record**

Contents

Using Tcl

About Tcl

Comware V7 provides a built-in tool command language (Tcl) interpreter. From user view, you can use the **tclsh** command to enter Tcl configuration view to execute the following commands:

- Tcl 8.5 commands.
- Comware commands.

The Tcl configuration view is equivalent to the user view. You can use Comware commands in Tcl configuration view in the same way they are used in user view.

Restrictions and guidelines: Tcl

To return from a subview under Tcl configuration view to the upper-level view, use the **quit** command.

To return from a subview under Tcl configuration view to the Tcl configuration view, press **Ctrl+Z**.

Using Tcl commands to configure the device

Restrictions and guidelines

When you use Tcl to configure the device, follow these restrictions and guidelines:

- You can apply Tcl environment variables to Comware commands.
- No online help information is provided for Tcl commands.
- You cannot press **Tab** to complete an abbreviated Tcl command.
- Make sure the Tcl commands can be executed correctly.
- As a best practice, log in through Telnet or SSH. You cannot stop Tcl commands by using a shortcut key or a CLI command. If a problem occurs when the Tcl commands are being executed, you can terminate the process by closing the connection if you logged in through Telnet or SSH. If you logged in from the console port, you must perform one of the following tasks:
  - Restart the device.
  - Log in to the device by using a different method, and use the **free line** command to release the console or AUX line. For more information about the command, see *Fundamentals Command Reference*.
- You can press **Ctrl+D** to abort Tcl command **read stdin**.

Procedure

1. Enter Tcl configuration view from user view.
   tclsh
2. Execute a Tcl command.
   Tcl command
3. Return from Tcl configuration view to user view.

- **tclquit**
- **quit**

Executing Comware commands in Tcl configuration view

About executing Comware commands in Tcl configuration view

To execute a Comware command in Tcl configuration view, use one of the following methods:

- Enter the Comware command directly. If a Tcl command uses the same command string as the Comware command, the Tcl command is executed.
- Prefix the Comware command with the **cli** keyword. If a Tcl command uses the same command string as the Comware command, the Comware command is executed.

Restrictions and guidelines

Follow these restrictions and guidelines when you execute Comware commands in Tcl configuration view:

- To specify a string enclosed in quotation marks (") or braces ({ and }), you must use the escape character (\) before the quotation marks or braces. For example, to specify **"a"** as the description for an interface, you must enter **description \"a\"**. If you enter **description "a"**, the description is **a**.
- For Comware commands, you can enter **?** to obtain online help or press **Tab** to complete an abbreviated command. For more information, see "Using the CLI."
- The **cli** command is a Tcl command, so you cannot enter **?** to obtain online help or press **Tab** to complete an abbreviated command.
- Successfully executed Comware commands are saved to command history buffers. You can use the upper arrow or lower arrow key to obtain executed commands.
- To execute multiple Comware commands in one operation, use one of the following methods:
  - Enter multiple Comware commands separated by semi-colons to execute the commands in the order they are entered. For example, **vlan 2;description Tech**.
  - Specify multiple Comware commands for the **cli** command, quote them, and separate them by a space and a semicolon. For example, **cli "vlan 2 ;description Tech"**.
  - Specify one Comware command for each **cli** command and separate them by a space and a semicolon. For example, **cli vlan 2 ;cli description Tech**.

Procedure

1. Enter Tcl configuration view

   tclsh
2. Execute Comware commands.
   - Execute Comware commands directly.

     Command
   - Execute Comware commands by using the **cli** command.

     cli *command*

3. Return from Tcl configuration view to user view.
    - **`tclquit`**
    - **`quit`**

Contents

Using Python

About Python

Comware 7 provides a built-in Python interpreter. You can use Python to perform the following tasks:

- Execute Python scripts to implement automatic device configuration.
- Enter Python shell to configure the device by using the following items:
  - Python 2.7 commands.
  - Python 2.7 standard API.
  - Extended API. For more information about the extended API, see "Comware 7 extended Python API."

Executing a Python script

To execute a Python script, use the following command in user view:

python *filename*

Entering the Python shell

To enter the Python shell from user view, execute the following command:

python

Importing and using the extended Python API

To use the extended Python API, you must first import the API to Python.

Importing the entire extended API and using the API

Procedure

1. Enter the Python shell from user view.
   python
2. Import the entire extended API.
   import comware
3. Execute an extended API function.
   comware.*api*

Example

Use extended API function **Transfer** to download the **test.cfg** file from TFTP server 192.168.1.26.

```
<Sysname> python
Python 2.7.3 (default)
[GCC 4.4.1] on linux2
Type "help", "copyright", "credits" or "license" for more information.
>>> import comware
```

```
>>> comware.Transfer('tftp', '192.168.1.26', 'test.cfg', 'flash:/test.cfg', user='',
password='')
<comware.Transfer object at 0xb7eab0e0>
```

Importing an extended API function and using the function

Procedure

1. Enter the Python shell from user view.
   python
2. Import an extended API function.
   from comware import *api-name*
3. Execute an extended API function.
   api-function

Example

Use extended API function **Transfer** to download the **test.cfg** file from TFTP server 192.168.1.26.

```
<Sysname> python
Python 2.7.3 (default)
[GCC 4.4.1] on linux2
Type "help", "copyright", "credits" or "license" for more information.
>>> from comware import Transfer
>>> Transfer('tftp', '192.168.1.26', 'test.cfg', 'flash:/test.cfg', user='',
password='')
<comware.Transfer object at 0xb7e5e0e0>
```

Exiting the Python shell

To exit the Python shell, execute the following command in the Python shell.

exit()

Python usage examples

Example: Using a Python script for device configuration

Network configuration

Use a Python script to perform the following tasks:

- Download configuration files **main.cfg** and **backup.cfg** to the device.
- Configure the files as the main and backup configuration files for the next startup.

Figure 1 Network diagram

Procedure

Use a text editor on the PC to configure Python script **test.py** as follows:

```
#!usr/bin/python
import comware

comware.Transfer('tftp', '192.168.1.26', 'main.cfg', 'flash:/main.cfg')
comware.Transfer('tftp', '192.168.1.26', 'backup.cfg', 'flash:/backup.cfg')
comware.CLI('startup saved-configuration flash:/main.cfg main ;startup
saved-configuration flash:/backup.cfg backup')
```

Use TFTP to download the script to the device.

```
<Sysname> tftp 192.168.1.26 get test.py
```

Execute the script.

```
<Sysname> python flash:/test.py
<Sysname>startup saved-configuration flash:/main.cfg main
Please wait...... Done.
<Sysname>startup saved-configuration flash:/backup.cfg backup
Please wait...... Done.
```

Verifying the configuration

Display startup configuration files.

```
<Sysname> display startup
 Current startup saved-configuration file: flash:/startup.cfg
 Next main startup saved-configuration file: flash:/main.cfg
 Next backup startup saved-configuration file: flash:/backup.cfg
```

Comware 7 extended Python API

The Comware 7 extended Python API is compatible with the Python syntax.

CLI

Use **CLI** to execute Comware 7 CLI commands and create CLI objects.

Syntax

CLI(*command*='', *do_print*=True)

Parameters

command: Specifies the commands to be executed. To enter multiple commands, use a space and a semicolon (;) as the delimiter. To enter a command in a view other than user view, you must first enter the commands used to enter the view. For example, you must enter **'system-view ;local-user test class manage'** to execute the **local-user test class manage** command.

do_print: Specifies whether to output the execution result:

- **True**—Outputs the execution result. This value is the default.
- **False**—Does not output the execution result.

Usage guidelines

This API function supports only Comware commands. It does not support Linux, Python, or Tcl commands.

Returns

CLI objects

Examples

Add a local user named **test**.

```
<Sysname> python
Python 2.7.3 (default)
[GCC 4.4.1] on linux2
Type "help", "copyright", "credits" or "license" for more information.
>>> import comware
>>> comware.CLI('system-view ;local-user test class manage')
```

Sample output

```
<Sysname> system-view
System View: return to User View with Ctrl+Z.
[Sysname] local-user test class manage
New local user added.
<comware.CLI object at 0xb7f680a0>
```

get_error

Use **get_error** to get the error information from the download operation.

Syntax

`Transfer.get_error()`

Returns

Error information (if there is no error information, **None** is returned)

Examples

Download file **test.cfg** from TFTP server 1.1.1.1 and get the error information from the operation.

```
<Sysname> python
Python 2.7.3 (default)
[GCC 4.4.1] on linux2
Type "help", "copyright", "credits" or "license" for more information.
>>> import comware
>>> c = comware.Transfer('tftp', '1.1.1.1', 'test.cfg', 'flash:/test.cfg', user='',
password='')
>>> c.get_error()
```

Sample output

```
"Timeout was reached”
```

get_output

Use **`get_output`** to get the output from executed commands.

Syntax

`CLI.get_output()`

Returns

Output from executed commands

Examples

Add a local user and get the output from the command.

```
<Sysname> python
Python 2.7.3 (default)
[GCC 4.4.1] on linux2
Type "help", "copyright", "credits" or "license" for more information.
>>> import comware
>>> c = comware.CLI('system-view ;local-user test class manage', False)
>>> c.get_output()
```

Sample output

```
['<Sysname>system-view', 'System View: return to User View with Ctrl+Z.',
'[Sysname]local-user test class manage', 'New local user added.']
```

get_self_slot

Use **`get_self_slot`** to get the member ID of the master device.

Syntax

`get_self_slot()`

Returns

A list object in the format of [-1,*slot-number*]. The *slot-number* indicates the member ID of the master device.

Examples

Get the member ID of the master device.

```
<Sysname> python
Python 2.7.3 (default)
[GCC 4.4.1] on linux2
Type "help", "copyright", "credits" or "license" for more information.
>>> import comware
>>> comware.get_self_slot()
```

Sample output

```
[-1,0]
```

get_slot_info

Use **get_slot_info** to get information about a member device.

Syntax

get_slot_info()

Returns

A dictionary object in the format of {'Slot': *slot-number*, 'Status': '*status*', 'Chassis': *chassis-number*, 'Role': '*role*', 'Cpu': *CPU-number* }. The *slot-number* argument indicates the member ID of the device. The *status* argument indicates the status of the member device. The *chassis-number* and *CPU-number* arguments are fixed at 0. The *role* argument indicates the role of the member device.

Examples

Get information about the device or a member device.

```
<Sysname> python
Python 2.7.3 (default)
[GCC 4.4.1] on linux2
Type "help", "copyright", "credits" or "license" for more information.
>>> import comware
>>> comware.get_slot_info(1)
```

Sample output

```
{'Slot': 1, 'Status': 'Normal', 'Chassis': 0, 'Role': 'Master', 'Cpu': 0}
```

get_slot_range

Use **get_slot_range** to get the supported IRF member ID range.

Syntax

get_slot_range()

Returns

A dictionary object in the format of {'MaxSlot': *max-slot-number*, 'MinSlot': *min-slot-number* }. The *max-slot-number* argument indicates the maximum member ID. The *min-slot-number* argument indicates the minimum member ID.

Examples

Get the supported IRF member ID range.

```
<Sysname> python
Python 2.7.3 (default)
[GCC 4.4.1] on linux2
Type "help", "copyright", "credits" or "license" for more information.
>>> import comware
>>> comware.get_slot_range()
```

Sample output

```
{'MaxSlot': 10, 'MinSlot': 1}
```

get_standby_slot

Use **`get_standby_slot`** to get the member IDs of the subordinate devices.

Syntax

`get_standby_slot()`

Returns

A list object in one of the following formats:

- [ ]—The IRF fabric does not have a subordinate device.
- [[-1,*slot-number*]]—The IRF fabric has only one subordinate device.
- [[-1,*slot-number1*] , [-1,*slot-number2*] ,...]—The IRF fabric has multiple subordinate devices.

The *slot-number* arguments indicate the member IDs of the subordinate devices.

Examples

Get the member IDs of the subordinate devices.

```
<Sysname> python
Python 2.7.3 (default)
[GCC 4.4.1] on linux2
Type "help", "copyright", "credits" or "license" for more information.
>>> import comware
>>> comware.get_standby_slot()
```

Sample output

```
[[-1, 1], [-1, 2]]
```

Transfer

Use **`Transfer`** to download a file from a server.

Syntax

`Transfer`(*`protocol`*='', *`host`*='', *`source`*='', *`dest`*='',*`login_timeout`*=10, *`user`*='', *`password`*='')

Parameters

`protocol`: Specifies the protocol used to download a file:

- **`ftp`**—Uses FTP.

- **tftp**—Uses TFTP.
- **http**—Uses HTTP.

host: Specifies the IP address of the remote server.

source: Specifies the name of the file to be downloaded from the remote server.

dest: Specifies a name for the downloaded file.

login_timeout: Specifies the timeout for the operation, in seconds. The default is 10.

user: Specifies the username for logging in to the server.

password: Specifies the login password.

Returns

Transfer object

Examples

Download file **test.cfg** from TFTP server 192.168.1.26.

```
<Sysname> python
Python 2.7.3 (default)
[GCC 4.4.1] on linux2
Type "help", "copyright", "credits" or "license" for more information.
>>> import comware
>>> comware.Transfer('tftp', '192.168.1.26', 'test.cfg', 'flash:/test.cfg', user='',
password='')
```

Sample output

```
<comware.Transfer object at 0xb7f700e0>
```

Contents

Using automatic configuration

About automatic configuration

When the device starts up without a valid next-startup configuration file, the device searches the root directory of its default file system for the autocfg.py, autocfg.tcl, and autocfg.cfg files. Only one of files might exist in the root directory. If any one of the files exists, the device loads the file. If none of the files exists, the device uses the automatic configuration feature to obtain a set of configuration settings.

With the automatic configuration feature, the device can automatically obtain a set of configuration settings at startup. This feature simplifies network configuration and maintenance.

Automatic configuration can be implemented by using the implementation methods in Table 1.

Table 1 Automatic configuration implementation methods

Implementation method	Configuration file location	Application scenarios
Server-based automatic configuration	File server	A number of geographically distributed devices need to be configured.

Using server-based automatic configuration

About server-based automatic configuration

With server-based automatic configuration, a device without a configuration file can run the DHCP client to obtain a configuration file from a file server at startup.

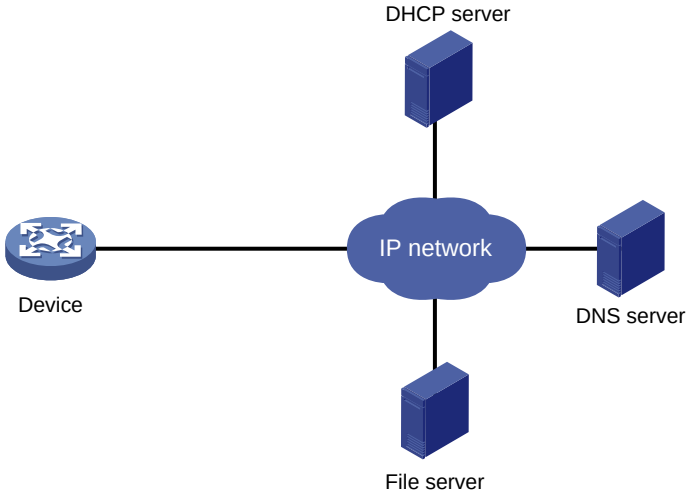
You can deploy server-based automatic configuration on both IPv4 and IPv6 networks by using the same method. This chapter describes the tasks for deploying server-based automatic configuration on an IPv4 network.

Typical server-based automatic configuration network

As shown in Figure 1, a typical server-based automatic configuration network consists of the following servers:

- DHCP server.
- File server (TFTP or HTTP server).
- (Optional.) DNS server.

Figure 1 Server-based automatic configuration network diagram



Server-based automatic configuration tasks at a glance

To configure server-based automatic configuration, perform the following tasks:

1. Configuring the file server
2. Prepare the files for automatic configuration:
   - Preparing configuration files
   - Preparing script files
3. Configuring the DHCP server
4. (Optional.) Configuring the DNS server
5. (Optional.) Configuring the gateway
6. Preparing the interface used for automatic configuration
7. Starting and completing automatic configuration

Configuring the file server

For devices to obtain configuration information from a TFTP server, start TFTP service on the file server.

For devices to obtain configuration information from an HTTP server, start HTTP service on the file server.

Preparing configuration files

Configuration file types

The device supports the configuration file types listed in Table 2.

Table 2 Configuration file types

Configuration file type	Application objects	File name requirements	Supported file server types
Dedicated configuration file	Devices that require different settings	*File name*.**cfg** For simple file name	• TFTP server • HTTP server

Configuration file type	Application objects	File name requirements	Supported file server types
		identification, use configuration file names that do not contain spaces.	
Common configuration file	Devices that share all or some settings	*File name*.**cfg**	• TFTP server • HTTP server
Default configuration file	Other devices. The file contains only common configurations that devices use to start up.	**device.cfg**	TFTP server

Identifying requirements for and preparing configuration files

1. Identify the requirements of the devices for configuration files.
2. For devices that require different configurations, prepare a configuration file for each of them and save the file to the file server.
3. For devices that share all or some configurations, save the common configurations to a .cfg file on the file server.
4. If a TFTP file server is used, you can save the common configurations that devices use to start up to the **device.cfg** file on the server. The file is assigned to a device only when the device does not have any other configuration file to use.

Preparing the host name file on the TFTP server

If a TFTP server is used and the DHCP server does not assign configuration file names, you can configure a host name file on the TFTP server. The host name file contains the host name-IP address mappings of the devices to be automatically configured.

To prepare the host name file:

1. Create a host name file named **network.cfg**.
2. Add each mapping entry in the **ip host** *host-name ip-address* format on a separate line. For example:

```
ip host host1 101.101.101.101
ip host host2 101.101.101.102
ip host client1 101.101.101.103
ip host client2 101.101.101.104
```

IMPORTANT:

The host name for a device must be the same as the name of the configuration file configured for the device.

Preparing script files

About script files

Script files can be used for automatic software upgrade and automatic configuration.

The device supports Python scripts (.py files) and Tcl scripts (.tcl files). For more information about Python and Tcl scripts, see "Using Python" and "Using Tcl."

The device supports dedicated script files and common dedicated script files. It does not support using a default script file. For information about dedicated script files and common dedicated script files, see Table 2.

When script files are used, you cannot use a host name file to provide the host name-IP address mappings for devices.

Restrictions and guidelines

To use a Tcl script, make sure all commands in the script are supported and correctly configured. Any error in a command causes the automatic configuration process to quit.

Procedure

- For devices that share all or some configurations, create a script file that contains the common configurations.
- For the other devices, create a separate script file for each of them.

Configuring the DHCP server

About the DHCP server

The DHCP server assigns the following items to devices that need to be automatically configured:

- IP addresses.
- Paths of the configuration or script files.

Restrictions and guidelines

When you configure the DHCP server, follow these guidelines:

- For devices for which you have prepared different configuration files, perform the following tasks for each of the devices on the DHCP server:
  - Create a DHCP address pool.
  - Configure a static address binding.
  - Specify a configuration file or script file.

  Because an address pool can use only one configuration file, you can specify only one static address binding for an address pool.
- For devices for which you have prepared the same configuration file, use either of the following methods:
  - Method 1:
    - Create a DHCP address pool for the devices.
    - Configure a static address binding for each of the devices in the address pool.
    - Specify the configuration file for the devices.
  - Method 2:
    - Create a DHCP address pool for the devices.
    - Specify the subnet for dynamic allocation.
    - Specify the TFTP server.
    - Specify the configuration file for the devices.
- If all devices on a subnet share the same configuration file or script file, perform the following tasks on the DHCP server:
  - Configure dynamic address allocation.
  - Specify the configuration file or script file for the devices.

  The configuration file can contain only the common settings for the devices. You can provide a method for the device administrators to change the configurations after their devices start up.

Configuring the DHCP server when an HTTP file server is used

1. Enter system view.

system-view

2. Enable DHCP.

   dhcp enable

   By default, DHCP is disabled.

3. Create a DHCP address pool and enter its view.

   dhcp server ip-pool *pool-name*

4. Configure the address pool.

   Choose the options to configure as needed:

   - Specify the primary subnet for the address pool:

     network *network-address* [*mask-length* | **mask** *mask*]

     By default, no primary subnet is specified.

   - Configure a static binding:

     static-bind ip-address *ip-address* [*mask-length* | **mask** *mask*] { **client-identifier** *client-identifier* | **hardware-address** *hardware-address* [**ethernet** | **token-ring**] }

     By default, no static binding is configured.

     You can configure multiple static bindings. However, one IP address can be bound to only one client. To change the binding for a DHCP client, you must remove the binding and reconfigure a binding.

5. Specify the URL of the configuration or script file.

   bootfile-name *url*

   By default, no configuration or script file URL is specified.

Configuring the DHCP server when a TFTP file server is used

1. Enter system view.

   system-view

2. Enable DHCP.

   dhcp enable

   By default, DHCP is disabled.

3. Create a DHCP address pool and enter its view.

   dhcp server ip-pool *pool-name*

4. Configure the address pool.

   Choose the options to configure as needed:

   - Specify the primary subnet for the address pool:

     network *network-address* [*mask-length* | **mask** *mask*]

     By default, no primary subnet is specified.

   - Configure a static binding:

     static-bind ip-address *ip-address* [*mask-length* | **mask** *mask*] { **client-identifier** *client-identifier* | **hardware-address** *hardware-address* [**ethernet** | **token-ring**] }

     By default, no static binding is configured.

     You can configure multiple static bindings. However, one IP address can be bound to only one client. To change the binding for a DHCP client, you must remove the binding and reconfigure a binding.

5. Specify a TFTP server.

   Choose one option as needed:

- Specify the IP address of the TFTP server:

  tftp-server ip-address *ip-address*

  By default, no TFTP server IP address is specified.
- Specify the name of the TFTP server:

  tftp-server domain-name *domain-name*

  By default, no TFTP server name is specified.

  If you specify a TFTP server by its name, a DNS server is required on the network.

6. Specify the name of the configuration or script file.

   bootfile-name *bootfile-name*

   By default, no configuration or script file name is specified.

Configuring the DNS server

A DNS server is required in the following situations:

- The TFTP server does not have a host name file.

  Devices need to provide the DNS server with their IP addresses to obtain their host names. Then, the devices can obtain configuration files named in the *host name***.cfg** format from the TFTP server.
- The DHCP server assigns the TFTP server domain name through the DHCP reply message. Devices must use the domain name to obtain the IP address of the TFTP server.

Configuring the gateway

If the devices to be automatically configured and the servers for automatic configuration reside in different network segments, you must perform the following tasks:

- Deploy a gateway and make sure the devices can communicate with the servers.
- Configure the DHCP relay agent feature on the gateway.
- Configure the UDP helper feature on the gateway.

  This task is required if devices send requests to a TFTP server by using broadcast packets. A device uses broadcast packets to send requests to a TFTP server in the following situations:
  - The DHCP reply does not contain the IP address or domain name of the TFTP server.
  - The IP address or domain name of the TFTP server is invalid.

  The UDP helper transforms a broadcast packet into a unicast packet and forwards the unicast packet to the file server. For more information about UDP helper, see *Layer 3—IP Services Configuration Guide*.

Preparing the interface used for automatic configuration

The device uses the following steps to select the interface for automatic configuration:

1. Identifies the status of the management Ethernet interface at Layer 2. If the status is up, the device uses the management Ethernet interface.
2. Identifies the status of Layer 2 Ethernet interfaces. If one or more Layer 2 Ethernet interfaces are in up state, the device uses the VLAN interface of the default VLAN.
3. If no Layer 2 Ethernet interfaces are in up state, the device waits 30 seconds and goes to step 1 to try again.

For fast automatic device configuration, connect only the management Ethernet interface on each device to the network.

Starting and completing automatic configuration

1. Power on the devices to be automatically configured.

   If a device does not find a next-start configuration file locally, it starts the automatic configuration process to obtain a configuration file.

   - If the device obtains a configuration file and executes the file successfully, the automatic configuration process ends.
   - If one attempt fails, the device tries again until the maximum number of attempts is reached. To stop the process, press **Ctrl+C** or **Ctrl+D**.

   If the device fails to obtain a configuration file, the device starts up without loading any configuration.

2. Save the running configuration.

   save

   The device does not save the obtained configuration file locally. If you do not save the running configuration, the device must use the automatic configuration feature again after a reboot.

   For more information about the **save** command, see *Fundamentals Command Reference*.

Server-based automatic configuration examples

Example: Using a TFTP server for automatic configuration

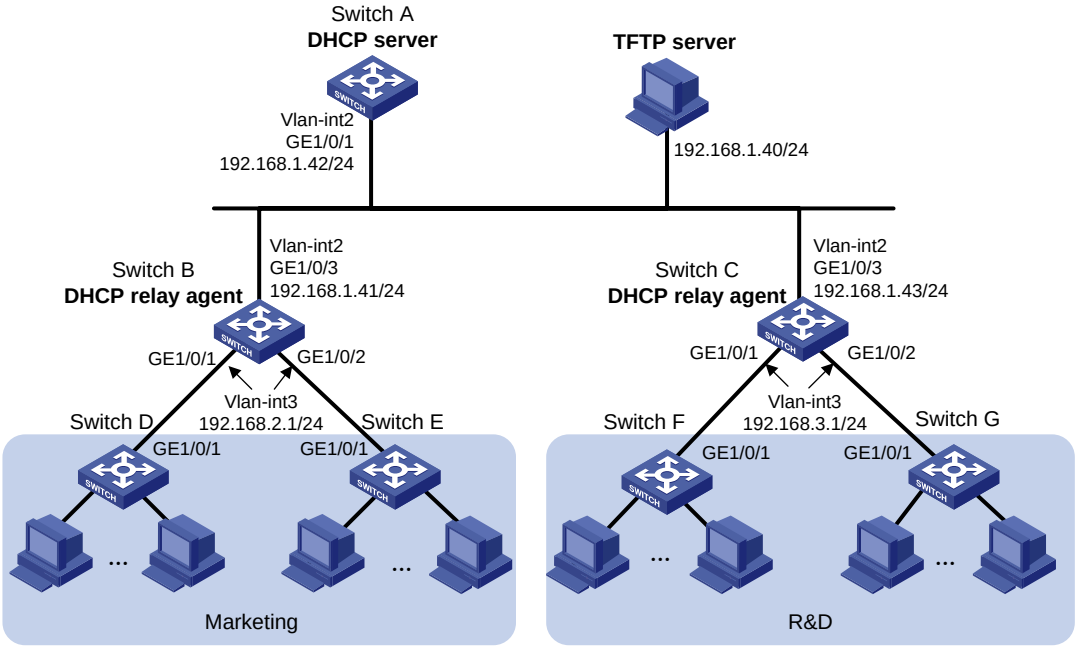
Network configuration

As shown in Figure 2, two departments of a company are connected to the network through gateways (Switch B and Switch C). Access devices Switch D, Switch E, Switch F, and Switch G do not have a configuration file.

Configure the servers and gateways so the access devices can obtain a configuration file to complete the following configuration tasks:

- Enable administrators of access devices to Telnet to and manage their respective access devices.
- Require administrators to enter their respective usernames and passwords at login.

Figure 2 Network diagram



Procedure

1. Configure the DHCP server:

Create a VLAN interface and assign an IP address to the interface.

```
<SwitchA> system-view
[SwitchA] vlan 2
[SwitchA-vlan2] port gigabitethernet 1/0/1
[SwitchA-vlan2] quit
[SwitchA] interface vlan-interface 2
[SwitchA-Vlan-interface2] ip address 192.168.1.42 24
[SwitchA-Vlan-interface2] quit
```

Enable DHCP.

```
[SwitchA] dhcp enable
```

Enable the DHCP server on VLAN-interface 2.

```
[SwitchA] interface vlan-interface 2
[SwitchA-Vlan-interface2] dhcp select server
[SwitchA-Vlan-interface2] quit
```

Configure address pool **market** to assign IP addresses on the 192.168.2.0/24 subnet to clients in the Marketing department. Specify the TFTP server, gateway, and configuration file name for the clients.

```
[SwitchA] dhcp server ip-pool market
[SwitchA-dhcp-pool-market] network 192.168.2.0 24
[SwitchA-dhcp-pool-market] tftp-server ip-address 192.168.1.40
[SwitchA-dhcp-pool-market] gateway-list 192.168.2.1
[SwitchA-dhcp-pool-market] bootfile-name market.cfg
[SwitchA-dhcp-pool-market] quit
```

Configure address pool **rd** to assign IP addresses on the 192.168.3.0/24 subnet to clients in the R&D department. Specify the TFTP server, gateway, and configuration file name for the clients.

```
[SwitchA] dhcp server ip-pool rd
[SwitchA-dhcp-pool-rd] network 192.168.3.0 24
[SwitchA-dhcp-pool-rd] tftp-server ip-address 192.168.1.40
[SwitchA-dhcp-pool-rd] gateway-list 192.168.3.1
[SwitchA-dhcp-pool-rd] bootfile-name rd.cfg
[SwitchA-dhcp-pool-rd] quit
```

Configure static routes to the DHCP relay agents.

```
[SwitchA] ip route-static 192.168.2.0 24 192.168.1.41
[SwitchA] ip route-static 192.168.3.0 24 192.168.1.43
[SwitchA] quit
```

2. Configure the gateway Switch B:

Create VLAN interfaces and assign IP addresses to the interfaces.

```
<SwitchB> system-view
[SwitchB] vlan 2
[SwitchB-vlan2] port gigabitethernet 1/0/3
[SwitchB-vlan2] quit
[SwitchB] interface vlan-interface 2
[SwitchB-Vlan-interface2] ip address 192.168.1.41 24
[SwitchB-Vlan-interface2] quit
[SwitchB] vlan 3
[SwitchB-vlan3] port gigabitethernet 1/0/1
[SwitchB-vlan3] port gigabitethernet 1/0/2
[SwitchB-vlan3] quit
[SwitchB] interface vlan-interface 3
[SwitchB-Vlan-interface3] ip address 192.168.2.1 24
[SwitchB-Vlan-interface3] quit
```

Enable DHCP.

```
[SwitchB] dhcp enable
```

Enable the DHCP relay agent on VLAN-interface 3.

```
[SwitchB] interface vlan-interface 3
[SwitchB-Vlan-interface3] dhcp select relay
```

Specify the DHCP server address.

```
[SwitchB-Vlan-interface3] dhcp relay server-address 192.168.1.42
```

3. Configure the gateway Switch C:

Create VLAN interfaces and assign IP addresses to the interfaces.

```
<SwitchC> system-view
[SwitchC] vlan 2
[SwitchC-vlan2] port gigabitethernet 1/0/3
[SwitchC-vlan2] quit
[SwitchC] interface vlan-interface 2
[SwitchC-Vlan-interface2] ip address 192.168.1.43 24
[SwitchC-Vlan-interface2] quit
[SwitchC] vlan 3
[SwitchC-vlan3] port gigabitethernet 1/0/1
[SwitchC-vlan3] port gigabitethernet 1/0/2
[SwitchC-vlan3] quit
[SwitchC] interface vlan-interface 3
[SwitchC-Vlan-interface3] ip address 192.168.3.1 24
```

```
[SwitchC-Vlan-interface3] quit
```

Enable DHCP.

```
[SwitchC] dhcp enable
```

Enable the DHCP relay agent on VLAN-interface 3.

```
[SwitchC] interface vlan-interface 3
[SwitchC-Vlan-interface3] dhcp select relay
```

Specify the DHCP server address.

```
[SwitchC-Vlan-interface3] dhcp relay server-address 192.168.1.42
```

4. Configure the TFTP server:

On the TFTP server, create a configuration file named **market.cfg**.

```
#
 sysname Market
#
 telnet server enable
#
vlan 3
#
local-user market
 password simple market
 service-type telnet
 quit
#
interface Vlan-interface3
 ip address dhcp-alloc
 quit
#
interface gigabitethernet 1/0/1
 port access vlan 3
 quit
#
user-interface vty 0 63
 authentication-mode scheme
 user-role network-admin
#
return
```

On the TFTP server, create a configuration file named **rd.cfg**.

```
#
 sysname RD
#
 telnet server enable
#
vlan 3
#
local-user rd
 password simple rd
 service-type telnet
 quit
#
```

```
interface Vlan-interface3
 ip address dhcp-alloc
 quit
#
interface gigabitethernet 1/0/1
 port access vlan 3
 quit
#
user-interface vty 0 63
 authentication-mode scheme
 user-role network-admin
#
return
```

Start TFTP service software, and specify the folder where the two configuration files reside as the working directory. (Details not shown.)

Verify that the TFTP server and DHCP relay agents can reach each other. (Details not shown.)

Verifying the configuration

1. Power on Switch D, Switch E, Switch F, and Switch G.
2. After the access devices start up, display assigned IP addresses on Switch A.

```
<SwitchA> display dhcp server ip-in-use
IP address       Client-identifier/    Lease expiration      Type
                 Hardware address
192.168.2.2      3030-3066-2e65-3233-  May 6 05:21:25 2013   Auto(C)
                 642e-3561-6633-2d56-
                 6c61-6e2d-696e-7465-
                 7266-6163-6533
192.168.2.3      3030-3066-2e65-3230-  May 6 05:22:50 2013   Auto(C)
                 302e-3232-3033-2d56-
                 6c61-6e2d-696e-7465-
                 7266-6163-6533
192.168.3.2      3030-6530-2e66-6330-  May 6 05:23:15 2013   Auto(C)
                 302e-3335-3131-2d56-
                 6c61-6e2d-696e-7465-
                 7266-6163-6531
192.168.3.3      3030-6530-2e66-6330-  May 6 05:24:10 2013   Auto(C)
                 302e-3335-3135-2d56-
                 6c61-6e2d-696e-7465-
                 7266-6163-6532
```

3. Telnet to 192.168.2.2 from Switch A.

```
<SwitchA> telnet 192.168.2.2
```

4. Enter username **market** and password **market** as prompted. (Details not shown.)

   You are logged in to Switch D or Switch E.

Example: Using an HTTP server and Tcl scripts for automatic configuration

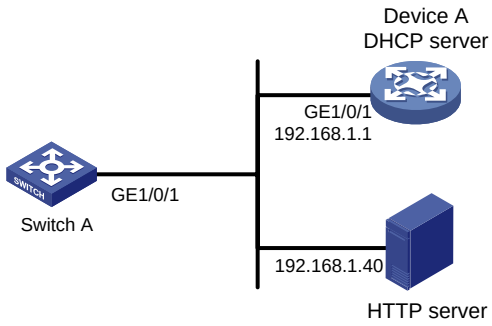
Network configuration

As shown in Figure 3, Switch A does not have a configuration file.

Configure the servers so Switch A can obtain a Tcl script to complete the following configuration tasks:

- Enable the administrator to Telnet to Switch A to manage Switch A.
- Require the administrator to enter the correct username and password at login.

Figure 3 Network diagram



Procedure

1. Configure the DHCP server:

   # Enable DHCP.

   ```
   <DeviceA> system-view
   [DeviceA] dhcp enable
   ```

   # Configure address pool **1** to assign IP addresses on the 192.168.1.0/24 subnet to clients.

   ```
   [DeviceA] dhcp server ip-pool 1
   [DeviceA-dhcp-pool-1] network 192.168.1.0 24
   ```

   # Specify the URL of the script file for the clients.

   ```
   [DeviceA-dhcp-pool-1] bootfile-name http://192.168.1.40/device.tcl
   ```

2. Configure the HTTP server:

   # Create a configuration file named **device.tcl** on the HTTP server.

   ```
   system-view
   telnet server enable
   local-user user
   password simple abcabc
   service-type telnet
   quit
   user-interface vty 0 63
   authentication-mode scheme
   user-role network-admin
   quit

   interface Vlan-interface 1
   ip address dhcp-alloc
   ```

```
return
```

Start HTTP service software and enable HTTP service. (Details not shown.)

Verifying the configuration

1. Power on Switch A.
2. After Switch A starts up, display assigned IP addresses on Device A.

```
<DeviceA> display dhcp server ip-in-use
IP address       Client identifier/    Lease expiration      Type
                 Hardware address
192.168.1.2      0030-3030-632e-3239-  Dec 12 17:41:15 2013  Auto(C)
                 3035-2e36-3736-622d-
                 4574-6830-2f30-2f32
```

3. Telnet to 192.168.1.2 from Device A.

```
<DeviceA> telnet 192.168.1.2
```

4. Enter username **user** and password **abcabc** as prompted. (Details not shown.)

   You are logged in to Switch A.

Example: Using an HTTP server and Python scripts for automatic configuration

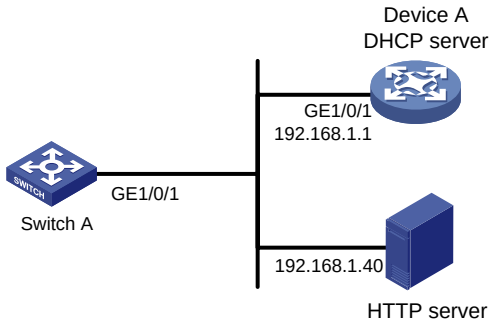
Network configuration

As shown in Figure 4, Switch A does not have a configuration file.

Configure the servers so Switch A can obtain a Python script to complete the following configuration tasks:

- Enable the administrator to Telnet to Switch A to manage Switch A.
- Require the administrator to enter the correct username and password at login.

Figure 4 Network diagram



Procedure

1. Configure the DHCP server:

   # Enable DHCP.

```
<DeviceA> system-view
[DeviceA] dhcp enable
```

   # Configure address pool **1** to assign IP addresses on the 192.168.1.0/24 subnet to clients.

```
[DeviceA] dhcp server ip-pool 1
[DeviceA-dhcp-pool-1] network 192.168.1.0 24
```

   # Specify the URL of the script file for the clients.

```
[DeviceA-dhcp-pool-1] bootfile-name http://192.168.1.40/device.py
```

2. Configure the HTTP server:

   # Create a configuration file named **device.py** on the HTTP server.

```
#!usr/bin/python

import comware
comware.CLI('system-view ;telnet server enable ;local-user user ;password simple
abcabc ;service-type telnet ;quit ;user-interface vty 0 63 ;authentication-mode
scheme ;user-role network-admin ;quit ;interface Vlan-interface 1 ;ip address
dhcp-alloc ;return')
```

   # Start HTTP service software and enable HTTP service. (Details not shown.)

Verifying the configuration

1. Power on Switch A.
2. After Switch A starts up, display assigned IP addresses on Device A.

```
<DeviceA> display dhcp server ip-in-use
IP address       Client identifier/    Lease expiration      Type
                 Hardware address
192.168.1.2      0030-3030-632e-3239-  Dec 12 17:41:15 2013  Auto(C)
                 3035-2e36-3736-622d-
                 4574-6830-2f30-2f32
```

3. Telnet to 192.168.1.2 from Device A.

```
<DeviceA> telnet 192.168.1.2
```

4. Enter username **user** and password **abcabc** as prompted. (Details not shown.)

   You are logged in to Switch A.

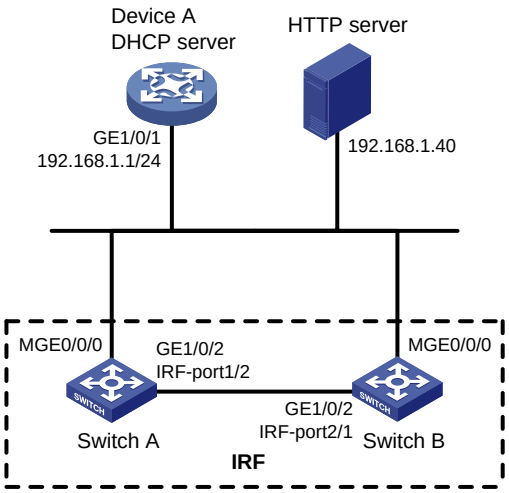
Example: Setting up an IRF fabric

Network configuration

As shown in Figure 5, Switch A and Switch B do not have a configuration file.

Configure the servers so the switches can obtain a Python script to complete their respective configurations and form an IRF fabric.

Figure 5 Network diagram



Procedure

1. Assign IP addresses to the interfaces. Make sure the devices can reach each other. (Details not shown.)
2. Configure the following files on the HTTP server:

File	Content	Remarks
.cfg configuration file	Commands required for IRF setup.	You can create a configuration file by copying and modifying the configuration file of an existing IRF fabric.
sn.txt	Serial numbers of the member switches.	Each SN uniquely identifies a switch. These SNs will be used for assigning a unique IRF member ID to each member switch.
(Optional.) .ipe or .bin software image file	Software images.	If the member switches are running different software versions, you must prepare the software image file used for software upgrade.
.py Python script file	Python commands that complete the following tasks: **a** (Optional.) Verify that the flash memory has sufficient space for the files to be downloaded. **b** Download the configuration file and **sn.txt**. **c** (Optional.) Download the software image file and specify it as the main startup image file. **d** Resolve **sn.txt** and assign a unique IRF member ID to each SN. **e** Specify the configuration file as the main next-startup configuration file. **f** Reboot the member switches.	For more information about Python script configuration, see "Using Python."

3. Configure Device A as the DHCP server:

   # Enable DHCP.

   ```
   <DeviceA> system-view
   [DeviceA] dhcp enable
   ```

   # Configure address pool **1** to assign IP addresses on the 192.168.1.0/24 subnet to clients.

   ```
   [DeviceA] dhcp server ip-pool 1
   [DeviceA-dhcp-pool-1] network 192.168.1.0 24
   ```

   # Specify the URL of the script file for the clients.

   ```
   [DeviceA-dhcp-pool-1] bootfile-name http://192.168.1.40/device.py
   [DeviceA-dhcp-pool-1] quit
   ```

   # Enable the DHCP server on GigabitEthernet 1/0/1.

   ```
   [DeviceA] interface gigabitethernet 1/0/1
   [DeviceA-GigabitEthernet1/0/1] dhcp select server
   [DeviceA-GigabitEthernet1/0/1] quit
   ```

4. Power on Switch A and Switch B.

Switch A and Switch B will obtain the Python script file from the DHCP server and execute the script. After completing the IRF configuration, Switch A and Switch B reboot.

5. After Switch A and Switch B start up again, use a cable to connect Switch A and Switch B through their IRF physical ports.

   Switch A and Switch B will elect a master member. The subordinate member will reboot to join the IRF fabric.

Verifying the configuration

On Switch A, display IRF member devices. You can also use the **`display irf`** command on Switch B to display IRF member devices.

```
<Switch A> display irf
MemberID  Slot  Role    Priority  CPU-Mac         Description
   1      1     Standby 1         00e0-fc0f-8c02  ---
 *+2      1     Master  30        00e0-fc0f-8c14  ---
-------------------------------------------------
 * indicates the device is the master.
 + indicates the device through which the user logs in.

 The Bridge MAC of the IRF is: 000c-1000-1111
 Auto upgrade                : yes
 Mac persistent              : always
 Domain ID                   : 0
 Auto merge                  : yes
```

The output shows that the switches have formed an IRF fabric.

Contents

Managing licenses

About licenses

To use license-based features, you must purchase licenses from H3C and install the licenses.

To obtain information about license-based features, their licensing status, and license availability, execute the **display license feature** command on the device. Then, you can purchase and install licenses as needed.

To install a formal license for a feature:

1. Purchase a software license certificate through an official channel.
2. Access the H3C license management platform at http://www.h3c.com/en/License, and then enter the license key in the certificate and the required device information to obtain an activation file.
3. Install the activation file on the device.

Basic concepts

The following information describes the basic concepts that you might encounter when you register, install, and manage licenses.

H3C license management platform

The H3C license management platform provides product licensing services for H3C customers. You can access this system to obtain an activation file.

The H3C license management platform is accessible at http://www.h3c.com/en/License/.

Software license certificate

A software license certificate allows users to use a license-based feature. It contains license key, license capacity, and other information.

License key

A license key uniquely identifies a license.

To obtain a formal license key, purchase a software license certificate. The authorization serial number in the software license certificate is the license key.

Device serial number

A device serial number (SN or S/N) is a barcode that uniquely identifies a device. It comes with the device and must be provided when you request a license on the H3C license management platform.

Device ID (DID) and DID file

A DID is a string of characters that uniquely identifies a hardware device. A DID file stores the DID and other information. The device comes with a DID or DID file. You must provide the DID or DID file when you request a license for the device on the H3C license management platform.

Activation file

To use a license-based feature on a system, you must perform the following tasks:

1. Use the license key and the system's SN and DID information to obtain an activation file from the H3C license management platform.
2. Install the activation file on the system.

Uninstall key and Uninstall file

When you uninstall a license, an Uninstall file that contains an Uninstall key is created. The Uninstall key is required for transferring the license.

License storage

License storage is a persistent storage of fixed size for storing licensing information. This information includes the licensing state, validity period, Uninstall key or Uninstall file, and other related information.

Data in the license storage persists through reboot. This ensures licensing accuracy and continuity.

Restrictions and guidelines: License management

Management operation restrictions

- Purchase licenses from H3C official channels.
- For licenses that have been installed on the device, execute the **`display license`** command to view the license validity period. To use a license-based feature continuously, install a new license for the feature before the old license expires.
- Licenses are typically device locked. To ensure a successful licensing, use the following licensing guidelines:
  a. When you purchase a license certificate, verify the following items:
    - Make sure the license is compatible with the target device.
    - Make sure its licensed functionality and capacity meet your requirements.
  b. When you obtain an activation file, make sure the provided license key and hardware information are correct.
  c. Install the activation file on the correct target device.
- Make sure no one else is performing license management tasks while you are managing licenses on the device.

File operation restrictions

When you manage DID files, activation files, or Uninstall files, follow these restrictions and guidelines:

- To avoid licensing error, do not modify the name of a DID file, activation file, or Uninstall file, or edit the file content.
- Before you install an activation file, download the activation file to the storage media of the device such as flash memory. When installing an activation file, the device automatically copies the activation file to the **license** folder in the root directory of the storage media. The **license** folder stores important files for licensing. For licensed features to function correctly, do not delete or modify the **license** folder or the files in this folder.

Configuring local licensing

About local licensing

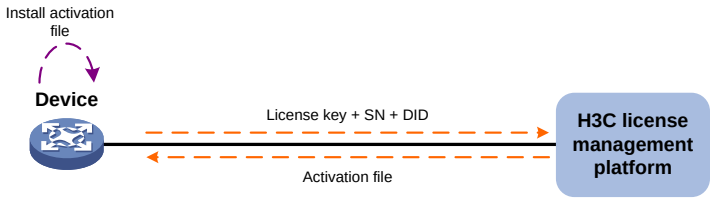
Local licensing requires license activation device by device. It is applicable to small-sized networks.

To install a license on a device:

1. Obtain the license key and the device SN and DID information of the device.
2. Access the H3C license management platform to apply for an activation file based on the license key and the device's SN and DID information.
3. Install the activation file on the device to activate the license.

The activation file for a license is device locked. You cannot install the activation file for one device to activate the license on another device.

Figure 1 Local licensing procedure



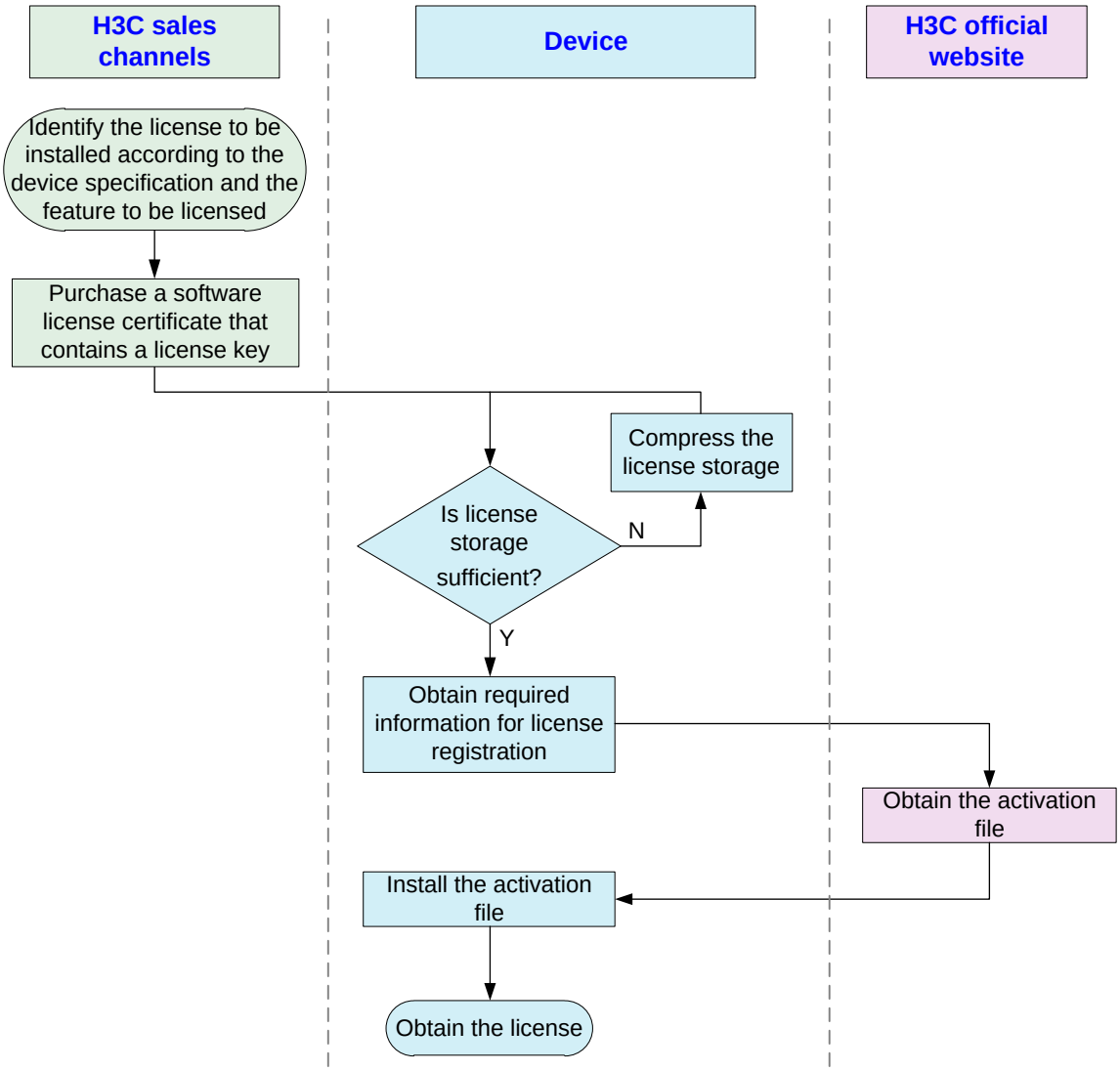
Registering and installing a license

License registration and installation workflow

Figure 2 shows the procedure for registering and installing a license.

This chapter only describes the operations performed on the device and H3C license management platform. For more information, see the licensing guide for the device.

Figure 2 License registration and installation workflow



Identifying the license storage

To identify the free space of the license storage, execute the following command in any view:

`display license feature`

From the command output, view the **Total** and **Usage** fields to examine whether the remaining license storage is sufficient for installing new licenses. If the remaining license storage is not sufficient, compress the license storage.

Compressing the license storage

About this task

The license storage stores licensing information and has a fixed size.

You can compress the license storage to delete expired and uninstalled license information to ensure sufficient storage space for installing new licenses.

If no licenses have been installed on the device, you do not need to compress the license storage.

Prerequisites

Back up the Uninstall keys or Uninstall files for the uninstalled licenses for subsequent license transferring or license uninstallation.

If uninstalled licenses or expired licenses exist on the device, the compression operation will make the DID or DID file change. You will be unable to install the activation file obtained by using the old DID or DID file on the device. As a best practice, install all activation files registered with the old DID or DID file before performing a compression.

If you have not installed an activation file registered with the old DID, take the following actions:

- If the license storage is sufficient, install the activation file on the device.
- If the license storage is insufficient and the activation file cannot be installed after the compression, contact H3C Support.

Procedure

1. Enter system view.

   system-view
2. Compress the license storage.

   license compress slot *slot-number*

Obtaining required information for license registration

To obtain the SN and DID information, execute the following command in any view:

display license device-id slot *slot-number*

Registering a license on the H3C license management platform

About registering a license

License registration has the following procedures:

- Registering licenses for the first time—Register a license for a device that has not previously been registered.
- Registering upgrade licenses—Register licenses for capacity expansion, feature enhancement, or a time extension. This procedure is also applicable to the scenario that you register a new license for a device that has expired or uninstalled licenses.

If you do not know which registration procedure should be used, select registering licenses for the first time. If the selection is not correct, the website will display messages for the correct registration choice after you enter the required information.

Restrictions and guidelines

If you cannot download the activation file due to issues such as operating system and browser errors, try to re-register the license. If the issue persists, contact H3C Support.

Registering licenses for the first time

1. Visit the H3C website at http://www.h3c.com/en/License/.
2. Select **Register the First Time**.
3. Enter the authorization serial number in the **Input the license key** field and click **Submit**.

   A dialog box opens, displaying product categories matching the license key.
4. In the dialog box, select a product category from the **Product category** dropdown list and click **OK**.

5. Enter the device SN.
6. Enter the DID or upload the DID file.
7. Enter the required contact information and verify code, select **I accept all terms of H3C Legal Statement**, and click **Get activation key or file**.
8. Download the activation file to the PC.

   A copy of the activation file will also be sent to the email address that you enter in the contact information.

Registering upgrade licenses

1. Visit the H3C website at http://www.h3c.com/en/License/.
2. Select **Register Upgrade Licenses**.
3. Enter the authorization serial number in the **Input the license key** field and click **Submit**.

   A dialog box opens, displaying product categories matching the license key.
4. In the dialog box, select a product category from the **Product category** dropdown list and click **OK**.
5. Enter the device SN.
6. Enter the DID or upload the DID file and click **Submit**.
7. Enter the required contact information and verify code, select **I accept all terms of H3C Legal Statement**, and click **Get activation key or file**.
8. Download the activation file to the PC.

   A copy of the activation file will also be sent to the email address that you enter in the contact information.

Installing an activation file

About this task

CAUTION:

Back up an activation file before you install it. If the activation file is inadvertently deleted or becomes unavailable for some other reason, you can use the backup activation file to restore the license.

To obtain a license, install an activation file for the license on the device.

Prerequisites

Use FTP or TFTP to upload the activation file to be installed to the device. If FTP is used to transfer the activation file, set it in binary mode.

Procedure

1. Enter system view.

   system-view
2. Install an activation file.

   license activation-file install *file-name* **slot** *slot-number*

   You can install a single .ak file or multiple .ak files through one operation. To install multiple .ak files, save all activation files in the same directory and specify the directory as the value of the *file-name* argument.

Transferring a license

About this task

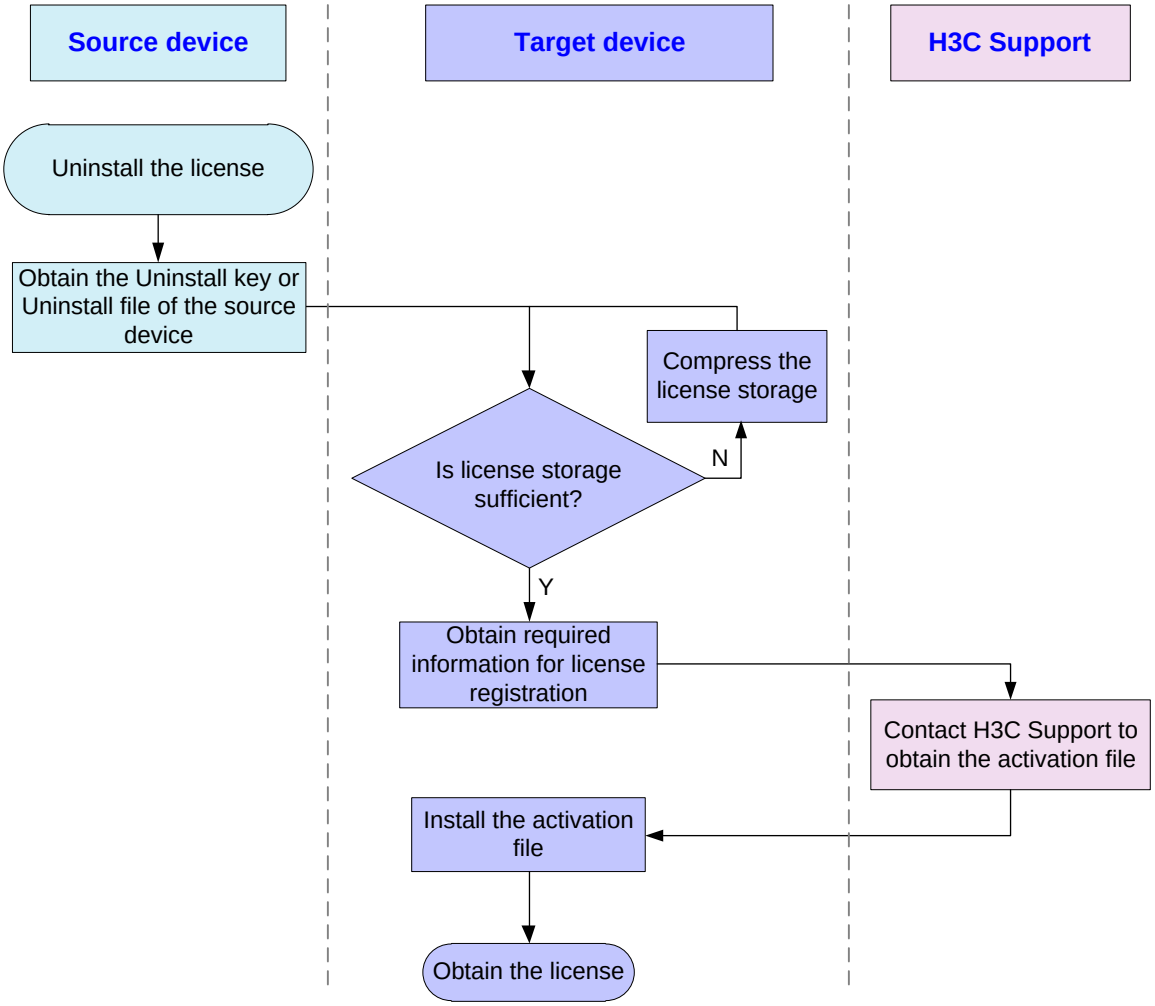
Perform this task to transfer a license that has not expired from one device to another in the same product series.

License transferring workflow

To transfer licenses from one device to another, use the workflow in Figure 3.

This chapter describes only the operations performed on the source device. For the operations performed on the target device, see "Registering and installing a license." For more information about license transferring, contact H3C Support.

Figure 3 License transferring workflow



Obtaining an Uninstall file

1. Execute the **`display license`** command to view the activation file to be uninstalled.
2. Enter system view.

system-view

3. Uninstall an activation file.

   license activation-file uninstall *license-file* **slot** *slot-number*

   You can uninstall a single .ak file or multiple .ak files through one operation. To uninstall multiple .ak files, save all activation files in the same directory and specify the directory as the value of the *license-file* argument.

Uninstalling a license

About license uninstallation

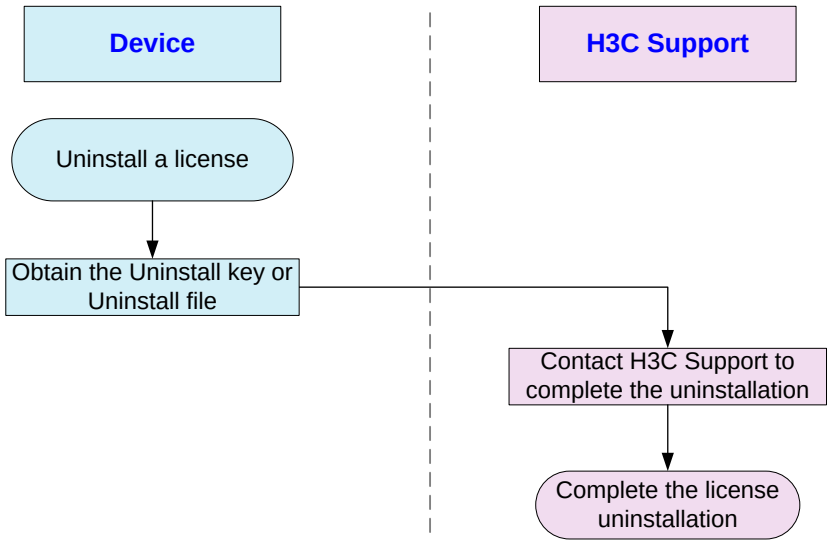
A license key is bound to a device once you activate the license key on the H3C license management platform. You cannot bind this license key to another device. To unbind a license key for a license that has not expired from a device, obtain the Uninstall key or Uninstall file for the license on the device. Then, contact H3C Support to complete the license uninstallation.

To restore the license on the local device or transfer the license to another device, you must contact H3C Support to obtain a new activation file for the license. Then, install the new activation file on the target device.

License uninstallation workflow

For information about obtaining the Uninstall file, see "Obtaining an Uninstall file." For more information about license uninstallation, contact H3C Support.

Figure 4 License uninstallation workflow



Recovering an activation file

If you mistakenly delete an activation file, use the following procedure to recover the activation file:

1. Use the **copy** command to copy the backup activation file to the **license** folder in the root directory of the storage media.
2. Use the **display license** command to verify that the state of the recovered activation file is **In use**.

3. Restart the device if the license state is **In use** but the licensed feature cannot function correctly.

Display and maintenance commands for license management

Execute **display** commands in any view.

Task	Command
Display detailed license information.	**display license** [**activation-file**] [**slot** *slot-number*]
Display the SN and DID information.	**display license device-id slot** *slot-number*
Display brief feature license information.	**display license feature**

Virtual Technologies Configuration Guide

This command reference is applicable to the following switches and software versions:

H3C S5120V2-LI switch series (Release 6308P01 and later)
H3C S3100V3-SI switch series (Release 6309P01 and later)
H3C S5110V2 switch series (Release 6310 and later)
H3C S5110V2-SI switch series (Release 6310 and later)
H3C S5000V3-EI switch series (Release 6310 and later)
H3C S5000V5-EI switch series (Release 6319P01 and later)
H3C S5000E-X switch series (Release 6310 and later)
H3C S5130S-LI switch series (Release 6310 and later)
H3C MS4320V2 switch series (Release 6308P01 and later)
H3C MS4320 switch series (Release 6308P01 and later)
H3C MS4300V2 switch series (Release 6308P01 and later)
H3C MS4200 switch series (Release 6310 and later)
H3C WS5810-WiNet switch series (Release 6308P01 and later)
H3C WS5820-WiNet switch series (Release 6308P01 and later)
H3C WAS6000 switch series (Release 6308P01 and later)
H3C S5000X-EI switch series (Release 6329 and later)
H3C MS4320V3 switch series (Release 6329 and later)
H3C S5120V3-SI switch series (Release 6329 and later)
H3C S5120V3-LI switch series (Release 6329 and later)

New H3C Technologies Co., Ltd.
http://www.h3c.com

Software version: Release 63xx
Document version: 6W105-20230524

Preface

This configuration guide describes how to set up an IRF fabric of multiple switches, including:

This preface includes the following topics about the documentation:

Audience

This documentation is intended for:

- Network planners.
- Field technical support and servicing engineers.
- Network administrators.

Conventions

The following information describes the conventions used in the documentation.

Command conventions

Convention	Description
Boldface	**Bold** text represents commands and keywords that you enter literally as shown.
Italic	*Italic* text represents arguments that you replace with actual values.
[ ]	Square brackets enclose syntax choices (keywords or arguments) that are optional.
{ x | y | ... }	Braces enclose a set of required syntax choices separated by vertical bars, from which you select one.
[x | y | ...]	Square brackets enclose a set of optional syntax choices separated by vertical bars, from which you select one or none.
{ x | y | ... } *	Asterisk marked braces enclose a set of required syntax choices separated by vertical bars, from which you select a minimum of one.
[x | y | ...] *	Asterisk marked square brackets enclose optional syntax choices separated by vertical bars, from which you select one choice, multiple choices, or none.
&<1-n>	The argument or keyword and argument combination before the ampersand (&) sign can be entered 1 to n times.
#	A line that starts with a pound (#) sign is comments.

GUI conventions

Convention	Description
Boldface	Window names, button names, field names, and menu items are in Boldface. For example, the **New User** window opens; click **OK**.
>	Multi-level menus are separated by angle brackets. For example, **File** > **Create** > **Folder**.

Symbols

Convention	Description
WARNING!	An alert that calls attention to important information that if not understood or followed can result in personal injury.
CAUTION:	An alert that calls attention to important information that if not understood or followed can result in data loss, data corruption, or damage to hardware or software.
IMPORTANT:	An alert that calls attention to essential information.
NOTE:	An alert that contains additional or supplementary information.
TIP:	An alert that provides helpful information.

Network topology icons

Convention	Description
	Represents a generic network device, such as a router, switch, or firewall.
	Represents a routing-capable device, such as a router or Layer 3 switch.
	Represents a generic switch, such as a Layer 2 or Layer 3 switch, or a router that supports Layer 2 forwarding and other Layer 2 features.
	Represents an access controller, a unified wired-WLAN module, or the access controller engine on a unified wired-WLAN switch.
	Represents an access point.
	Represents a wireless terminator unit.
	Represents a wireless terminator.
	Represents a mesh access point.
	Represents omnidirectional signals.
	Represents directional signals.
	Represents a security product, such as a firewall, UTM, multiservice security gateway, or load balancing device.
	Represents a security module, such as a firewall, load balancing, NetStream, SSL VPN, IPS, or ACG module.

Examples provided in this document

Examples in this document might use devices that differ from your device in hardware model, configuration, or software version. It is normal that the port numbers, sample output, screenshots, and other information in the examples differ from what you have on your device.

Documentation feedback

You can e-mail your comments about product documentation to info@h3c.com.

We appreciate your comments.

Contents

Configuring an IRF fabric

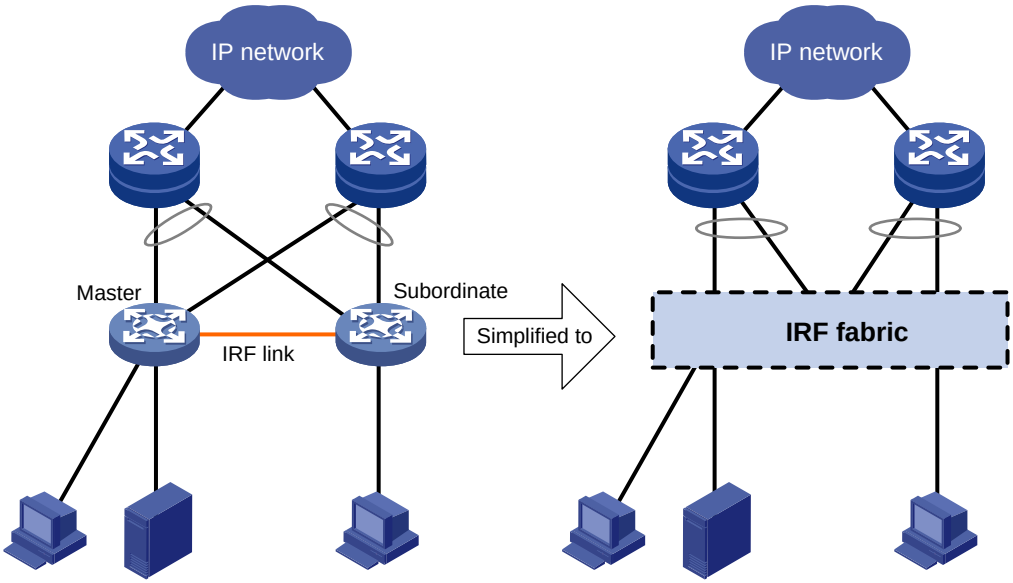
About IRF

The Intelligent Resilient Framework (IRF) technology virtualizes multiple physical devices at the same layer into one virtual fabric to provide data center class availability and scalability. IRF virtualization technology offers processing power, interaction, unified management, and uninterrupted maintenance of multiple devices.

IRF network model

Figure 1 shows an IRF fabric that has two devices, which appear as a single node to the upper-layer and lower-layer devices.

Figure 1 IRF application scenario



IRF benefits

IRF provides the following benefits:

- **Simplified topology and easy management**—An IRF fabric appears as one node and is accessible at a single IP address on the network. You can use this IP address to log in at any member device to manage all the members of the IRF fabric. In addition, you do not need to run the spanning tree feature among the IRF members.
- **1:N redundancy**—In an IRF fabric, one member acts as the master to manage and control the entire IRF fabric. All the other members process services while backing up the master. When the master fails, all the other member devices elect a new master from among them to take over without interrupting services.
- **IRF link aggregation**—You can assign several physical links between neighboring members to their IRF ports to create a load-balanced aggregate IRF connection with redundancy.
- **Multichassis link aggregation**—You can use the Ethernet link aggregation feature to aggregate the physical links between the IRF fabric and its upstream or downstream devices across the IRF members.

- **Network scalability and resiliency**—Processing capacity of an IRF fabric equals the total processing capacities of all the members. You can increase ports, network bandwidth, and processing capacity of an IRF fabric simply by adding member devices without changing the network topology.

Basic concepts

IRF member roles

IRF uses two member roles: master and standby (called subordinate throughout the documentation).

When devices form an IRF fabric, they elect a master to manage and control the IRF fabric, and all the other devices back up the master. When the master device fails, the other devices automatically elect a new master. For more information about master election, see "Master election."

IRF member ID

An IRF fabric uses member IDs to uniquely identify and manage its members. This member ID information is included as the first part of interface numbers and file paths to uniquely identify interfaces and files in an IRF fabric. Two devices cannot form an IRF fabric if they use the same member ID. A device cannot join an IRF fabric if its member ID has been used in the fabric.

Member priority

Member priority determines the possibility of a member device to be elected the master. A member with higher priority is more likely to be elected the master.

IRF port

An IRF port is a logical interface that connects IRF member devices. Every IRF-capable device has two IRF ports.

The IRF ports are named IRF-port *n*/1 and IRF-port *n*/2, where *n* is the member ID of the device. The two IRF ports are referred to as IRF-port 1 and IRF-port 2.

To use an IRF port, you must bind a minimum of one physical interface to it. The physical interfaces assigned to an IRF port automatically form an aggregate IRF link. An IRF port goes down when all its IRF physical interfaces are down.

IRF physical interface

IRF physical interfaces connect IRF member devices and must be bound to an IRF port. They forward traffic between member devices, including IRF protocol packets and data packets that must travel across IRF member devices.

IRF split

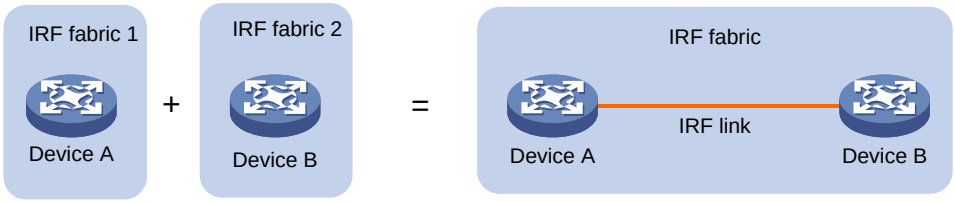
IRF split occurs when an IRF fabric breaks up into multiple IRF fabrics because of IRF link failures, as shown in Figure 2. The split IRF fabrics operate with the same IP address. IRF split causes routing and forwarding problems on the network. To quickly detect a multi-active collision, configure a minimum of one MAD mechanism (see "Configuring MAD").

Figure 2 IRF split

IRF merge

IRF merge occurs when two split IRF fabrics reunite or when two independent IRF fabrics are united, as shown in Figure 3.

Figure 3 IRF merge



MAD

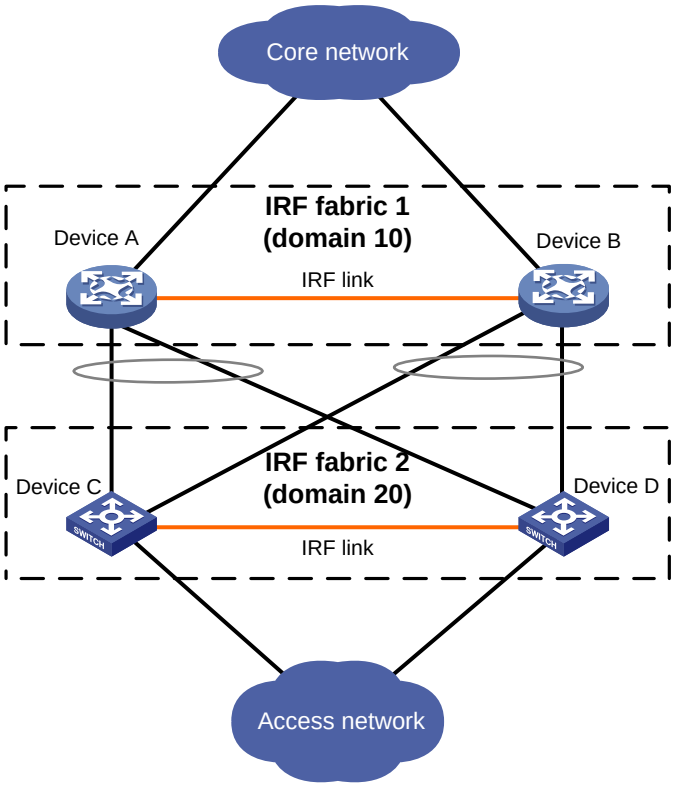
An IRF link failure causes an IRF fabric to split in two IRF fabrics operating with the same Layer 3 settings, including the same IP address. To avoid IP address collision and network problems, IRF uses multi-active detection (MAD) mechanisms to detect the presence of multiple identical IRF fabrics, handle collisions, and recover from faults.

IRF domain ID

One IRF fabric forms one IRF domain. IRF uses IRF domain IDs to uniquely identify IRF fabrics and prevent IRF fabrics from interfering with one another.

As shown in Figure 4, IRF fabric 1 contains Device A and Device B, and IRF fabric 2 contains Device C and Device D. Both fabrics use the LACP aggregate links between them for MAD. When a member device receives an extended LACPDU for MAD, it checks the domain ID to determine whether the packet is from the local IRF fabric. Then, the member device can handle the packet correctly.

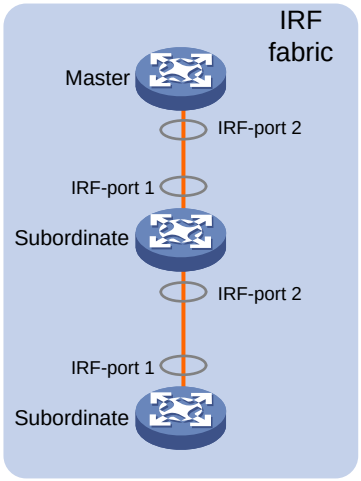
Figure 4 A network that contains two IRF domains



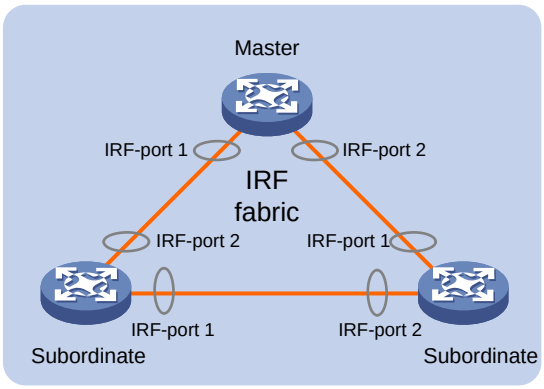
IRF network topology

An IRF fabric can use a daisy-chain or ring topology. As shown in Figure 5, a ring topology is more reliable. In ring topology, the failure of one IRF link does not cause the IRF fabric to split as in daisy-chain topology. Rather, the IRF fabric changes to a daisy-chain topology without interrupting network services.

Figure 5 Daisy-chain topology vs. ring topology



Daisy-chain topology



Ring topology

Master election

Master election occurs each time the IRF fabric topology changes in the following situations:

- The IRF fabric is established.
- The master device fails or is removed.
- The IRF fabric splits.
- Independent IRF fabrics merge.

NOTE:

Master election does not occur when split IRF fabrics merge. For information about the master device of the merged IRF fabric, see "Failure recovery."

Master election selects a master in descending order:

1. Current master, even if a new member has higher priority.

   When an IRF fabric is being formed, all members consider themselves as the master. This rule is skipped.
2. Member with higher priority.
3. Member with the longest system uptime.

   Two members are considered to start up at the same time if the difference between their startup times is equal to or less than 10 minutes. For these members, the next tiebreaker applies.
4. Member with the lowest CPU MAC address.

For the setup of a new IRF fabric, the subordinate devices must reboot to complete the setup after the master election.

For an IRF merge, devices must reboot if they are in the IRF fabric that fails the master election.

Interface naming conventions

A physical interface is numbered in the *chassis-number/slot-number/interface-index* format.

- ***chassis-number***—Member ID of the device. The default value for this argument is 1. Any change to the member ID takes effect after a reboot.
- ***slot-number***—Slot number of the interface. The slot number is fixed at 0.
- ***interface-index***—Interface index on the device. Interface index depends on the number of physical interfaces available on the device. To identify the index of a physical interface, examine its index mark on the chassis.

For example, GigabitEthernet 3/0/1 represents the first physical interface on member device 3. Set its link type to trunk, as follows:

```
<Sysname> system-view
[Sysname] interface gigabitethernet 3/0/1
[Sysname-GigabitEthernet3/0/1] port link-type trunk
```

File system naming conventions

On a single-chassis fabric, you can use its storage device name to access its file system.

On a multichassis IRF fabric, you can use the storage device name to access the file system of the master. To access the file system of any other member device, use the name in the **slot***member-ID#storage-device-name* format.

For more information about storage device naming conventions, see *Fundamentals Configuration Guide*.

For example:

- To create and access the **test** folder under the root directory of the flash memory on the master switch:

  ```
  <Master> mkdir test
  Creating directory flash:/test... Done.
  <Master> cd test
  <Master> dir
  Directory of flash:/test
  The directory is empty.

  251904 KB total (70964 KB free)
  ```

- To create and access the **test** folder under the root directory of the flash memory on member device 3:

  ```
  <Master> mkdir slot3#flash:/test
  Creating directory slot3#flash:/test... Done.
  <Master> cd slot3#flash:/test
  <Master> dir
  Directory of slot3#flash:/test
  The directory is empty.

  251904 KB total (70964 KB free)
  ```

Configuration synchronization

IRF uses a strict running-configuration synchronization mechanism. In an IRF fabric, all devices obtain and run the running configuration of the master. Configuration changes are automatically propagated from the master to the remaining devices. The configuration files of these devices are retained, but the files do not take effect. The devices use their own startup configuration files only after they are removed from the IRF fabric.

As a best practice, back up the next-startup configuration file on a device before adding the device to an IRF fabric as a subordinate.

A subordinate device's next-startup configuration file might be overwritten if the master and the subordinate use the same file name for their next-startup configuration files. You can use the backup file to restore the original configuration after removing the subordinate from the IRF fabric.

For more information about configuration management, see *Fundamentals Configuration Guide*.

Multi-active handling procedure

The multi-active handling procedure includes detection, collision handling, and failure recovery.

Detection

IRF provides MAD mechanisms by extending LACP, BFD, ARP, and IPv6 ND to detect multi-active collisions. As a best practice, configure a minimum of one MAD mechanism on an IRF fabric. For more information about the MAD mechanisms and their application scenarios, see "MAD mechanisms."

For information about LACP, see Ethernet link aggregation in *Layer 2—LAN Switching Configuration Guide*. For information about BFD, see *High Availability Configuration Guide*. For information about ARP, see *Layer 3—IP Services Configuration Guide*. For information about ND, see IPv6 basics in *Layer 3—IP Services Configuration Guide*.

Collision handling

When detecting a multi-active collision, MAD disables all IRF fabrics except one from forwarding data traffic by placing them in Recovery state. The IRF fabrics placed in Recovery state are called inactive IRF fabrics. The IRF fabric that continues to forward traffic is called the active IRF fabric.

LACP MAD and BFD MAD use the following process to handle a multi-active collision:

1. Compare the number of members in each fabric.
2. Set all fabrics to the Recovery state except the one that has the most members.
3. Compare the member IDs of the masters if all IRF fabrics have the same number of members.
4. Set all fabrics to the Recovery state except the one that has the lowest numbered master.
5. Shut down all common network interfaces in the Recovery-state fabrics except for the following interfaces:
   - Interfaces automatically excluded from being shut down by the system.
   - Interfaces specified by using the **`mad exclude interface`** command.

ARP MAD and ND MAD use the following process to handle a multi-active collision:

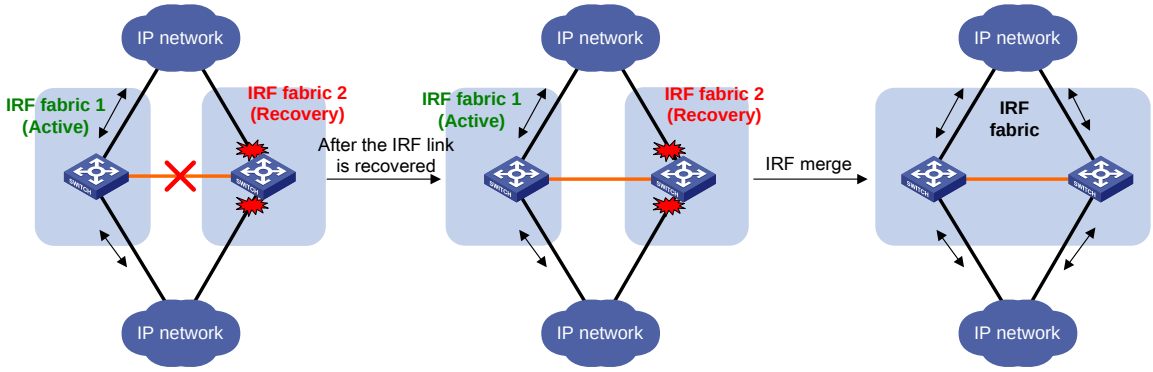
1. Compare the member IDs of the masters in the IRF fabrics.
2. Set all fabrics to the Recovery state except the one that has the lowest numbered master.
3. Take the same action as LACP MAD and BFD MAD on the network interfaces in Recovery-state fabrics.

Failure recovery

To merge two split IRF fabrics, first repair the failed IRF link and remove the IRF link failure.

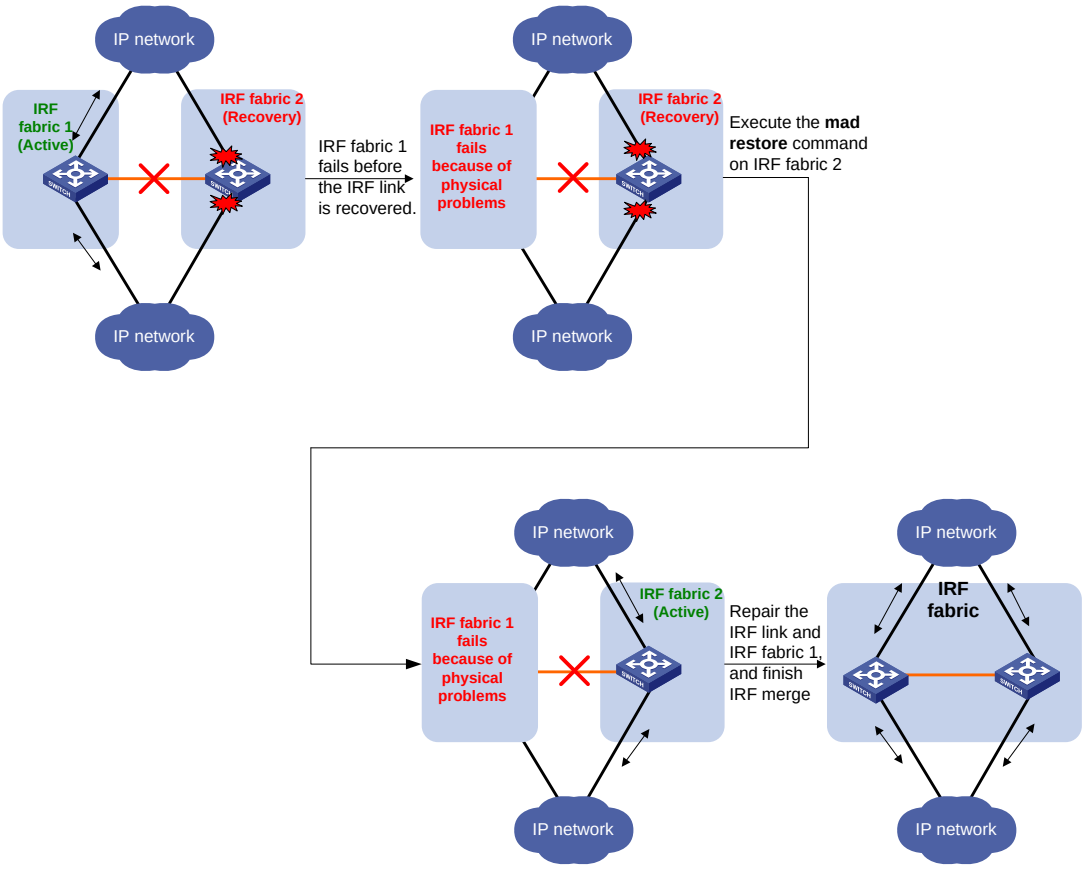
When the failed IRF link between two split IRF fabrics is recovered, all member devices in the inactive IRF fabric automatically reboot to join the active IRF fabric as subordinate members. The network interfaces that have been shut down by MAD automatically restore their original state, as shown in Figure 6.

Figure 6 Recovering the IRF fabric



If the active IRF fabric fails before the IRF link is recovered (see Figure 7), use the **`mad restore`** command on the inactive IRF fabric to recover the inactive IRF fabric. This command brings up all network interfaces that were shut down by MAD. After the IRF link is repaired, merge the two parts into a unified IRF fabric.

Figure 7 Active IRF fabric fails before the IRF link is recovered



MAD mechanisms

IRF provides MAD mechanisms by extending LACP, BFD, ARP, and IPv6 ND.

Table 1 compares the MAD mechanisms and their application scenarios.

Table 1 Comparison of MAD mechanisms

MAD mechanism	Advantages	Disadvantages	Application scenarios
LACP MAD	• Detection speed is fast. • Runs on existing aggregate links without requiring MAD-dedicated physical links or Layer 3 interfaces.	Requires an intermediate device that supports extended LACP for MAD.	Link aggregation is used between the IRF fabric and its upstream or downstream device.
BFD MAD	• Detection speed is fast. • Intermediate device, if used, can come from any vendor.	Requires MAD dedicated physical links and Layer 3 interfaces, which cannot be used for transmitting user traffic.	• No special requirements for network scenarios. • If no intermediate device is used, this mechanism is only suitable for IRF fabrics that have only two members that are geographically close to one another.
ARP MAD	• No intermediate device is required. • Intermediate device, if used, can come from any vendor. • Does not require MAD dedicated ports.	• Detection speed is slower than BFD MAD and LACP MAD. • The spanning tree feature must be enabled if common Ethernet ports are used for ARP MAD links.	Non-link aggregation IPv4 network scenarios. Spanning tree-enabled non-link aggregation IPv4 network scenarios if common Ethernet ports are used.
ND MAD	• No intermediate device is required. • Intermediate device, if used, can come from any vendor. • Does not require MAD dedicated ports.	• Detection speed is slower than BFD MAD and LACP MAD. • The spanning tree feature must be enabled if common Ethernet ports are used for ND MAD links.	Non-link aggregation IPv6 network scenarios. Spanning tree-enabled non-link aggregation IPv6 network scenarios if common Ethernet ports are used.

LACP MAD

As shown in Figure 8, LACP MAD has the following requirements:

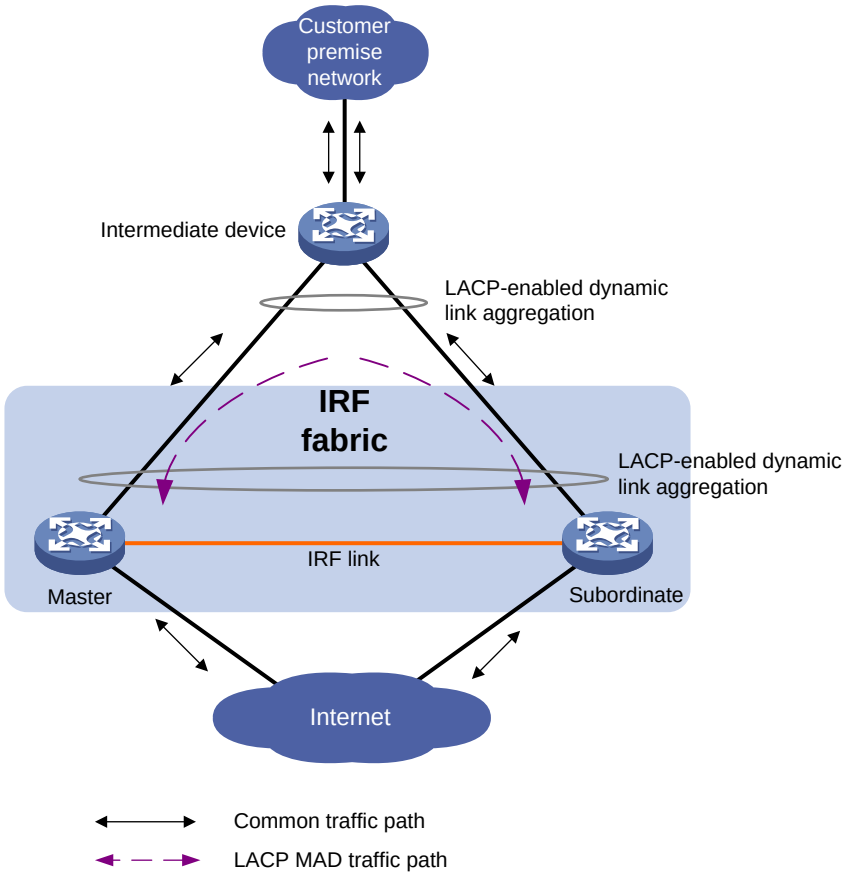
- Every IRF member must have a link with an intermediate device.
- All the links form a dynamic link aggregation group.
- The intermediate device must be a device that supports extended LACP for MAD.

The IRF member devices send extended LACPDUs that convey a domain ID and an active ID (the member ID of the master). The intermediate device transparently forwards the extended LACPDUs received from one member device to all the other member devices.

- If the domain IDs and active IDs sent by all the member devices are the same, the IRF fabric is integrated.

- If the extended LACPDUs convey the same domain ID but different active IDs, a split has occurred. LACP MAD handles this situation as described in "Collision handling."

Figure 8 LACP MAD scenario



BFD MAD

BFD MAD detects multi-active collisions by using BFD.

You can use common or management Ethernet ports for BFD MAD. To avoid data plane issues from affecting BFD MAD, use management Ethernet ports (if any) for BFD MAD as long as possible.

If management Ethernet ports are used, BFD MAD has the following requirements:

- An intermediate device is required and each IRF member device must have a BFD MAD link to the intermediate device.
- Each member device is assigned a MAD IP address on the master's management Ethernet port.

Follow these guidelines when you use management Ethernet ports for BFD MAD:

- As a best practice, use the management Ethernet ports for BFD MAD only if you will not access the device through the management Ethernet ports for out-of-band management.
- You can establish direct BFD links between management ports only if the IRF fabric has two member devices.
- If you directly connect the management ports on a two-member IRF fabric, you will be unable to access the device at the IP address of the management ports for out-of-band management. To access the device remotely, you must connect to the IP address of a common Layer 3 interface for in-band management.
- As a best practice, do not access the device at the IP address of the management ports after they are used for BFD MAD. Doing so might cause unexpected issues and interference with

BFD MAD. To access the device, connect to the IP address of a common Layer 3 interface for in-band management.

If common Ethernet ports are used, BFD MAD has the following requirements:

- If an intermediate device is used, each member device must have a BFD MAD link to the intermediate device. If no intermediate device is used, all member devices must have a BFD MAD link to each other. As a best practice, use an intermediate device to connect IRF member devices if the IRF fabric has more than two member devices. A full mesh of IRF members might cause broadcast loops.
- Ports on BFD MAD links are assigned to the same VLAN. Each member device is assigned a MAD IP address on the VLAN interface.

The BFD MAD links and BFD MAD VLAN must be dedicated. Do not use the BFD MAD links or BFD MAD VLAN for any other purposes.

NOTE:

- The MAD addresses identify the member devices and must belong to the same subnet.
- Of all management Ethernet ports on an IRF fabric, only the master's management Ethernet port is accessible.

Figure 9 shows a typical BFD MAD scenario that uses an intermediate device. On the intermediate device, assign the ports on the BFD MAD links to the same VLAN.

Figure 10 shows a typical BFD MAD scenario that does not use an intermediate device.

With BFD MAD, the master attempts to establish BFD sessions with other member devices by using its MAD IP address as the source IP address.

- If the IRF fabric is integrated, only the MAD IP address of the master takes effect. The master cannot establish a BFD session with any other member. If you execute the **`display bfd session`** command, the state of the BFD sessions is **Down**.
- When the IRF fabric splits, the IP addresses of the masters in the split IRF fabrics take effect. The masters can establish a BFD session. If you execute the **`display bfd session`** command, the state of the BFD session between the two devices is **Up**.

Figure 9 BFD MAD scenario with an intermediate device

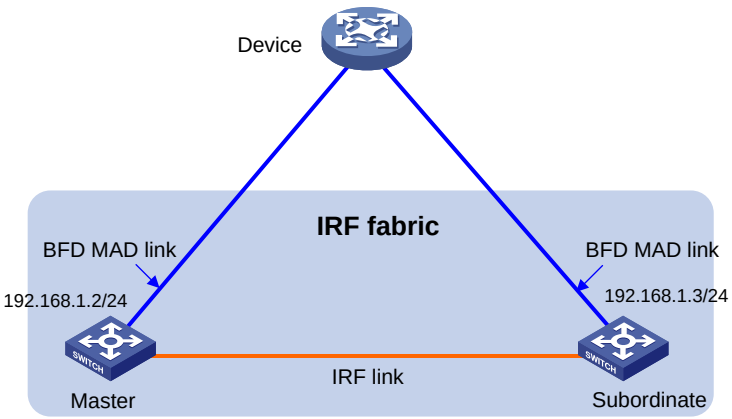
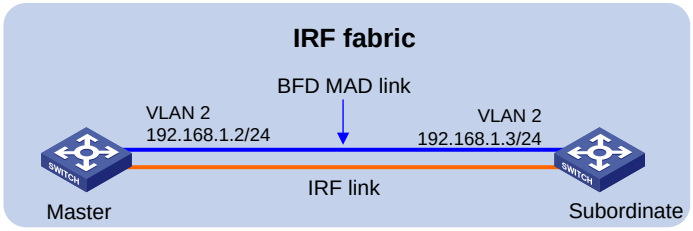


Figure 10 BFD MAD scenario without an intermediate device



ARP MAD

ARP MAD detects multi-active collisions by using extended ARP packets that convey the IRF domain ID and the active ID.

You can use common or management Ethernet ports for ARP MAD.

If management Ethernet ports are used, ARP MAD must work with an intermediate device. Make sure the following requirements are met:

- Connect a management Ethernet port on each member device to the intermediate device.
- On the intermediate device, you must assign the ports used for ARP MAD to the same VLAN.

Follow these guidelines when you use management Ethernet ports for ARP MAD:

- As a best practice, use the management Ethernet ports for ARP MAD only if you will not access the device through the management Ethernet ports for out-of-band management.
- You can establish direct ARP MAD links between management ports only if the IRF fabric has two member devices.
- If you directly connect the management ports on a two-member IRF fabric, you will be unable to access the device at the IP address of the management ports for out-of-band management. To access the device remotely, you must connect to the IP address of a common Layer 3 interface for in-band management.
- As a best practice, do not access the device at the IP address of the management ports after they are used for ARP MAD. Doing so might cause unexpected issues and interference with ARP MAD. To access the device, connect to the IP address of a common Layer 3 interface for in-band management.

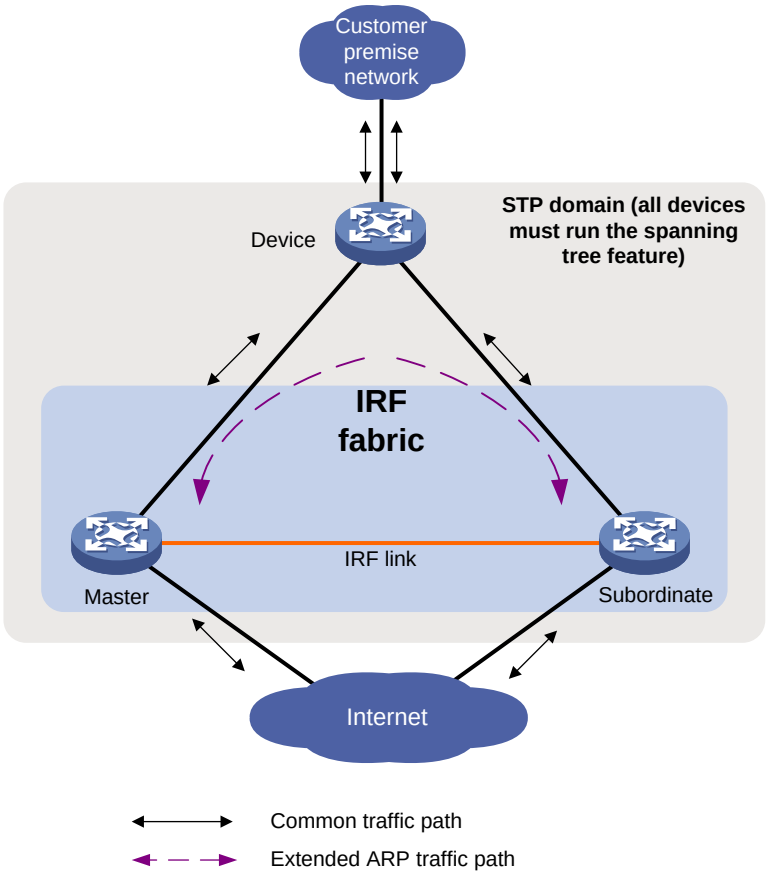
If common Ethernet ports are used, ARP MAD can work with or without an intermediate device. Make sure the following requirements are met:

- If an intermediate device is used, connect each IRF member device to the intermediate device, as shown in Figure 11. Run the spanning tree feature between the IRF fabric and the intermediate device. In this situation, data links can be used.
- If no intermediate device is used, connect each IRF member device to all other member devices. In this situation, IRF links cannot be used for ARP MAD.

Each IRF member compares the domain ID and the active ID (the member ID of the master) in incoming extended ARP packets with its domain ID and active ID.

- If the domain IDs are different, the extended ARP packet is from a different IRF fabric. The device does not continue to process the packet with the MAD mechanism.
- If the domain IDs are the same, the device compares the active IDs.
  - If the active IDs are different, the IRF fabric has split.
  - If the active IDs are the same, the IRF fabric is integrated.

Figure 11 ARP MAD scenario (common Ethernet ports)



ND MAD

ND MAD detects multi-active collisions by using NS packets to transmit the IRF domain ID and the active ID.

You can use common or management Ethernet ports for ND MAD.

If management Ethernet ports are used, ND MAD must work with an intermediate device. Make sure the following requirements are met:

- Connect a management Ethernet port on each member device to the intermediate device.
- On the intermediate device, you must assign the ports used for ND MAD to the same VLAN.

Follow these guidelines when you use management Ethernet ports for ND MAD:

- As a best practice, use the management Ethernet ports for ND MAD only if you will not access the device through the management Ethernet ports for out-of-band management.
- You can establish direct ND MAD links between management ports only if the IRF fabric has two member devices.
- If you directly connect the management ports on a two-member IRF fabric, you will be unable to access the device at the IP address of the management ports for out-of-band management. To access the device remotely, you must connect to the IP address of a common Layer 3 interface for in-band management.
- As a best practice, do not access the device at the IP address of the management ports after they are used for ND MAD. Doing so might cause unexpected issues and interference with ND MAD. To access the device, connect to the IP address of a common Layer 3 interface for in-band management.

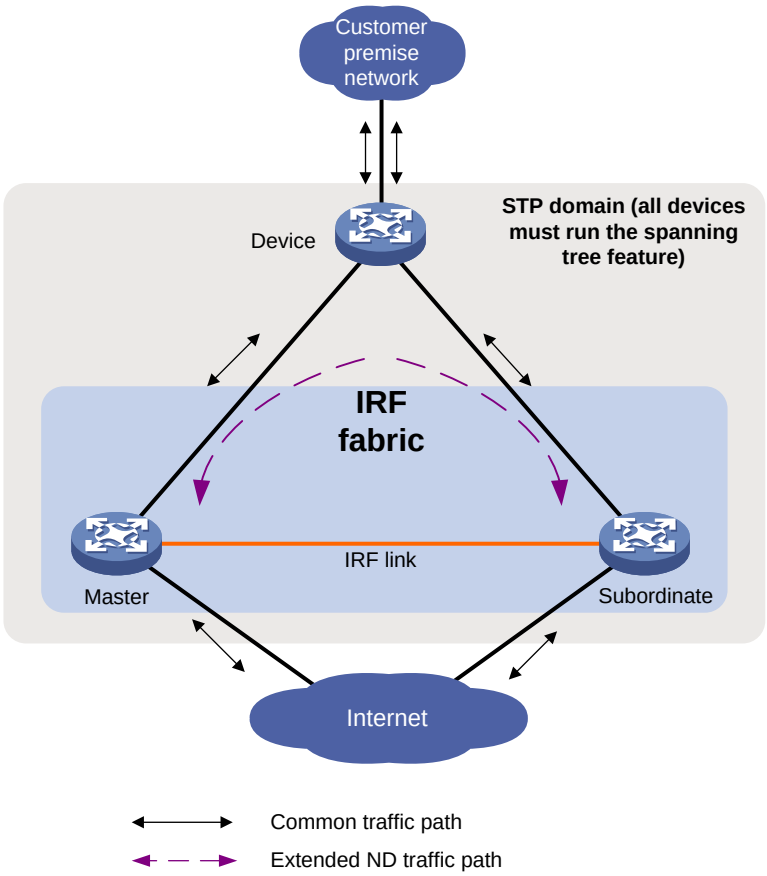
If common Ethernet ports are used, ND MAD can work with or without an intermediate device. Make sure the following requirements are met:

- If an intermediate device is used, connect each IRF member device to the intermediate device, as shown in Figure 12. Run the spanning tree feature between the IRF fabric and the intermediate device. In this situation, data links can be used.
- If no intermediate device is used, connect each IRF member device to all other member devices. In this situation, IRF links cannot be used for ND MAD.

Each IRF member device compares the domain ID and the active ID (the member ID of the master) in incoming NS packets with its domain ID and active ID.

- If the domain IDs are different, the NS packet is from a different IRF fabric. The device does not continue to process the packet with the MAD mechanism.
- If the domain IDs are the same, the device compares the active IDs.
  - If the active IDs are different, the IRF fabric has split.
  - If the active IDs are the same, the IRF fabric is integrated.

Figure 12 ND MAD scenario (common Ethernet ports)



Restrictions and guidelines: IRF configuration

Hardware compatibility with IRF

A switch from the following switch series can form an IRF fabric only with switches in the same series:

- S5110V2.

- S5110V2-SI.
- S5120V3-SI.
- S5000V3-EI.
- S5000V5-EI.
- S5000E-X.
- S5000X-EI.
- S5120V2-LI.
- S5130S-LI.
- S5120V3-LI.
- S3100V3-SI.
- MS4320V2.
- MS4320V3.
- MS4320.
- MS4200.
- MS4300V2.
- WS5810-WiNet.
- WS5820-WiNet.
- WAS6000.

Switches from different switch series cannot form an IRF fabric.

In addition, models in some of the switch series are grouped, as shown in Table 2. If a series has model groups, you can use only models in the same group to establish an IRF fabric.

Table 2 Model-grouped switch series

Switch series	Groups
S5120V3-LI	**Group 1**: S5120V3-LI switches with the following product codes: • LS-5120V3-20P-LI. • LS-5120V3-28P-LI. • LS-5120V3-52P-LI. • LS-5120V3-28P-PWR-LI. • LS-5120V3-52P-PWR-LI. **Group 2**: The S5120V3-LI switch models not listed in group 1.
S3100V3-SI	**Group 1**: S3100V3-SI switches with the following product codes: • LS-3100V3-28TP-SI-H1. • LS-3100V3_18TP_SI-H1. • LS-3100V3_52TP_SI-H1. • LS-3100V3_20TP_PWR_SI-H1. **Group 2**: The S3100V3-SI switch models not listed in group 1.
MS4320V2	**Group 1**: MS4320V2-28F. **Group 2**:

	• MS4320V2-28S-PWR. • MS4320V2-52S. • MS4320V2-28S.
MS4320V3	**Group 1**: MS4320V3 switches with the following product codes: • LS-MS4320V3-28P. • LS-MS4320V3-52P. **Group 2**: The MS4320V3 switch models not listed in group 1.
MS4320	**Group 1**: MS4320S-28F-H3. **Group 2**: • MS4320S-20P-PWR. • MS4320S-28P-PWR. • MS4320S-52P. • MS4320S-28P-H3.
MS4200	**Group 1**: MS4200 switches with the following product codes: • LS-MS4200-28TP-H1. • LS-MS4200_20TP_PWR-H1. • LS-MS4200_18TP-H1. **Group 2**: The MS4200 switch models not listed in group 1.
MS4300V2	**Group 1**: MS4300V2-10P. **Group 2**: • MS4300V2-28P. • MS4300V2-52P.
WS5810-WiNet	**Group 1**: WS5810-WiNet switches with product code WS5820-10P-WiNet. **Group 2**: WS5810-WiNet switch models not listed in group 1.
WS5820-WiNet	**Group 1**: WS5820-28P-POE-WiNet. **Group 2**: • WS5820-28P-WiNet. • WS5820-52X-WiNet. • WS5820-28X-WiNet. • WS5820-28X-POE-WiNet. • WS5820-28TP-POE-WiNet. • WS5820-52TP-WiNet.
WAS6000	**Group 1**: • WAS6108-HPWR. • WAS6108. • WAS6124-X **Group 2**: WAS6000 switch models not listed in group 1.

Software requirements for IRF

All IRF member devices must run the same software image version. Make sure the software auto-update feature is enabled on all member devices.

Candidate IRF physical interfaces

You can use 10G or 1G Ethernet ports as IRF physical interfaces, depending on the device model.

- The 10G or 1G Ethernet ports must operate at 10 Gbps or 1 Gbps, respectively, when they are used as IRF physical interfaces.
- The ports bound to an IRF port must belong to the same port group. However, ports in the same group can be bound to different IRF ports. To obtain the port group information, execute the **`debug port mapping`** command in probe view and view the **Unit** value for each port. Ports in one port group have the same **Unit** value.

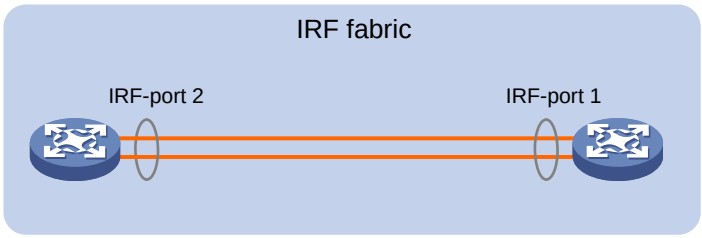
For more information about the ports that can be used as IRF physical interfaces, the port group information, and the available transceiver modules and cables, see IRF fabric setup in the switch installation guide.

IRF port connection

When you connect two neighboring IRF members, follow these restrictions and guidelines:

- You must connect the physical interfaces of IRF-port 1 on one member to the physical interfaces of IRF-port 2 on the other.
- For high availability, bind multiple physical interfaces to an IRF port. You can bind a maximum of eight physical interfaces to an IRF port. Due to hardware restrictions, you might be unable to bind as many as eight physical interfaces to an IRF port.

Figure 13 Connecting IRF physical interfaces



IRF physical interface configuration restrictions and guidelines

Command configuration restrictions

On a physical interface bound to an IRF port, you can execute only the following commands:

- Basic interface commands, including **`shutdown`** and **`description`**. For more information about these commands, see Ethernet interface commands in *Layer 2—LAN Switching Command Reference*.
- The **`flow-interval`** command, which sets the statistics polling interval on an interface. For more information about this command, see Ethernet interface commands in *Layer 2—LAN Switching Command Reference*.

- The **`port link-flap protect enable`** command, which enables link flapping protection on an interface. To prevent IRF link flapping from affecting system performance, link flapping protection acts differently on IRF physical interfaces than on common network interfaces, as follows:
  - Link flapping protection is enabled by default on IRF physical interfaces. This feature takes effect on an IRF physical interface as long as it is enabled on that interface, regardless of whether link flapping protection has been enabled globally.
  - If the number of link flappings on an IRF physical interface crosses the link flapping threshold during a flapping detection interval, the system displays event messages. However, the system does not shut down that IRF physical interface as it would do with a common network interface.

  For more information about this command, see Ethernet interface commands in *Layer 2—LAN Switching Command Reference*.
- The **`mirroring-group reflector-port`** command, which specifies the physical interface as a reflector port for remote mirroring. For more information about this command, see port mirroring in *Network Management and Monitoring Command Reference*.

IMPORTANT:

Do not execute the **`mirroring-group reflector-port`** command on an IRF physical interface if that interface is the only member interface of an IRF port. Doing so will split the IRF fabric, because this command also removes the binding of the physical interface and IRF port.

Suppressing SNMP notifications of packet drops on IRF physical interfaces

Before an IRF member device forwards a packet, it examines its forwarding path in the IRF fabric for a loop. If a loop exists, the device discards the packet on the source interface of the looped path. This loop elimination mechanism will drop a large number of broadcast packets on the IRF physical interfaces.

To suppress SNMP notifications of packet drops that do not require attention, do not monitor packet forwarding on the IRF physical interfaces.

Configuration rollback restrictions

The configuration rollback feature cannot roll back the following IRF settings:

- Member device description (set by using the **`irf member description`** command).
- Member device priority (set by using the **`irf member priority`** command).
- IRF physical interface and IRF port bindings (set by using the **`port group interface`** command).

For more information about the configuration rollback feature, see configuration file management in *Fundamentals Configuration Guide*.

IRF tasks at a glance

To configure IRF, perform the following tasks:

1. Setting up an IRF fabric
2. Configuring MAD

   Configure a minimum of one MAD mechanism on an IRF fabric. For the MAD compatibility, see "MAD mechanism compatibility."
   - Configuring LACP MAD
   - Configuring BFD MAD

- Configuring ARP MAD
- Configuring ND MAD
- Excluding interfaces from the shutdown action upon detection of multi-active collision

  This feature excludes an interface from the shutdown action for management or other special purposes when an IRF fabric transits to the Recovery state.
- Recovering an IRF fabric

3. (Optional.) Optimizing IRF settings for an IRF fabric
   - Configuring a member device description
   - Configuring IRF bridge MAC address settings
   - Enabling software auto-update for software image synchronization

     This feature automatically synchronizes the current software images of the master to devices that are attempting to join the IRF fabric.
   - Setting the IRF link status change report delay

Planning the IRF fabric setup

Consider the following items when you plan an IRF fabric:

- Hardware compatibility and restrictions.
- IRF fabric size.
- Master device.
- Member ID and priority assignment scheme.
- Fabric topology and cabling scheme.
- IRF physical interfaces.

Setting up an IRF fabric

IRF setup tasks at a glance

To set up an IRF fabric, perform the following tasks:

1. Configure member IDs, priorities, and IRF physical interfaces separately.
   a. Assigning a member ID to each IRF member device
   b. (Optional.) Specifying a priority for each member device
   c. Binding physical interfaces to IRF ports

   Skip these tasks if you configure member IDs, priorities, domain ID, and IRF physical interfaces in bulk.
2. Bulk-configuring basic IRF settings for a member device

   Skip this task if you configure member IDs, priorities, domain ID, and IRF physical interfaces separately.
3. Connecting IRF physical interfaces
4. Accessing the IRF fabric

Assigning a member ID to each IRF member device

Restrictions and guidelines

CAUTION:
An IRF member ID change can invalidate member ID-related settings and cause data loss. Make sure you fully understand its impact on your live network.

To create an IRF fabric, you must assign a unique IRF member ID to each member device.

The new member ID of a device takes effect at a reboot. After the device reboots, the settings on all member ID-related physical resources (including common physical network interfaces) are removed, regardless of whether you have saved the configuration.

Procedure

1. Enter system view.
   system-view
2. Assign a member ID to a member device.
   irf member *member-id* **renumber** *new-member-id*
   The default IRF member ID is 1.

   CAUTION:
   An IRF member ID change can invalidate member ID-related settings and cause data loss. Make sure you fully understand its impact on your live network.
3. (Optional.) Save the configuration.
   save
   If you have bound physical interfaces to IRF ports or assigned member priority, you must perform this step for these settings to take effect after the reboot.
4. Return to user view.
   quit
5. Reboot the device.
   reboot [**slot** *slot-number*] [**force**]

Specifying a priority for each member device

About specifying an IRF member priority

IRF member priority represents the possibility for a device to be elected the master in an IRF fabric. A larger priority value indicates a higher priority.

A change to member priority affects the election result at the next master election, but it does not cause an immediate master re-election.

Procedure

1. Enter system view.
   system-view
2. Specify a priority for the device.
   irf member *member-id* **priority** *priority*
   The default IRF member priority is 1.

Binding physical interfaces to IRF ports

Restrictions and guidelines

Select qualified physical interfaces as IRF physical interfaces as described in "Candidate IRF physical interfaces."

After binding physical interfaces to IRF ports for the first time, you must use the **irf-port-configuration active** command to activate the settings on the IRF ports.

The system activates the IRF port settings automatically only in the following situations:

- The configuration file that the device starts with contains IRF port bindings.
- You are adding physical interfaces to an IRF port (in UP state) after an IRF fabric is formed.

Procedure

1. Enter system view.

   system-view

2. Enter interface view or interface range view.
   - Enter interface view.

     interface *interface-type interface-number*
   - Enter interface range view. Choose one of the following commands:

     interface range { *interface-type interface-number* [**to** *interface-type interface-number*] } &<1-24>

     interface range name *name* [**interface** { *interface-type interface-number* [**to** *interface-type interface-number*] } &<1-24>]

   To shut down a range of IRF physical interfaces, enter interface range view.

   To shut down one IRF physical interface, enter its interface view.

3. Shut down the physical interfaces.

   shutdown

   By default, a physical interface is not administratively down.

4. Return to system view.

   quit

5. Enter IRF port view.

   irf-port *member-id/irf-port-number*

6. Bind each physical interface to the IRF port.

   port group interface *interface-type interface-number*

   By default, no physical interfaces are bound to an IRF port.

   Repeat this step to assign multiple physical interfaces to the IRF port.

7. Return to system view.

   quit

8. Enter interface view or interface range view.
   - Enter interface view.

     interface *interface-type interface-number*
   - Enter interface range view. Choose one of the following commands:

     interface range { *interface-type interface-number* [**to** *interface-type interface-number*] } &<1-24>

     interface range name *name* [**interface** { *interface-type interface-number* [**to** *interface-type interface-number*] } &<1-24>]

9. Bring up the physical interfaces.

   undo shutdown

10. Return to system view.

    quit

11. Save the configuration.

    save

    Activating IRF port configurations causes IRF merge and reboot. To avoid data loss, save the running configuration to the startup configuration file before you perform the operation.

12. Activate the IRF port settings.

    irf-port-configuration active

Bulk-configuring basic IRF settings for a member device

About easy IRF

Use the easy IRF feature to bulk-configure basic IRF settings for a member device, including the member ID, domain ID, priority, and IRF port bindings.

The easy IRF feature provides the following configuration methods:

- **Interactive method**—Enter the **easy-irf** command without parameters. The system will guide you to set the parameters step by step.
- **Non-interactive method**—Enter the **easy-irf** command with parameters.

As a best practice, use the interactive method if you are new to IRF.

Restrictions and guidelines

The member device reboots immediately after you specify a new member ID for it. Make sure you are aware of the impact on the network.

If you execute the **easy-irf** command multiple times, the following settings take effect:

- The most recent settings for the member ID, domain ID, and priority.
- IRF port bindings added through repeated executions of the command. To remove an IRF physical interface from an IRF port, you must use the **undo port group interface** command in IRF port view.

If you specify IRF physical interfaces by using the interactive method, you must also follow these restrictions and guidelines:

- Do not enter spaces between the interface type and interface number.
- Use a comma (,) to separate two physical interfaces. No spaces are allowed between interfaces.

Procedure

1. Enter system view.

   system-view

2. Bulk-configure basic IRF settings for the device.

   easy-irf [**member** *member-id* [**renumber** *new-member-id*] **domain** *domain-id* [**priority** *priority*] [**irf-port1** *interface-list1*] [**irf-port2** *interface-list2*]]

   Make sure the new member ID is unique in the IRF fabric to which the device will be added.

Connecting IRF physical interfaces

Follow the restrictions in "IRF port connection" to connect IRF physical interfaces as well as based on the topology and cabling scheme. The devices perform master election. The member devices that fail the master election automatically reboot to form an IRF fabric with the master device.

Accessing the IRF fabric

The IRF fabric appears as one device after it is formed. You configure and manage all IRF members at the CLI of the master. All settings you have made are automatically propagated to the IRF members.

The following methods are available for accessing an IRF fabric:

- **Local login**—Log in through the console port of any member device.
- **Remote login**—Log in at a Layer 3 interface on any member device by using methods including Telnet and SNMP.

When you log in to an IRF fabric, you are placed at the CLI of the master, regardless of at which member device you are logged in.

For more information, see login configuration in *Fundamentals Configuration Guide*.

Configuring MAD

Restrictions and guidelines for MAD configuration

Hardware compatibility with MAD

Some models do not have management Ethernet ports. They do not support configuring MAD on a management Ethernet port. For information about these models, see the installation guide.

MAD mechanism compatibility

As a best practice, configure a minimum of one MAD mechanism on an IRF fabric for prompt IRF split detection. Because MAD mechanisms use different collision handling processes, follow these restrictions and guidelines when you configure multiple MAD mechanisms on an IRF fabric:

- Do not configure LACP MAD together with ARP MAD or ND MAD.
- Do not configure BFD MAD together with ARP MAD or ND MAD.

Assigning IRF domain IDs

An IRF fabric has only one IRF domain ID. You can change the IRF domain ID by using the following commands: **`irf domain`**, **`mad enable`**, **`mad arp enable`**, or **`mad nd enable`**. The IRF domain IDs configured by using these commands overwrite each other.

If LACP MAD, ARP MAD, or ND MAD runs between two IRF fabrics, assign each fabric a unique IRF domain ID. (For BFD MAD, this task is optional.)

Actions on interfaces shut down by MAD

To prevent a multi-active collision from causing network issues, avoid using the **`undo shutdown`** command to bring up the interfaces shut down by a MAD mechanism on a Recovery-state IRF fabric.

Configuring LACP MAD

1. Enter system view.

system-view

2. Assign a domain ID to the IRF fabric.

   irf domain *domain-id*

   The default IRF domain ID is 0.

> **CAUTION:**
>
> Changing the IRF domain ID of an IRF member device will remove that member device from the IRF fabric. This member device will be unable to exchange IRF protocol packets with the remaining member devices in the IRF fabric.

3. Create a Layer 2 aggregate interface and enter its view.

   interface bridge-aggregation *interface-number*

   Perform this step also on the intermediate device.

4. Configure the aggregation group to operate in dynamic aggregation mode.

   link-aggregation mode dynamic

   By default, an aggregation group operates in static aggregation mode.

   LACP MAD takes effect only on dynamic aggregate interfaces.

   Perform this step also on the intermediate device.

5. Enable LACP MAD.

   mad enable

   By default, LACP MAD is disabled.

6. Return to system view.

   quit

7. Enter Ethernet interface view or interface range view.

   - Enter Ethernet interface view.

     interface *interface-type interface-number*

   - Enter interface range view. Choose one of the following commands:

     interface range { *interface-type interface-number* [**to** *interface-type interface-number*] } &<1-24>

     interface range name *name* [**interface** { *interface-type interface-number* [**to** *interface-type interface-number*] } &<1-24>]

   To assign a range of ports to the aggregation group, enter interface range view.

   To assign one port to the aggregation group, enter Ethernet interface view.

8. Assign the Ethernet port or the range of Ethernet ports to the specified aggregation group.

   port link-aggregation group *group-id*

   Multichassis link aggregation is allowed.

   Perform this step also on the intermediate device.

Configuring BFD MAD

Restrictions and guidelines for configuring BFD MAD

As a best practice, use the following procedure to set up BFD MAD:

1. Choose a BFD MAD link scheme as described in "BFD MAD."
2. Configure BFD MAD.
3. Connect the BFD MAD links.

When you configure BFD MAD on a VLAN interface, follow these restrictions and guidelines:

Category	Restrictions and guidelines

BFD MAD VLAN	• Do not enable BFD MAD on VLAN-interface 1.
	• If you are using an intermediate device, perform the following tasks:
	  ○ On the IRF fabric and the intermediate device, create a VLAN for BFD MAD.
	  ○ On the IRF fabric and the intermediate device, assign the ports of BFD MAD links to the BFD MAD VLAN.
	  ○ On the IRF fabric, create a VLAN interface for the BFD MAD VLAN.
	• Make sure the IRF fabrics on the network use different BFD MAD VLANs.
	• Make sure the BFD MAD VLAN contains only ports on the BFD MAD links. Exclude a port from the BFD MAD VLAN if that port is not on a BFD MAD link. If you have assigned that port to all VLANs by using the **`port trunk permit vlan all`** command, use the **`undo port trunk permit`** command to exclude that port from the BFD MAD VLAN.

BFD MAD VLAN and feature compatibility	Do not use the BFD MAD VLAN and its member ports for any purpose other than configuring BFD MAD. • Use only the **`mad bfd enable`** and **`mad ip address`** commands on the BFD MAD-enabled VLAN interface. If you configure other features, both BFD MAD and other features on the interface might run incorrectly. • Disable the spanning tree feature on any Layer 2 Ethernet ports in the BFD MAD VLAN. The MAD feature is mutually exclusive with the spanning tree feature.
MAD IP address	• To avoid network issues, only use the **`mad ip address`** command to configure IP addresses on the BFD MAD-enabled VLAN interface. Do not configure an IP address by using the **`ip address`** command or configure a VRRP virtual address on the BFD MAD-enabled VLAN interface. • Make sure all the MAD IP addresses are on the same subnet.

When you configure BFD MAD on a management Ethernet port, follow these restrictions and guidelines:

Category	Restrictions and guidelines
Management Ethernet ports for BFD MAD	Connect a management Ethernet port on each IRF member device to the common Ethernet ports on the intermediate device.
BFD MAD VLAN	• On the intermediate device, create a VLAN for BFD MAD, and assign the ports used for BFD MAD to the VLAN. On the IRF fabric, you do not need to assign the management Ethernet ports to the VLAN. • Make sure the IRF fabrics on the network use different BFD MAD VLANs. • Make sure the BFD MAD VLAN on the intermediate device contains only ports on the BFD MAD links.
MAD IP address	• Use the **`mad ip address`** command instead of the **`ip address`** command to configure MAD IP addresses on the BFD MAD-enabled management Ethernet ports. • Make sure all the MAD IP addresses are on the same subnet.

Configuring BFD MAD on a VLAN interface

1. Enter system view.

   `system-view`

2. (Optional.) Assign a domain ID to the IRF fabric.

   irf domain *domain-id*

   By default, the domain ID of an IRF fabric is 0.

CAUTION:

Changing the IRF domain ID of an IRF member device will remove that member device from the IRF fabric. This member device will be unable to exchange IRF protocol packets with the remaining member devices in the IRF fabric.

3. Create a VLAN dedicated to BFD MAD.

   vlan *vlan-id*

   By default, only VLAN 1 exists.

   Do not enable BFD MAD on VLAN-interface 1.

   Perform this step also on the intermediate device (if any).

4. Return to system view.

   quit

5. Enter Ethernet interface view or interface range view.

   - Enter Ethernet interface view.

     interface *interface-type interface-number*

   - Enter interface range view. Choose one of the following commands:

     interface range { *interface-type interface-number* [**to** *interface-type interface-number*] } &<1-24>

     interface range name *name* [**interface** { *interface-type interface-number* [**to** *interface-type interface-number*] } &<1-24>]

   To assign a range of ports to the BFD MAD VLAN, enter interface range view.

   To assign one port to the BFD MAD VLAN, enter Ethernet interface view.

6. Assign the port or the range of ports to the BFD MAD VLAN.

   - Assign the ports to the VLAN as access ports.

     port access vlan *vlan-id*

   - Assign the ports to the VLAN as trunk ports.

     port trunk permit vlan *vlan-id*

   - Assign the ports to the VLAN as hybrid ports.

     port hybrid vlan *vlan-id* { **tagged** | **untagged** }

   The link type of BFD MAD ports can be access, trunk, or hybrid.

   The default link type of a port is access.

   Perform this step also on the intermediate device (if any).

7. Return to system view.

   quit

8. Enter VLAN interface view.

   interface vlan-interface *vlan-interface-id*

9. Enable BFD MAD.

   mad bfd enable

   By default, BFD MAD is disabled.

10. Assign a MAD IP address to a member device on the VLAN interface.

    mad ip address *ip-address* { *mask* | *mask-length* } **member** *member-id*

By default, no MAD IP addresses are configured on any VLAN interfaces.

Repeat this step to assign a MAD IP address to each member device on the VLAN interface.

Configuring BFD MAD on a management Ethernet port

1. Enter system view.

   system-view

2. (Optional.) Assign a domain ID to the IRF fabric.

   irf domain *domain-id*

   By default, the domain ID of an IRF fabric is 0.

CAUTION:

Changing the IRF domain ID of an IRF member device will remove that member device from the IRF fabric. This member device will be unable to exchange IRF protocol packets with the remaining member devices in the IRF fabric.

3. Enter management Ethernet interface view.

   interface m-gigabitethernet *interface-number*

   Of all management Ethernet ports on an IRF fabric, only the master's management Ethernet port is accessible.

4. Enable BFD MAD.

   mad bfd enable

   By default, BFD MAD is disabled.

5. Assign a MAD IP address to each member device.

   mad ip address *ip-address* { *mask* | *mask-length* } **member** *member-id*

   By default, no MAD IP addresses are configured.

Configuring ARP MAD

Restrictions and guidelines for configuring ARP MAD

As a best practice, use the following procedure to set up ARP MAD:

1. Choose an ARP MAD link scheme as described in "ARP MAD."
2. Configure ARP MAD.
3. Connect the ARP MAD links if you are not using existing data links as ARP MAD links.

When you configure ARP MAD on a VLAN interface, follow these restrictions and guidelines:

Category	Restrictions and guidelines

ARP MAD VLAN	• Do not enable ARP MAD on VLAN-interface 1.
	• If you are using an intermediate device, perform the following tasks:
	  ○ On the IRF fabric and the intermediate device, create a VLAN for ARP MAD.
	  ○ On the IRF fabric and the intermediate device, assign the ports of ARP MAD links to the ARP MAD VLAN.
	  ○ On the IRF fabric, create a VLAN interface for the ARP MAD VLAN.
	• Do not use the ARP MAD VLAN for any other purposes.

ARP MAD and feature configuration	If an intermediate device is used, make sure the following requirements are met: • Run the spanning tree feature between the IRF fabric and the intermediate device to ensure that there is only one ARP MAD link in forwarding state. For more information about the spanning tree feature

Category	Restrictions and guidelines
	and its configuration, see *Layer 2—LAN Switching Configuration Guide*. • Enable the IRF fabric to change its bridge MAC address as soon as the address owner leaves. • If the intermediate device is also an IRF fabric, assign the two IRF fabrics different domain IDs for correct split detection.

When you configure ARP MAD on a management Ethernet port, follow these restrictions and guidelines:

Category	Restrictions and guidelines
Management Ethernet ports for ARP MAD	Connect a management Ethernet port on each member device to the common Ethernet ports on the intermediate device.
ARP MAD VLAN	On the intermediate device, create a VLAN for ARP MAD, and assign the ports used for ARP MAD to the VLAN. On the IRF fabric, you do not need to assign the management Ethernet ports to the VLAN.
ARP MAD and feature configuration	• Enable the IRF fabric to change its bridge MAC address as soon as the address owner leaves. • If the intermediate device is also an IRF fabric, assign the two IRF fabrics different domain IDs for correct split detection.

Configuring ARP MAD on a VLAN interface

1. Enter system view.

   `system-view`
2. Assign a domain ID to the IRF fabric.

   `irf domain` *`domain-id`*

   The default IRF domain ID is 0.

CAUTION:

Changing the IRF domain ID of an IRF member device will remove that member device from the IRF fabric. This member device will be unable to exchange IRF protocol packets with the remaining member devices in the IRF fabric.

3. Configure the IRF bridge MAC address to change as soon as the address owner leaves.

   `undo irf mac-address persistent`

   By default, the IRF bridge MAC address remains unchanged for 6 minutes after the address owner leaves.

CAUTION:

IRF bridge MAC address change will cause transient traffic disruption.

4. Create a VLAN dedicated to ARP MAD.

   `vlan` *`vlan-id`*

   By default, only VLAN 1 exists.

   Do not configure ARP MAD on VLAN-interface 1.

   Perform this task also on the intermediate device (if any).
5. Return to system view.

   `quit`
6. Enter Ethernet interface view or interface range view.

- Enter Ethernet interface view.

  interface *interface-type interface-number*
- Enter interface range view. Choose one of the following commands:

  interface range { *interface-type interface-number* [**to** *interface-type interface-number*] } &<1-24>

  interface range name *name* [**interface** { *interface-type interface-number* [**to** *interface-type interface-number*] } &<1-24>]

To assign a range of ports to the ARP MAD VLAN, enter interface range view.

To assign one port to the ARP MAD VLAN, enter Ethernet interface view.

7. Assign the port or the range of ports to the ARP MAD VLAN.

- Assign the ports to the VLAN as access ports.

  port access vlan *vlan-id*
- Assign the ports to the VLAN as trunk ports.

  port trunk permit vlan *vlan-id*
- Assign the ports to the VLAN as hybrid ports.

  port hybrid vlan *vlan-id* { **tagged** | **untagged** }

The link type of ARP MAD ports can be access, trunk, or hybrid.

The default link type of a port is access.

Perform this task also on the intermediate device (if any).

8. Return to system view.

quit

9. Enter VLAN interface view.

interface vlan-interface *vlan-interface-id*

10. Assign the interface an IP address.

ip address *ip-address* { *mask* | *mask-length* }

By default, no IP addresses are assigned to any VLAN interfaces.

11. Enable ARP MAD.

mad arp enable

By default, ARP MAD is disabled.

Configuring ARP MAD on a management Ethernet port

1. Enter system view.

system-view

2. Assign a domain ID to the IRF fabric.

irf domain *domain-id*

The default IRF domain ID is 0.

CAUTION:

Changing the IRF domain ID of an IRF member device will remove that member device from the IRF fabric. This member device will be unable to exchange IRF protocol packets with the remaining member devices in the IRF fabric.

3. Configure the IRF bridge MAC address to change as soon as the address owner leaves.

undo irf mac-address persistent

By default, the IRF bridge MAC address remains unchanged for 6 minutes after the address owner leaves.

CAUTION:
IRF bridge MAC address change will cause transient traffic disruption.

4. Enter management Ethernet interface view.
   interface m-gigabitethernet *interface-number*
   Of all management Ethernet ports on an IRF fabric, only the master's management Ethernet port is accessible.
5. Assign an IP address to the management Ethernet port.
   ip address ip-address { *mask* | *mask-length* }
   By default, no IP addresses are configured.
6. Enable ARP MAD.
   mad arp enable
   By default, ARP MAD is disabled.

Configuring ND MAD

Restrictions and guidelines for configuring ND MAD

As a best practice, use the following procedure to set up ND MAD:

1. Choose an ND MAD link scheme as described in "ND MAD."
2. Configure ND MAD.
3. Connect the ND MAD links if you are not using existing data links as ND MAD links.

When you configure ND MAD on a VLAN interface, follow these restrictions and guidelines:

Category	Restrictions and guidelines

ND MAD VLAN	• Do not enable ND MAD on VLAN-interface 1.
	• If you are using an intermediate device, perform the following tasks:
	  ○ On the IRF fabric and the intermediate device, create a VLAN for ND MAD.
	  ○ On the IRF fabric and the intermediate device, assign the ports of ND MAD links to the ND MAD VLAN.
	  ○ On the IRF fabric, create a VLAN interface for the ND MAD VLAN.
	• Do not use the ND MAD VLAN for any other purposes.

ND MAD and feature configuration	If an intermediate device is used, make sure the following requirements are met: • Run the spanning tree feature between the IRF fabric and the intermediate device to ensure that there is only one ND MAD link in forwarding state. For more information about the spanning tree feature and its configuration, see *Layer 2—LAN Switching Configuration Guide*. • Enable the IRF fabric to change its bridge MAC address as soon as the address owner leaves. • If the intermediate device is also an IRF fabric, assign the two IRF fabrics different domain IDs for correct split detection.

When you configure ND MAD on a management Ethernet port, follow these restrictions and guidelines:

Category	Restrictions and guidelines
Management Ethernet ports for ND MAD	Connect a management Ethernet port on each member device to the common Ethernet ports on the intermediate device.

Category	Restrictions and guidelines
ND MAD VLAN	On the intermediate device, create a VLAN for ND MAD, and assign the ports used for ND MAD to the VLAN. On the IRF fabric, you do not need to assign the management Ethernet ports to the VLAN.
ND MAD and feature configuration	• Enable the IRF fabric to change its bridge MAC address as soon as the address owner leaves. • If the intermediate device is also an IRF fabric, assign the two IRF fabrics different domain IDs for correct split detection.

Configuring ND MAD on a VLAN interface

1. Enter system view.

   system-view

2. Assign a domain ID to the IRF fabric.

   irf domain *domain-id*

   The default IRF domain ID is 0.

   CAUTION:

   Changing the IRF domain ID of an IRF member device will remove that member device from the IRF fabric. This member device will be unable to exchange IRF protocol packets with the remaining member devices in the IRF fabric.

3. Configure the IRF bridge MAC address to change as soon as the address owner leaves.

   undo irf mac-address persistent

   By default, the IRF bridge MAC address remains unchanged for 6 minutes after the address owner leaves the fabric.

   CAUTION:

   IRF bridge MAC address change will cause transient traffic disruption.

4. Create a VLAN dedicated to ND MAD.

   vlan *vlan-id*

   By default, only VLAN 1 exists.

   Do not configure ND MAD on VLAN-interface 1.

   Perform this task also on the intermediate device (if any).

5. Return to system view.

   quit

6. Enter Ethernet interface view or interface range view.

   - Enter Ethernet interface view.

     interface *interface-type interface-number*

   - Enter interface range view. Choose one of the following commands:

     interface range { *interface-type interface-number* [**to** *interface-type interface-number*] } &<1-24>

     interface range name *name* [**interface** { *interface-type interface-number* [**to** *interface-type interface-number*] } &<1-24>]

   To assign a range of ports to the ND MAD VLAN, enter interface range view.

   To assign one port to the ND MAD VLAN, enter Ethernet interface view.

7. Assign the port or the range of ports to the ND MAD VLAN.

- Assign the ports to the VLAN as access ports.
  port access vlan *vlan-id*
- Assign the ports to the VLAN as trunk ports.
  port trunk permit vlan *vlan-id*
- Assign the ports to the VLAN as hybrid ports.
  port hybrid vlan *vlan-id* { **tagged** | **untagged** }

The link type of ND MAD ports can be access, trunk, or hybrid.

The default link type of a port is access.

Perform this task also on the intermediate device (if any).

8. Return to system view.
   quit
9. Enter VLAN interface view.
   interface vlan-interface *interface-number*
10. Assign the interface an IPv6 address.
    ipv6 address { *ipv6-address/prefix-length* | *ipv6-address prefix-length* }

    By default, no IPv6 addresses are assigned to a VLAN interface.
11. Enable ND MAD.
    mad nd enable

    By default, ND MAD is disabled.

Configuring ND MAD on a management Ethernet port

1. Enter system view.
   system-view
2. Assign a domain ID to the IRF fabric.
   irf domain *domain-id*

   The default IRF domain ID is 0.

CAUTION:

Changing the IRF domain ID of an IRF member device will remove that member device from the IRF fabric. This member device will be unable to exchange IRF protocol packets with the remaining member devices in the IRF fabric.

3. Configure the IRF bridge MAC address to change as soon as the address owner leaves.
   undo irf mac-address persistent

   By default, the IRF bridge MAC address remains unchanged for 6 minutes after the address owner leaves the fabric.

CAUTION:

IRF bridge MAC address change will cause transient traffic disruption.

4. Enter management Ethernet interface view.
   interface m-gigabitethernet *interface-number*

   Of all management Ethernet ports on an IRF fabric, only the master's management Ethernet port is accessible.
5. Assign an IPv6 address to the management Ethernet port.
   ipv6 address { *ipv6-address/pre-length* | *ipv6 address pre-length* }

By default, no IPv6 addresses are assigned to a management Ethernet port.

6. Enable ND MAD.

   mad nd enable

   By default, ND MAD is disabled.

Excluding interfaces from the shutdown action upon detection of multi-active collision

About excluding interfaces from being shut down

When an IRF fabric transits to the Recovery state, the system automatically excludes the following network interfaces from being shut down:

- IRF physical interfaces.
- Interfaces used for BFD MAD.
- Member interfaces of an aggregate interface if the aggregate interface is excluded from being shut down.

You can exclude an interface from the shutdown action for management or other special purposes. For example:

- Exclude a port from the shutdown action so you can Telnet to the port for managing the device.
- Exclude a VLAN interface and its Layer 2 ports from the shutdown action so you can log in through the VLAN interface.

Restrictions and guidelines

If the Layer 2 ports of a VLAN interface are distributed on multiple member devices, the exclusion operation might introduce IP collision risks. The VLAN interface might be up on both active and inactive IRF fabrics.

Procedure

1. Enter system view.

   system-view

2. Configure an interface to not shut down when the IRF fabric transits to the Recovery state.

   mad exclude interface *interface-type interface-number*

   By default, all network interfaces on a Recovery-state IRF fabric are shut down, except for the network interfaces automatically excluded by the system.

Recovering an IRF fabric

About recovering an IRF fabric

If the active IRF fabric fails before the IRF link is recovered, perform this task on the inactive IRF fabric to recover the inactive IRF fabric for traffic forwarding. The manual recovery operation brings up all interfaces that were shut down by MAD on the inactive IRF fabric.

Procedure

1. Enter system view.

   system-view

2. Recover the inactive IRF fabric.

   mad restore

Optimizing IRF settings for an IRF fabric

Configuring a member device description

1. Enter system view.
   system-view
2. Configure a description for a member device.
   irf member *member-id* **description** *text*
   By default, no member device description is configured.

Configuring IRF bridge MAC address settings

About IRF bridge MAC address configuration

The bridge MAC address of a system must be unique on a switched LAN. IRF bridge MAC address identifies an IRF fabric by Layer 2 protocols (for example, LACP) on a switched LAN.

By default, an IRF fabric uses the bridge MAC address of the master as the IRF bridge MAC address. After the master leaves, the IRF bridge MAC address persists for a period of time or permanently depending on the IRF bridge MAC persistence setting. When the IRF bridge MAC persistence timer expires, the IRF fabric uses the bridge MAC address of the current master as the IRF bridge MAC address.

If IRF fabric merge occurs, IRF determines the IRF bridge MAC address of the merged IRF fabric as follows:

1. When IRF fabrics merge, IRF ignores the IRF bridge MAC addresses and checks the bridge MAC address of each member device in the IRF fabrics. IRF merge fails if any two member devices have the same bridge MAC address.
2. After IRF fabrics merge, the merged IRF fabric uses the bridge MAC address of the merging IRF fabric that won the master election as the IRF bridge MAC address.

Restrictions and guidelines for IRF bridge MAC address configuration

CAUTION:
Bridge MAC address change will cause transient traffic disruption.

When you configure IRF bridge MAC persistence, follow these restrictions and guidelines:

- If ARP MAD or ND MAD is used with the spanning tree feature, you must disable IRF bridge MAC persistence by using the **undo irf mac-address persistent** command.
- If the IRF fabric has multichassis aggregate links, do not use the **undo irf mac-address persistent** command. Use of this command might cause traffic disruption.

Configuring IRF bridge MAC persistence

1. Enter system view.
   system-view
2. Configure IRF bridge MAC persistence.
   - Retain the bridge MAC address permanently even if the address owner has left the fabric.
     irf mac-address persistent always
   - Retain the bridge MAC address for 6 minutes after the address owner leaves the fabric.
     irf mac-address persistent timer
   - Change the bridge MAC address as soon as the address owner leaves the fabric.

undo irf mac-address persistent

By default, the IRF bridge MAC address remains unchanged for 6 minutes after the address owner leaves the fabric.

The **irf mac-address persistent timer** command avoids unnecessary bridge MAC address changes caused by device reboot, transient link failure, or purposeful link disconnection.

Enabling software auto-update for software image synchronization

About IRF software auto-update

The software auto-update feature automatically synchronizes the current software images of the master to devices that are attempting to join the IRF fabric.

To join an IRF fabric, a device must use the same software images as the master in the fabric.

When you add a device to the IRF fabric, software auto-update compares the startup software images of the device with the current software images of the IRF master. If the two sets of images are different, the device automatically performs the following operations:

1. Downloads the current software images of the master.
2. Sets the downloaded images as its main startup software images.
3. Reboots with the new software images to rejoin the IRF fabric.

You must manually update the new device with the software images running on the IRF fabric if software auto-update is disabled.

Restrictions and guidelines

To ensure a successful software auto-update in a multi-user environment, prevent anyone from rebooting member devices during the auto-update process. To inform administrators of the auto-update status, configure the information center to output the status messages to configuration terminals (see *Network Management and Monitoring Configuration Guide*).

Make sure the device you are adding to the IRF fabric has sufficient storage space for the new software images.

If sufficient storage space is not available, the device automatically deletes the current software images. If the reclaimed space is still insufficient, the device cannot complete the auto-update. You must reboot the device, and then access the BootWare menu to delete files.

Procedure

1. Enter system view.

   system-view
2. Enable software auto-update.

   irf auto-update enable

   By default, software auto-update is enabled.

Setting the IRF link status change report delay

About IRF link status change report delay

To prevent frequent IRF splits and merges during link flapping, configure the IRF ports to delay reporting link status change events.

An IRF port does not report a link status change event to the IRF fabric immediately after its link changes from up to down or from down to up. If the IRF link state change persists when the delay is reached, the port reports the change to the IRF fabric.

The device delays reporting link status change events of an IRF port, but it does not delay reporting link status change events of an IRF physical interface.

Restrictions and guidelines

Make sure the IRF link status change report delay is shorter than the heartbeat or hello timeout settings of upper-layer protocols (for example, CFD and OSPF). If the report delay is longer than the timeout setting of a protocol, unnecessary recalculations might occur.

Set the delay to 0 seconds in the following situations:

- The IRF fabric requires a fast master/subordinate or IRF link switchover.
- The RRPP, BFD, or GR feature is used.
- You want to shut down an IRF physical interface or reboot an IRF member device. (After you complete the operation, reconfigure the delay depending on the network condition.)

Procedure

1. Enter system view.
   `system-view`
2. Set the IRF link status change report delay.
   `irf link-delay` *`interval`*
   The default IRF link status change report delay is 4 seconds.

Display and maintenance commands for IRF

Execute **`display`** commands in any view.

Task	Command
Display information about all IRF members.	**`display irf`**
Display the IRF fabric topology.	**`display irf topology`**
Display IRF link information.	**`display irf link`**
Display IRF configuration.	**`display irf configuration`**
Display MAD configuration.	**`display mad`** [**`verbose`**]

IRF configuration examples

The IRF configuration examples show how to set up IRF fabrics that use different MAD mechanisms.

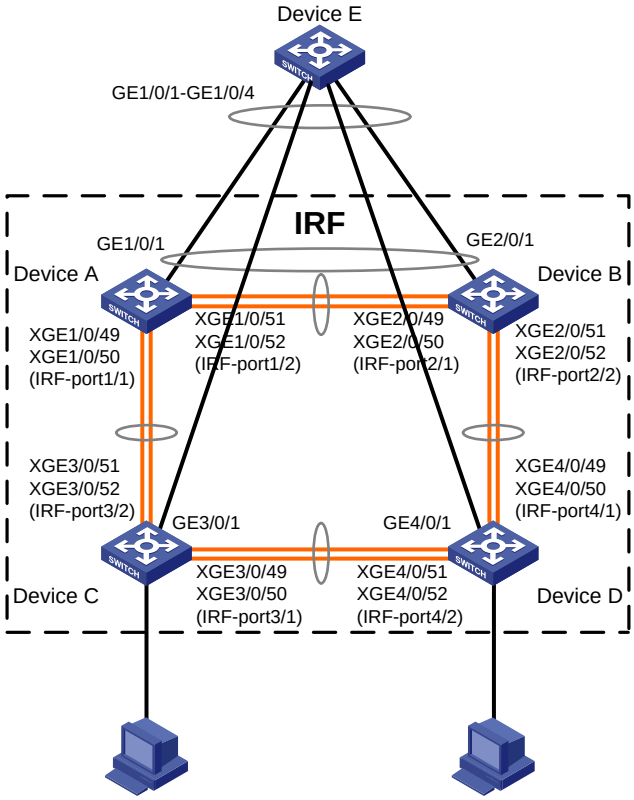
Example: Configuring an LACP MAD-enabled IRF fabric

Network configuration

As shown in Figure 14, set up a four-chassis IRF fabric at the access layer of the enterprise network.

Configure LACP MAD on the multichassis aggregation to Device E, which supports extended LACP.

Figure 14 Network diagram



Procedure

1. Configure Device A:

   # Shut down the physical interfaces used for IRF links. In this example, the physical interfaces are shut down in batch. For more information, see *Layer 2—LAN Switching Configuration Guide*.

   ```
   <Sysname> system-view
   [Sysname] interface range ten-gigabitethernet 1/0/49 to ten-gigabitethernet 1/0/52
   [Sysname-if-range] shutdown
   [Sysname-if-range] quit
   ```

   # Bind Ten-GigabitEthernet 1/0/49 and Ten-GigabitEthernet 1/0/50 to IRF-port 1/1.

   ```
   [Sysname] irf-port 1/1
   [Sysname-irf-port1/1] port group interface ten-gigabitethernet 1/0/49
   [Sysname-irf-port1/1] port group interface ten-gigabitethernet 1/0/50
   [Sysname-irf-port1/1] quit
   ```

   # Bind Ten-GigabitEthernet 1/0/51 and Ten-GigabitEthernet 1/0/52 to IRF-port 1/2.

   ```
   [Sysname] irf-port 1/2
   [Sysname-irf-port1/2] port group interface ten-gigabitethernet 1/0/51
   [Sysname-irf-port1/2] port group interface ten-gigabitethernet 1/0/52
   [Sysname-irf-port1/2] quit
   ```

   # Bring up the physical interfaces and save the configuration.

   ```
   [Sysname] interface range ten-gigabitethernet 1/0/49 to ten-gigabitethernet 1/0/52
   [Sysname-if-range] undo shutdown
   [Sysname-if-range] quit
   [Sysname] save
   ```

Activate the IRF port configuration.

```
[Sysname] irf-port-configuration active
```

2. Configure Device B:

Change the member ID of Device B to 2 and reboot the device to have the change take effect.

```
<Sysname> system-view
[Sysname] irf member 1 renumber 2
Renumbering the member ID may result in configuration change or loss. Continue? [Y/N]:y
[Sysname] quit
<Sysname> reboot
```

Connect Device B to Device A as shown in Figure 14, and log in to Device B. (Details not shown.)

Shut down the physical interfaces for IRF links.

```
<Sysname> system-view
[Sysname] interface range ten-gigabitethernet 2/0/49 to ten-gigabitethernet 2/0/52
[Sysname-if-range] shutdown
[Sysname-if-range] quit
```

Bind Ten-GigabitEthernet 2/0/49 and Ten-GigabitEthernet 2/0/50 to IRF-port 2/1.

```
[Sysname] irf-port 2/1
[Sysname-irf-port2/1] port group interface ten-gigabitethernet 2/0/49
[Sysname-irf-port2/1] port group interface ten-gigabitethernet 2/0/50
[Sysname-irf-port2/1] quit
```

Bind Ten-GigabitEthernet 2/0/51 and Ten-GigabitEthernet 2/0/52 to IRF-port 2/2.

```
[Sysname] irf-port 2/2
[Sysname-irf-port2/2] port group interface ten-gigabitethernet 2/0/51
[Sysname-irf-port2/2] port group interface ten-gigabitethernet 2/0/52
[Sysname-irf-port2/2] quit
```

Bring up the physical interfaces and save the configuration.

```
[Sysname] interface range ten-gigabitethernet 2/0/49 to ten-gigabitethernet 2/0/52
[Sysname-if-range] undo shutdown
[Sysname-if-range] quit
[Sysname] save
```

Activate the IRF port configuration.

```
[Sysname] irf-port-configuration active
```

The two devices perform master election, and the one that has lost the election reboots to form an IRF fabric with the master.

3. Configure Device C:

Change the member ID of Device C to 3 and reboot the device to have the change take effect.

```
<Sysname> system-view
[Sysname] irf member 1 renumber 3
Renumbering the member ID may result in configuration change or loss. Continue? [Y/N]:y
[Sysname] quit
<Sysname> reboot
```

Connect Device C to Device A as shown in Figure 14, and log in to Device C. (Details not shown.)

Shut down the physical interfaces for IRF links.

```
<Sysname> system-view
[Sysname] interface range ten-gigabitethernet 3/0/49 to ten-gigabitethernet 3/0/52
[Sysname-if-range] shutdown
```

```
[Sysname-if-range] quit
```

Bind Ten-GigabitEthernet 3/0/49 and Ten-GigabitEthernet 3/0/50 to IRF-port 3/1.

```
[Sysname] irf-port 3/1
[Sysname-irf-port3/1] port group interface ten-gigabitethernet 3/0/49
[Sysname-irf-port3/1] port group interface ten-gigabitethernet 3/0/50
[Sysname-irf-port3/1] quit
```

Bind Ten-GigabitEthernet 3/0/51 and Ten-GigabitEthernet 3/0/52 to IRF-port 3/2.

```
[Sysname] irf-port 3/2
[Sysname-irf-port3/2] port group interface ten-gigabitethernet 3/0/51
[Sysname-irf-port3/2] port group interface ten-gigabitethernet 3/0/52
[Sysname-irf-port3/2] quit
```

Bring up the physical interfaces and save the configuration.

```
[Sysname] interface range ten-gigabitethernet 3/0/49 to ten-gigabitethernet 3/0/52
[Sysname-if-range] undo shutdown
[Sysname-if-range] quit
[Sysname] save
```

Activate the IRF port configuration.

```
[Sysname] irf-port-configuration active
```

Device C reboots to join the IRF fabric.

4. Configure Device D:

Change the member ID of Device D to 4 and reboot the device to have the change take effect.

```
<Sysname> system-view
[Sysname] irf member 1 renumber 4
Renumbering the member ID may result in configuration change or loss. Continue? [Y/N]:y
[Sysname] quit
<Sysname> reboot
```

Connect Device D to Device B and Device C as shown in Figure 14, and log in to Device D. (Details not shown.)

Shut down the physical interfaces.

```
<Sysname> system-view
[Sysname] interface range ten-gigabitethernet 4/0/49 to ten-gigabitethernet 4/0/52
[Sysname-if-range] shutdown
[Sysname-if-range] quit
```

Bind Ten-GigabitEthernet 4/0/49 and Ten-GigabitEthernet 4/0/50 to IRF-port 4/1.

```
[Sysname] irf-port 4/1
[Sysname-irf-port4/1] port group interface ten-gigabitethernet 4/0/49
[Sysname-irf-port4/1] port group interface ten-gigabitethernet 4/0/50
[Sysname-irf-port4/1] quit
```

Bind Ten-GigabitEthernet 4/0/51 and Ten-GigabitEthernet 4/0/52 to IRF-port 4/2.

```
[Sysname] irf-port 4/2
[Sysname-irf-port4/2] port group interface ten-gigabitethernet 4/0/51
[Sysname-irf-port4/2] port group interface ten-gigabitethernet 4/0/52
[Sysname-irf-port4/2] quit
```

Bring up the physical interfaces and save the configuration.

```
[Sysname] interface range ten-gigabitethernet 4/0/49 to ten-gigabitethernet 4/0/52
[Sysname-if-range] undo shutdown
[Sysname-if-range] quit
```

```
[Sysname] save
```

Activate the IRF port configuration.

```
[Sysname] irf-port-configuration active
```

Device D reboots to join the IRF fabric. A four-chassis IRF fabric is formed.

5. Configure LACP MAD on the IRF fabric:

Set the domain ID of the IRF fabric to 1.

```
<Sysname> system-view
[Sysname] irf domain 1
```

Create a dynamic aggregate interface and enable LACP MAD.

```
[Sysname] interface bridge-aggregation 2
[Sysname-Bridge-Aggregation2] link-aggregation mode dynamic
[Sysname-Bridge-Aggregation2] mad enable
You need to assign a domain ID (range: 0-4294967295)
[Current domain ID is: 1]:
The assigned domain ID is: 1
[Sysname-Bridge-Aggregation2] quit
```

Assign GigabitEthernet 1/0/1, GigabitEthernet 2/0/1, GigabitEthernet 3/0/1, and GigabitEthernet 4/0/1 to the aggregate interface.

```
[Sysname] interface range gigabitethernet 1/0/1 gigabitethernet 2/0/1
gigabitethernet 3/0/1 gigabitethernet 4/0/1
[Sysname-if-range] port link-aggregation group 2
[Sysname-if-range] quit
```

6. Configure Device E as the intermediate device:

CAUTION:

If the intermediate device is also an IRF fabric, assign the two IRF fabrics different domain IDs for correct split detection. False detection causes IRF split.

Create a dynamic aggregate interface.

```
<Sysname> system-view
[Sysname] interface bridge-aggregation 2
[Sysname-Bridge-Aggregation2] link-aggregation mode dynamic
[Sysname-Bridge-Aggregation2] quit
```

Assign GigabitEthernet 1/0/1, GigabitEthernet 1/0/2, GigabitEthernet 1/0/3, and GigabitEthernet 1/0/4 to the aggregate interface.

```
[Sysname] interface range gigabitethernet 1/0/1 to gigabitethernet 1/0/4
[Sysname-if-range] port link-aggregation group 2
[Sysname-if-range] quit
```

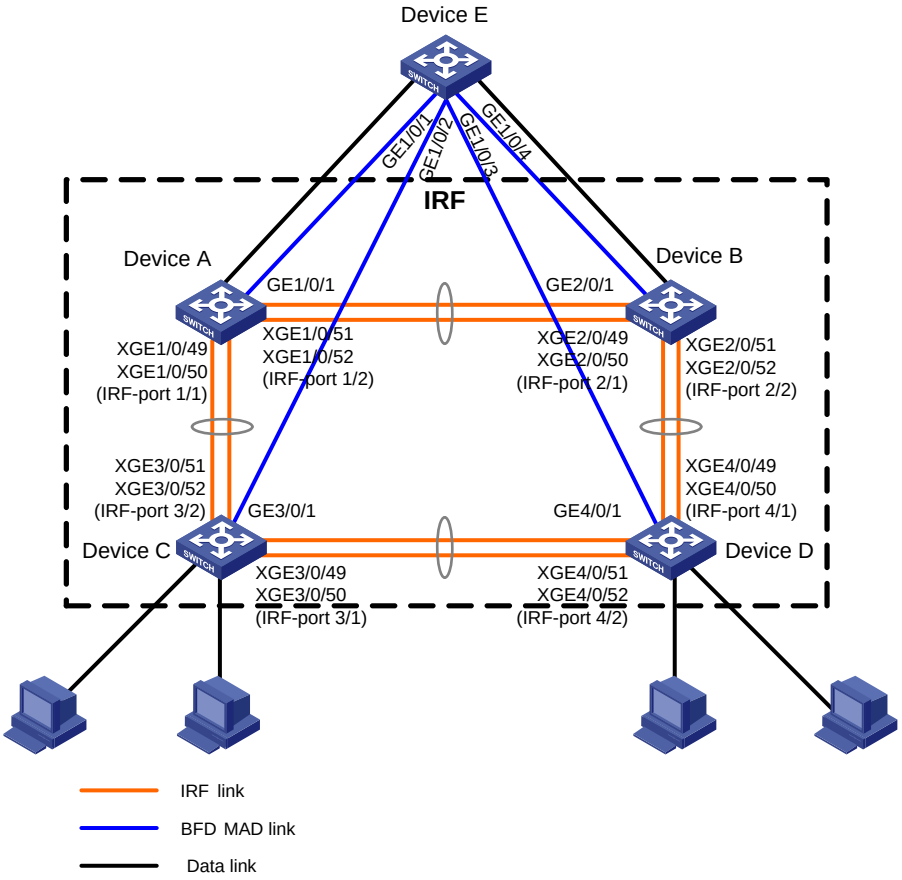
Example: Configuring a BFD MAD-enabled IRF fabric

Network configuration

As shown in Figure 15, set up a four-chassis IRF fabric at the distribution layer of the enterprise network.

- Configure BFD MAD on the IRF fabric and set up BFD MAD links between each member device and the intermediate device.
- Disable the spanning tree feature on the ports used for BFD MAD, because the two features conflict with each other.

Figure 15 Network diagram



Procedure

1. Configure Device A:

   # Shut down the physical interfaces used for IRF links.

   ```
   <Sysname> system-view
   [Sysname] interface range ten-gigabitethernet 1/0/49 to ten-gigabitethernet 1/0/52
   [Sysname-if-range] shutdown
   [Sysname-if-range] quit
   ```

   # Bind Ten-GigabitEthernet 1/0/49 and Ten-GigabitEthernet 1/0/50 to IRF-port 1/1.

   ```
   [Sysname] irf-port 1/1
   [Sysname-irf-port1/1] port group interface ten-gigabitethernet 1/0/49
   [Sysname-irf-port1/1] port group interface ten-gigabitethernet 1/0/50
   [Sysname-irf-port1/1] quit
   ```

   # Bind Ten-GigabitEthernet 1/0/51 and Ten-GigabitEthernet 1/0/52 to IRF-port 1/2.

   ```
   [Sysname] irf-port 1/2
   [Sysname-irf-port1/2] port group interface ten-gigabitethernet 1/0/51
   [Sysname-irf-port1/2] port group interface ten-gigabitethernet 1/0/52
   [Sysname-irf-port1/2] quit
   ```

   # Bring up the physical interfaces and save the configuration.

   ```
   [Sysname] interface range ten-gigabitethernet 1/0/49 to ten-gigabitethernet 1/0/52
   [Sysname-if-range] undo shutdown
   [Sysname-if-range] quit
   ```

```
[Sysname] save
```

Activate the IRF port configuration.

```
[Sysname] irf-port-configuration active
```

2. Configure Device B:

Change the member ID of Device B to 2 and reboot the device to have the change take effect.

```
<Sysname> system-view
[Sysname] irf member 1 renumber 2
Renumbering the member ID may result in configuration change or loss. Continue? [Y/N]:y
[Sysname] quit
<Sysname> reboot
```

Connect Device B to Device A as shown in Figure 15, and log in to Device B. (Details not shown.)

Shut down the physical interfaces used for IRF links.

```
<Sysname> system-view
[Sysname] interface range ten-gigabitethernet 2/0/49 to ten-gigabitethernet 2/0/52
[Sysname-if-range] shutdown
[Sysname-if-range] quit
```

Bind Ten-GigabitEthernet 2/0/49 and Ten-GigabitEthernet 2/0/50 to IRF-port 2/1.

```
[Sysname] irf-port 2/1
[Sysname-irf-port2/1] port group interface ten-gigabitethernet 2/0/49
[Sysname-irf-port2/1] port group interface ten-gigabitethernet 2/0/50
[Sysname-irf-port2/1] quit
```

Bind Ten-GigabitEthernet 2/0/51 and Ten-GigabitEthernet 2/0/52 to IRF-port 2/2.

```
[Sysname] irf-port 2/2
[Sysname-irf-port2/2] port group interface ten-gigabitethernet 2/0/51
[Sysname-irf-port2/2] port group interface ten-gigabitethernet 2/0/52
[Sysname-irf-port2/2] quit
```

Bring up the physical interfaces and save the configuration.

```
[Sysname] interface range ten-gigabitethernet 2/0/49 to ten-gigabitethernet 2/0/52
[Sysname-if-range] undo shutdown
[Sysname-if-range] quit
[Sysname] save
```

Activate the IRF port configuration.

```
[Sysname] irf-port-configuration active
```

The two devices perform master election, and the one that has lost the election reboots to form an IRF fabric with the master.

3. Configure Device C:

Change the member ID of Device C to 3 and reboot the device to have the change take effect.

```
<Sysname> system-view
[Sysname] irf member 1 renumber 3
Renumbering the member ID may result in configuration change or loss. Continue? [Y/N]:y
[Sysname] quit
<Sysname> reboot
```

Connect Device C to Device A as shown in Figure 15, and log in to Device C. (Details not shown.)

Shut down the physical interfaces used for IRF links.

```
<Sysname> system-view
```

```
[Sysname] interface range ten-gigabitethernet 3/0/49 to ten-gigabitethernet 3/0/52
[Sysname-if-range] shutdown
[Sysname-if-range] quit
```

Bind Ten-GigabitEthernet 3/0/49 and Ten-GigabitEthernet 3/0/50 to IRF-port 3/1.

```
[Sysname] irf-port 3/1
[Sysname-irf-port3/1] port group interface ten-gigabitethernet 3/0/49
[Sysname-irf-port3/1] port group interface ten-gigabitethernet 3/0/50
[Sysname-irf-port3/1] quit
```

Bind Ten-GigabitEthernet 3/0/51 and Ten-GigabitEthernet 3/0/52 to IRF-port 3/2.

```
[Sysname] irf-port 3/2
[Sysname-irf-port3/2] port group interface ten-gigabitethernet 3/0/51
[Sysname-irf-port3/2] port group interface ten-gigabitethernet 3/0/52
[Sysname-irf-port3/2] quit
```

Bring up the physical interfaces and save the configuration.

```
[Sysname] interface range ten-gigabitethernet 3/0/49 to ten-gigabitethernet 3/0/52
[Sysname-if-range] undo shutdown
[Sysname-if-range] quit
[Sysname] save
```

Activate the IRF port configuration.

```
[Sysname] irf-port-configuration active
```

Device C reboots to join the IRF fabric.

4. Configure Device D:

Change the member ID of Device D to 4 and reboot the device to have the change take effect.

```
<Sysname> system-view
[Sysname] irf member 1 renumber 4
Renumbering the member ID may result in configuration change or loss. Continue? [Y/N]:y
[Sysname] quit
<Sysname> reboot
```

Connect Device D to Device B and Device C as shown in Figure 15, and log in to Device D. (Details not shown.)

Shut down the physical interfaces used for IRF links.

```
<Sysname> system-view
[Sysname] interface range ten-gigabitethernet 4/0/49 to ten-gigabitethernet 4/0/52
[Sysname-if-range] shutdown
[Sysname-if-range] quit
```

Bind Ten-GigabitEthernet 4/0/49 and Ten-GigabitEthernet 4/0/50 to IRF-port 4/1.

```
[Sysname] irf-port 4/1
[Sysname-irf-port4/1] port group interface ten-gigabitethernet 4/0/49
[Sysname-irf-port4/1] port group interface ten-gigabitethernet 4/0/50
[Sysname-irf-port4/1] quit
```

Bind Ten-GigabitEthernet 4/0/51 and Ten-GigabitEthernet 4/0/52 to IRF-port 4/2.

```
[Sysname] irf-port 4/2
[Sysname-irf-port4/2] port group interface ten-gigabitethernet 4/0/51
[Sysname-irf-port4/2] port group interface ten-gigabitethernet 4/0/52
[Sysname-irf-port4/2] quit
```

Bring up the physical interfaces and save the configuration.

```
[Sysname] interface range ten-gigabitethernet 4/0/49 to ten-gigabitethernet 4/0/52
```

```
[Sysname-if-range] undo shutdown
[Sysname-if-range] quit
[Sysname] save
```

Activate the IRF port configuration.

```
[Sysname] irf-port-configuration active
```

Device D reboots to join the IRF fabric. A four-chassis IRF fabric is formed.

5. Configure BFD MAD on the IRF fabric:

   # Create VLAN 3, and add GigabitEthernet 1/0/1, GigabitEthernet 2/0/1, GigabitEthernet 3/0/1, and GigabitEthernet 4/0/1 to VLAN 3.

```
[Sysname] vlan 3
[Sysname-vlan3] port gigabitethernet 1/0/1 gigabitethernet 2/0/1 gigabitethernet
3/0/1 gigabitethernet 4/0/1
[Sysname-vlan3] quit
```

   # Create VLAN-interface 3, and configure a MAD IP address for each member device on the VLAN interface.

```
[Sysname] interface vlan-interface 3
[Sysname-Vlan-interface3] mad bfd enable
[Sysname-Vlan-interface3] mad ip address 192.168.2.1 24 member 1
[Sysname-Vlan-interface3] mad ip address 192.168.2.2 24 member 2
[Sysname-Vlan-interface3] mad ip address 192.168.2.3 24 member 3
[Sysname-Vlan-interface3] mad ip address 192.168.2.4 24 member 4
[Sysname-Vlan-interface3] quit
```

   # Disable the spanning tree feature on GigabitEthernet 1/0/1, GigabitEthernet 2/0/1, GigabitEthernet 3/0/1, and GigabitEthernet 4/0/1.

```
[Sysname] interface range gigabitethernet 1/0/1 gigabitethernet 2/0/1
gigabitethernet 3/0/1 gigabitethernet 4/0/1
[Sysname-if-range] undo stp enable
[Sysname-if-range] quit
```

6. Configure Device E as the intermediate device:

   # Create VLAN 3, and assign GigabitEthernet 1/0/1, GigabitEthernet 1/0/2, GigabitEthernet 1/0/3, and GigabitEthernet 1/0/4 to VLAN 3 for forwarding BFD MAD packets.

```
<DeviceE> system-view
[DeviceE] vlan 3
[DeviceE-vlan3] port gigabitethernet 1/0/1 to gigabitethernet 1/0/4
[DeviceE-vlan3] quit
```

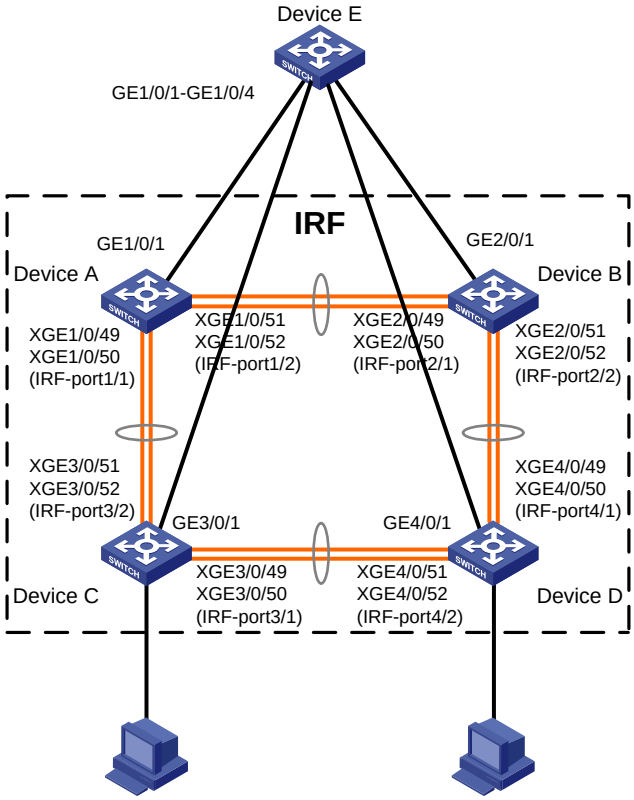
Example: Configuring an ARP MAD-enabled IRF fabric

Network configuration

As shown in Figure 16, set up a four-chassis IRF fabric in the enterprise network.

- Configure ARP MAD on the IRF fabric and use the links connected to Device E for transmitting ARP MAD packets.
- To prevent loops, run the spanning tree feature between Device E and the IRF fabric.

Figure 16 Network diagram



Procedure

1. Configure Device A:

   # Shut down the physical interfaces used for IRF links.

   ```
   <Sysname> system-view
   [Sysname] interface range ten-gigabitethernet 1/0/49 to ten-gigabitethernet 1/0/52
   [Sysname-if-range] shutdown
   [Sysname-if-range] quit
   ```

   # Bind Ten-GigabitEthernet 1/0/49 and Ten-GigabitEthernet 1/0/50 to IRF-port 1/1.

   ```
   [Sysname] irf-port 1/1
   [Sysname-irf-port1/1] port group interface ten-gigabitethernet 1/0/49
   [Sysname-irf-port1/1] port group interface ten-gigabitethernet 1/0/50
   [Sysname-irf-port1/1] quit
   ```

   # Bind Ten-GigabitEthernet 1/0/51 and Ten-GigabitEthernet 1/0/52 to IRF-port 1/2.

   ```
   [Sysname] irf-port 1/2
   [Sysname-irf-port1/2] port group interface ten-gigabitethernet 1/0/51
   [Sysname-irf-port1/2] port group interface ten-gigabitethernet 1/0/52
   [Sysname-irf-port1/2] quit
   ```

   # Bring up the physical interfaces and save the configuration.

   ```
   [Sysname] interface range ten-gigabitethernet 1/0/49 to ten-gigabitethernet 1/0/52
   [Sysname-if-range] undo shutdown
   [Sysname-if-range] quit
   [Sysname] save
   ```

   # Activate the IRF port configuration.

   ```
   [Sysname] irf-port-configuration active
   ```

2. Configure Device B:

   # Change the member ID of Device B to 2 and reboot the device to have the change take effect.

```
<Sysname> system-view
[Sysname] irf member 1 renumber 2
Renumbering the member ID may result in configuration change or loss. Continue? [Y/N]:y
[Sysname] quit
<Sysname> reboot
```

   # Connect Device B to Device A as shown in Figure 16, and log in to Device B. (Details not shown.)

   # Shut down the physical interfaces used for IRF links.

```
<Sysname> system-view
[Sysname] interface range ten-gigabitethernet 2/0/49 to ten-gigabitethernet 2/0/52
[Sysname-if-range] shutdown
[Sysname-if-range] quit
```

   # Bind Ten-GigabitEthernet 2/0/49 and Ten-GigabitEthernet 2/0/50 to IRF-port 2/1.

```
[Sysname] irf-port 2/1
[Sysname-irf-port2/1] port group interface ten-gigabitethernet 2/0/49
[Sysname-irf-port2/1] port group interface ten-gigabitethernet 2/0/50
[Sysname-irf-port2/1] quit
```

   # Bind Ten-GigabitEthernet 2/0/51 and Ten-GigabitEthernet 2/0/52 to IRF-port 2/2.

```
[Sysname] irf-port 2/2
[Sysname-irf-port2/2] port group interface ten-gigabitethernet 2/0/51
[Sysname-irf-port2/2] port group interface ten-gigabitethernet 2/0/52
[Sysname-irf-port2/2] quit
```

   # Bring up the physical interfaces and save the configuration.

```
[Sysname] interface range ten-gigabitethernet 2/0/49 to ten-gigabitethernet 2/0/52
[Sysname-if-range] undo shutdown
[Sysname-if-range] quit
[Sysname] save
```

   # Activate the IRF port configuration.

```
[Sysname] irf-port-configuration active
```

   The two devices perform master election, and the one that has lost the election reboots to form an IRF fabric with the master.

3. Configure Device C:

   # Change the member ID of Device C to 3 and reboot the device to have the change take effect.

```
<Sysname> system-view
[Sysname] irf member 1 renumber 3
Renumbering the member ID may result in configuration change or loss. Continue? [Y/N]:y
[Sysname] quit
<Sysname> reboot
```

   # Connect Device C to Device A as shown in Figure 16, and log in to Device C. (Details not shown.)

   # Shut down the physical interfaces used for IRF links.

```
<Sysname> system-view
[Sysname] interface range ten-gigabitethernet 3/0/49 to ten-gigabitethernet 3/0/52
[Sysname-if-range] shutdown
[Sysname-if-range] quit
```

   # Bind Ten-GigabitEthernet 3/0/49 and Ten-GigabitEthernet 3/0/50 to IRF-port 3/1.

```
[Sysname] irf-port 3/1
[Sysname-irf-port3/1] port group interface ten-gigabitethernet 3/0/49
[Sysname-irf-port3/1] port group interface ten-gigabitethernet 3/0/50
[Sysname-irf-port3/1] quit
```

Bind Ten-GigabitEthernet 3/0/51 and Ten-GigabitEthernet 3/0/52 to IRF-port 3/2.

```
[Sysname] irf-port 3/2
[Sysname-irf-port3/2] port group interface ten-gigabitethernet 3/0/51
[Sysname-irf-port3/2] port group interface ten-gigabitethernet 3/0/52
[Sysname-irf-port3/2] quit
```

Bring up the physical interfaces and save the configuration.

```
[Sysname] interface range ten-gigabitethernet 3/0/49 to ten-gigabitethernet 3/0/52
[Sysname-if-range] undo shutdown
[Sysname-if-range] quit
[Sysname] save
```

Activate the IRF port configuration.

```
[Sysname] irf-port-configuration active
```

Device C reboots to join the IRF fabric.

4. Configure Device D:

Change the member ID of Device D to 4 and reboot the device to have the change take effect.

```
<Sysname> system-view
[Sysname] irf member 1 renumber 4
Renumbering the member ID may result in configuration change or loss. Continue? [Y/N]:y
[Sysname] quit
<Sysname> reboot
```

Connect Device D to Device B and Device C as shown in Figure 16, and log in to Device D. (Details not shown.)

Shut down the physical interfaces used for IRF links.

```
<Sysname> system-view
[Sysname] interface range ten-gigabitethernet 4/0/49 to ten-gigabitethernet 4/0/52
[Sysname-if-range] shutdown
[Sysname-if-range] quit
```

Bind Ten-GigabitEthernet 4/0/49 and Ten-GigabitEthernet 4/0/50 to IRF-port 4/1.

```
[Sysname] irf-port 4/1
[Sysname-irf-port4/1] port group interface ten-gigabitethernet 4/0/49
[Sysname-irf-port4/1] port group interface ten-gigabitethernet 4/0/50
[Sysname-irf-port4/1] quit
```

Bind Ten-GigabitEthernet 4/0/51 and Ten-GigabitEthernet 4/0/52 to IRF-port 4/2.

```
[Sysname] irf-port 4/2
[Sysname-irf-port4/2] port group interface ten-gigabitethernet 4/0/51
[Sysname-irf-port4/2] port group interface ten-gigabitethernet 4/0/52
[Sysname-irf-port4/2] quit
```

Bring up the physical interfaces and save the configuration.

```
[Sysname] interface range ten-gigabitethernet 4/0/49 to ten-gigabitethernet 4/0/52
[Sysname-if-range] undo shutdown
[Sysname-if-range] quit
[Sysname] save
```

Activate the IRF port configuration.

```
[Sysname] irf-port-configuration active
```

Device D reboots to join the IRF fabric. A four-chassis IRF fabric is formed.

5. Configure ARP MAD on the IRF fabric:

Enable the spanning tree feature globally. Map the ARP MAD VLAN to MSTI 1 in the MST region.

```
<Sysname> system-view
[Sysname] stp global enable
[Sysname] stp region-configuration
[Sysname-mst-region] region-name arpmad
[Sysname-mst-region] instance 1 vlan 3
[Sysname-mst-region] active region-configuration
[Sysname-mst-region] quit
```

Configure the IRF fabric to change its bridge MAC address as soon as the address owner leaves.

```
[Sysname] undo irf mac-address persistent
```

Set the domain ID of the IRF fabric to 1.

```
[Sysname] irf domain 1
```

Create VLAN 3, and assign GigabitEthernet 1/0/1, GigabitEthernet 2/0/1, GigabitEthernet 3/0/1, and GigabitEthernet 4/0/1 to VLAN 3.

```
[Sysname] vlan 3
[Sysname-vlan3] port gigabitethernet 1/0/1 gigabitethernet 2/0/1 gigabitethernet
3/0/1 gigabitethernet 4/0/1
[Sysname-vlan3] quit
```

Create VLAN-interface 3, assign it an IP address, and enable ARP MAD on the interface.

```
[Sysname] interface vlan-interface 3
[Sysname-Vlan-interface3] ip address 192.168.2.1 24
[Sysname-Vlan-interface3] mad arp enable
You need to assign a domain ID (range: 0-4294967295)
[Current domain is: 1]:
The assigned domain ID is: 1
```

6. Configure Device E as the intermediate device:

CAUTION:

If the intermediate device is also in an IRF fabric, assign the two IRF fabrics different domain IDs for correct split detection. False detection causes IRF split.

Enable the spanning tree feature globally. Map the ARP MAD VLAN to MSTI 1 in the MST region.

```
<DeviceE> system-view
[DeviceE] stp global enable
[DeviceE] stp region-configuration
[DeviceE-mst-region] region-name arpmad
[DeviceE-mst-region] instance 1 vlan 3
[DeviceE-mst-region] active region-configuration
[DeviceE-mst-region] quit
```

Create VLAN 3, and assign GigabitEthernet 1/0/1, GigabitEthernet 1/0/2, GigabitEthernet 1/0/3, and GigabitEthernet 1/0/4 to VLAN 3 for forwarding ARP MAD packets.

```
[DeviceE] vlan 3
[DeviceE-vlan3] port gigabitethernet 1/0/1 to gigabitethernet 1/0/4
```

```
[DeviceE-vlan3] quit
```

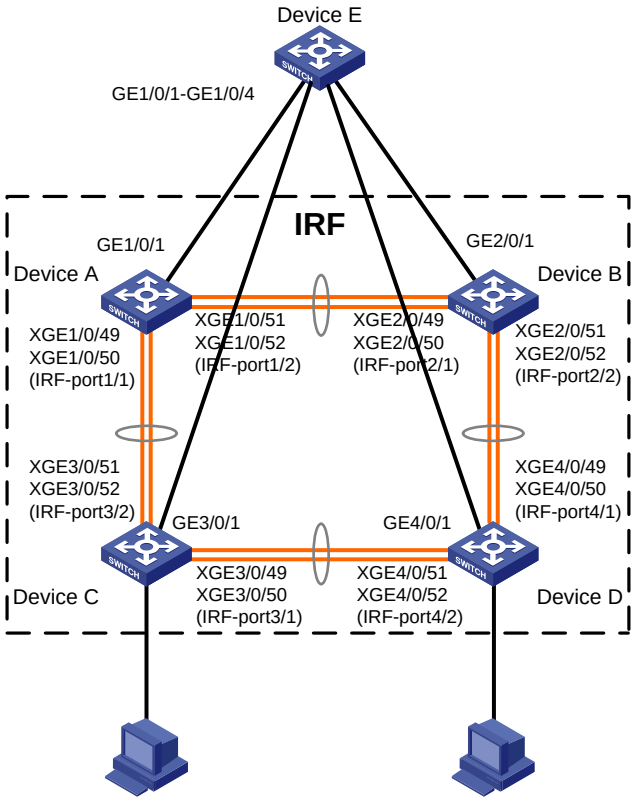
Example: Configuring an ND MAD-enabled IRF fabric

Network configuration

As shown in Figure 17, set up a four-chassis IRF fabric in the IPv6 enterprise network.

- Configure ND MAD on the IRF fabric and use the links connected to Device E for transmitting ND MAD packets.
- To prevent loops, run the spanning tree feature between Device E and the IRF fabric.

Figure 17 Network diagram



Procedure

1. Configure Device A:

   # Shut down the physical interfaces used for IRF links.

   ```
   <Sysname> system-view
   [Sysname] interface range ten-gigabitethernet 1/0/49 to ten-gigabitethernet 1/0/52
   [Sysname-if-range] shutdown
   [Sysname-if-range] quit
   ```

   # Bind Ten-GigabitEthernet 1/0/49 and Ten-GigabitEthernet 1/0/50 to IRF-port 1/1.

   ```
   [Sysname] irf-port 1/1
   [Sysname-irf-port1/1] port group interface ten-gigabitethernet 1/0/49
   [Sysname-irf-port1/1] port group interface ten-gigabitethernet 1/0/50
   [Sysname-irf-port1/1] quit
   ```

   # Bind Ten-GigabitEthernet 1/0/51 and Ten-GigabitEthernet 1/0/52 to IRF-port 1/2.

   ```
   [Sysname] irf-port 1/2
   ```

```
[Sysname-irf-port1/2] port group interface ten-gigabitethernet 1/0/51
[Sysname-irf-port1/2] port group interface ten-gigabitethernet 1/0/52
[Sysname-irf-port1/2] quit
```

Bring up the physical interfaces and save the configuration.

```
[Sysname] interface range ten-gigabitethernet 1/0/49 to ten-gigabitethernet 1/0/52
[Sysname-if-range] undo shutdown
[Sysname-if-range] quit
[Sysname] save
```

Activate the IRF port configuration.

```
[Sysname] irf-port-configuration active
```

2. Configure Device B:

Change the member ID of Device B to 2 and reboot the device to have the change take effect.

```
<Sysname> system-view
[Sysname] irf member 1 renumber 2
Renumbering the member ID may result in configuration change or loss. Continue? [Y/N]:y
[Sysname] quit
<Sysname> reboot
```

Connect Device B to Device A as shown in Figure 17, and log in to Device B. (Details not shown.)

Shut down the physical interfaces used for IRF links.

```
<Sysname> system-view
[Sysname] interface range ten-gigabitethernet 2/0/49 to ten-gigabitethernet 2/0/52
[Sysname-if-range] shutdown
[Sysname-if-range] quit
```

Bind Ten-GigabitEthernet 2/0/49 and Ten-GigabitEthernet 2/0/50 to IRF-port 2/1.

```
[Sysname] irf-port 2/1
[Sysname-irf-port2/1] port group interface ten-gigabitethernet 2/0/49
[Sysname-irf-port2/1] port group interface ten-gigabitethernet 2/0/50
[Sysname-irf-port2/1] quit
```

Bind Ten-GigabitEthernet 2/0/51 and Ten-GigabitEthernet 2/0/52 to IRF-port 2/2.

```
[Sysname] irf-port 2/2
[Sysname-irf-port2/2] port group interface ten-gigabitethernet 2/0/51
[Sysname-irf-port2/2] port group interface ten-gigabitethernet 2/0/52
[Sysname-irf-port2/2] quit
```

Bring up the physical interfaces and save the configuration.

```
[Sysname] interface range ten-gigabitethernet 2/0/49 to ten-gigabitethernet 2/0/52
[Sysname-if-range] undo shutdown
[Sysname-if-range] quit
[Sysname] save
```

Activate the IRF port configuration.

```
[Sysname] irf-port-configuration active
```

The two devices perform master election, and the one that has lost the election reboots to form an IRF fabric with the master.

3. Configure Device C:

Change the member ID of Device C to 3 and reboot the device to have the change take effect.

```
<Sysname> system-view
[Sysname] irf member 1 renumber 3
```

```
Renumbering the member ID may result in configuration change or loss. Continue? [Y/N]:y
[Sysname] quit
<Sysname> reboot
```

Connect Device C to Device A as shown in Figure 17, and log in to Device C. (Details not shown.)

Shut down the physical interfaces used for IRF links.

```
<Sysname> system-view
[Sysname] interface range ten-gigabitethernet 3/0/49 to ten-gigabitethernet 3/0/52
[Sysname-if-range] shutdown
[Sysname-if-range] quit
```

Bind Ten-GigabitEthernet 3/0/49 and Ten-GigabitEthernet 3/0/50 to IRF-port 3/1.

```
[Sysname] irf-port 3/1
[Sysname-irf-port3/1] port group interface ten-gigabitethernet 3/0/49
[Sysname-irf-port3/1] port group interface ten-gigabitethernet 3/0/50
[Sysname-irf-port3/1] quit
```

Bind Ten-GigabitEthernet 3/0/51 and Ten-GigabitEthernet 3/0/52 to IRF-port 3/2.

```
[Sysname] irf-port 3/2
[Sysname-irf-port3/2] port group interface ten-gigabitethernet 3/0/51
[Sysname-irf-port3/2] port group interface ten-gigabitethernet 3/0/52
[Sysname-irf-port3/2] quit
```

Bring up the physical interfaces and save the configuration.

```
[Sysname] interface range ten-gigabitethernet 3/0/49 to ten-gigabitethernet 3/0/52
[Sysname-if-range] undo shutdown
[Sysname-if-range] quit
[Sysname] save
```

Activate the IRF port configuration.

```
[Sysname] irf-port-configuration active
```

Device C reboots to join the IRF fabric.

4. Configure Device D:

Change the member ID of Device D to 4 and reboot the device to have the change take effect.

```
<Sysname> system-view
[Sysname] irf member 1 renumber 4
Renumbering the member ID may result in configuration change or loss. Continue? [Y/N]:y
[Sysname] quit
<Sysname> reboot
```

Connect Device D to Device B and Device C as shown in Figure 17, and log in to Device D. (Details not shown.)

Shut down the physical interfaces used for IRF links.

```
<Sysname> system-view
[Sysname] interface range ten-gigabitethernet 4/0/49 to ten-gigabitethernet 4/0/52
[Sysname-if-range] shutdown
[Sysname-if-range] quit
```

Bind Ten-GigabitEthernet 4/0/49 and Ten-GigabitEthernet 4/0/50 to IRF-port 4/1.

```
[Sysname] irf-port 4/1
[Sysname-irf-port4/1] port group interface ten-gigabitethernet 4/0/49
[Sysname-irf-port4/1] port group interface ten-gigabitethernet 4/0/50
[Sysname-irf-port4/1] quit
```

Bind Ten-GigabitEthernet 4/0/51 and Ten-GigabitEthernet 4/0/52 to IRF-port 4/2.

```
[Sysname] irf-port 4/2
[Sysname-irf-port4/2] port group interface ten-gigabitethernet 4/0/51
[Sysname-irf-port4/2] port group interface ten-gigabitethernet 4/0/52
[Sysname-irf-port4/2] quit
```

Bring up the physical interfaces and save the configuration.

```
[Sysname] interface range ten-gigabitethernet 4/0/49 to ten-gigabitethernet 4/0/52
[Sysname-if-range] undo shutdown
[Sysname-if-range] quit
[Sysname] save
```

Activate the IRF port configuration.

```
[Sysname] irf-port-configuration active
```

Device D reboots to join the IRF fabric. A four-chassis IRF fabric is formed.

5. Configure ND MAD on the IRF fabric:

Enable the spanning tree feature globally. Map the ND MAD VLAN to MSTI 1 in the MST region.

```
<Sysname> system-view
[Sysname] stp global enable
[Sysname] stp region-configuration
[Sysname-mst-region] region-name ndmad
[Sysname-mst-region] instance 1 vlan 3
[Sysname-mst-region] active region-configuration
[Sysname-mst-region] quit
```

Configure the IRF fabric to change its bridge MAC address as soon as the address owner leaves.

```
[Sysname] undo irf mac-address persistent
```

Set the domain ID of the IRF fabric to 1.

```
[Sysname] irf domain 1
```

Create VLAN 3, and add GigabitEthernet 1/0/1, GigabitEthernet 2/0/1, GigabitEthernet 3/0/1, and GigabitEthernet 4/0/1 to VLAN 3.

```
[Sysname] vlan 3
[Sysname-vlan3] port gigabitethernet 1/0/1 gigabitethernet 2/0/1 gigabitethernet
3/0/1 gigabitethernet 4/0/1
[Sysname-vlan3] quit
```

Create VLAN-interface 3, assign it an IPv6 address, and enable ND MAD on the interface.

```
[Sysname] interface vlan-interface 3
[Sysname-Vlan-interface3] ipv6 address 2001::1 64
[Sysname-Vlan-interface3] mad nd enable
You need to assign a domain ID (range: 0-4294967295)
[Current domain is: 1]:
The assigned domain ID is: 1
```

6. Configure Device E as the intermediate device:

CAUTION:

If the intermediate device is also in an IRF fabric, assign the two IRF fabrics different domain IDs for correct split detection. False detection causes IRF split.

Enable the spanning tree feature globally. Map the ND MAD VLAN to MSTI 1 in the MST region.

```
<DeviceE> system-view
[DeviceE] stp global enable
[DeviceE] stp region-configuration
[DeviceE-mst-region] region-name ndmad
[DeviceE-mst-region] instance 1 vlan 3
[DeviceE-mst-region] active region-configuration
[DeviceE-mst-region] quit
```

Create VLAN 3, and add GigabitEthernet 1/0/1, GigabitEthernet1/0/2, GigabitEthernet 1/0/3, and GigabitEthernet 1/0/4 to VLAN 3 for forwarding ND MAD packets.

```
[DeviceE] vlan 3
[DeviceE-vlan3] port gigabitethernet 1/0/1 to gigabitethernet 1/0/4
[DeviceE-vlan3] quit
```

Layer 2—LAN Switching Configuration Guide

This command reference is applicable to the following switches and software versions:

H3C S5120V2-LI switch series (Release 6308P01 and later)
H3C S3100V3-SI switch series (Release 6309P01 and later)
H3C S5110V2 switch series (Release 6310 and later)
H3C S5110V2-SI switch series (Release 6310 and later)
H3C S5000V3-EI switch series (Release 6310 and later)
H3C S5000V5-EI switch series (Release 6319P01 and later)
H3C S5000E-X switch series (Release 6310 and later)
H3C S5130S-LI switch series (Release 6310 and later)
H3C MS4320V2 switch series (Release 6308P01 and later)
H3C MS4320 switch series (Release 6308P01 and later)
H3C MS4300V2 switch series (Release 6308P01 and later)
H3C MS4200 switch series (Release 6310 and later)
H3C WS5810-WiNet switch series (Release 6308P01 and later)
H3C WS5820-WiNet switch series (Release 6308P01 and later)
H3C WAS6000 switch series (Release 6308P01 and later)
H3C S5000X-EI switch series (Release 6329 and later)
H3C MS4320V3 switch series (Release 6329 and later)
H3C S5120V3-SI switch series (Release 6329 and later)
H3C S5120V3-LI switch series (Release 6329 and later)

New H3C Technologies Co., Ltd.
http://www.h3c.com

Software version: Release 63xx
Document version: 6W105-20230524

Preface

This configuration guide describes LAN switching fundamentals and configuration procedures. It describes how to configure a Layer 2 network in the following aspects:

This preface includes the following topics about the documentation:

Audience

This documentation is intended for:

- Network planners.
- Field technical support and servicing engineers.
- Network administrators.

Conventions

The following information describes the conventions used in the documentation.

Command conventions

Convention	Description
Boldface	**Bold** text represents commands and keywords that you enter literally as shown.
Italic	*Italic* text represents arguments that you replace with actual values.
[ ]	Square brackets enclose syntax choices (keywords or arguments) that are optional.
{ x | y | ... }	Braces enclose a set of required syntax choices separated by vertical bars, from which you select one.
[x | y | ...]	Square brackets enclose a set of optional syntax choices separated by vertical bars, from which you select one or none.
{ x | y | ... } *	Asterisk marked braces enclose a set of required syntax choices separated by vertical bars, from which you select a minimum of one.
[x | y | ...] *	Asterisk marked square brackets enclose optional syntax choices separated by vertical bars, from which you select one choice, multiple choices, or none.
&<1-n>	The argument or keyword and argument combination before the ampersand (&) sign can be entered 1 to n times.
#	A line that starts with a pound (#) sign is comments.

GUI conventions

Convention	Description
Boldface	Window names, button names, field names, and menu items are in Boldface. For example, the **New User** window opens; click **OK**.
>	Multi-level menus are separated by angle brackets. For example, **File** > **Create** > **Folder**.

Symbols

Convention	Description
WARNING!	An alert that calls attention to important information that if not understood or followed can result in personal injury.
CAUTION:	An alert that calls attention to important information that if not understood or followed can result in data loss, data corruption, or damage to hardware or software.
IMPORTANT:	An alert that calls attention to essential information.
NOTE:	An alert that contains additional or supplementary information.
TIP:	An alert that provides helpful information.

Network topology icons

Convention	Description
	Represents a generic network device, such as a router, switch, or firewall.
	Represents a routing-capable device, such as a router or Layer 3 switch.
	Represents a generic switch, such as a Layer 2 or Layer 3 switch, or a router that supports Layer 2 forwarding and other Layer 2 features.
	Represents an access controller, a unified wired-WLAN module, or the access controller engine on a unified wired-WLAN switch.
	Represents an access point.
	Represents a wireless terminator unit.
	Represents a wireless terminator.
	Represents a mesh access point.
	Represents omnidirectional signals.
	Represents directional signals.
	Represents a security product, such as a firewall, UTM, multiservice security gateway, or load balancing device.
	Represents a security module, such as a firewall, load balancing, NetStream, SSL VPN, IPS, or ACG module.

Examples provided in this document

Examples in this document might use devices that differ from your device in hardware model, configuration, or software version. It is normal that the port numbers, sample output, screenshots, and other information in the examples differ from what you have on your device.

Documentation feedback

You can e-mail your comments about product documentation to info@h3c.com.

We appreciate your comments.

Contents

Configuring Ethernet interfaces

About Ethernet interface

The Switch Series supports Ethernet interfaces and Console interfaces. For the interface types and the number of interfaces supported by a switch model, see the installation guide.

This chapter describes how to configure management Ethernet interfaces and Ethernet interfaces.

Ethernet interface naming conventions

The Ethernet interfaces are named in the format of **interface type A/B/C**. The letters that follow the interface type represent the following elements:

- **A**—IRF member ID. If the switch is not in an IRF fabric, A is 1 by default.
- **B**—Card slot number. **0** indicates the interface is a fixed interface of the switch.
- **C**—Port index.

Configuring common Ethernet interface settings

Configuring the physical type for a combo interface (single combo interface)

About combo interface

A combo interface is a logical interface that physically comprises one fiber combo port and one copper combo port. The two ports share one forwarding channel and one interface view. As a result, they cannot work simultaneously. When you activate one port, the other port is automatically disabled. If you execute the **`combo enable auto`** command on a combo interface, the interface automatically identifies the media inserted and activates the corresponding combo port. In the interface view, you can activate the fiber or copper combo port, and configure other port attributes such as the interface rate and duplex mode.

Configuration restrictions and guidelines

This feature is available only on devices that support combo interfaces.

Prerequisites

Before you configure combo interfaces, complete the following tasks:

- Determine the combo interfaces on your device. Identify the two physical interfaces that belong to each combo interface according to the marks on the device panel.
- Use the **`display interface`** command to determine which port (fiber or copper) of each combo interface is active:
  - If the copper port is active, the output includes "Media type is twisted pair."
  - If the fiber port is active, the output does not include this information.

Procedure

1. Enter system view.

   `system-view`
2. Enter Ethernet interface view.

interface *interface-type interface-number*

3. Activate the copper combo port or fiber combo port.

   combo enable { **auto** | **copper** | **fiber** }

   The default is **auto**.

Configuring basic settings of an Ethernet interface

About Ethernet interface basic settings

You can configure an Ethernet interface to operate in one of the following duplex modes:

- **Full-duplex mode**—The interface can send and receive packets simultaneously.
- **Half-duplex mode**—The interface can only send or receive packets at a given time.
- **Autonegotiation mode**—The interface negotiates a duplex mode with its peer.

You can set the speed of an Ethernet interface or enable it to automatically negotiate a speed with its peer. For a 100-Mbps or 1000-Mbps Layer 2 Ethernet interface, you can also set speed options for autonegotiation. The two ends can select a speed only from the available options. For more information, see "Setting speed options for autonegotiation on an Ethernet interface."

Restrictions and guidelines

The **shutdown** command cannot be configured on an interface in a loopback test.

Procedure

1. Enter system view.

   system-view

2. Enter Ethernet interface view.

   interface *interface-type interface-number*

3. Set the description for the Ethernet interface.

   description *text*

   The default setting is *interface-name* **Interface**. For example, **GigabitEthernet1/0/1 Interface**.

4. Set the duplex mode for the Ethernet interface.

   duplex { **auto** | **full** | **half** }

   By default, the duplex mode is **auto** for Ethernet interfaces.

   Ethernet copper ports that operate in 1000 Mbps or 10000 Mbps and fiber ports do not support the **half** keyword.

5. Set the speed for the Ethernet interface.

   speed { **10** | **100** | **1000** | **2500** | **5000** | **10000** | **auto** }

   By default, an Ethernet interface negotiates a speed with its peer.

6. Set the expected bandwidth for the Ethernet interface.

   bandwidth *bandwidth-value*

   By default, the expected bandwidth (in kbps) is the interface baud rate divided by 1000.

7. Bring up the Ethernet interface.

   undo shutdown

   By default, Ethernet interfaces are in up state.

Enabling automatic negotiation for speed downgrading

About automatic negotiation for speed downgrading

Perform this task to enable interfaces at two ends of a link to automatically negotiate about downgrading their speed when the following conditions exist:

- The interfaces automatically negotiate a speed of 1000 Mbps.
- The interfaces cannot operate at 1000 Mbps because of link restrictions.

Restrictions and guidelines

This feature is available only on GE interfaces.

Procedure

1. Enter system view.

   system-view
2. Enter Ethernet interface view.

   interface *interface-type interface-number*
3. Enable automatic negotiation for speed downgrading.

   speed auto downgrade

   By default, automatic negotiation for speed downgrading is enabled.

Configuring jumbo frame support

About jumbo frame

Jumbo frames are frames larger than 1522 bytes and are typically received by an Ethernet interface during high-throughput data exchanges, such as file transfers.

The Ethernet interface processes jumbo frames in the following ways:

- When the Ethernet interface is configured to deny jumbo frames (by using the **undo jumboframe enable** command), the Ethernet interface discards jumbo frames.
- When the Ethernet interface is configured with jumbo frame support, the Ethernet interface performs the following operations:
  - Processes jumbo frames within the specified length.
  - Discards jumbo frames that exceed the specified length.

Procedure

1. Enter system view.

   system-view
2. Enter Ethernet interface view.

   interface *interface-type interface-number*
3. Configure jumbo frame support.

   jumboframe enable [*size*]

   By default, the device allows jumbo frames within 10240 bytes to pass through.

   If you set the *size* argument multiple times, the most recent configuration takes effect.

Configuring physical state change suppression on an Ethernet interface

About physical state change suppression

The physical link state of an Ethernet interface is either up or down. Each time the physical link of an interface comes up or goes down, the interface immediately reports the change to the CPU. The CPU then performs the following operations:

- Notifies the upper-layer protocol modules (such as routing and forwarding modules) of the change for guiding packet forwarding.
- Automatically generates traps and logs to inform users to take the correct actions.

To prevent frequent physical link flapping from affecting system performance, configure physical state change suppression. You can configure this feature to suppress only link-down events, only link-up events, or both. If an event of the specified type still exists when the suppression interval expires, the system reports the event to the CPU.

Restrictions and guidelines

Do not enable this feature on an interface that has RRPP, spanning tree protocols, or Smart Link enabled. S5000E-X, S5000X-EI, S5110V2-SI, S5000V3-EI, S5000V5-EI, and WAS6000 switches do not support RRPP or Smart Link.

You can configure different suppression intervals for link-up and link-down events.

If you execute the **link-delay** command multiple times on an interface, the following rules apply:

- You can configure the suppression intervals for link-up and link-down events separately.
- If you configure the suppression interval multiple times for link-up or link-down events, the most recent configuration takes effect.

The **link-delay**, **dampening**, and **port link-flap protect enable** commands are mutually exclusive on an Ethernet interface.

Procedure

1. Enter system view.

   system-view
2. Enter Ethernet interface view.

   interface *interface-type interface-number*
3. Configure physical state change suppression.

   link-delay { **down** | **up** } [**msec**] *delay-time*

   By default, each time the physical link of an interface goes up or comes down, the interface immediately reports the change to the CPU.

Configuring dampening on an Ethernet interface

About dampening

The interface dampening feature uses an exponential decay mechanism to prevent excessive interface flapping events from adversely affecting routing protocols and routing tables in the network. Suppressing interface state change events protects the system resources.

If an interface is not dampened, its state changes are reported. For each state change, the system also generates an SNMP trap and log message.

After a flapping interface is dampened, it does not report its state changes to the CPU. For state change events, the interface only generates SNMP trap and log messages.

Parameters

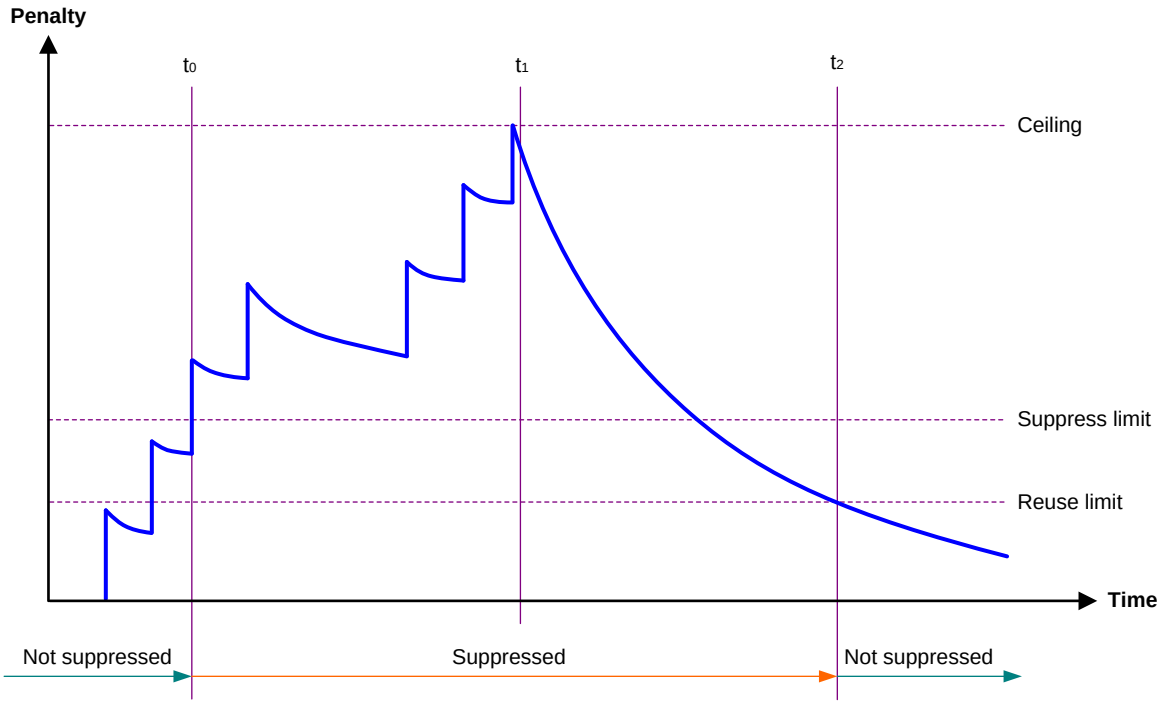
- **Penalty**—The interface has an initial penalty of 0. When the interface flaps, the penalty increases by 1000 for each down event until the ceiling is reached. It does not increase for up events. When the interface stops flapping, the penalty decreases by half each time the half-life timer expires until the penalty drops to the reuse threshold.
- **Ceiling**—The penalty stops increasing when it reaches the ceiling.
- **Suppress-limit**—The accumulated penalty that triggers the device to dampen the interface. In dampened state, the interface does not report its state changes to the CPU. For state change events, the interface only generates SNMP traps and log messages.
- **Reuse-limit**—When the accumulated penalty decreases to this reuse threshold, the interface is not dampened. Interface state changes are reported to the upper layers. For each state change, the system also generates an SNMP trap and log message.
- **Decay**—The amount of time (in seconds) after which a penalty is decreased.
- **Max-suppress-time**—The maximum amount of time the interface can be dampened. If the penalty is still higher than the reuse threshold when this timer expires, the penalty stops increasing for down events. The penalty starts to decrease until it drops below the reuse threshold.

When executing the **dampening** command, follow these rules to set the values mentioned above:

- The ceiling is equal to $2^{(\text{Max-suppress-time/Decay})}$ × reuse-limit. It is not user configurable.
- The configured suppress limit is lower than or equal to the ceiling.
- The ceiling is lower than or equal to the maximum suppress limit supported.

Figure 1 shows the change rule of the penalty value. The lines t_0 and t_2 indicate the start time and end time of the suppression, respectively. The period from t_0 to t_2 indicates the suppression period, t_0 to t_1 indicates the max-suppress-time, and t_1 to t_2 indicates the complete decay period.

Figure 1 Change rule of the penalty value



Restrictions and guidelines

- The **dampening**, **link-delay**, and **port link-flap protect enable** commands are mutually exclusive on an interface.

- The **dampening** command does not take effect on the administratively down events. When you execute the **shutdown** command, the penalty restores to 0, and the interface reports the down event to the upper-layer protocols.
- Do not enable the dampening feature on an interface with RRPP, MSTP, or Smart Link enabled. S5000E-X, S5000X-EI, S5110V2-SI, S5000V3-EI, S5000V5-EI, and WAS6000 switches do not support RRPP or Smart Link.

Procedure

1. Enter system view.
   system-view
2. Enter Ethernet interface view.
   interface *interface-type interface-number*
3. Enable dampening on the interface.
   dampening [*half-life reuse suppress max-suppress-time*]
   By default, interface dampening is disabled on Ethernet interfaces.

Enabling link flapping protection on an interface

About link flapping protection

Link flapping on an interface changes network topology and increases the system overhead. For example, in an active/standby link scenario, when interface status on the active link changes between **UP** and **DOWN**, traffic switches between active and standby links. To solve this problem, configure this feature on the interface.

With this feature enabled on an interface, when the interface goes down, the system enables link flapping detection. During the link flapping detection interval, if the number of detected flaps reaches or exceeds the link flapping detection threshold, the system shuts down the interface.

Restrictions and guidelines

This feature takes effect only if it is configured in both the system view and Ethernet interface view.

IRF system stability might be affected by IRF physical link flapping. For IRF system stability, this feature is enabled by default on IRF physical interfaces and the enabling status of this feature is not affected by the status of global link flapping protection. When the number of flaps detected on an IRF physical interface exceeds the threshold within the detection interval, the device outputs a log rather than shuts down the IRF physical interface.

The **dampening**, **link-delay**, and **port link-flap protect enable** commands are mutually exclusive on an Ethernet interface.

To bring up an interface that has been shut down by link flapping protection, execute the **undo shutdown** command.

In the **display interface** command output, the **Link-Flap DOWN** value of the **Current state** field indicates that the interface has been shut down by link flapping protection.

Procedure

1. Enter system view.
   system-view
2. Enable link flapping protection globally.
   link-flap protect enable
   By default, link flapping protection is disabled globally.
3. Enter Ethernet interface view.
   interface *interface-type interface-number*

4. Enable link flapping protection on the Ethernet interface.

   port link-flap protect enable [**interval** *interval* | **threshold** *threshold*] *

   By default, link flapping protection is disabled on an Ethernet interface.

Configuring storm suppression

About storm suppression

The storm suppression feature ensures that the size of a particular type of traffic (broadcast, multicast, or unknown unicast traffic) does not exceed the threshold on an interface. When the broadcast, multicast, or unknown unicast traffic on the interface exceeds this threshold, the system discards packets until the traffic drops below this threshold.

Both storm suppression and storm control can suppress storms on an interface. Storm suppression uses the chip to suppress traffic. Storm suppression has less impact on the device performance than storm control, which uses software to suppress traffic.

Restrictions and guidelines

- For the traffic suppression result to be determined, do not configure storm control together with storm suppression for the same type of traffic. For more information about storm control, see "Configuring storm control on an Ethernet interface."
- When you configure the suppression threshold in kbps, the actual suppression threshold might be different from the configured one as follows:
  - If the configured value is smaller than 64, the value of 64 takes effect.
  - If the configured value is greater than 64 but not an integer multiple of 64, the integer multiple of 64 that is greater than and closest to the configured value takes effect.

  For the suppression threshold that takes effect, see the prompt on the device.

Procedure

1. Enter system view.

   system-view

2. Enter Ethernet interface view.

   interface *interface-type interface-number*

3. Enable broadcast suppression and set the broadcast suppression threshold.

   broadcast-suppression { *ratio* | **pps** *max-pps* | **kbps** *max-kbps* }

   By default, broadcast suppression is disabled.

4. Enable multicast suppression and set the multicast suppression threshold.

   multicast-suppression { *ratio* | **pps** *max-pps* | **kbps** *max-kbps* }

   By default, multicast suppression is disabled.

5. Enable unknown unicast suppression and set the unknown unicast suppression threshold.

   unicast-suppression { *ratio* | **pps** *max-pps* | **kbps** *max-kbps* }

   By default, unknown unicast suppression is disabled.

Configuring generic flow control on an Ethernet interface

About generic flow control

To avoid dropping packets on a link, you can enable generic flow control at both ends of the link. When traffic congestion occurs at the receiving end, the receiving end sends a flow control (Pause)

frame to ask the sending end to suspend sending packets. Generic flow control includes the following types:

- **TxRx-mode generic flow control**—Enabled by using the **flow-control** command. With TxRx-mode generic flow control enabled, an interface can both send and receive flow control frames:
  - When congestion occurs, the interface sends a flow control frame to its peer.
  - When the interface receives a flow control frame from its peer, it suspends sending packets to its peer.
- **Rx-mode generic flow control**—Enabled by using the **flow-control receive enable** command. With Rx-mode generic flow control enabled, an interface can receive flow control frames, but it cannot send flow control frames:
  - When congestion occurs, the interface cannot send flow control frames to its peer.
  - When the interface receives a flow control frame from its peer, it suspends sending packets to its peer.

To handle unidirectional traffic congestion on a link, configure the **flow-control receive enable** command at one end and the **flow-control** command at the other end. To enable both ends of a link to handle traffic congestion, configure the **flow-control** command at both ends.

Procedure

1. Enter system view.
   system-view
2. Enter Ethernet interface view.
   interface *interface-type interface-number*
3. Enable generic flow control.
   - Enable TxRx-mode generic flow control.
     flow-control
   - Enable Rx-mode generic flow control.
     flow-control receive enable

   By default, generic flow control is disabled on an Ethernet interface.

Enabling energy saving features on an Ethernet interface

About energy saving features on an Ethernet interface

This feature contains auto power-down and Energy Efficient Ethernet (EEE) on an Ethernet interface.

When an Ethernet interface with auto power-down enabled has been down for a certain period of time, both of the following events occur:

- The device automatically stops supplying power to the Ethernet interface.
- The Ethernet interface enters the power save mode.

The time period depends on the chip specifications and is not configurable.

When the Ethernet interface comes up, both of the following events occur:

- The device automatically restores power supply to the Ethernet interface.
- The Ethernet interface restores to its normal state.

With Energy Efficient Ethernet (EEE) enabled, a link-up interface enters low power state if it has not received any packet for a period of time. The time period depends on the chip specifications and is not configurable. When a packet arrives later, the device automatically restores power supply to the interface and the interface restores to the normal state.

Restrictions and guidelines

Fiber ports do not support this feature.

Configuring auto power-down on an Ethernet interface

1. Enter system view.
   system-view
2. Enter Ethernet interface view.
   interface *interface-type interface-number*
3. Enable auto power-down on the Ethernet interface.
   port auto-power-down
   By default, auto power-down is disabled on an Ethernet interface.

Configuring EEE on an Ethernet interface

1. Enter system view.
   system-view
2. Enter Ethernet interface view.
   interface *interface-type interface-number*
3. Enable EEE on the Ethernet interface.
   eee enable
   By default, EEE is disabled on an Ethernet interface.

Setting the statistics polling interval

About statistics polling interval

To display the interface statistics collected in the last statistics polling interval, use the **display interface** command. To clear the interface statistics, use the **reset counters interface** command.

A device supports either the system view settings or the Ethernet interface view settings.

- The statistics polling interval configured in system view takes effect on all Ethernet interfaces.
- The statistics polling interval configured in Ethernet interface view takes effect only on the current interface.

For an Ethernet interface, the statistics polling interval configured in Ethernet interface view takes priority.

Restrictions and guidelines for setting the statistics polling interval

- Configuring the statistics polling interval in system view is supported in only Release 6328 and later.
- As a best practice, use the default setting when you set the statistics polling interval in system view. A short statistics polling interval might decrease the system performance and result in inaccurate statistics.

Setting the statistics polling interval in system view

1. Enter system view.
   system-view
2. Set the statistics polling interval.
   flow-interval *interval*
   The default setting is 300 seconds.

Setting the statistics polling interval in Ethernet interface view

1. Enter system view.
   system-view
2. Enter Ethernet interface view.
   interface *interface-type interface-number*
3. Set the statistics polling interval for the Ethernet interface.
   flow-interval *interval*
   By default, the statistics polling interval is 300 seconds.

Enabling loopback testing on an Ethernet interface

About loopback testing

Perform this task to determine whether an Ethernet link works correctly.

Loopback testing includes the following types:

- **Internal loopback testing**—Tests the device where the Ethernet interface resides. The Ethernet interface sends outgoing packets back to the local device. If the device fails to receive the packets, the device fails.
- **External loopback testing**—Tests the hardware function of the Ethernet interface. The Ethernet interface sends outgoing packets to the local device through a self-loop plug. If the device fails to receive the packets, the hardware function of the Ethernet interface fails.

Restrictions and guidelines

- After you enable this feature on an Ethernet interface, the interface does not forward data traffic.
- An Ethernet interface in a loopback test cannot correctly forward data packets.
- You cannot perform a loopback test on Ethernet interfaces manually brought down (displayed as in **ADM** or **Administratively DOWN** state).
- The **speed**, **duplex**, **mdix-mode**, and **shutdown** commands cannot be configured on an Ethernet interface in a loopback test.
- After you enable this feature on an Ethernet interface, the Ethernet interface switches to full duplex mode. After you disable this feature, the Ethernet interface restores to its duplex setting.
- The **shutdown**, **port up-mode**, and **loopback** commands are mutually exclusive.

Procedure

1. Enter system view.
   system-view
2. Enter Ethernet interface view.
   interface *interface-type interface-number*
3. Configure loopback testing on the Ethernet interface.
   - Enable loopback testing on the Ethernet interface.
     loopback{ **external** | **internal** }
     By default, loopback testing is disabled on an Ethernet interface.
   - Perform a loopback test.
     loopback-test{ **external** | **internal** }

     NOTE:
     This command is supported only in Release 6346 and later.

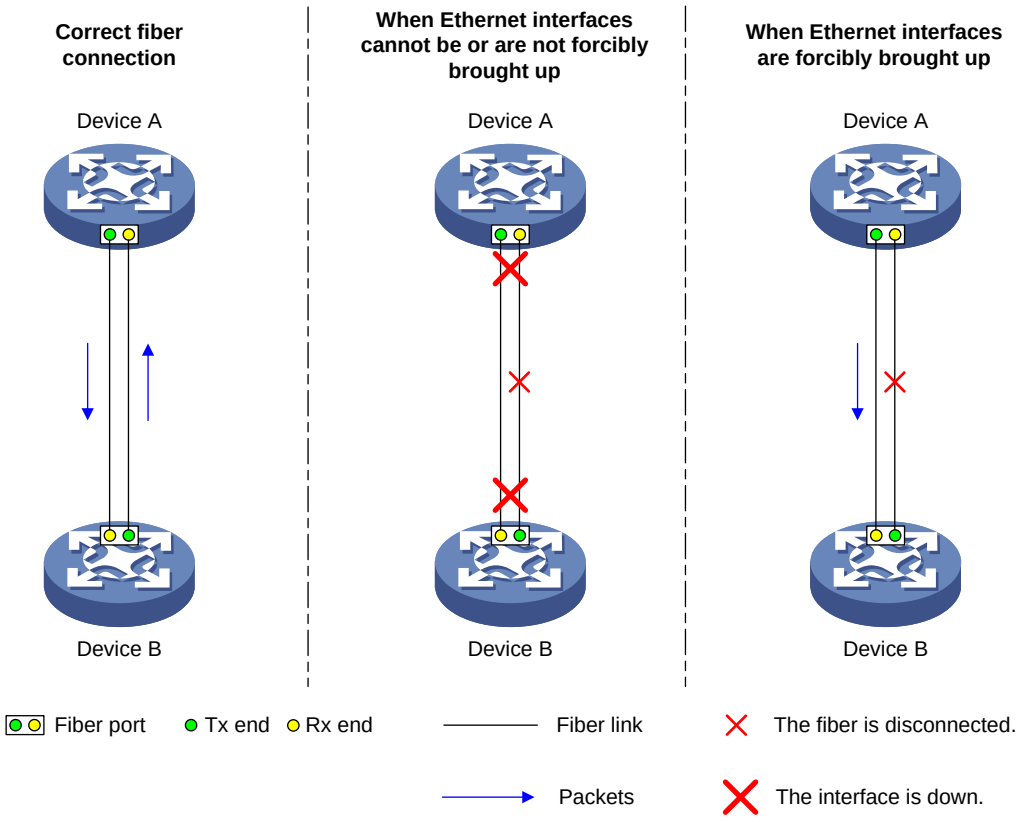
Forcibly bringing up a fiber port

About this task

As shown in Figure 2, a fiber port uses separate fibers for transmitting and receiving packets. The physical state of the fiber port is up only when both transmit and receive fibers are physically connected. If one of the fibers is disconnected, the fiber port does not work.

To enable a fiber port to forward traffic over a single link, you can use the **port up-mode** command. This command forcibly brings up a fiber port, even when no fiber links or transceiver modules are present for the fiber port. When one fiber link is present and up, the fiber port can forward packets over the link unidirectionally.

Figure 2 Forcibly bring up a fiber port



Restrictions and guidelines

Copper ports and combo interfaces do not support this feature. This feature is supported only in Release 6312 and later.

The **port up-mode**, **shutdown**, and **loopback** commands are mutually exclusive.

A fiber port does not support this feature if the port joins a Layer 2 aggregation group.

Procedure

1. Enter system view.
   system-view
2. Enter Ethernet interface view.
   interface *interface-type interface-number*
3. Forcibly bring up the fiber port.

port up-mode

By default, a fiber port is not forcibly brought up.

Configuring interface alarm functions

About this task

With the interface alarm functions enabled, when the number of error packets on an interface in normal state within the specified interval exceeds the upper threshold, the interface generates an upper threshold exceeding alarm and enters the alarm state. When the number of error packets on an interface in the alarm state within the specified interval drops below the lower threshold, the interface generates a recovery alarm and restores to the normal state.

Software and feature compatibility

This feature is supported only in Release 6342 and later.

Restrictions and guidelines

You can configure the error packet alarm parameters in system view and interface view.

- The configuration in system view takes effect on all interfaces of the specified slot. The configuration in interface view takes effect only on the current interface.
- For an interface, the configuration in interface view takes priority, and the configuration in system view is used only when no configuration is made in interface view.

An interface that is shut down because of error packet alarms cannot automatically recover. To bring up the interface, execute the **undo shutdown** command on the interface.

For the error packet statistics to be accurate, set the statistics collection and comparison interval to be greater than 7 seconds by using the **interval** *interval* keyword.

Enabling interface alarm functions

1. Enter system view.

   system-view

2. Enable alarm functions for the interface monitoring module.

   snmp-agent trap enable ifmonitor [**crc-error** | **input-error** | **output-error**] *

   By default, all alarm functions are enabled for interfaces.

Configuring CRC error packet parameters

1. Enter system view.

   system-view

2. Configure global CRC error packet alarm parameters.

   ifmonitor crc-error slot *slot-number* **high-threshold** *high-value* **low-threshold** *low-value* **interval** *interval* [**shutdown**]

   By default, the upper threshold is 1000, the lower threshold is 100, and the statistics collection and comparison interval is 10 seconds for CRC error packets.

3. Enter Ethernet interface view.

   interface *interface-type interface-number*

4. Configure CRC error packet alarm parameters for the interface.

   port ifmonitor crc-error high-threshold *high-value* **low-threshold** *low-value* **interval** *interval* [**shutdown**]

   By default, an interface uses the global CRC error packet alarm parameters.

Configuring input error packet alarm parameters

1. Enter system view.

   system-view

2. Configure global input error packet alarm parameters.

   ifmonitor input-error slot *slot-number* **high-threshold** *high-value* **low-threshold** *low-value* **interval** *interval* [**shutdown**]

   By default, the upper threshold is 1000, the lower threshold is 100, and the statistics collection and comparison interval is 10 seconds for input error packets.

3. Enter Ethernet interface view.

   interface *interface-type interface-number*

4. Configure input error packet alarm parameters for the interface.

   port ifmonitor input-error high-threshold *high-value* **low-threshold** *low-value* **interval** *interval* [**shutdown**]

   By default, an interface uses the global input error packet alarm parameters.

Configuring output error packet alarm parameters

1. Enter system view.

   system-view

2. Configure global output error packet alarm parameters.

   ifmonitor output-error slot *slot-number* **high-threshold** *high-value* **low-threshold** *low-value* **interval** *interval* [**shutdown**]

   By default, the upper threshold is 1000, the lower threshold is 100, and the statistics collection and comparison interval is 10 seconds for output error packets.

3. Enter Ethernet interface view.

   interface *interface-type interface-number*

4. Configure output error packet alarm parameters.

   port ifmonitor output-error high-threshold *high-value* **low-threshold** *low-value* **interval** *interval* [**shutdown**]

   By default, an interface uses the global output error packet alarm parameters.

Restoring the default settings for an interface

Restrictions and guidelines

CAUTION:

This feature might interrupt ongoing network services. Make sure you are fully aware of the impacts of this feature when you use it in a live network.

This feature might fail to restore the default settings for some commands because of command dependencies or system restrictions. You can use the **display this** command in interface view to check for these commands and perform their **undo** forms or follow the command reference to restore their default settings. If your restoration attempt still fails, follow the error message to resolve the problem.

Procedure

1. Enter system view.

   system-view

2. Enter Ethernet interface view.

   interface *interface-type interface-number*

3. Restore the default settings for the interface.
   default

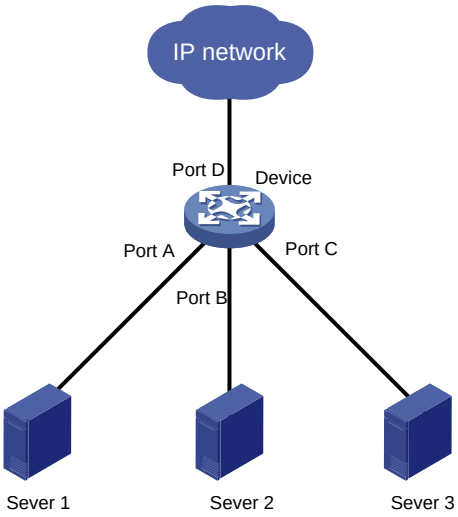
Configuring a Layer 2 Ethernet interface

Setting speed options for autonegotiation on an Ethernet interface

About speed options for autonegotiation

By default, speed autonegotiation enables an Ethernet interface to negotiate with its peer for the highest speed that both ends support. You can narrow down the speed option list for negotiation.

Figure 3 Speed autonegotiation application scenario



As shown in Figure 3:

- All interfaces on the device are operating in speed autonegotiation mode, with the highest speed of 1000 Mbps.
- Port D provides access to the Internet for the servers.

If the transmission rate of each server in the server cluster is 1000 Mbps, their total transmission rate exceeds the capability of Port D.

To avoid congestion on Port D, configure 100 Mbps as the only option available for speed negotiation on interfaces Port A, Port B, and Port C. As a result, the transmission rate on each interface connected to a server is limited to 100 Mbps.

Restrictions and guidelines

The **speed** and **speed auto** commands supersede each other, and whichever is configured last takes effect.

Procedure

1. Enter system view.
   system-view
2. Enter Ethernet interface view.
   interface *interface-type interface-number*
3. Set speed options for autonegotiation.

speed auto { **10** | **100** | **1000** } *

No speed options are set for autonegotiation.

Setting the MDIX mode of an Ethernet interface

IMPORTANT:

Fiber ports do not support the MDIX mode setting.

About MDIX mode

A physical Ethernet interface has eight pins, each of which plays a dedicated role. For example, pins 1 and 2 transmit signals, and pins 3 and 6 receive signals. You can use both crossover and straight-through Ethernet cables to connect copper Ethernet interfaces. To accommodate these types of cables, a copper Ethernet interface can operate in one of the following Medium Dependent Interface-Crossover (MDIX) modes:

- **MDIX mode**—Pins 1 and 2 are receive pins and pins 3 and 6 are transmit pins.
- **MDI mode**—Pins 1 and 2 are transmit pins and pins 3 and 6 are receive pins.
- **AutoMDIX mode**—The interface negotiates pin roles with its peer.

NOTE:

This feature does not take effect on pins 4, 5, 7, and 8 of physical Ethernet interfaces.

- Pins 4, 5, 7, and 8 of interfaces operating at 10 Mbps or 100 Mbps do not receive or transmit signals.
- Pins 4, 5, 7, and 8 of interfaces operating at 1000 Mbps or higher rates receive and transmit signals.

Restrictions and guidelines

To enable a copper Ethernet interface to communicate with its peer, set the MDIX mode of the interface by following these guidelines:

- Typically, set the MDIX mode of the interface to AutoMDIX. Set the MDIX mode of the interface to MDI or MDIX only when the device cannot determine the cable type.
- When a straight-through cable is used, configure the interface to operate in an MDIX mode different than its peer.
- When a crossover cable is used, perform one of the following tasks:
  - Configure the interface to operate in the same MDIX mode as its peer.
  - Configure either end to operate in AutoMDIX mode.

Procedure

1. Enter system view.

   system-view
2. Enter Ethernet interface view.

   interface *interface-type interface-number*
3. Set the MDIX mode of the Ethernet interface.

   mdix-mode { **automdix** | **mdi** | **mdix** }

   By default, a copper Ethernet interface operates in auto mode to negotiate pin roles with its peer.

Configuring storm control on an Ethernet interface

About storm control

Storm control compares broadcast, multicast and unknown unicast traffic regularly with their respective traffic thresholds on an Ethernet interface. For each type of traffic, storm control provides a lower threshold and an upper threshold.

Depending on your configuration, when a particular type of traffic exceeds its upper threshold, the interface performs either of the following operations:

- **Blocks this type of traffic and forwards other types of traffic**—Even though the interface does not forward the blocked traffic, it still counts the traffic. When the blocked traffic drops below the lower threshold, the interface begins to forward the traffic.
- **Goes down automatically**—The interface goes down automatically and stops forwarding any traffic. When the blocked traffic drops below the lower threshold, the interface does not automatically come up. To bring up the interface, use the **undo shutdown** command or disable the storm control feature.

You can configure an Ethernet interface to output threshold event traps and log messages when monitored traffic meets one of the following conditions:

- Exceeds the upper threshold.
- Drops below the lower threshold.

Both storm suppression and storm control can suppress storms on an interface. Storm suppression uses the chip to suppress traffic. Storm suppression has less impact on the device performance than storm control, which uses software to suppress traffic. For more information about storm suppression, see "Configuring storm suppression."

Storm control uses a complete polling cycle to collect traffic data, and analyzes the data in the next cycle. An interface takes one to two polling intervals to take a storm control action.

Restrictions and guidelines

For the traffic suppression result to be determined, do not configure storm control together with storm suppression for the same type of traffic.

Procedure

1. Enter system view.

   system-view

2. (Optional.) Set the statistics polling interval of the storm control module.

   storm-constrain interval *interval*

   The default setting is 10 seconds.

   For network stability, use the default or set a longer statistics polling interval.

3. Enter Ethernet interface view.

   interface *interface-type interface-number*

4. Enable storm control, and set the lower and upper thresholds for broadcast, multicast, or unknown unicast traffic.

   storm-constrain { **broadcast** | **multicast** | **unicast** } { **pps** | **kbps** | **ratio** } *upperlimit lowerlimit*

   By default, storm control is disabled.

5. Set the control action to take when monitored traffic exceeds the upper threshold.

   storm-constrain control { **block** | **shutdown** }

   By default, storm control is disabled.

6. Enable the Ethernet interface to output log messages when it detects storm control threshold events.

   storm-constrain enable log

   By default, the Ethernet interface outputs log messages when monitored traffic exceeds the upper threshold or drops below the lower threshold from a value above the upper threshold.

7. Enable the Ethernet interface to send storm control threshold event traps.

   storm-constrain enable trap

   By default, the Ethernet interface sends traps when monitored traffic exceeds the upper threshold or drops below the lower threshold from the upper threshold from a value above the upper threshold.

Testing the cable connection of an Ethernet interface

IMPORTANT:

If the link of an Ethernet interface is up, testing its cable connection will cause the link to go down and then come up.

About testing the cable connection of an Ethernet interface

This feature tests the cable connection of an Ethernet interface and displays cable test result within 5 seconds. The test result includes the cable's status and some physical parameters. If any fault is detected, the test result shows the length from the local port to the faulty point.

Restrictions and guidelines

Fiber ports do not support this feature.

Procedure

1. Enter any view.
2. Perform a test for the cable connected to an Ethernet interface.

   virtual-cable-test interface [*interface-type interface-number* | *interface-name*]

   The **interface** [*interface-type interface-number* | *interface-name*] option is supported only in R6350 and later versions.

   Performing this operation on an Ethernet interface will automatically bring the link down and up once, if it is already up.

Enabling bridging on an Ethernet interface

About enabling bridging on an Ethernet interface

By default, the device drops packets whose outgoing interface and incoming interface are the same.

To enable the device to forward such packets rather than drop them, enable the bridging feature in Ethernet interface view.

Procedure

1. Enter system view.

   system-view

2. Enter Ethernet interface view.

   interface *interface-type interface-number*

3. Enable bridging on the Ethernet interface.

   port bridge enable

By default, bridging is disabled on an Ethernet interface.

Display and maintenance commands for Ethernet interfaces

Execute **display** commands in any view and **reset** commands in user view.

Task	Command
Display interface traffic statistics.	**display counters** { **inbound** | **outbound** } **interface** [*interface-type* [*interface-number*]]
Display traffic rate statistics of interfaces in up state over the last statistics polling interval.	**display counters rate** { **inbound** | **outbound** } **interface** [*interface-type* [*interface-number*]]
Display the Ethernet module statistics.	**display ethernet statistics slot** *slot-number*
Display the operational and status information of the specified interfaces.	**display interface** [*interface-type* [*interface-number*]] [**brief** [**description** | **down**]]
Display information about link flapping protection on interfaces.	**display link-flap protection** [**interface** *interface-type* [*interface-number*]]
Display information about storm control on the specified interfaces.	**display storm-constrain** [**broadcast** | **multicast** | **unicast**] [**interface** *interface-type interface-number*]
Display test results for the cable connected to an Ethernet interface.	**display virtual-cable-test interface** [*interface-type interface-number* | *interface-name*]
Clear interface statistics.	**reset counters interface** [*interface-type* [*interface-number*]]
Clear the Ethernet module statistics.	**reset ethernet statistics** [**slot** *slot-number*]
Display the status and packet statistics of interfaces.	**display interface link-info**
Clear test results for the cable connected to an Ethernet interface.	**reset interface** [*interface-type interface-number* | *interface-name*] **virtual-cable-test**

Contents

Configuring loopback, null, and inloopback interfaces

This chapter describes how to configure a loopback interface, a null interface, and an inloopback interface.

About loopback, null, and inloopback interfaces

About loopback interfaces

A loopback interface is a virtual interface. The physical layer state of a loopback interface is always up unless the loopback interface is manually shut down. Because of this benefit, loopback interfaces are widely used in the following scenarios:

- **Configuring a loopback interface address as the source address of the IP packets that the device generates**—Because loopback interface addresses are stable unicast addresses, they are usually used as device identifications.

  When you configure a rule on an authentication or security server, you can configure it to permit or deny packets carrying the loopback interface address of a device. This simplifies your configuration and achieves the effect of permitting or denying packets that the device generates. To use a loopback interface address as the source address of IP packets, make sure the loopback interface is reachable from the peer by performing routing configuration. All data packets sent to the loopback interface are considered packets sent to the device itself, so the device does not forward these packets.
- **Using a loopback interface in dynamic routing protocols**—With no router ID configured for a dynamic routing protocol, the system selects the highest loopback interface IP address as the router ID.

About null interfaces

A null interface is a virtual interface and is always up, but you cannot use it to forward data packets or configure it with an IP address or link layer protocol. The null interface provides a simpler way to filter packets than ACL. You can filter undesired traffic by transmitting it to a null interface instead of applying an ACL. For example, if you specify a null interface as the next hop of a static route to a network segment, any packets routed to the network segment are dropped.

About inloopback interfaces

An inloopback interface is a virtual interface created by the system, which cannot be configured or deleted. The physical layer and link layer protocol states of an inloopback interface are always up. All IP packets sent to an inloopback interface are considered packets sent to the device itself and are not forwarded.

Configuring a loopback interface

1. Enter system view.

   system-view
2. Create a loopback interface and enter loopback interface view.

   interface loopback *interface-number*

3. Configure the interface description.

   description *text*

   The default setting is *interface name* **Interface** (for example, **LoopBack1 Interface**).
4. Configure the expected bandwidth of the loopback interface.

   bandwidth *bandwidth-value*

   By default, the expected bandwidth of a loopback interface is 0 kbps.
5. Bring up the loopback interface.

   undo shutdown

   By default, a loopback interface is up.

Configuring a null interface

1. Enter system view.

   system-view
2. Enter null interface view.

   interface null 0

   Interface Null 0 is the default null interface on the device and cannot be manually created or removed.

   Only one null interface, Null 0, is supported on the device. The null interface number is always 0.
3. Configure the interface description.

   description *text*

   The default setting is NULL0 Interface.

Restoring the default settings for an interface

Restrictions and guidelines

CAUTION:

This feature might interrupt ongoing network services. Make sure you are fully aware of the impact of this feature when you use it on a live network.

This feature might fail to restore the default settings for some commands because of command dependencies or system restrictions. You can use the **display this** command in interface view to check for these commands and perform their **undo** forms or follow the command reference to restore their default settings. If your restoration attempt still fails, follow the error message to resolve the problem.

Procedure

1. Enter system view.

   system-view
2. Enter loopback interface view or null interface view.
   - **interface loopback** *interface-number*
   - **interface null 0**
3. Restore the default settings for the interface.

   default

Display and maintenance commands for loopback, null, and inloopback interfaces

Execute **display** commands in any view and **reset** commands in user view.

Task	Command
Display information about the inloopback interface.	**display interface** [**inloopback** [**0**]] [**brief** [**description** | **down**]]
Display information about the specified or all loopback interfaces.	**display interface** [**loopback** [*interface-number*]] [**brief** [**description** | **down**]]
Display information about the null interface.	**display interface** [**null** [**0**]] [**brief** [**description** | **down**]]
Clear the statistics on the specified or all loopback interfaces.	**reset counters interface** [**loopback** [*interface-number*]]
Clear the statistics on the null interface.	**reset counters interface** [**null** [**0**]]

Contents

Bulk configuring interfaces

About interface bulk configuration

You can enter interface range view to bulk configure multiple interfaces with the same feature instead of configuring them one by one. For example, you can execute the **shutdown** command in interface range view to shut down a range of interfaces.

To configure interfaces in bulk, you must configure an interface range and enter its view by using the **interface range** or **interface range name** command.

The interface range created by using the **interface range** command is not saved to the running configuration. You cannot use the interface range repeatedly. To create an interface range that can be used repeatedly, use the **interface range name** command.

Restrictions and guidelines: Bulk interface configuration

When you bulk configure interfaces in interface range view, follow these restrictions and guidelines:

- In interface range view, only the commands supported by the first interface in the specified interface list (alphabetically sorted) are available for configuration.
- Before you configure an interface as the first interface in an interface range, make sure you can enter the view of the interface by using the **interface** *interface-type interface-number* command.
- Do not assign both an aggregate interface and any of its member interfaces to an interface range. Some commands, after being executed on both an aggregate interface and its member interfaces, can break up the aggregation.
- Understand that the more interfaces you specify, the longer the command execution time.
- To guarantee bulk interface configuration performance, configure fewer than 1000 interface range names.

The device does not output prompt or alarm messages during the bulk interface configuration process. Make sure you are fully aware of the impacts of the bulk interface configuration.

- After a command is executed in interface range view, one of the following situations might occur:
  - The system displays an error message and stays in interface range view. This means that the execution failed on one or multiple member interfaces.
    - If the execution failed on the first member interface, the command is not executed on any member interfaces.
    - If the execution failed on a non-first member interface, the command takes effect on the remaining member interfaces.
  - The system returns to system view. This means that:
    - The command is supported in both system view and interface view.
    - The execution failed on a member interface in interface range view and succeeded in system view.
    - The command is not executed on the subsequent member interfaces.

You can use the **display this** command to verify the configuration in interface view of each member interface. In addition, if the configuration in system view is not needed, use the **undo** form of the command to remove the configuration.

Procedure

1. Enter system view.

   system-view
2. Create an interface range and enter interface range view.
   - Create an interface range without specifying a name.

     interface range { *interface-type interface-number* [**to** *interface-type interface-number*] } &<1-24>
   - Create a named interface range.

     interface range name *name* [**interface** { *interface-type interface-number* [**to** *interface-type interface-number*] } &<1-24>]
3. (Optional.) Display commands available for the first interface in the interface range.

   Enter a question mark (?) at the interface range prompt.
4. Use available commands to configure the interfaces.

   Available commands depend on the interface.
5. (Optional.) Verify the configuration.

   display this

Display and maintenance commands for bulk interface configuration

Execute the **display** command in any view.

Task	Command
Display information about the interface ranges created by using the **interface range name** command.	**display interface range** [**name** *name*]

Contents

Configuring the MAC address table

About the MAC address table

An Ethernet device uses a MAC address table to forward frames. A MAC address entry includes a destination MAC address, an outgoing interface, and a VLAN ID. When the device receives a frame, it uses the destination MAC address of the frame to look for a match in the MAC address table.

- The device forwards the frame out of the outgoing interface in the matching entry if a match is found.
- The device floods the frame in the VLAN of the frame if no match is found.

How a MAC address entry is created

The entries in the MAC address table include entries automatically learned by the device and entries manually added.

MAC address learning

The device can automatically populate its MAC address table by learning the source MAC addresses of incoming frames on each interface.

The device performs the following operations to learn the source MAC address of incoming packets:

1. Checks the source MAC address (for example, MAC-SOURCE) of the frame.
2. Looks up the source MAC address in the MAC address table.
    - The device updates the entry if an entry is found.
    - The device adds an entry for MAC-SOURCE and the incoming port if no entry is found.

When the device receives a frame destined for MAC-SOURCE after learning this source MAC address, the device performs the following operations:

1. Finds the MAC-SOURCE entry in the MAC address table.
2. Forwards the frame out of the port in the entry.

The device performs the learning process for each incoming frame with an unknown source MAC address until the table is fully populated.

Manually configuring MAC address entries

Dynamic MAC address learning does not distinguish between illegitimate and legitimate frames, which can invite security hazards. When Host A is connected to Port A, a MAC address entry will be learned for the MAC address of Host A (for example, MAC A). When an illegal user sends frames with MAC A as the source MAC address to Port B, the device performs the following operations:

1. Learns a new MAC address entry with Port B as the outgoing interface and overwrites the old entry for MAC A.
2. Forwards frames destined for MAC A out of Port B to the illegal user.

As a result, the illegal user obtains the data of Host A. To improve the security for Host A, manually configure a static entry to bind Host A to Port A. Then, the frames destined for Host A are always sent out of Port A. Other hosts using the forged MAC address of Host A cannot obtain the frames destined for Host A.

Types of MAC address entries

A MAC address table can contain the following types of entries:

- **Static entries**—A static entry is manually added to forward frames with a specific destination MAC address out of the associated interface, and it never ages out. A static entry has higher priority than a dynamically learned one.
- **Dynamic entries**—A dynamic entry can be manually configured or dynamically learned to forward frames with a specific destination MAC address out of the associated interface. A dynamic entry might age out. A manually configured dynamic entry has the same priority as a dynamically learned one.
- **Blackhole entries**—A blackhole entry is manually configured and never ages out. A blackhole entry is configured for filtering out frames with a specific source or destination MAC address. For example, to block all frames destined for or sourced from a user, you can configure the MAC address of the user as a blackhole MAC address entry. A blackhole entry has higher priority than a dynamically learned one.
- **Multiport unicast entries**—A multiport unicast entry is manually added to send frames with a specific unicast destination MAC address out of multiple ports, and it never ages out. A multiport unicast entry has higher priority than a dynamically learned one.

A static, blackhole, or multiport unicast MAC address entry can overwrite a dynamic MAC address entry, but not vice versa. A static entry, a blackhole entry, and a multiport unicast entry cannot overwrite one another.

This document does not cover the configuration of static multicast MAC address entries. For more information about configuring static multicast MAC address entries, see IGMP snooping in *IP Multicast Configuration Guide*.

MAC address table tasks at a glance

All MAC address table configuration tasks are optional.

To configure the MAC address table, perform the following tasks:

- Configuring MAC address entries
  - Adding or modifying a static or dynamic MAC address entry
  - Adding or modifying a blackhole MAC address entry
  - Adding or modifying a multiport unicast MAC address entry
- Setting the aging timer for dynamic MAC address entries
- Configuring MAC address learning
  - Disabling MAC address learning
  - Setting the MAC learning limit
  - Configuring the unknown frame forwarding rule after the MAC learning limit is reached
- Enabling MAC address synchronization
- Configuring MAC address move notifications and suppression
- Enabling ARP fast update for MAC address moves
- Setting the hash bucket size of the MAC address table
- Enabling MAC hashing conflict logging
- Disabling packet filter when the source MAC address is a multicast or broadcast MAC address
- Enabling SNMP notifications for the MAC address table

Configuring MAC address entries

About MAC address entry-based frame forwarding

A frame whose source MAC address matches different types of MAC address entries is processed differently.

Type	Description
Static MAC address entry	Forwards the frame according to the destination MAC address regardless of whether the frame's ingress interface is the same as that in the entry.
Multiport unicast MAC address entry	• Learns the MAC address of the frame and generates a dynamic MAC address entry, but the generated dynamic MAC address entry does not take effect. • Forwards the frame based on the multiport unicast MAC address entry.
Blackhole MAC address entry	Drops the frame.
Dynamic MAC address entry	• Learns the MAC address of the frames received on a different interface from that in the entry and overwrites the original entry. • Forwards the frame received on the same interface as that in the entry and updates the aging timer for the entry.

Restrictions and guidelines for MAC address entry configuration

A manually configured dynamic MAC address entry will overwrite a learned entry that already exists with a different outgoing interface for the MAC address.

The manually configured static, blackhole, and multiport unicast MAC address entries cannot survive a reboot if you do not save the configuration. The manually configured dynamic MAC address entries are lost upon reboot whether or not you save the configuration.

Do not configure the reserved MAC addresses of the device as static, dynamic, blackhole, or multiport unicast MAC addresses. The reserved MAC addresses of a device are MAC addresses from the bridge MAC address of the device to the bridge MAC address plus 95. For information about bridge MAC addresses, see IRF in *Virtual Technologies Configuration Guide*.

Prerequisites for MAC address entry configuration

Before manually configuring a MAC address entry for an interface, make sure the VLAN in the entry has been created.

Adding or modifying a static or dynamic MAC address entry

Adding or modifying a static or dynamic MAC address entry globally

1. Enter system view.

   system-view

2. Add or modify a static or dynamic MAC address entry.

   mac-address { **dynamic** | **static** } *mac-address* **interface** *interface-type interface-number* **vlan** *vlan-id*

By default, no MAC address entry is configured globally.

Make sure you have assigned the interface to the VLAN.

Adding or modifying a static or dynamic MAC address entry on an interface

1. Enter system view.
   system-view
2. Enter interface view.
   - Enter Layer 2 Ethernet interface view.
     interface *interface-type interface-number*
   - Enter Layer 2 aggregate interface view.
     interface bridge-aggregation *interface-number*
3. Add or modify a static or dynamic MAC address entry.
   mac-address { **dynamic** | **static** } *mac-address* **vlan** *vlan-id*

   By default, no MAC address entry is configured on an interface.

   Make sure you have assigned the interface to the VLAN.

Adding or modifying a blackhole MAC address entry

1. Enter system view.
   system-view
2. Add or modify a blackhole MAC address entry.
   mac-address blackhole *mac-address* **vlan** *vlan-id*

   By default, no blackhole MAC address entry is configured.

Adding or modifying a multiport unicast MAC address entry

About multiport unicast MAC address entry configuration

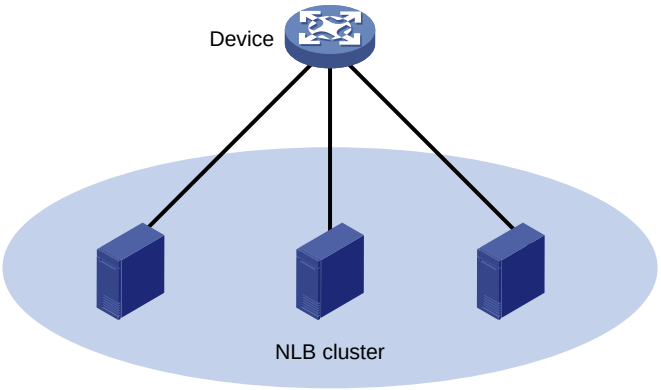
You can configure a multiport unicast MAC address entry to associate a unicast destination MAC address with multiple ports. The frame with a destination MAC address matching the entry is sent out of multiple ports.

For example, in NLB unicast mode (see Figure 1):

- All servers within a cluster uses the cluster's MAC address as their own address.
- Frames destined for the cluster are forwarded to every server in the group.

In this case, you can configure a multiport unicast MAC address entry on the device connected to the server group. Then, the device forwards the frame destined for the server group to every server through all ports connected to the servers within the cluster.

Figure 1 NLB cluster



You can configure a multiport unicast MAC address entry globally or on an interface.

Configuring a multiport unicast MAC address entry globally

1. Enter system view.
   system-view
2. Add or modify a multiport unicast MAC address entry.
   mac-address multiport *mac-address* **interface** *interface-list* **vlan** *vlan-id*
   By default, no multiport unicast MAC address entry is configured globally.
   Make sure you have assigned the interface to the VLAN.

Configuring a multiport unicast MAC address entry on an interface

1. Enter system view.
   system-view
2. Enter interface view.
   - Enter Layer 2 Ethernet interface view.
     interface *interface-type interface-number*
   - Enter Layer 2 aggregate interface view.
     interface bridge-aggregation *interface-number*
3. Add the interface to a multiport unicast MAC address entry.
   mac-address multiport *mac-address* **vlan** *vlan-id*
   By default, no multiport unicast MAC address entry is configured on an interface.
   Make sure you have assigned the interface to the VLAN.

Setting the aging timer for dynamic MAC address entries

About aging timer for dynamic MAC address entries

For security and efficient use of table space, the MAC address table uses an aging timer for each dynamic MAC address entry. If a dynamic MAC address entry is not updated before the aging timer expires, the device deletes the entry. This aging mechanism ensures that the MAC address table can promptly update to accommodate latest network topology changes.

A stable network requires a longer aging interval, and an unstable network requires a shorter aging interval.

An aging interval that is too long might cause the MAC address table to retain outdated entries. As a result, the MAC address table resources might be exhausted, and the MAC address table might fail to update its entries to accommodate the latest network changes.

An interval that is too short might result in removal of valid entries, which would cause unnecessary floods and possibly affect the device performance.

To reduce floods on a stable network, set a long aging timer or disable the timer to prevent dynamic entries from unnecessarily aging out. Reducing floods improves the network performance. Reducing flooding also improves the security because it reduces the chances for a data frame to reach unintended destinations.

Procedure

1. Enter system view.

   system-view
2. Set the aging timer for dynamic MAC address entries.

   mac-address timer { **aging** *seconds* | **no-aging** }

   By default, the aging timer is 300 seconds for dynamic MAC address entries.

Disabling MAC address learning

About disabling MAC address learning

MAC address learning is enabled by default. To prevent the MAC address table from being saturated when the device is experiencing attacks, disable MAC address learning. For example, you can disable MAC address learning to prevent the device from being attacked by a large amount of frames with different source MAC addresses.

After MAC address learning is disabled, the device immediately deletes existing dynamic MAC address entries.

Disabling global MAC address learning

Restrictions and guidelines

After you disable global MAC address learning, the device cannot learn MAC addresses on any interfaces.

Procedure

1. Enter system view.

   system-view
2. Disable global MAC address learning.

   undo mac-address mac-learning enable

   By default, global MAC address learning is enabled.

Disabling MAC address learning on an interface

About disabling MAC address learning on an interface

When global MAC address learning is enabled, you can disable MAC address learning on a single interface.

Procedure

1. Enter system view.

system-view

2. Enter interface view.
   - Enter Layer 2 Ethernet interface view.
     interface *interface-type interface-number*
   - Enter Layer 2 aggregate interface view.
     interface bridge-aggregation *interface-number*
3. Disable MAC address learning on the interface.
   undo mac-address mac-learning enable
   By default, MAC address learning is enabled on an interface.

Disabling MAC address learning on a VLAN

About disabling MAC address learning on a VLAN

When global MAC address learning is enabled, you can disable MAC address learning on a per-VLAN basis.

Procedure

1. Enter system view.
   system-view
2. Enter VLAN view.
   vlan *vlan-id*
3. Disable MAC address learning on the VLAN.
   undo mac-address mac-learning enable
   By default, MAC address learning on the VLAN is enabled.

Setting the MAC learning limit

About interface-based MAC learning limit

This feature limits the MAC address table size. A large MAC address table will degrade forwarding performance.

Restrictions and guidelines

The MAC learning limit does not control the number of MAC addresses learned in voice VLANs. For more information, see "Configuring voice VLANs."

Procedure

1. Enter system view.
   system-view
2. Enter Layer 2 Ethernet interface view.
   interface *interface-type interface-number*
3. Set the MAC learning limit on the interface.
   mac-address max-mac-count *count*
   By default, no MAC learning limit is configured on an interface.

Configuring the unknown frame forwarding rule after the MAC learning limit is reached

In this document, unknown frames refer to frames whose source MAC addresses are not in the MAC address table.

About unknown frame forwarding rule configuration

You can enable or disable forwarding of unknown frames after the MAC learning limit is reached.

Procedure

1. Enter system view.
   `system-view`
2. Enter Layer 2 Ethernet interface view.
   `interface` *`interface-type interface-number`*
3. Configure the device to forward unknown frames received on the interface after the MAC learning limit on the interface is reached.
   `mac-address max-mac-count enable-forwarding`
   By default, the device can forward unknown frames received on an interface after the MAC learning limit on the interface is reached.

Enabling MAC address synchronization

About MAC address synchronization

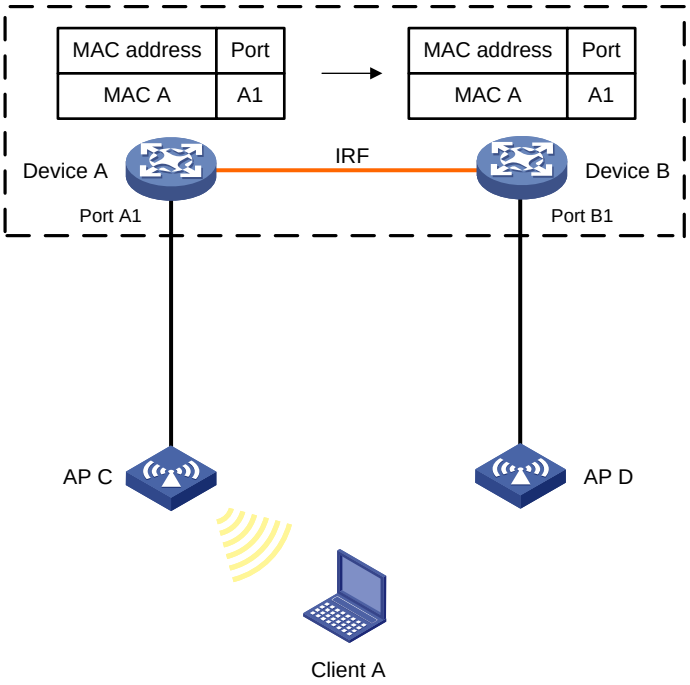
To avoid unnecessary floods and improve forwarding speed, make sure all member devices have the same MAC address table. After you enable MAC address synchronization, each member device advertises learned MAC address entries to other member devices.

As shown in Figure 2:

- Device A and Device B form an IRF fabric enabled with MAC address synchronization.
- Device A and Device B connect to AP C and AP D, respectively.

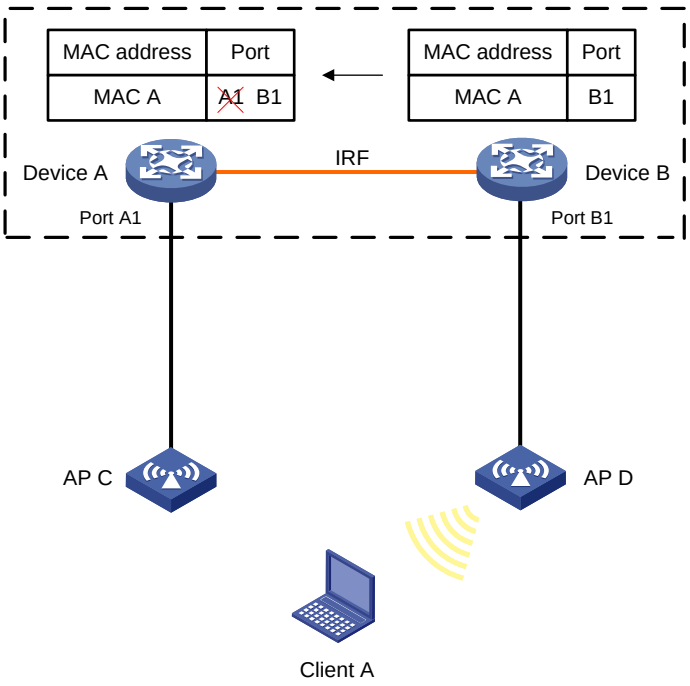
When Client A associates with AP C, Device A learns a MAC address entry for Client A and advertises it to Device B.

Figure 2 MAC address tables of devices when Client A accesses AP C



When Client A roams to AP D, Device B learns a MAC address entry for Client A. Device B advertises it to Device A to ensure service continuity for Client A, as shown in Figure 3.

Figure 3 MAC address tables of devices when Client A roams to AP D



Procedure

1. Enter system view.

   ```
   system-view
   ```

2. Enable MAC address synchronization.

mac-address mac-roaming enable

By default, MAC address synchronization is disabled.

Configuring MAC address move notifications and suppression

About MAC address move notifications and suppression

The outgoing interface for a MAC address entry learned on interface A is changed to interface B when the following conditions exist:

- Interface B receives a packet with the MAC address as the source MAC address.
- Interface B belongs to the same VLAN as interface A.

In this case, the MAC address is moved from interface A to interface B, and a MAC address move occurs.

The MAC address move notifications feature enables the device to output MAC address move logs when MAC address moves are detected.

If a MAC address is continuously moved between the two interfaces, Layer 2 loops might occur. To detect and locate loops, you can view the MAC address move information. To display the MAC address move records after the device is started, use the **display mac-address mac-move** command.

If the system detects that MAC address moves occur frequently on an interface, you can configure MAC address move suppression to shut the interface down. The interface automatically goes up after a suppression interval. Or, you can manually bring up the interface.

Restrictions and guidelines

After you configure MAC address move notifications, the system sends only log messages to the information center module. If the device is also configured with the **snmp-agent trap enable mac-address** command, the system also sends SNMP notifications to the SNMP module.

Procedure

1. Enter system view.

   system-view

2. Enable MAC address move notifications and optionally specify a MAC move detection interval.

   mac-address notification mac-move [**interval** *interval*]

   By default, MAC address move notifications are disabled.

3. (Optional.) Set MAC address move suppression parameters.

   mac-address notification mac-move suppression { **interval** *interval* | **threshold** *threshold* }

   By default, the suppression interval is 30 seconds, and the suppression threshold is 3.

   For the MAC address move suppression parameters to take effect, enable the MAC address move suppression on a port.

4. Enter interface view.

   - Enter Layer 2 Ethernet interface view.

     interface *interface-type interface-number*

   - Enter Layer 2 aggregate interface view.

     interface bridge-aggregation *interface-number*

5. Enable MAC address move suppression.

   mac-address notification mac-move suppression

By default, MAC address move suppression is disabled.

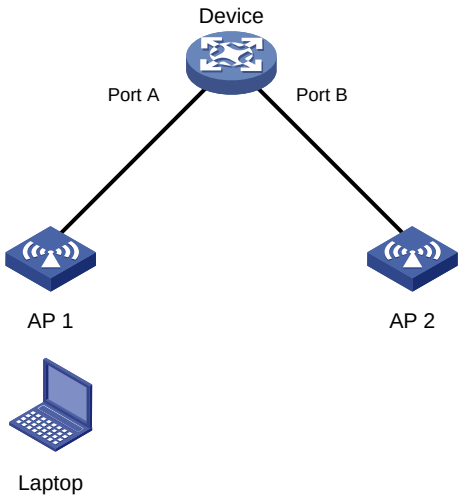
Enabling ARP fast update for MAC address moves

About ARP fast update for MAC address moves

ARP fast update for MAC address moves allows the device to update an ARP entry immediately after the outgoing interface for a MAC address changes. This feature ensures data connection without interruption.

As shown in Figure 4, a mobile user laptop accesses the network by connecting to AP 1 or AP 2. When the AP to which the user connects changes, the device updates the ARP entry for the user immediately after it detects a MAC address move.

Figure 4 ARP fast update application scenario



Procedure

1. Enter system view.
   ```
   system-view
   ```
2. Enable ARP fast update for MAC address moves.
   ```
   mac-address mac-move fast-update
   ```
   By default, ARP fast update for MAC address moves is disabled.

Setting the hash bucket size of the MAC address table

About the hash bucket size of the MAC address table

The device saves the MAC address table through hash chains. If multiple MAC addresses obtain the same key through hashing, MAC address hash conflicts occur, and the device cannot learn some of these MAC addresses. The device will broadcast the traffic destined for the unknown MAC addresses, which consumes bandwidth and resources.

You can increase the hash bucket size of the MAC address table to reduce MAC address hash conflicts. A larger hash bucket size requires more system resources. Please set the hash bucket size

appropriately depending on system resources. You can use the **display mac-address hash-bucket-size** command to view the current hash bucket size and the hash bucket size that will take effect at the next startup.

Restrictions and guidelines

The set hash bucket size takes effect at the next startup.

Procedure

1. Enter system view.
   system-view
2. Set the hash bucket size of the MAC address table.
   mac-address hash-bucket-size *size*
   By default, the hash bucket size of the MAC address table is 4.

Enabling MAC hashing conflict logging

About this task

MAC hashing conflict logging enables the device to generate log messages for the MAC hashing conflicts that occur in MAC address learning. You can use this feature to identify the MAC addresses that the device fails to learn because of hashing conflicts. To display the log messages generated for MAC hashing conflicts, execute the **display mac-address hash-conflict-record** command.

Software version and feature compatibility

This feature is supported only in Release 6328 and later.

Restrictions and guidelines

This feature consumes system resources. When you enable it on the device, make sure you are fully aware of the impact on device performance.

Procedure

1. Enter system view.
   system-view
2. Enable MAC hashing conflict logging.
   mac-address hash-conflict-record enable slot *slot-number*
   By default, MAC hashing conflict logging is disabled.

Disabling packet filter when the source MAC address is a multicast or broadcast MAC address

About this task

By default, the device will drop a frame whose source MAC address is a multicast or broadcast MAC address. To avoid the user traffic loss and ensure user trasffic to be forwarded correctly in this scenario, you can disable packet filter on the device where its source MAC address is a multicast or broadcast MAC address.

Procedure

1. Enter system view.
   system-view

2. Disable packet filter when the source MAC address is a multicast or broadcast MAC address.

   undo mac-address multicast-source packet-filter

   By default, packet filter is enabled on the device where its source MAC address is a multicast or broadcast MAC address.

Enabling SNMP notifications for the MAC address table

About SNMP notifications for the MAC address table

To report critical MAC address move events to an NMS, enable SNMP notifications for the MAC address table. For MAC address move event notifications to be sent correctly, you must also configure SNMP on the device.

When SNMP notifications are disabled for the MAC address table, the device sends the generated logs to the information center. To display the logs, configure the log destination and output rule configuration in the information center.

For more information about SNMP and information center configuration, see the network management and monitoring configuration guide for the device.

Procedure

1. Enter system view.

   system-view

2. Enable SNMP notifications for the MAC address table.

   snmp-agent trap enable mac-address [**mac-move**]

   By default, SNMP notifications are enabled for the MAC address table.

   When SNMP notifications are disabled for the MAC address table, syslog messages are sent to notify important events on the MAC address table module.

Display and maintenance commands for MAC address table

IMPORTANT:

The **display mac-address hash-conflict-record** command is supported only in Release 6328 and later.

Execute **display** commands in any view.

Task	Command
Display MAC address table information.	**display mac-address** [*mac-address* [**vlan** *vlan-id*] | [[**dynamic** | **static**] [**interface** *interface-type interface-number*] | **blackhole** | **multiport**] [**vlan** *vlan-id*] [**count**]]
Display the aging timer for dynamic MAC address entries.	**display mac-address aging-time**
Display the hash bucket size of the	**display mac-address hash-bucket-size**

Task	Command
MAC address table.	
Display the log messages generated for MAC hashing conflicts.	**display mac-address hash-conflict-record slot** *slot-number*
Display the system or interface MAC address learning state.	**display mac-address mac-learning** [**interface** *interface-type interface-number*]
Display the MAC address move records.	**display mac-address mac-move** [**slot** *slot-number*]
Display MAC address statistics.	**display mac-address statistics**

MAC address table configuration examples

Example: Configuring the MAC address table

Network configuration

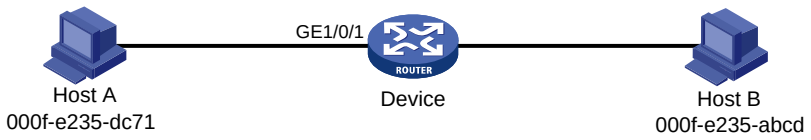
As shown in Figure 5:

- Host A at MAC address 000f-e235-dc71 is connected to GigabitEthernet 1/0/1 of Device and belongs to VLAN 1.
- Host B at MAC address 000f-e235-abcd, which behaved suspiciously on the network, also belongs to VLAN 1.

Configure the MAC address table as follows:

- To prevent MAC address spoofing, add a static entry for Host A in the MAC address table of Device.
- To drop all frames destined for Host B, add a blackhole MAC address entry for Host B.
- Set the aging timer to 500 seconds for dynamic MAC address entries.

Figure 5 Network diagram



Procedure

Add a static MAC address entry for MAC address 000f-e235-dc71 on GigabitEthernet 1/0/1 that belongs to VLAN 1.

```
<Device> system-view
[Device] mac-address static 000f-e235-dc71 interface gigabitethernet 1/0/1 vlan 1
```

Add a blackhole MAC address entry for MAC address 000f-e235-abcd that belongs to VLAN 1.

```
[Device] mac-address blackhole 000f-e235-abcd vlan 1
```

Set the aging timer to 500 seconds for dynamic MAC address entries.

```
[Device] mac-address timer aging 500
```

Verifying the configuration

Display the static MAC address entries for GigabitEthernet 1/0/1.

```
[Device] display mac-address static interface gigabitethernet 1/0/1
```

```
MAC Address      VLAN ID    State           Port/Nickname           Aging
000f-e235-dc71   1          Static          GE1/0/1                 N
```

Display the blackhole MAC address entries.

```
[Device] display mac-address blackhole
MAC Address      VLAN ID    State           Port/Nickname           Aging
000f-e235-abcd   1          Blackhole       N/A                     N
```

Display the aging time of dynamic MAC address entries.

```
[Device] display mac-address aging-time
MAC address aging time: 500s.
```

Configuring MAC Information

About MAC Information

The MAC Information feature can generate syslog messages or SNMP notifications when MAC address entries are learned or deleted. You can use these messages to monitor user's leaving or joining the network and analyze network traffic.

The MAC Information feature buffers the MAC change syslog messages or SNMP notifications in a queue. The device overwrites the oldest MAC address change written into the queue with the most recent MAC address change when the following conditions exist:

- The MAC change notification interval does not expire.
- The queue has been exhausted.

To send a syslog message or SNMP notification immediately after it is created, set the queue length to zero.

Enabling MAC Information

Restrictions and guidelines

For MAC Information to take effect, you must enable MAC Information both globally and on interfaces.

Procedure

1. Enter system view.
   `system-view`
2. Enable MAC Information globally.
   `mac-address information enable`
   By default, MAC Information is globally disabled.
3. Enter Layer 2 Ethernet interface view.
   `interface` *`interface-type interface-number`*
4. Enable MAC Information on the interface.
   `mac-address information enable` { **`added`** | **`deleted`** }
   By default, MAC Information is disabled on an interface.

Configuring the MAC Information mode

About MAC Information modes

The following MAC Information modes are available for sending MAC address changes:

- **Syslog**—The device sends syslog messages to notify MAC address changes. The device sends syslog messages to the information center, which then outputs them to the monitoring terminal. For more information about information center, see *Network Management and Monitoring Configuration Guide*.
- **Trap**—The device sends SNMP notifications to notify MAC address changes. The device sends SNMP notifications to the NMS. For more information about SNMP, see *Network Management and Monitoring Configuration Guide*.

Procedure

1. Enter system view.
   system-view
2. Configure the MAC Information mode.
   mac-address information mode { **syslog** | **trap** }
   The default setting is **trap**.

Setting the MAC change notification interval

About the MAC change notification interval

To prevent syslog messages or SNMP notifications from being sent too frequently, you can set the MAC change notification interval to a larger value.

Procedure

1. Enter system view.
   system-view
2. Set the MAC change notification interval.
   mac-address information interval *interval*
   The default setting is 1 second.

Setting the MAC Information queue length

About the MAC Information queue length

If the MAC Information queue length is 0, the device sends a syslog message or SNMP notification immediately after learning or deleting a MAC address.

If the MAC Information queue length is not 0, the device stores MAC changes in the queue:

- The device overwrites the oldest MAC change written into the queue with the most recent MAC change when the following conditions exist:
  - The MAC change notification interval does not expire.
  - The queue has been exhausted.
- The device sends syslog messages or SNMP notifications only if the MAC change notification interval expires.

Procedure

1. Enter system view.
   system-view
2. Set the MAC Information queue length.
   mac-address information queue-length *value*
   The default setting is 50.

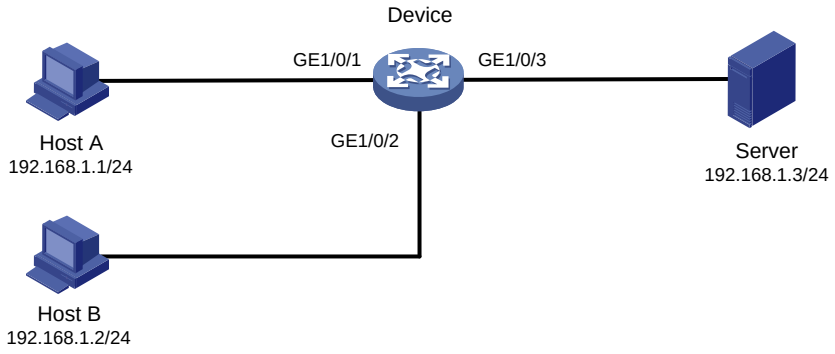
MAC Information configuration examples

Example: Configuring MAC Information

Network configuration

Enable MAC Information on GigabitEthernet 1/0/1 on Device in Figure 6 to send MAC address changes in syslog messages to the log host, Host B, through interface GigabitEthernet 1/0/2.

Figure 6 Network diagram



Restrictions and guidelines

When you edit file **/etc/syslog.conf**, follow these restrictions and guidelines:

- Comments must be on a separate line and must begin with a pound sign (#).
- No redundant spaces are allowed after the file name.

The logging facility name and the severity level specified in the **/etc/syslog.conf** file must be the same as those configured on the device. Otherwise, the log information might not be output correctly to the log host. The logging facility name and the severity level are configured by using the **`info-center loghost`** and **`info-center source`** commands, respectively.

Procedure

1. Configure Device to send syslog messages to Host B:

   # Enable the information center.

   ```
   <Device> system-view
   [Device] info-center enable
   ```

   # Specify the log host 192.168.1.2/24 and specify **local4** as the logging facility.

   ```
   [Device] info-center loghost 192.168.1.2 facility local4
   ```

   # Disable log output to the log host.

   ```
   [Device] info-center source default loghost deny
   ```

   To avoid output of unnecessary information, disable all modules from outputting logs to the specified destination (**loghost**, in this example) before you configure an output rule.

   # Configure an output rule to output to the log host MAC address logs that have a severity level no lower than **informational**.

   ```
   [Device] info-center source mac loghost level informational
   ```

2. Configure the log host, Host B:

   Configure Solaris as follows. Configure other UNIX operating systems in the same way Solaris is configured.

   a. Log in to the log host as a root user.

   b. Create a subdirectory named **Device** in directory **/var/log/**.

```
# mkdir /var/log/Device
```

c. Create file **info.log** in the **Device** directory to save logs from **Device**.

```
# touch /var/log/Device/info.log
```

d. Edit the file **syslog.conf** in directory **/etc/** and add the following contents:

```
# Device configuration messages
local4.info /var/log/Device/info.log
```

In this configuration, **local4** is the name of the logging facility that the log host uses to receive logs, and **info** is the informational level. The UNIX system records the log information that has a severity level no lower than **informational** to file **/var/log/Device/info.log**.

e. Display the process ID of **syslogd**, end the **syslogd** process, and then restart **syslogd** using the **–r** option to make the new configuration take effect.

```
# ps -ae | grep syslogd
147
# kill -HUP 147
# syslogd -r &
```

The device can output MAC address logs to the log host, which stores the logs to the specified file.

3. Enable MAC Information on Device:

Enable MAC Information globally.

```
[Device] mac-address information enable
```

Configure the MAC Information mode as syslog.

```
[Device] mac-address information mode syslog
```

Enable MAC Information on GigabitEthernet 1/0/1 to enable the port to record MAC address change information when the interface performs either of the following operations:

- Learns a new MAC address.
- Deletes an existing MAC address.

```
[Device] interface gigabitethernet 1/0/1
[Device-GigabitEthernet1/0/1] mac-address information enable added
[Device-GigabitEthernet1/0/1] mac-address information enable deleted
[Device-GigabitEthernet1/0/1] quit
```

Set the MAC Information queue length to 100.

```
[Device] mac-address information queue-length 100
```

Set the MAC change notification interval to 20 seconds.

```
[Device] mac-address information interval 20
```

Contents

Configuring Ethernet link aggregation

About Ethernet link aggregation

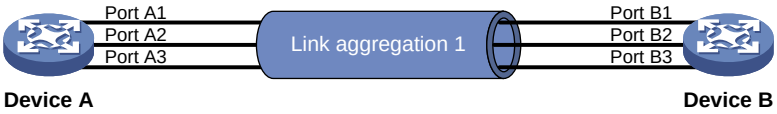
Ethernet link aggregation bundles multiple physical Ethernet links into one logical link (called an aggregate link). Link aggregation provides the following benefits:

- Increased bandwidth beyond the limits of a single individual link. In an aggregate link, traffic is distributed across the member ports.
- Improved link reliability. The member ports dynamically back up one another. When a member port fails, its traffic is automatically switched to other member ports.

Ethernet link aggregation application scenario

As shown in Figure 1, Device A and Device B are connected by three physical Ethernet links. These physical Ethernet links are combined into an aggregate link called link aggregation 1. The bandwidth of this aggregate link can reach up to the total bandwidth of the three physical Ethernet links. At the same time, the three Ethernet links back up one another. When a physical Ethernet link fails, the traffic transmitted on the failed link is switched to the other two links.

Figure 1 Ethernet link aggregation diagram



Aggregate interface, aggregation group, and member port

Each link aggregation is represented by a logical aggregate interface. Each aggregate interface has an automatically created aggregation group, which contains member ports to be used for aggregation. The type and number of an aggregation group are the same as its aggregate interface.

Supported aggregate interface types

The device supports Layer 2 aggregate interfaces. A Layer 2 aggregate interface is created manually. The member ports in a Layer 2 aggregation group can only be Layer 2 Ethernet interfaces.

The port rate of an aggregate interface equals the total rate of its Selected member ports. Its duplex mode is the same as that of the Selected member ports. For more information about Selected member ports, see "Aggregation states of member ports in an aggregation group."

Aggregation states of member ports in an aggregation group

A member port in an aggregation group can be in any of the following aggregation states:

- **Selected**—A Selected port can forward traffic.
- **Unselected**—An Unselected port cannot forward traffic.
- **Individual**—An Individual port can forward traffic as a normal physical port. This state is peculiar to the member ports of edge aggregate interfaces. A member port is placed in Individual state if it has not received LACPDUs before the first expiration of the LACP timeout timer after either of the following event occurs:
  - The aggregate interface is configured as an edge aggregate interface.
  - The member port goes down and then comes up after it is placed in Unselected or Selected state.

For more information about edge aggregate interfaces, see "Edge aggregate interface."

Operational key

When aggregating ports, the system automatically assigns each port an operational key based on port information, such as port rate and duplex mode. Any change to this information triggers a recalculation of the operational key.

In an aggregation group, all Selected ports have the same operational key.

Configuration types

Port configuration includes the attribute configuration and protocol configuration. Attribute configuration affects the aggregation state of the port but the protocol configuration does not.

Attribute configuration

To become a Selected port, a member port must have the same attribute configuration as the aggregate interface. Table 1 describes the attribute configuration.

Table 1 Attribute configuration

Feature	Attribute configuration
Port isolation	Membership of the port in an isolation group. Isolation group number.
QinQ	QinQ status (enabled/disabled), TPID for VLAN tags, and VLAN transparent transmission. For information about QinQ, see "Configuring QinQ."
VLAN mapping	VLAN mapping configured on the port. For more information about VLAN mapping, see "Configuring VLAN mapping."
VLAN	VLAN attribute settings: • Permitted VLAN IDs. • PVID. • Link type (trunk, hybrid, or access). • PVLAN port type (promiscuous, trunk promiscuous, host, or trunk secondary). • IP subnet-based VLAN configuration. • Protocol-based VLAN configuration. • VLAN tagging mode. For information about VLANs, see "Configuring VLANs."

Protocol configuration

Protocol configuration of a member port does not affect the aggregation state of the member port. MAC address learning and spanning tree settings are examples of the protocol configuration.

Link aggregation modes

An aggregation group operates in one of the following modes:

- **Static**—Static aggregation is stable. An aggregation group in static mode is called a static aggregation group. The aggregation states of the member ports in a static aggregation group are not affected by the peer ports.
- **Dynamic**—An aggregation group in dynamic mode is called a dynamic aggregation group. Dynamic aggregation is implemented through IEEE 802.3ad Link Aggregation Control Protocol

(LACP). The local system and the peer system automatically maintain the aggregation states of the member ports. Dynamic link aggregation reduces the administrators' workload.

How static link aggregation works

Reference port selection process

When setting the aggregation states of the ports in an aggregation group, the system automatically chooses a member port as the reference port. A Selected port must have the same operational key and attribute configurations as the reference port.

The system chooses a reference port from the member ports in up state.

The candidate reference ports are organized into different priority levels following these rules:

1. In descending order of port priority.
2. Full duplex.
3. In descending order of speed.
4. Half duplex.
5. In descending order of speed.

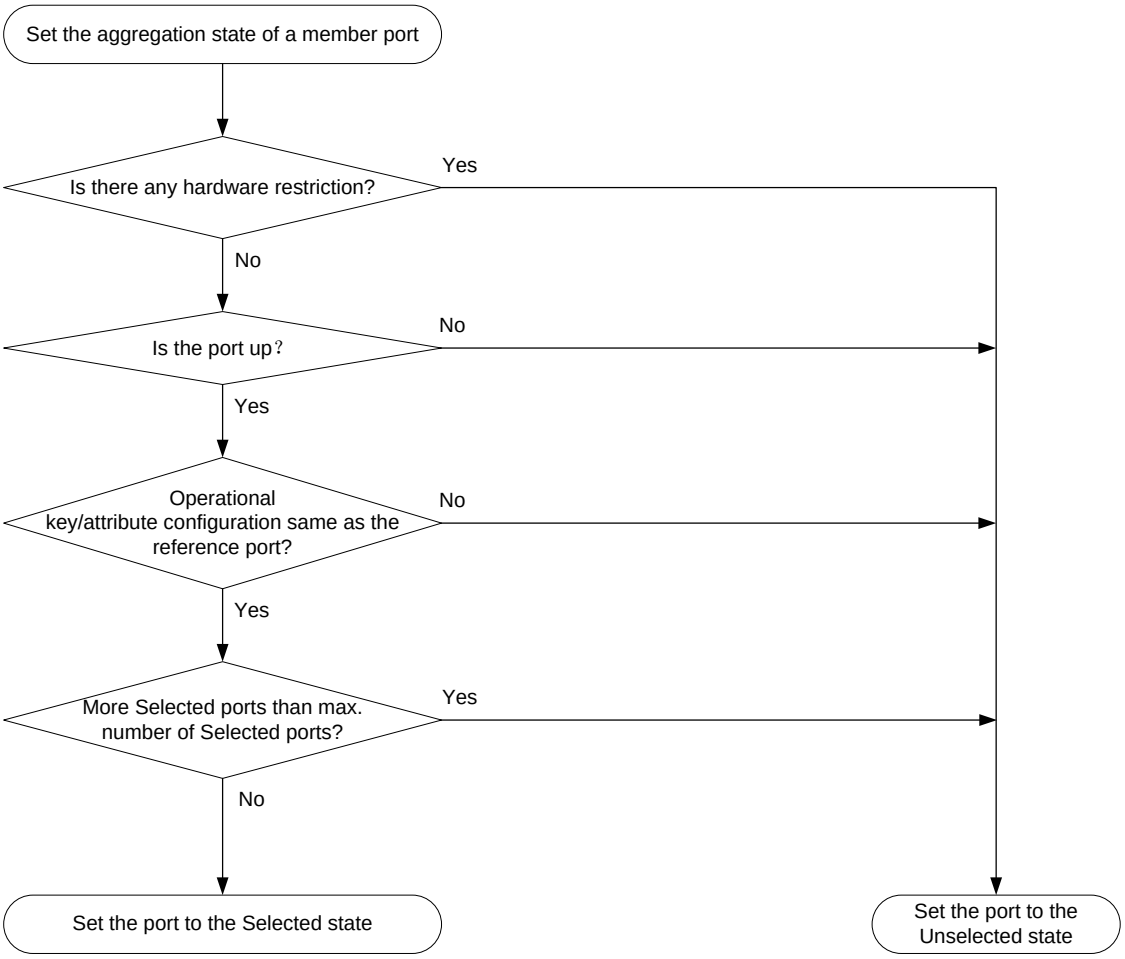
From the candidate ports with the same attribute configurations as the aggregate interface, the one with the highest priority level is chosen as the reference port.

- If multiple ports have the same priority level, the port that has been Selected (if any) is chosen. If multiple ports with the same priority level have been Selected, the one with the smallest port number is chosen.
- If multiple ports have the same priority level and none of them has been Selected, the port with the smallest port number is chosen.

Setting the aggregation state of each member port

After the reference port is chosen, the system sets the aggregation state of each member port in the static aggregation group.

Figure 2 Setting the aggregation state of a member port in a static aggregation group



After the limit on Selected ports is reached, the aggregation state of a new member port varies by following conditions:

- The port is placed in Unselected state if the port and the Selected ports have the same port priority. This mechanism prevents traffic interruption on the existing Selected ports. A device reboot can cause the device to recalculate the aggregation states of member ports.
- The port is placed in Selected state when the following conditions are met:
  - The port and the Selected ports have different port priorities, and the port has a higher port priority than a minimum of one Selected port.
  - The port has the same attribute configurations as the aggregate interface.

Any operational key or attribute configuration change might affect the aggregation states of link aggregation member ports.

Dynamic link aggregation

About LACP

Dynamic aggregation is implemented through IEEE 802.3ad Link Aggregation Control Protocol (LACP).

LACP uses LACPDUs to exchange aggregation information between LACP-enabled devices. Each member port in a dynamic aggregation group can exchange information with its peer. When a member port receives an LACPDU, it compares the received information with information received

on the other member ports. In this way, the two systems reach an agreement on which ports are placed in Selected state.

LACP functions

LACP offers basic LACP functions and extended LACP functions, as described in Table 2.

Table 2 Basic and extended LACP functions

Category	Description
Basic LACP functions	Implemented through the basic LACPDU fields, including the LACP system priority, system MAC address, port priority, port number, and operational key.
Extended LACP functions	Implemented by extending the LACPDU with new TLV fields. Extended LACP can implement LACP MAD for the IRF feature. The device can participate in LACP MAD as either an IRF member device or an intermediate device. For more information about IRF and the LACP MAD mechanism, see *Virtual Technologies Configuration Guide*.

LACP operating modes

LACP can operate in active or passive mode.

When LACP is operating in passive mode on a local member port and its peer port, both ports cannot send LACPDUs. When LACP is operating in active mode on either end of a link, both ports can send LACPDUs.

LACP priorities

LACP priorities include LACP system priority and port priority, as described in Table 3. The smaller the priority value, the higher the priority.

Table 3 LACP priorities

Type	Description
LACP system priority	Used by two peer devices (or systems) to determine which one is superior in link aggregation. In dynamic link aggregation, the system that has higher LACP system priority sets the Selected state of member ports on its side. The system that has lower priority sets the aggregation state of local member ports the same as their respective peer ports.
Port priority	Determines the likelihood of a member port to be a Selected port on a system. A port with a higher port priority is more likely to become Selected.

LACP timeout interval

The LACP timeout interval specifies how long a member port waits to receive LACPDUs from the peer port. If a local member port has not received LACPDUs from the peer within the LACP timeout interval plus 3 seconds, the member port considers the peer as failed.

The LACP timeout interval also determines the LACPDU sending rate of the peer. LACP timeout intervals include the following types:

- **Short timeout interval**—3 seconds. If you use the short timeout interval, the peer sends one LACPDU per second.
- **Long timeout interval**—90 seconds. If you use the long timeout interval, the peer sends one LACPDU every 30 seconds.

Methods to assign interfaces to a dynamic link aggregation group

You can use one of the following methods to assign interfaces to a dynamic link aggregation group:

- **Manual assignment**—Manually assign interfaces to the dynamic link aggregation group.
- **Automatic assignment**—Enable automatic assignment on interfaces to have them automatically join a dynamic link aggregation group depending on the peer information in the received LACPDUs.

NOTE:

When you use automatic assignment on one end, you must use manual assignment on the other end.

Alternatively, you can use automatic link aggregation for two devices to automatically create a dynamic link aggregation between them by using LLDP.

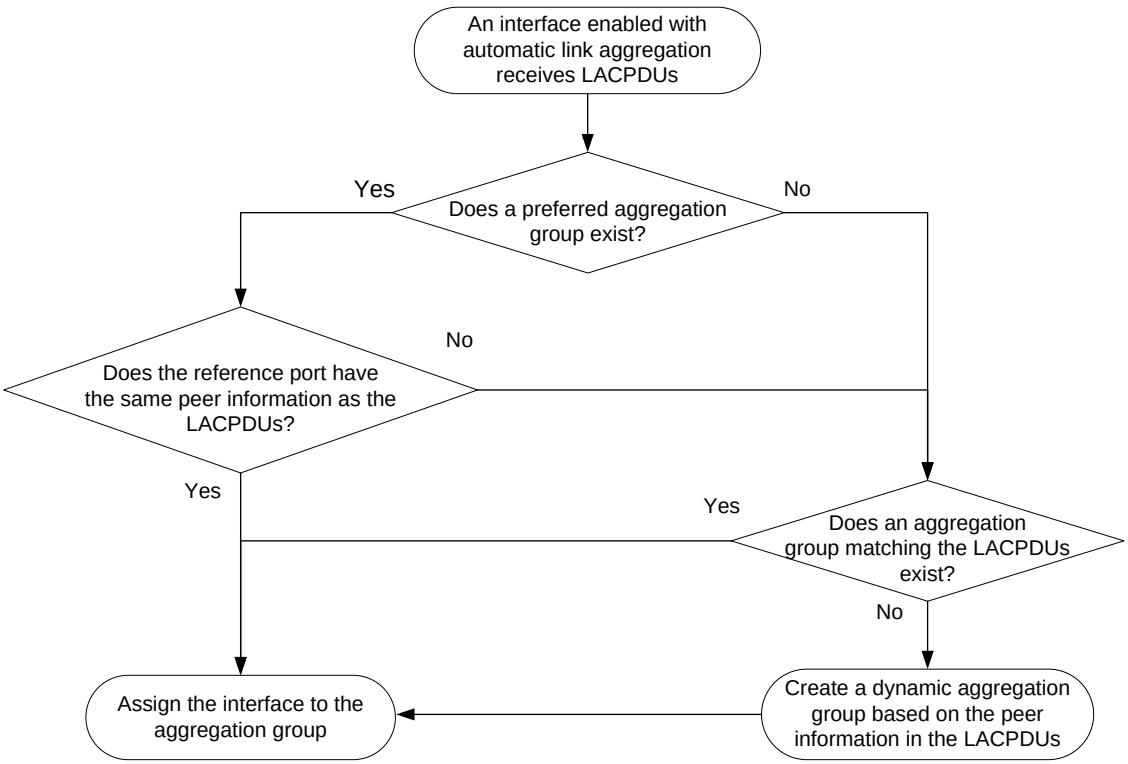
Automatic member port assignment

This feature automates the assignment of aggregation member ports to an aggregation group. You can use this feature when setting up an aggregate link to a server.

As shown in Figure 3, an interface enabled with automatic assignment joins a dynamic aggregation group based on the peer information in the LACPDUs received from the aggregation peer. If none of the existing dynamic aggregation groups is qualified, the device automatically creates a new dynamic aggregation group, Then, the device assigns the interface to that group and synchronizes the interface's attribute configurations to the aggregate interface.

A dynamic aggregation group that contains automatically assigned member ports selects a reference port and Selected ports as described in "How dynamic link aggregation works." The assignment methods of member ports do not change the processes of reference port selection and Selected port selection.

Figure 3 Automatic member port assignment process



Automatic link aggregation

Automatic link aggregation enables two devices to automatically create a dynamic link aggregation between them by using LLDP.

After you enable automatic link aggregation and LLDP on two connected devices, they automatically establish a dynamic link aggregation based on the information in incoming LLDP frames. The devices each automatically create a dynamic aggregate interface and assign the redundant ports connected to the peer to the aggregation group of that interface. When assigning the first member port to the aggregate group, the device synchronizes the member port's attribute configuration to the aggregate interface.

An automatically created dynamic aggregation group selects a reference port and Selected ports as described in "How dynamic link aggregation works." The aggregation group creation methods do not change the processes of reference port selection and Selected port selection.

IMPORTANT:

As a best practice to ensure correct operation of dynamic aggregation groups, do not use automatic link aggregation and automatic member port assignment together.

How dynamic link aggregation works

Choosing a reference port

The system chooses a reference port from the member ports in up state. A Selected port must have the same operational key and attribute configurations as the reference port.

The local system (the actor) and the peer system (the partner) negotiate a reference port by using the following workflow:

1. The two systems determine the system with the smaller system ID.

   A system ID contains the LACP system priority and the system MAC address.

   a. The two systems compare their LACP priority values.

      The lower the LACP priority, the smaller the system ID. If the LACP priority values are the same, the two systems proceed to step b.

   b. The two systems compare their MAC addresses.

      The lower the MAC address, the smaller the system ID.

2. The system with the smaller system ID chooses the port with the smallest port ID as the reference port.

   A port ID contains a port priority and a port number. The lower the port priority, the smaller the port ID.

   a. The system chooses the port with the lowest priority value as the reference port.

      If the ports have the same priority, the system proceeds to step b.

   b. The system compares their port numbers.

      The smaller the port number, the smaller the port ID.

      The port with the smallest port number and the same attribute configurations as the aggregate interface is chosen as the reference port.

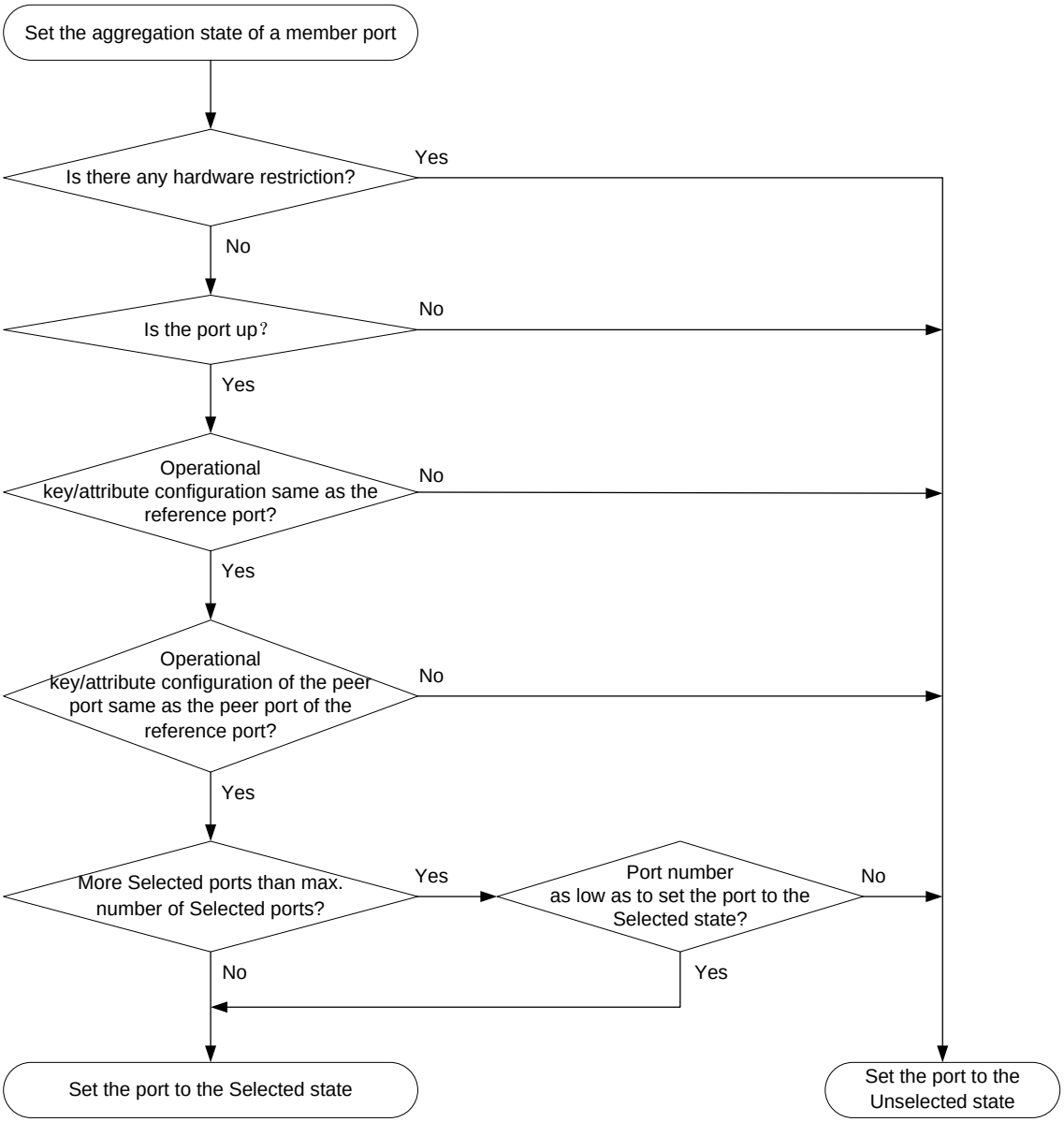
NOTE:

To identify the port numbers of aggregation member ports, execute the **`display link-aggregation verbose`** command and examine the **`Index`** field in the command output.

Setting the aggregation state of each member port

After the reference port is chosen, the system with the smaller system ID sets the state of each member port on its side.

Figure 4 Setting the state of a member port in a dynamic aggregation group



The system with the greater system ID can detect the aggregation state changes on the peer system. The system with the greater system ID sets the aggregation state of local member ports the same as their peer ports.

When you aggregate interfaces in dynamic mode, follow these guidelines:

- A dynamic link aggregation group chooses only full-duplex ports as the Selected ports.
- For stable aggregation and service continuity, do not change the operational key or attribute configurations on any member port.
- When a member port changes to the Selected or Unselected state, its peer port changes to the same aggregation state.
- After the Selected port limit is reached, a newly joining port becomes a Selected port if it is more eligible than a current Selected port.

Edge aggregate interface

Dynamic link aggregation fails on a server-facing aggregate interface if dynamic link aggregation is configured only on the device. The device forwards traffic by using only one of the physical ports that are connected to the server.

To improve link reliability, configure the aggregate interface as an edge aggregate interface. This feature enables all member ports of the aggregation group to forward traffic. When a member port fails, its traffic is automatically switched to other member ports.

After dynamic link aggregation is configured on the server, the device can receive LACPDUs from the server. Then, link aggregation between the device and the server operates correctly.

An edge aggregate interface takes effect only when it is configured on an aggregate interface corresponding to a dynamic aggregation group.

Load sharing modes for link aggregation groups

In a link aggregation group, traffic can be load shared across the Selected ports based on any of the following modes:

- **Per-flow load sharing**—Distributes traffic on a per-flow basis. The load sharing mode classifies packets into flows and forwards packets of the same flow on the same link. This mode can be one of or a combination of the following traffic classification criteria:
  - Ingress port.
  - Source or destination IP.
  - Source or destination MAC.
  - Source or destination port number.
- **Packet type-based load sharing**—Distributes traffic automatically based on packet types.

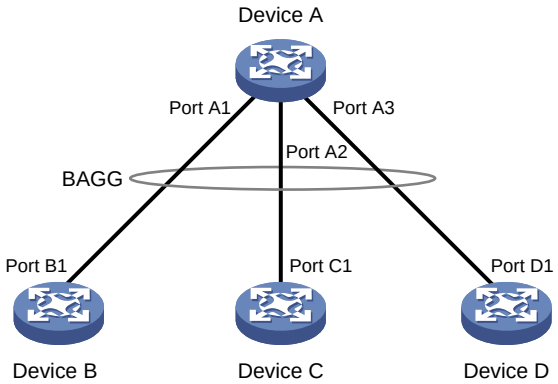
S-MLAG

Simple multichassis link aggregation (S-MLAG) enhances dynamic link aggregation to establish an aggregation that spans multiple devices to a remote device.

An S-MLAG multichassis aggregation connects one dynamic Layer 2 aggregate interface on each S-MLAG device to the remote device, as shown in Figure 5.

S-MLAG uses an S-MLAG group to manage the aggregate interfaces for each aggregation, and it runs LACP to maintain each aggregation as does dynamic link aggregation. To the remote device, the S-MLAG devices appear as one peer aggregation system.

Figure 5 S-MLAG application scenario



Restrictions and guidelines: Mixed use of manual and automatic link aggregation configuration

To avoid unexpected aggregation issues, do not use manual assignment, automatic assignment, and automatic link aggregation in any combination. If you use any two of these features in combination, an automatically assigned member port might move between aggregation groups or undesirably change from Selected to Unselected in some situations.

Ethernet link aggregation tasks at a glance

To configure Ethernet link aggregation, perform the following tasks:

1. Configuring link aggregation
   - Configuring a manual link aggregation
   - Configuring S-MLAG
2. (Optional.) Configuring an aggregate interface
   - Configuring the description of an aggregate interface
   - Configuring jumbo frame support
   - Setting the expected bandwidth for an aggregate interface
   - Configuring an edge aggregate interface

     An edge aggregate interface uses all member ports to forward traffic when the aggregation peer is not enabled with dynamic link aggregation.
   - Configuring physical state change suppression on an aggregate interface
   - Shutting down an aggregate interface
   - Restoring the default settings for an aggregate interface
3. (Optional.) Adjusting aggregation states of link aggregation member ports
   - Setting the minimum and maximum numbers of Selected ports for an aggregation group
   - Disabling the default action of selecting a Selected port for dynamic aggregation groups that have not received LACPDUs
   - Configuring a dynamic aggregation group to use port speed as the prioritized criterion for reference port selection
4. (Optional.) Configuring load sharing for link aggregation groups
   - Setting load sharing modes for link aggregation groups
   - Enabling local-first load sharing for link aggregation
5. (Optional.) Enabling link-aggregation traffic redirection

   This feature redirects traffic on an unavailable Selected port to the remaining available Selected ports of an aggregation group to avoid traffic interruption.
6. (Optional.) Enabling BFD for an aggregation group

Configuring a manual link aggregation

Restrictions and guidelines for aggregation group configuration

Layer 2 aggregation group restrictions

You cannot assign an interface to a Layer 2 aggregation group if any features in Table 4 are configured on that interface.

Table 4 Features incompatible with Layer 2 aggregation member ports

Feature on the interface	Reference
MAC authentication	MAC authentication in *Security Configuration Guide*
Port security	Port security in *Security Configuration Guide*
802.1X	802.1X in *Security Configuration Guide*

Aggregation member port restrictions

Deleting an aggregate interface also deletes its aggregation group and causes all member ports to leave the aggregation group.

An interface cannot join an aggregation group if it has different attribute configurations from the aggregate interface. After joining an aggregation group, an interface inherits the attribute configurations on the aggregate interface. You can modify the attribute configurations only on the aggregate interface.

Do not assign a reflector port for port mirroring to an aggregation group. For more information about reflector ports, see *Network Management and Monitoring Configuration Guide*.

Attribute and protocol configuration restrictions

For a link aggregation group, attribute configurations are configurable only on the aggregate interface and are automatically synchronized to all member ports. You cannot configure attribute configurations on a member port until it is removed from the link aggregation group. The configurations that have been synchronized from the aggregate interface are retained on the member ports even after the aggregate interface is deleted.

If an attribute setting on the aggregate interface fails to be synchronized to a Selected member port, the port might change to the Unselected state.

The protocol configurations for an aggregate interface take effect only on the current aggregate interface. The protocol configurations for a member port take effect only when the port leaves its aggregation group.

Configuration consistency requirements

You must configure the same aggregation mode at the two ends of an aggregate link.

- For a successful static aggregation, make sure the ports at both ends of each link are in the same aggregation state.
- For a successful dynamic aggregation:
  - Make sure the ports at both ends of a link are assigned to the correct aggregation group. The two ends can automatically negotiate the aggregation state of each member port.
  - If you use automatic interface assignment on one end, you must use manual assignment on the other end.

Configuring a Layer 2 aggregation group

Configuring a Layer 2 static aggregation group

1. Enter system view.

   system-view

2. Create a Layer 2 aggregate interface and enter Layer 2 aggregate interface view.

   interface bridge-aggregation *interface-number*

   When you create a Layer 2 aggregate interface, the system automatically creates a Layer 2 static aggregation group numbered the same as that interface.

3. Return to system view.

   quit

4. Assign an interface to the Layer 2 aggregation group:

   a. Enter Layer 2 Ethernet interface view.

      interface *interface-type interface-number*

   b. Assign the interface to the Layer 2 aggregation group.

      port link-aggregation group *group-id* [**force**]

   Repeat the substeps to assign more interfaces to the aggregation group.

   To synchronize the attribute configurations from the aggregate interface when the current interface joins the aggregation group, specify the **force** keyword.

5. (Optional.) Set the port priority of the interface.

   link-aggregation port-priority *priority*

   The default port priority of an interface is 32768.

Configuring a Layer 2 dynamic aggregation group

1. Enter system view.

   system-view

2. Set the LACP system priority.

   lacp system-priority *priority*

   By default, the LACP system priority is 32768.

   Changing the LACP system priority might affect the aggregation states of the ports in a dynamic aggregation group.

3. Create a Layer 2 aggregate interface and enter Layer 2 aggregate interface view.

   interface bridge-aggregation *interface-number*

   When you create a Layer 2 aggregate interface, the system automatically creates a Layer 2 static aggregation group numbered the same as that interface.

4. Configure the aggregation group to operate in dynamic mode.

   link-aggregation mode dynamic

   By default, an aggregation group operates in static mode.

5. Return to system view.

   quit

6. Assign an interface to the Layer 2 aggregation group:

   a. Enter Layer 2 Ethernet interface view.

      interface *interface-type interface-number*

   b. Assign the interface to the Layer 2 aggregation group or enable automatic assignment on that interface.

port link-aggregation group { *group-id* [**force**] | **auto** [*group-id*] }

Repeat these two substeps to assign more Layer 2 Ethernet interfaces to the aggregation group.

To synchronize the attribute configurations from the aggregate interface when the current interface joins the aggregation group, specify the **force** keyword.

To enable automatic assignment, specify the **auto** keyword. As a best practice, do not modify the configuration on an automatically created aggregate interface or its member ports.

7. Set the LACP operating mode for the interface.
   - Set the LACP operating mode to passive.
     lacp mode passive
   - Set the LACP operating mode to active.
     undo lacp mode

   By default, LACP is operating in active mode.
8. (Optional.) Set the port priority for the interface.
   link-aggregation port-priority *priority*

   The default setting is 32768.
9. (Optional.) Set the short LACP timeout interval (3 seconds) for the interface.
   lacp period short

   By default, the long LACP timeout interval (90 seconds) is used by the interface.

Configuring S-MLAG

Restrictions and guidelines

Use S-MLAG to set up link aggregations only with servers.

S-MLAG is intended for a non-IRF environment. Do not configure it on an IRF fabric. For more formation about IRF, see *Virtual Technologies Configuration Guide*.

Each S-MLAG group can contain only one aggregate interface on each device.

Do not configure the following settings on S-MLAG devices:

- LACP MAD.
- Link-aggregation traffic redirection.
- Maximum or minimum number of Selected ports.
- Automatic member port assignment.

As a best practice, maintain consistency across S-MLAG devices in service feature configuration.

Prerequisites

Configure the link aggregation settings other than S-MLAG settings on each S-MLAG device. Make sure the settings are consistent across the S-MLAG devices.

Procedure

1. Enter system view.
   system-view
2. Set the LACP system MAC address.
   lacp system-mac *mac-address*

   By default, the LACP system MAC address is the bridge MAC address of the device.

   All S-MLAG devices must use the same LACP system MAC address.

3. Set the LACP system priority.
   lacp system-priority *priority*
   By default, the LACP system priority is 32768.
   All S-MLAG devices must use the same LACP system priority.
4. Set the LACP system number.
   lacp system-number *number*
   By default, the LACP system number is not set.
   You must assign a unique LACP system number to each S-MLAG device.
5. Enter Layer 2 aggregate interface view.
   interface bridge-aggregation *interface-number*
6. Set the link aggregation mode to dynamic.
   link-aggregation mode dynamic
   By default, an aggregation group operates in static mode.
7. Assign the aggregate interface to an S-MLAG group.
   port s-mlag group *group-id*
   By default, an aggregate interface is not assigned to any S-MLAG group.

Configuring an aggregate interface

Most settings that can be made on Layer 2 Ethernet interfaces can also be made on Layer 2 aggregate interfaces.

Configuring the description of an aggregate interface

About the aggregate interface description

You can configure the description of an aggregate interface for administration purposes, for example, describing the purpose of the interface.

Procedure

1. Enter system view.
   system-view
2. Enter Layer 2 aggregate interface view.
   interface bridge-aggregation *interface-number*
3. Configure the interface description.
   description *text*
   By default, the description of an interface is *interface-name* **Interface**.

Configuring jumbo frame support

About jumbo frames

An aggregate interface might receive frames larger than 1522 bytes during high-throughput data exchanges, such as file transfers. These frames are called jumbo frames.

How an aggregate interface processes jumbo frames depends on whether jumbo frame support is enabled on the interface.

- If configured to deny jumbo frames, the aggregate interface discards jumbo frames.

- If enabled with jumbo frame support, the aggregate interface performs the following operations:
  - Processes jumbo frames that are within the allowed length.
  - Discards jumbo frames that exceed the allowed length.

Procedure

1. Enter system view.
   system-view
2. Enter Layer 2 aggregate interface view.
   interface bridge-aggregation *interface-number*
3. Allow jumbo frames.
   jumboframe enable [*size*]
   By default, an aggregate interface allows jumbo frames with a maximum length of 10240 bytes to pass through.
   If you execute this command multiple times, the most recent configuration takes effect.

Setting the expected bandwidth for an aggregate interface

About expected bandwidth

Expected bandwidth is an informational parameter used only by higher-layer protocols for calculation. You cannot adjust the actual bandwidth of an interface by performing this task.

Procedure

1. Enter system view.
   system-view
2. Enter Layer 2 aggregate interface view.
   interface bridge-aggregation *interface-number*
3. Set the expected bandwidth for the interface.
   bandwidth *bandwidth-value*
   By default, the expected bandwidth (in kbps) is the interface baud rate divided by 1000.

Configuring an edge aggregate interface

Restrictions and guidelines

You can only configure an aggregate interface in dynamic mode as an edge interface.

Configure only aggregate interfaces connected to endpoints such as servers as edge aggregate interfaces. Do not connect edge aggregate interfaces to network devices.

Link-aggregation traffic redirection cannot operate correctly on an edge aggregate interface. For more information about link-aggregation traffic redirection, see "Enabling link-aggregation traffic redirection."

Procedure

1. Enter system view.
   system-view
2. Enter Layer 2 aggregate interface view.
   interface bridge-aggregation *interface-number*
3. Configure the aggregate interface as an edge aggregate interface.
   lacp edge-port

By default, an aggregate interface does not operate as an edge aggregate interface.

Configuring physical state change suppression on an aggregate interface

About physical state change suppression

The physical link state of an aggregate interface is either up or down. Each time the physical link of an interface comes up or goes down, the system immediately reports the change to the CPU. The CPU then performs the following operations:

- Notifies the upper-layer protocol modules (such as routing and forwarding modules) of the change for guiding packet forwarding.
- Automatically generates traps and logs to inform users to take the correct actions.

To prevent frequent physical link flapping from affecting system performance, configure physical state change suppression. You can configure this feature to suppress link-down events, link-up events, or both. If an event of the specified type still exists when the suppression interval expires, the system reports the event to the CPU.

Restrictions and guidelines

Do not use this feature in combination with S-MLAG.

When you use this feature on an aggregate interface, make sure its peer is also an aggregate interface. In addition, you must set the physical state change suppression interval to the same value on those aggregate interfaces.

On an interface, you can configure different suppression intervals for link-up and link-down events. If you execute the **link-delay** command multiple times for an event type, the most recent configuration takes effect on that event type.

Procedure

1. Enter system view.

   system-view
2. Enter Layer 2 aggregate interface view.

   interface bridge-aggregation *interface-number*
3. Configure physical state change suppression.

   link-delay { **down** | **up** } [**msec**] *delay-time*

   By default, each time the physical link of an aggregate interface goes up or comes down, the system immediately reports the change to the CPU.

Shutting down an aggregate interface

Restrictions and guidelines

CAUTION:

The **shutdown** command will disconnect all links established on an interface. Make sure you are fully aware of the impacts of this command when you use it on a live network.

Shutting down or bringing up an aggregate interface affects the aggregation states and link states of member ports in the corresponding aggregation group as follows:

- When an aggregate interface is shut down, all its Selected ports become Unselected and all member ports go down.

- When an aggregate interface is brought up, the aggregation states of all its member ports are recalculated.

When you shut down or bring up a Layer 3 aggregate interface, all its aggregate subinterfaces are also shut down or brought up. Shutting down or bringing up a Layer 3 aggregate subinterface does not affect the state of the main aggregate interface.

Procedure

1. Enter system view.
   system-view
2. Enter Layer 2 aggregate interface view.
   interface bridge-aggregation *interface-number*
3. Shut down the interface.
   Shutdown

Restoring the default settings for an aggregate interface

Restrictions and guidelines

CAUTION:
The **default** command might interrupt ongoing network services. Make sure you are fully aware of the impacts of this command when you execute it on a live network.

The **default** command might fail to restore the default settings for some commands for reasons such as command dependencies and system restrictions.

To resolve this issue:

1. Use the **display this** command in interface view to identify these commands.
2. Use their **undo** forms or follow the command reference to restore their default settings.
3. If the restoration attempt still fails, follow the error message instructions to resolve the issue.

Procedure

1. Enter system view.
   system-view
2. Enter Layer 2 aggregate interface view.
   interface bridge-aggregation *interface-number*
3. Restore the default settings for the aggregate interface.
   Default

Setting the minimum and maximum numbers of Selected ports for an aggregation group

About the minimum and maximum numbers of Selected ports for an aggregation group

The bandwidth of an aggregate link increases as the number of Selected member ports increases. To avoid congestion, you can set the minimum number of Selected ports required for bringing up an aggregate interface.

This minimum threshold setting affects the aggregation states of aggregation member ports and the state of the aggregate interface.

- When the number of member ports eligible to be Selected ports is smaller than the minimum threshold, the following events occur:
  - The eligible member ports are placed in Unselected state.
  - The link layer state of the aggregate interface becomes down.
- When the number of member ports eligible to be Selected ports reaches or exceeds the minimum threshold, the following events occur:
  - The eligible member ports are placed in Selected state.
  - The link layer state of the aggregate interface becomes up.

The maximum number of Selected ports allowed in an aggregation group is limited by either manual configuration or hardware limitation, whichever value is smaller.

You can implement backup between two ports by performing the following tasks:

- Assigning two ports to an aggregation group.
- Setting the maximum number of Selected ports to 1 for the aggregation group.

Then, only one Selected port is allowed in the aggregation group, and the Unselected port acts as a backup port.

Restrictions and guidelines

IMPORTANT:

After you set the minimum percentage of Selected ports for an aggregation group, aggregate interface flapping might occur when ports join or leave an aggregation group. Make sure you are fully aware of the impacts of this setting when you configure it on a live network.

You can set either the minimum number or the minimum percentage of Selected ports for an aggregation group. If you configure both settings on an aggregate interface, the higher Selected port number limit takes effect.

The minimum and maximum numbers of Selected ports must be the same between the two ends of an aggregate link.

The minimum percentage of Selected ports must be the same between the two ends of an aggregate link.

For an aggregation group, the maximum number of Selected ports must be equal to or higher than the minimum number of Selected ports.

Procedure

1. Enter system view.

   system-view
2. Enter Layer 2 aggregate interface view.

   interface bridge-aggregation *interface-number*
3. Set the minimum number of Selected ports for the aggregation group. Choose one of the following methods:
   - Set the minimum number of Selected ports.

     link-aggregation selected-port minimum *min-number*
   - Set the minimum percentage of Selected ports.

     link-aggregation selected-port minimum percentage *number*

   By default, the minimum number of Selected ports is not specified for an aggregation group.
4. Set the maximum number of Selected ports for the aggregation group.

   link-aggregation selected-port maximum *max-number*

   By default, an aggregation group can have a maximum of 8 Selected ports.

Disabling the default action of selecting a Selected port for dynamic aggregation groups that have not received LACPDUs

About the default port selection action

The default port selection action applies to dynamic aggregation groups.

This action automatically chooses the port with the lowest ID from among all up member ports as a Selected port if none of them has received LACPDUs before the LACP timeout interval expires.

After this action is disabled, a dynamic aggregation group will not have any Selected ports to forward traffic if it has not received LACPDUs before the LACP timeout interval expires.

Procedure

1. Enter system view.

   system-view

2. Disable the default port selection action.

   lacp default-selected-port disable

   By default, the default port selection action is enabled for dynamic aggregation groups.

Configuring a dynamic aggregation group to use port speed as the prioritized criterion for reference port selection

About prioritizing port speed in reference port selection

Perform this task to ensure that a dynamic aggregation group selects a high-speed member port as the reference port. After you perform this task, the reference port will be selected based on the criteria in order of device ID, port speed, and port ID.

Feature and software version compatibility

This feature is supported only in Release 6348P01 and later versions.

Restrictions and guidelines

Changing reference port selection criteria might cause transient traffic interruption. Make sure you understand the impact of this task on your network.

You must perform this task at both ends of the aggregate link so the peer aggregation systems use the same criteria for reference port selection.

As a best practice, shut down the peer aggregate interfaces before you execute this command and bring up the interfaces after this command is executed on both of them.

Procedure

1. Enter system view.

   system-view

2. Enter Layer 2 aggregate interface view.

   interface bridge-aggregation *interface-number*

3. Specify port speed as the prioritized criterion for reference port selection.

lacp select speed

By default, port ID is the prioritized criterion for reference port selection of a dynamic aggregation group.

Configuring load sharing for link aggregation groups

Setting load sharing modes for link aggregation groups

About load sharing modes

You can set a global load sharing mode for all link aggregation groups.

Restrictions and guidelines

The following are global load sharing modes supported on the device:

- Load sharing mode automatically determined based on the packet type.
- Source IP.
- Destination IP.
- Source MAC.
- Destination MAC.
- Source port.
- Destination port.
- Ingress port.
- Any combinations of ingress port, source IP, source port, destination IP, and destination port.
- Any combinations of ingress port, source port, source MAC, destination port, and destination MAC.

Procedure

1. Enter system view.

   system-view

2. Set the global link-aggregation load sharing mode.

   link-aggregation global load-sharing mode { **destination-ip** | **destination-mac** | **destination-port** | **ingress-port** | **source-ip** | **source-mac** | **source-port** } *

   By default, packets are load shared based on the following information:

   - Source and destination IP addresses.
   - Source and destination MAC addresses.

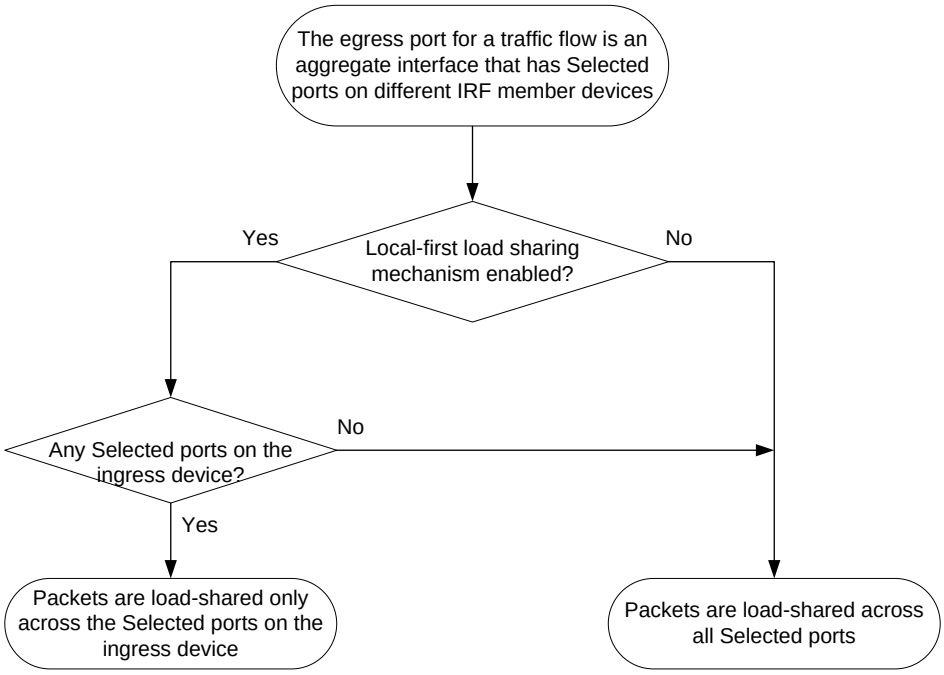
Enabling local-first load sharing for link aggregation

About local-first load sharing for link aggregation

Use local-first load sharing in a multidevice link aggregation scenario to distribute traffic preferentially across member ports on the ingress slot.

When you aggregate ports on different member devices in an IRF fabric, you can use local-first load sharing to reduce traffic on IRF links, as shown in Figure 6. For more information about IRF, see *Virtual Technologies Configuration Guide*.

Figure 6 Load sharing for multidevice link aggregation in an IRF fabric



Enabling local-first load sharing for link aggregation globally

1. Enter system view.
   `system-view`
2. Enable local-first load sharing for link aggregation globally.
   `link-aggregation load-sharing mode local-first`
   By default, local-first load sharing is enabled globally.

Enabling link-aggregation traffic redirection

About link-aggregation traffic redirection

This feature operates on dynamic link aggregation groups. It redirects traffic on a Selected port to the remaining available Selected ports of an aggregation group if one of the following events occurs:

- The port is shut down by using the **`shutdown`** command.
- The slot that hosts the port reboots, and the aggregation group spans multiple slots.

NOTE:

The device does not redirect traffic to member ports that become Selected during the traffic redirection process.

This feature ensures zero packet loss for known unicast traffic, but does not protect unknown unicast traffic.

You can enable link-aggregation traffic redirection globally or for an aggregation group. Global link-aggregation traffic redirection settings take effect on all aggregation groups. A link aggregation group preferentially uses the group-specific link-aggregation traffic redirection settings. If group-specific link-aggregation traffic redirection is not configured, the group uses the global link-aggregation traffic redirection settings.

Restrictions and guidelines for link-aggregation traffic redirection

Link-aggregation traffic redirection applies only to dynamic link aggregation groups.

As a best practice, enable link-aggregation traffic redirection on a per-interface basis. If you enable this feature globally, communication with a third-party peer device might be affected if the peer is not compatible with this feature.

To prevent traffic interruption, enable link-aggregation traffic redirection at both ends of the aggregate link.

To prevent packet loss that might occur at a slot reboot, do not enable the spanning tree feature together with link-aggregation traffic redirection.

Link-aggregation traffic redirection does not operate correctly on an edge aggregate interface.

Enabling link-aggregation traffic redirection globally

1. Enter system view.
   `system-view`
2. Enable link-aggregation traffic redirection globally.
   `link-aggregation lacp traffic-redirect-notification enable`
   By default, link-aggregation traffic redirection is disabled globally.

Enabling link-aggregation traffic redirection for an aggregation group

1. Enter system view.
   `system-view`
2. Enter Layer 2 aggregate interface view.
   `interface bridge-aggregation` *`interface-number`*
3. Enable link-aggregation traffic redirection for the aggregation group.
   `link-aggregation lacp traffic-redirect-notification enable`

By default, link-aggregation traffic redirection is disabled for an aggregation group.

Enabling BFD for an aggregation group

About BFD for Ethernet link aggregation

You can use BFD to monitor member link status in an aggregation group. After you enable BFD on an aggregate interface, each Selected port in the aggregation group establishes a BFD session with its peer port. BFD operates differently depending on the aggregation mode.

- **BFD on a static aggregation**—When BFD detects a link failure, BFD notifies the Ethernet link aggregation module that the peer port is unreachable. The local port is then placed in Unselected state. However, the BFD session between the local and peer ports remains, and the local port keeps sending BFD packets. When BFD on the local port receives packets from the peer port upon link recovery, BFD notifies the Ethernet link aggregation module that the peer port is reachable. Then, the local port is placed in Selected state again. This mechanism ensures that the local and peer ports of a static aggregate link have the same aggregation state.

- **BFD on a dynamic aggregation**—When BFD detects a link failure, BFD notifies the Ethernet link aggregation module that the peer port is unreachable. At the same time, BFD clears the session and stops sending BFD packets. When the local port is placed in Selected state again upon link recovery, the local port establishes a new session with the peer port and BFD notifies the Ethernet link aggregation module that the peer port is reachable. Because BFD provides fast failure detection, the local and peer systems of a dynamic aggregate link can negotiate the aggregation state of their member ports faster.

For more information about BFD, see *High Availability Configuration Guide*.

Restrictions and guidelines

When you enable BFD for an aggregation group, follow these restrictions and guidelines:

- Make sure the source and destination IP addresses are reversed between the two ends of an aggregate link. For example, if you execute **`link-aggregation bfd ipv4 source 1.1.1.1 destination 2.2.2.2`** at the local end, execute **`link-aggregation bfd ipv4 source 2.2.2.2 destination 1.1.1.1`** at the peer end. The source and destination IP addresses cannot be the same.
- The BFD parameters configured on an aggregate interface take effect on all BFD sessions established by the member ports in its aggregation group. BFD on an aggregate link supports only control packet mode for session establishment and maintenance. The two ends of an established BFD session can only operate in **Asynchronous** mode.
- As a best practice, do not configure BFD for any protocols on a BFD-enabled aggregate interface.
- Make sure the number of member ports in a BFD-enabled aggregation group is less than or identical to the number of BFD sessions supported by the device. If the aggregation group contains more member ports than the supported sessions, some Selected ports might change to the Unselected state.
- If the number of BFD sessions differs between the two ends of an aggregate link, check their settings for inconsistency in the maximum number of Selected ports. You must make sure the two ends have the same setting for the maximum number of Selected ports.

Procedure

1. Enter system view.
   `system-view`
2. Enter Layer 2 aggregate interface view.
   `interface bridge-aggregation` *`interface-number`*
3. Enable BFD for the aggregation group.
   `link-aggregation bfd ipv4 source` *`ip-address`* **`destination`** *`ip-address`*
   By default, BFD is disabled for an aggregation group.

Display and maintenance commands for Ethernet link aggregation

Execute **`display`** commands in any view and **`reset`** commands in user view.

Task	Command
Display information about aggregate interfaces.	**`display interface`** [**`bridge-aggregation`** [*`interface-number`*]] [**`brief`** [**`description`** | **`down`**]]
Display the local system ID.	**`display lacp system-id`**

Task	Command
Display the global or group-specific link-aggregation load sharing modes.	**display link-aggregation load-sharing mode** [**interface** [**bridge-aggregation** *interface-number*]]
Display detailed link aggregation information about link aggregation member ports.	**display link-aggregation member-port** [*interface-list* | **auto**]
Display summary information about all aggregation groups.	**display link-aggregation summary**
Display detailed information about the specified aggregation groups.	**display link-aggregation verbose** [**bridge-aggregation** [*interface-number*]]
Clear statistics for the specified aggregate interfaces.	**reset counters interface** [**bridge-aggregation** [*interface-number*]]
Clear LACP statistics for the specified link aggregation member ports.	**reset lacp statistics** [**interface** *interface-list*]

Ethernet link aggregation configuration examples

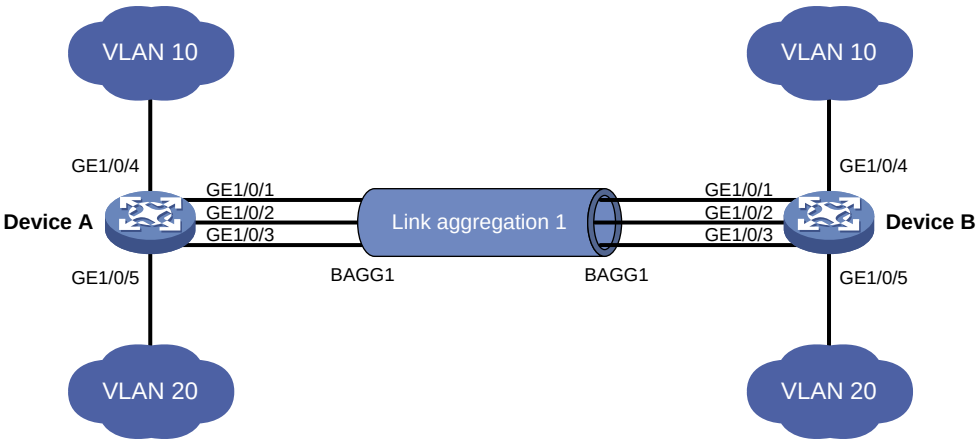
Example: Configuring a Layer 2 static aggregation group

Network configuration

On the network shown in Figure 7, perform the following tasks:

- Configure a Layer 2 static aggregation group on both Device A and Device B.
- Enable VLAN 10 at one end of the aggregate link to communicate with VLAN 10 at the other end.
- Enable VLAN 20 at one end of the aggregate link to communicate with VLAN 20 at the other end.

Figure 7 Network diagram



Procedure

1. Configure Device A:

Create VLAN 10, and assign port GigabitEthernet 1/0/4 to VLAN 10.

```
<DeviceA> system-view
[DeviceA] vlan 10
[DeviceA-vlan10] port gigabitethernet 1/0/4
[DeviceA-vlan10] quit
```

Create VLAN 20, and assign port GigabitEthernet 1/0/5 to VLAN 20.

```
[DeviceA] vlan 20
[DeviceA-vlan20] port gigabitethernet 1/0/5
[DeviceA-vlan20] quit
```

Create Layer 2 aggregate interface Bridge-Aggregation 1.

```
[DeviceA] interface bridge-aggregation 1
[DeviceA-Bridge-Aggregation1] quit
```

Assign ports GigabitEthernet 1/0/1 through GigabitEthernet 1/0/3 to link aggregation group 1.

```
[DeviceA] interface gigabitethernet 1/0/1
[DeviceA-GigabitEthernet1/0/1] port link-aggregation group 1
[DeviceA-GigabitEthernet1/0/1] quit
[DeviceA] interface gigabitethernet 1/0/2
[DeviceA-GigabitEthernet1/0/2] port link-aggregation group 1
[DeviceA-GigabitEthernet1/0/2] quit
[DeviceA] interface gigabitethernet 1/0/3
[DeviceA-GigabitEthernet1/0/3] port link-aggregation group 1
[DeviceA-GigabitEthernet1/0/3] quit
```

Configure Layer 2 aggregate interface Bridge-Aggregation 1 as a trunk port and assign it to VLANs 10 and 20.

```
[DeviceA] interface bridge-aggregation 1
[DeviceA-Bridge-Aggregation1] port link-type trunk
[DeviceA-Bridge-Aggregation1] port trunk permit vlan 10 20
[DeviceA-Bridge-Aggregation1] quit
```

2. Configure Device B in the same way Device A is configured. (Details not shown.)

Verifying the configuration

Display detailed information about all aggregation groups on Device A.

```
[DeviceA] display link-aggregation verbose
Loadsharing Type: Shar -- Loadsharing, NonS -- Non-Loadsharing
Port Status: S -- Selected, U -- Unselected, I -- Individual
Port: A -- Auto port, M -- Management port, R -- Reference port
Flags:  A -- LACP_Activity, B -- LACP_Timeout, C -- Aggregation,
        D -- Synchronization, E -- Collecting, F -- Distributing,
        G -- Defaulted, H -- Expired

Aggregate Interface: Bridge-Aggregation1
Aggregation Mode: Static
Loadsharing Type: Shar
Management VLANs: None
  Port            Status  Priority Oper-Key
  GE1/0/1(R)      S       32768    1
  GE1/0/2         S       32768    1
  GE1/0/3         S       32768    1
```

The output shows that link aggregation group 1 is a Layer 2 static aggregation group that contains three Selected ports.

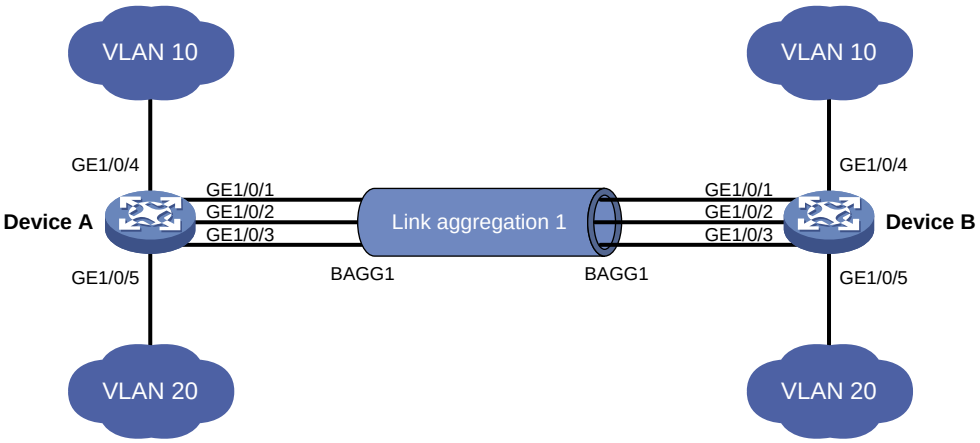
Example: Configuring a Layer 2 dynamic aggregation group

Network configuration

On the network shown in Figure 8, perform the following tasks:

- Configure a Layer 2 dynamic aggregation group on both Device A and Device B.
- Enable VLAN 10 at one end of the aggregate link to communicate with VLAN 10 at the other end.
- Enable VLAN 20 at one end of the aggregate link to communicate with VLAN 20 at the other end.

Figure 8 Network diagram



Procedure

1. Configure Device A:

Create VLAN 10, and assign the port GigabitEthernet 1/0/4 to VLAN 10.

```
<DeviceA> system-view
[DeviceA] vlan 10
[DeviceA-vlan10] port gigabitethernet 1/0/4
[DeviceA-vlan10] quit
```

Create VLAN 20, and assign the port GigabitEthernet 1/0/5 to VLAN 20.

```
[DeviceA] vlan 20
[DeviceA-vlan20] port gigabitethernet 1/0/5
[DeviceA-vlan20] quit
```

Create Layer 2 aggregate interface Bridge-Aggregation 1, and set the link aggregation mode to dynamic.

```
[DeviceA] interface bridge-aggregation 1
[DeviceA-Bridge-Aggregation1] link-aggregation mode dynamic
[DeviceA-Bridge-Aggregation1] quit
```

Assign ports GigabitEthernet 1/0/1 through GigabitEthernet 1/0/3 to link aggregation group 1.

```
[DeviceA] interface gigabitethernet 1/0/1
[DeviceA-GigabitEthernet1/0/1] port link-aggregation group 1
[DeviceA-GigabitEthernet1/0/1] quit
[DeviceA] interface gigabitethernet 1/0/2
```

```
[DeviceA-GigabitEthernet1/0/2] port link-aggregation group 1
[DeviceA-GigabitEthernet1/0/2] quit
[DeviceA] interface gigabitethernet 1/0/3
[DeviceA-GigabitEthernet1/0/3] port link-aggregation group 1
[DeviceA-GigabitEthernet1/0/3] quit
```

Configure Layer 2 aggregate interface Bridge-Aggregation 1 as a trunk port and assign it to VLANs 10 and 20.

```
[DeviceA] interface bridge-aggregation 1
[DeviceA-Bridge-Aggregation1] port link-type trunk
[DeviceA-Bridge-Aggregation1] port trunk permit vlan 10 20
[DeviceA-Bridge-Aggregation1] quit
```

2. Configure Device B in the same way Device A is configured. (Details not shown.)

Verifying the configuration

Display detailed information about all aggregation groups on Device A.

```
[DeviceA] display link-aggregation verbose
Loadsharing Type: Shar -- Loadsharing, NonS -- Non-Loadsharing
Port Status: S -- Selected, U -- Unselected, I -- Individual
Port: A -- Auto port, M -- Management port, R -- Reference port
Flags:  A -- LACP_Activity, B -- LACP_Timeout, C -- Aggregation,
        D -- Synchronization, E -- Collecting, F -- Distributing,
        G -- Defaulted, H -- Expired

Aggregate Interface: Bridge-Aggregation1
Creation Mode: Manual
Aggregation Mode: Dynamic
Loadsharing Type: Shar
Management VLANs: None
System ID: 0x8000, 000f-e267-6c6a
Local:
  Port                Status   Priority Index    Oper-Key               Flag
  GE1/0/1(R)          S        32768    11       1                      {ACDEF}
  GE1/0/2             S        32768    12       1                      {ACDEF}
  GE1/0/3             S        32768    13       1                      {ACDEF}
Remote:
  Actor               Priority Index    Oper-Key SystemID               Flag
  GE1/0/1             32768    81       1        0x8000, 000f-e267-57ad {ACDEF}
  GE1/0/2             32768    82       1        0x8000, 000f-e267-57ad {ACDEF}
  GE1/0/3             32768    83       1        0x8000, 000f-e267-57ad {ACDEF}
```

The output shows that link aggregation group 1 is a Layer 2 dynamic aggregation group that contains three Selected ports.

Example: Configuring a Layer 2 edge aggregate interface

Network configuration

As shown in Figure 9, a Layer 2 dynamic aggregation group is configured on the device. The server is not configured with dynamic link aggregation.

Configure an edge aggregate interface so that both GigabitEthernet 1/0/1 and GigabitEthernet 1/0/2 can forward traffic to improve link reliability.

Figure 9 Network diagram

Procedure

Create Layer 2 aggregate interface Bridge-Aggregation 1, and set the link aggregation mode to dynamic.

```
<Device> system-view
[Device] interface bridge-aggregation 1
[Device-Bridge-Aggregation1] link-aggregation mode dynamic
```

Configure Layer 2 aggregate interface Bridge-Aggregation 1 as an edge aggregate interface.

```
[Device-Bridge-Aggregation1] lacp edge-port
[Device-Bridge-Aggregation1] quit
```

Assign ports GigabitEthernet 1/0/1 and GigabitEthernet 1/0/2 to link aggregation group 1.

```
[Device] interface gigabitethernet 1/0/1
[Device-GigabitEthernet1/0/1] port link-aggregation group 1
[Device-GigabitEthernet1/0/1] quit
[Device] interface gigabitethernet 1/0/2
[Device-GigabitEthernet1/0/2] port link-aggregation group 1
[Device-GigabitEthernet1/0/2] quit
```

Verifying the configuration

Display detailed information about all aggregation groups on the device when the server is not configured with dynamic link aggregation.

```
[Device] display link-aggregation verbose
Loadsharing Type: Shar -- Loadsharing, NonS -- Non-Loadsharing
Port Status: S -- Selected, U -- Unselected, I -- Individual
Port: A -- Auto port, M -- Management port, R -- Reference port
Flags:  A -- LACP_Activity, B -- LACP_Timeout, C -- Aggregation,
        D -- Synchronization, E -- Collecting, F -- Distributing,
        G -- Defaulted, H -- Expired

Aggregate Interface: Bridge-Aggregation1
Creation Mode: Manual
Aggregation Mode: Dynamic
Loadsharing Type: Shar
Management VLANs: None
System ID: 0x8000, 000f-e267-6c6a
Local:
  Port                Status   Priority Index    Oper-Key               Flag
  GE1/0/1             I        32768    11       1                      {AG}
  GE1/0/2             I        32768    12       1                      {AG}

Remote:
  Actor               Priority Index    Oper-Key SystemID               Flag
  GE1/0/1             32768    81       0        0x8000, 0000-0000-0000 {DEF}
```

```
GE1/0/2             32768    82       0        0x8000, 0000-0000-0000 {DEF}
```

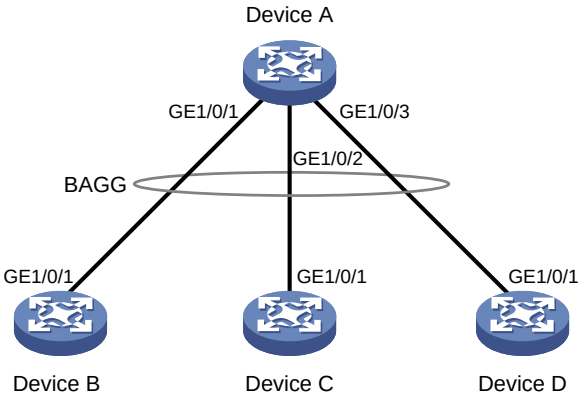
The output shows that GigabitEthernet 1/0/1 and GigabitEthernet 1/0/2 are in Individual state when they do not receive LACPDUs from the server. Both GigabitEthernet 1/0/1 and GigabitEthernet 1/0/2 can forward traffic. When one port fails, its traffic is automatically switched to the other port.

Example: Configuring S-MLAG

Network configuration

As shown in Figure 10, configure Device B, Device C, and Device D as S-MLAG devices to establish a multidevice aggregate link with Device A.

Figure 10 Network diagram



Procedure

1. Configure Device A:

   # Create Layer 2 aggregate interface Bridge-Aggregation 10, and set the link aggregation mode to dynamic.

   ```
   <DeviceA> system-view
   [DeviceA] interface bridge-aggregation 10
   [DeviceA-Bridge-Aggregation10] link-aggregation mode dynamic
   [DeviceA-Bridge-Aggregation10] quit
   ```

   # Assign GigabitEthernet 1/0/1 through GigabitEthernet 1/0/3 to aggregation group 10.

   ```
   [DeviceA] interface gigabitethernet 1/0/1
   [DeviceA-GigabitEthernet1/0/1] port link-aggregation group 10
   [DeviceA-GigabitEthernet1/0/1] quit
   [DeviceA] interface gigabitethernet 1/0/2
   [DeviceA-GigabitEthernet1/0/2] port link-aggregation group 10
   [DeviceA-GigabitEthernet1/0/2] quit
   [DeviceA] interface gigabitethernet 1/0/3
   [DeviceA-GigabitEthernet1/0/3] port link-aggregation group 10
   [DeviceA-GigabitEthernet1/0/3] quit
   ```

2. Configure Device B:

   # Set the LACP system MAC address to 0001-0001-0001.

   ```
   <DeviceB> system-view
   [DeviceB] lacp system-mac 1-1-1
   ```

   # Set the LACP system priority to 123.

   ```
   [DeviceB] lacp system-priority 123
   ```

Set the LACP system number to 1.

```
[DeviceB] lacp system-number 1
```

Create Layer 2 aggregate interface Bridge-Aggregation 2, and set the link aggregation mode to dynamic.

```
[DeviceB] interface bridge-aggregation 2
[DeviceB-Bridge-Aggregation2] link-aggregation mode dynamic
```

Assign Bridge-Aggregation 2 to S-MLAG group 100.

```
[DeviceB-Bridge-Aggregation2] port s-mlag group 100
```

Assign GigabitEthernet 1/0/1 to aggregation group 2.

```
[DeviceB] interface gigabitethernet 1/0/1
[DeviceB-GigabitEthernet1/0/1] port link-aggregation group 2
[DeviceB-GigabitEthernet1/0/1] quit
```

3. Configure Device C:

Set the LACP system MAC address to 0001-0001-0001.

```
<DeviceC> system-view
[DeviceC] lacp system-mac 1-1-1
```

Set the LACP system priority to 123.

```
[DeviceC] lacp system-priority 123
```

Set the LACP system number to 2.

```
[DeviceC] lacp system-number 2
```

Create Layer 2 aggregate interface Bridge-Aggregation 3, and set the link aggregation mode to dynamic.

```
[DeviceC] interface bridge-aggregation 3
[DeviceC-Bridge-Aggregation3] link-aggregation mode dynamic
```

Assign Bridge-Aggregation 3 to S-MLAG group 100.

```
[DeviceC-Bridge-Aggregation3] port s-mlag group 100
```

Assign GigabitEthernet 1/0/1 to aggregation group 3.

```
[DeviceC] interface gigabitethernet 1/0/1
[DeviceC-GigabitEthernet1/0/1] port link-aggregation group 3
[DeviceC-GigabitEthernet1/0/1] quit
```

4. Configure Device D:

Set the LACP system MAC address to 0001-0001-0001.

```
<DeviceD> system-view
[DeviceD] lacp system-mac 1-1-1
```

Set the LACP system priority to 123.

```
[DeviceD] lacp system-priority 123
```

Set the LACP system number to 3.

```
[DeviceD] lacp system-number 3
```

Create Layer 2 aggregate interface Bridge-Aggregation 4, and set the link aggregation mode to dynamic.

```
[DeviceD] interface bridge-aggregation 4
[DeviceD-Bridge-Aggregation4] link-aggregation mode dynamic
```

Assign Bridge-Aggregation 4 to S-MLAG group 100.

```
[DeviceD-Bridge-Aggregation4] port s-mlag group 100
```

Assign GigabitEthernet 1/0/1 to aggregation group 4.

```
[DeviceD] interface gigabitethernet 1/0/1
[DeviceD-GigabitEthernet1/0/1] port link-aggregation group 4
```

```
[DeviceD-GigabitEthernet1/0/1] quit
```

Verifying the configuration

Verify that GigabitEthernet 1/0/1 through GigabitEthernet 1/0/3 on Device A are Selected ports.

```
[DeviceA] display link-aggregation verbose
Loadsharing Type: Shar -- Loadsharing, NonS -- Non-Loadsharing
Port Status: S -- Selected, U -- Unselected, I -- Individual
Port: A -- Auto port, M -- Management port, R -- Reference port
Flags:  A -- LACP_Activity, B -- LACP_Timeout, C -- Aggregation,
        D -- Synchronization, E -- Collecting, F -- Distributing,
        G -- Defaulted, H -- Expired

Aggregate Interface: Bridge-Aggregation10
Creation Mode: Manual
Aggregation Mode: Dynamic
Loadsharing Type: Shar
Management VLANs: None
System ID: 0x8000, 40fa-264f-0100
Local:
  Port                Status   Priority Index    Oper-Key               Flag
  GE1/0/1(R)          S        32768    1        1                      {ACDEF}
  GE1/0/2             S        32768    2        1                      {ACDEF}
  GE1/0/3             S        32768    3        1                      {ACDEF}
Remote:
  Actor               Priority Index    Oper-Key SystemID               Flag
  GE1/0/1             32768    16385    50100    0x7b  , 0001-0001-0001 {ACDEF}
  GE1/0/2             32768    32769    50100    0x7b  , 0001-0001-0001 {ACDEF}
  GE1/0/3             32768    49153    50100    0x7b  , 0001-0001-0001 {ACDEF}
```

Contents

Configuring port isolation

About port isolation

The port isolation feature isolates Layer 2 traffic for data privacy and security without using VLANs.

Ports in an isolation group cannot communicate with each other. However, they can communicate with ports outside the isolation group.

Assigning a port to an isolation group

About port assignment to an isolation group

The device supports multiple isolation groups, which can be configured manually. The number of ports assigned to an isolation group is not limited.

Restrictions and guidelines

- You can assign a port to only one isolation group. If you execute the **port-isolate enable group** command multiple times, the most recent configuration takes effect.
- The configuration in Layer 2 Ethernet interface view applies only to the interface.
- The configuration in Layer 2 aggregate interface view applies to the Layer 2 aggregate interface and its aggregation member ports. If the device fails to apply the configuration to the aggregate interface, it does not assign any aggregation member port to the isolation group. If the failure occurs on an aggregation member port, the device skips the port and continues to assign other aggregation member ports to the isolation group.

Procedure

1. Enter system view.
   system-view
2. Create an isolation group.
   port-isolate group *group-id*
3. Enter interface view.
   - Enter Layer 2 Ethernet interface view.
     interface *interface-type interface-number*
   - Enter Layer 2 aggregate interface view.
     interface bridge-aggregation *interface-number*
4. Assign the port to the isolation group.
   port-isolate enable group *group-id*
   By default, the port is not in any isolation group.

Display and maintenance commands for port isolation

Execute **display** commands in any view.

Task	Command
Display isolation group information.	**display port-isolate group** [*group-id*]

Port isolation configuration examples

Example: Configuring port isolation

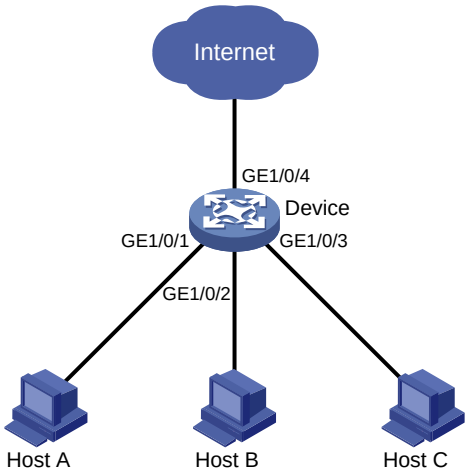
Network configuration

As shown in Figure 1:

- LAN users Host A, Host B, and Host C are connected to GigabitEthernet 1/0/1, GigabitEthernet 1/0/2, and GigabitEthernet 1/0/3 on the device, respectively.
- The device connects to the Internet through GigabitEthernet 1/0/4.

Configure the device to provide Internet access for the hosts, and isolate them from one another at Layer 2.

Figure 1 Network diagram



Procedure

Create isolation group 2.

```
<Device> system-view
[Device] port-isolate group 2
```

Assign GigabitEthernet 1/0/1, GigabitEthernet 1/0/2, and GigabitEthernet 1/0/3 to isolation group 2.

```
[Device] interface gigabitethernet 1/0/1
[Device-GigabitEthernet1/0/1] port-isolate enable group 2
[Device-GigabitEthernet1/0/1] quit
[Device] interface gigabitethernet 1/0/2
[Device-GigabitEthernet1/0/2] port-isolate enable group 2
[Device-GigabitEthernet1/0/2] quit
[Device] interface gigabitethernet 1/0/3
[Device-GigabitEthernet1/0/3] port-isolate enable group 2
[Device-GigabitEthernet1/0/3] quit
```

Verifying the configuration

Display information about isolation group 2.

```
[Device] display port-isolate group 2
 Port isolation group information:
 Group ID: 2
 Group members:
   GigabitEthernet1/0/1     GigabitEthernet1/0/2     GigabitEthernet1/0/3
```

The output shows that GigabitEthernet 1/0/1, GigabitEthernet 1/0/2, and GigabitEthernet 1/0/3 are assigned to isolation group 2. As a result, Host A, Host B, and Host C are isolated from one another at layer 2.

Contents

Spanning tree protocol overview

Spanning tree protocols eliminate loops in a physical link-redundant network by selectively blocking redundant links and putting them in a standby state.

The recent versions of STP include the Rapid Spanning Tree Protocol (RSTP), the Per-VLAN Spanning Tree (PVST), and the Multiple Spanning Tree Protocol (MSTP).

About STP

STP was developed based on the 802.1d standard of IEEE to eliminate loops at the data link layer in a LAN. Networks often have redundant links as backups in case of failures, but loops are a very serious problem. Devices running STP detect loops in the network by exchanging information with one another. They eliminate loops by selectively blocking certain ports to prune the loop structure into a loop-free tree structure. This avoids proliferation and infinite cycling of packets that would occur in a loop network.

In a narrow sense, STP refers to IEEE 802.1d STP. In a broad sense, STP refers to the IEEE 802.1d STP and various enhanced spanning tree protocols derived from that protocol.

STP protocol frames

STP uses bridge protocol data units (BPDUs), also known as configuration messages, as its protocol frames. This chapter uses BPDUs to represent all types of spanning tree protocol frames.

STP-enabled devices exchange BPDUs to establish a spanning tree. BPDUs contain sufficient information for the devices to complete spanning tree calculation.

STP uses two types of BPDUs, configuration BPDUs and topology change notification (TCN) BPDUs.

Configuration BPDUs

Devices exchange configuration BPDUs to elect the root bridge and determine port roles. Figure 1 shows the configuration BPDU format.

Figure 1 Configuration BPDU format

DMA: Destination MAC address
SMA: Source MAC address
L/T: Frame length
LLC header: Logical link control header
Payload: BPDU data

Fields	Byte
Protocol ID	2
Protocol version ID	1
BPDU type	1
Flags	1
Root ID	8
Root path cost	4
Bridge ID	8
Port ID	2
Message age	2
Max age	2
Hello time	2
Forward delay	2

The payload of a configuration BPDU includes the following fields:

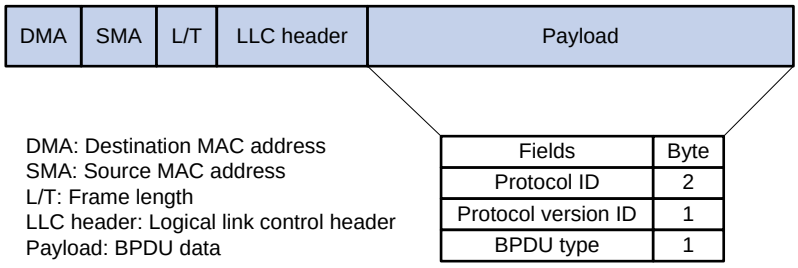
- **Protocol ID**—Fixed at 0x0000, which represents IEEE 802.1d.
- **Protocol version ID**—Spanning tree protocol version ID. The protocol version ID for STP is 0x00.
- **BPDU type**—Type of the BPDU. The value is 0x00 for a configuration BPDU.
- **Flags**—An 8-bit field indicates the purpose of the BPDU. The lowest bit is the Topology Change (TC) flag. The highest bit is the Topology Change Acknowledge (TCA) flag. All other bits are reserved.
- **Root ID**—Root bridge ID formed by the priority and MAC address of the root bridge.
- **Root path cost**—Cost of the path to the root bridge.
- **Bridge ID**—Designated bridge ID formed by the priority and MAC address of the designated bridge.
- **Port ID**—Designated port ID formed by the priority and global port number of the designated port.
- **Message age**—Age of the configuration BPDU while it propagates in the network.
- **Max age**—Maximum age of the configuration BPDU stored on the switch.
- **Hello time**—Configuration BPDU transmission interval.
- **Forward delay**—Delay for STP bridges to transit port state.

Devices use the root bridge ID, root path cost, designated bridge ID, designated port ID, message age, max age, hello time, and forward delay for spanning tree calculation.

TCN BPDUs

Devices use TCN BPDUs to announce changes in the network topology. Figure 2 shows the TCN BPDU format.

Figure 2 TCN BPDU format



The payload of a TCN BPDU includes the following fields:

- **Protocol ID**—Fixed at 0x0000, which represents IEEE 802.1d.
- **Protocol version ID**—Spanning tree protocol version ID. The protocol version ID for STP is 0x00.
- **BPDU type**—Type of the BPDU. The value is 0x80 for a TCN BPDU.

A non-root bridge sends TCN BPDUs when one of the following events occurs on the bridge:

- A port transits to the forwarding state, and the bridge has a minimum of one designated port.
- A port transits from the forwarding or learning state to the blocking state.

The non-root bridge uses TCN BPDUs to notify the root bridge once the network topology changes. The root bridge then sets the TC flag in its configuration BPDU and propagates it to other bridges.

Basic concepts in STP

Root bridge

A tree network must have a root bridge. The entire network contains only one root bridge, and all the other bridges in the network are called leaf nodes. The root bridge is not permanent, but can change with changes of the network topology.

Upon initialization of a network, each device generates and periodically sends configuration BPDUs, with itself as the root bridge. After network convergence, only the root bridge generates and periodically sends configuration BPDUs. The other devices only forward the BPDUs.

Root port

On a non-root bridge, the port nearest to the root bridge is the root port. The root port communicates with the root bridge. Each non-root bridge has only one root port. The root bridge has no root port.

Designated bridge and designated port

Classification	Designated bridge	Designated port
For a device	Device directly connected to the local device and responsible for forwarding BPDUs to the local device.	Port through which the designated bridge forwards BPDUs to this device.
For a LAN	Device responsible for forwarding BPDUs to this LAN segment.	Port through which the designated bridge forwards BPDUs to this LAN segment.

As shown in Figure 3, Device B and Device C are directly connected to a LAN.

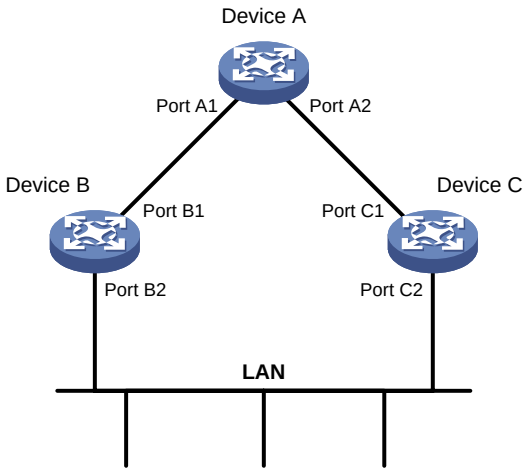
If Device A forwards BPDUs to Device B through port A1, the designated bridge and designated port are as follows:

- The designated bridge for Device B is Device A.
- The designated port for Device B is port A1 on Device A.

If Device B forwards BPDUs to the LAN, the designated bridge and designated port are as follows:

- The designated bridge for the LAN is Device B.
- The designated port for the LAN is port B2 on Device B.

Figure 3 Designated bridges and designated ports



Port states

Table 1 lists the port states in STP.

Table 1 STP port states

State	Receives/sends BPDUs	Learns MAC addresses	Forwards user data
Disabled	No	No	No
Listening	Yes	No	No
Learning	Yes	Yes	No
Forwarding	Yes	Yes	Yes
Blocking	Receive	No	No

Path cost

Path cost is a reference value used for link selection in STP. To prune the network into a loop-free tree, STP calculates path costs to select the most robust links and block redundant links that are less robust.

Calculation process of the STP algorithm

In STP calculation, a device compares the priorities of the received configuration BPDUs from different ports, and elects the root bridge, root ports and designated ports. When the spanning tree calculation is completed, a tree-shape topology forms.

The spanning tree calculation process described in the following sections is an example of a simplified process.

Network initialization

Upon initialization of a device, each port generates a BPDU with the following contents:

- The port as the designated port.
- The device as the root bridge.
- 0 as the root path cost.
- The device ID as the designated bridge ID.

Root bridge selection

The root bridge can be selected in the following methods:

- **Automatic election**—Initially, each STP-enabled device on the network assumes itself to be the root bridge, with its own device ID as the root bridge ID. By exchanging configuration BPDUs, the devices compare their root bridge IDs to elect the device with the smallest root bridge ID as the root bridge.
- **Manual assignment**—You can configure a device as the root bridge or a secondary root bridge of a spanning tree.
  - A spanning tree can have only one root bridge. If you configure multiple devices as the root bridge for a spanning tree, the device with the lowest MAC address is selected.
  - You can configure one or multiple secondary root bridges for a spanning tree. When the root bridge fails or is shut down, a secondary root bridge can take over. If multiple secondary root bridges are configured, the one with the lowest MAC address is selected. However, if a new root bridge is configured, the secondary root bridge is not selected.

Root port and designated ports selection on the non-root bridges

Step	Description
1	A non-root-bridge device regards the port on which it received the optimum configuration BPDU as the root port. Table 2 describes how the optimum configuration BPDU is selected.

Step	Description
2	Based on the configuration BPDU and the path cost of the root port, the device calculates a designated port configuration BPDU for each of the other ports. • The root bridge ID is replaced with that of the configuration BPDU of the root port. • The root path cost is replaced with that of the configuration BPDU of the root port plus the path cost of the root port. • The designated bridge ID is replaced with the ID of this device. • The designated port ID is replaced with the ID of this port.

3	The device compares the calculated configuration BPDU with the configuration BPDU on the port whose port role will be determined. Then, the device acts depending on the result of the comparison:
	• If the calculated configuration BPDU is superior, the device performs the following operations:
	  ○ Considers this port as the designated port.
	  ○ Replaces the configuration BPDU on the port with the calculated configuration BPDU.
	  ○ Periodically sends the calculated configuration BPDU.
	• If the configuration BPDU on the port is superior, the device blocks this port without updating its configuration BPDU. The blocked port can receive BPDUs, but cannot send BPDUs or forward data traffic.

When the network topology is stable, only the root port and designated ports forward user traffic. Other ports are all in the blocking state to receive BPDUs but not to forward BPDUs or user traffic.

Table 2 Selecting the optimum configuration BPDU

Step	Actions
1	Upon receiving a configuration BPDU on a port, the device compares the priority of the received configuration BPDU with that of the configuration BPDU generated by the port. • If the former priority is lower, the device discards the received configuration BPDU and keeps the configuration BPDU the port generated. • If the former priority is higher, the device replaces the content of the configuration BPDU generated by the port with the content of the received configuration BPDU.
2	The device compares the configuration BPDUs of all the ports and chooses the optimum configuration BPDU.

The following are the principles of configuration BPDU comparison:

1. The configuration BPDU with the lowest root bridge ID has the highest priority.
2. If configuration BPDUs have the same root bridge ID, their root path costs are compared. For example, the root path cost in a configuration BPDU plus the path cost of a receiving port is S. The configuration BPDU with the smallest S value has the highest priority.
3. If all configuration BPDUs have the same root bridge ID and S value, the following attributes are compared in sequence:
   a. Designated bridge IDs.
   b. Designated port IDs.
   c. IDs of the receiving ports.

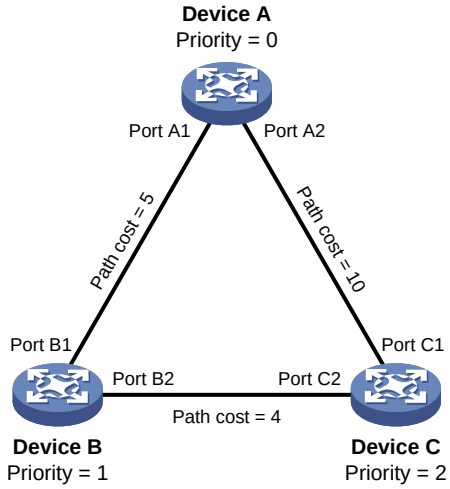
   The configuration BPDU that contains a smaller designated bridge ID, designated port ID, or receiving port ID is selected.

A tree-shape topology forms when the root bridge, root ports, and designated ports are selected.

Example of STP calculation

Figure 4 provides an example showing how the STP algorithm works.

Figure 4 The STP algorithm



As shown in Figure 4, the priority values of Device A, Device B, and Device C are 0, 1, and 2, respectively. The path costs of links among the three devices are 5, 10, and 4.

Device state initialization

In Table 3, each configuration BPDU contains the following fields: root bridge ID, root path cost, designated bridge ID, and designated port ID.

Table 3 Initial state of each device

Device	Port name	Configuration BPDU on the port
Device A	Port A1	{0, 0, 0, Port A1}
	Port A2	{0, 0, 0, Port A2}
Device B	Port B1	{1, 0, 1, Port B1}
	Port B2	{1, 0, 1, Port B2}
Device C	Port C1	{2, 0, 2, Port C1}
	Port C2	{2, 0, 2, Port C2}

Configuration BPDUs comparison on each device

In Table 4, each configuration BPDU contains the following fields: root bridge ID, root path cost, designated bridge ID, and designated port ID.

Table 4 Comparison process and result on each device

Device	Comparison process	Configuration BPDU on ports after comparison
Device A	Port A1 performs the following operations: **1.** Receives the configuration BPDU of Port B1 {1, 0, 1, Port B1}. **2.** Determines that its existing configuration BPDU {0, 0, 0, Port A1} is superior to the received configuration BPDU. **3.** Discards the received one. Port A2 performs the following operations: **1.** Receives the configuration BPDU of Port C1 {2, 0, 2, Port C1}. **2.** Determines that its existing configuration BPDU {0, 0, 0, Port A2} is superior to the received configuration BPDU. **3.** Discards the received one. Device A determines that it is both the root bridge and designated bridge in the configuration BPDUs of all its ports. It considers itself as the root bridge. It does not change the configuration BPDU of any port and starts to periodically send configuration BPDUs.	• Port A1: {0, 0, 0, Port A1} • Port A2: {0, 0, 0, Port A2}
Device B	Port B1 performs the following operations: **4.** Receives the configuration BPDU of Port A1 {0, 0, 0, Port A1}. **5.** Determines that the received configuration BPDU is superior to its existing configuration BPDU {1, 0, 1, Port B1}. **6.** Updates its configuration BPDU. Port B2 performs the following operations: **1.** Receives the configuration BPDU of Port C2 {2, 0, 2, Port C2}. **2.** Determines that its existing configuration BPDU {1, 0, 1, Port B2} is superior to the received configuration BPDU. **3.** Discards the received BPDU.	• Port B1: {0, 0, 0, Port A1} • Port B2: {1, 0, 1, Port B2}
	Device B performs the following operations: **1.** Compares the configuration BPDUs of all its ports. **2.** Decides that the configuration BPDU of Port B1 is the optimum. **3.** Selects Port B1 as the root port with the configuration BPDU unchanged. Based on the configuration BPDU and path cost of the root port, Device B calculates a designated port configuration BPDU for Port B2 {0, 5, 1, Port B2}. Device B compares it with the existing configuration BPDU of Port B2 {1, 0, 1, Port B2}. Device B determines that the calculated one is superior, and determines that Port B2 is the designated port. It replaces the configuration BPDU on Port B2 with the calculated one, and periodically sends the calculated configuration BPDU.	• Root port (Port B1): {0, 0, 0, Port A1} • Designated port (Port B2): {0, 5, 1, Port B2}
Device C	Port C1 performs the following operations: **1.** Receives the configuration BPDU of Port A2 {0, 0, 0, Port A2}. **2.** Determines that the received configuration BPDU is superior to its existing configuration BPDU {2, 0, 2,	• Port C1: {0, 0, 0, Port A2} • Port C2: {1, 0, 1, Port B2}

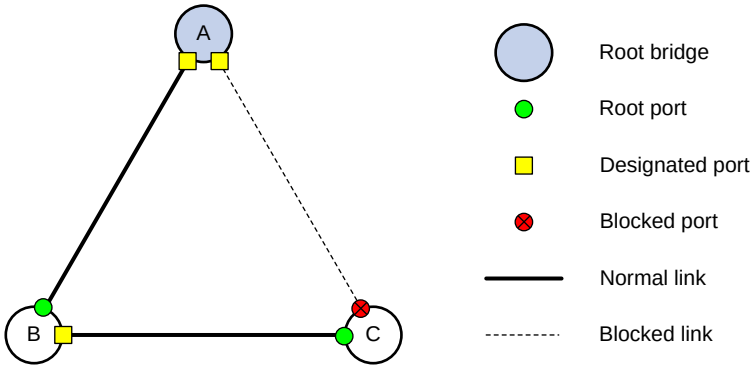
Device	Comparison process	Configuration BPDU on ports after comparison
	Port C1}. **3.** Updates its configuration BPDU. Port C2 performs the following operations: **1.** Receives the original configuration BPDU of Port B2 {1, 0, 1, Port B2}. **2.** Determines that the received configuration BPDU is superior to the existing configuration BPDU {2, 0, 2, Port C2}. **3.** Updates its configuration BPDU.	
	Device C performs the following operations: **1.** Compares the configuration BPDUs of all its ports. **2.** Decides that the configuration BPDU of Port C1 is the optimum. **3.** Selects Port C1 as the root port with the configuration BPDU unchanged. Based on the configuration BPDU and path cost of the root port, Device C calculates the configuration BPDU of Port C2 {0, 10, 2, Port C2}. Device C compares it with the existing configuration BPDU of Port C2 {1, 0, 1, Port B2}. Device C determines that the calculated configuration BPDU is superior to the existing one, selects Port C2 as the designated port, and replaces the configuration BPDU of Port C2 with the calculated one.	• Root port (Port C1): {0, 0, 0, Port A2} • Designated port (Port C2): {0, 10, 2, Port C2}
	Port C2 performs the following operations: **1.** Receives the updated configuration BPDU of Port B2 {0, 5, 1, Port B2}. **2.** Determines that the received configuration BPDU is superior to its existing configuration BPDU {0, 10, 2, Port C2}. **3.** Updates its configuration BPDU. Port C1 performs the following operations: **1.** Receives a periodic configuration BPDU {0, 0, 0, Port A2} from Port A2. **2.** Determines that it is the same as the existing configuration BPDU. **3.** Discards the received BPDU.	• Port C1: {0, 0, 0, Port A2} • Port C2: {0, 5, 1, Port B2}
	Device C determines that the root path cost of Port C1 is larger than that of Port C2. The root path cost of Port C1 is 10, root path cost of the received configuration BPDU (0) plus path cost of Port C1 (10). The root path cost of Port C2 is 9, root path cost of the received configuration BPDU (5) plus path cost of Port C2 (4). Device C determines that the configuration BPDU of Port C2 is the optimum, and selects Port C2 as the root port with the configuration BPDU unchanged. Based on the configuration BPDU and path cost of the root port, Device C performs the following operations: **1.** Calculates a designated port configuration BPDU for Port C1 {0, 9, 2, Port C1}. **2.** Compares it with the existing configuration BPDU of Port C1 {0, 0, 0, Port A2}. **3.** Determines that the existing configuration BPDU is superior to the calculated one and blocks Port C1 with the configuration BPDU unchanged. Port C1 does not forward data until a new event triggers a	• Blocked port (Port C1): {0, 0, 0, Port A2} • Root port (Port C2): {0, 5, 1, Port B2}

Device	Comparison process	Configuration BPDU on ports after comparison
	spanning tree calculation process: for example, the link between Device B and Device C is down.	

Final calculated spanning tree

After the comparison processes described in Table 4, a spanning tree with Device A as the root bridge is established, as shown in Figure 5.

Figure 5 The final calculated spanning tree



The configuration BPDU forwarding mechanism of STP

The configuration BPDUs of STP are forwarded according to these guidelines:

- Upon network initiation, every device regards itself as the root bridge and generates configuration BPDUs with itself as the root. Then it sends the configuration BPDUs at a regular hello interval.
- If the root port receives a configuration BPDU superior to the configuration BPDU of the port, the device performs the following operations:
  - Increases the message age carried in the configuration BPDU.
  - Starts a timer to time the configuration BPDU.
  - Sends this configuration BPDU through the designated port.
- If a designated port receives a configuration BPDU with a lower priority than its configuration BPDU, the port immediately responds with its configuration BPDU.
- If a path fails, the root port on this path no longer receives new configuration BPDUs and the old configuration BPDUs will be discarded due to timeout. The device generates a configuration BPDU with itself as the root and sends the BPDUs and TCN BPDUs. This triggers a new spanning tree calculation process to establish a new path to restore the network connectivity.

However, the newly calculated configuration BPDU cannot be propagated throughout the network immediately. As a result, the old root ports and designated ports that have not detected the topology change continue forwarding data along the old path. If the new root ports and designated ports begin to forward data as soon as they are elected, a temporary loop might occur.

STP timers

The most important timing parameters in STP calculation are forward delay, hello time, and max age.

- Forward delay

  Forward delay is the delay time for port state transition. By default, the forward delay is 15 seconds.

  A path failure can cause spanning tree re-calculation to adapt the spanning tree structure to the change. However, the resulting new configuration BPDU cannot propagate throughout the network immediately. If the newly elected root ports and designated ports start to forward data immediately, a temporary loop will likely occur.

  The newly elected root ports or designated ports must go through the listening and learning states before they transit to the forwarding state. This requires twice the forward delay time and allows the new configuration BPDU to propagate throughout the network.

- Hello time

  The device sends configuration BPDUs at the hello time interval to the neighboring devices to ensure that the paths are fault-free. By default, the hello time is 2 seconds. If the device does not receive configuration BPDUs within the timeout period, it recalculates the spanning tree. The formula for calculating the timeout period is timeout period = timeout factor × 3 × hello time.

- Max age

  The device uses the max age to determine whether a stored configuration BPDU has expired and discards it if the max age is exceeded. By default, the max age is 20 seconds. In the CIST of an MSTP network, the device uses the max age timer to determine whether a configuration BPDU received by a port has expired. If it is expired, a new spanning tree calculation process starts. The max age timer does not take effect on MSTIs.

If a port does not receive any configuration BPDUs within the timeout period, the port transits to the listening state. The device will recalculate the spanning tree. It takes the port 50 seconds to transit back to the forwarding state. This period includes 20 seconds for the max age, 15 seconds for the listening state, and 15 seconds for the learning state.

To ensure a fast topology convergence, make sure the timer settings meet the following formulas:

- 2 × (forward delay – 1 second) ≥ max age
- Max age ≥ 2 × (hello time + 1 second)

About RSTP

RSTP achieves rapid network convergence by allowing a newly elected root port or designated port to enter the forwarding state much faster than STP.

RSTP protocol frames

An RSTP BPDU uses the same format as an STP BPDU except that a Version1 length field is added to the payload of RSTP BPDUs. The differences between an RSTP BPDU and an STP BPDU are as follows:

- **Protocol version ID**—The value is 0x02 for RSTP.
- **BPDU type**—The value is 0x02 for RSTP BPDUs.
- **Flags**—All 8 bits are used.
- **Version1 length**—The value is 0x00, which means no version 1 protocol information is present.

RSTP does not use TCN BPDUs to advertise topology changes. RSTP floods BPDUs with the TC flag set in the network to advertise topology changes.

Basic concepts in RSTP

Port roles

In addition to root port and designated port, RSTP also uses the following port roles:

- **Alternate port**—Acts as the backup port for a root port. When the root port is blocked, the alternate port takes over.
- **Backup port**—Acts as the backup port of a designated port. When the designated port is invalid, the backup port becomes the new designated port. A loop occurs when two ports of the same spanning tree device are connected, so the device blocks one of the ports. The blocked port is the backup port.
- **Edge port**—Directly connects to a user host rather than a network device or network segment.

Port states

RSTP uses the discarding state to replace the disabled, blocking, and listening states in STP. Table 5 shows the differences between the port states in RSTP and STP.

Table 5 Port state differences between RSTP and STP

STP port state	RSTP port state	Sends BPDU	Learns MAC addresses	Forwards user data
Disabled	Discarding	No	No	No
Blocking	Discarding	No	No	No
Listening	Discarding	Yes	No	No
Learning	Learning	Yes	Yes	No
Forwarding	Forwarding	Yes	Yes	Yes

How RSTP works

During RSTP calculation, the following events occur:

- If a port in discarding state becomes an alternate port, it retains its state.
- If a port in discarding state is elected as the root port or designated port, it enters the learning state after the forward delay. The port learns MAC addresses, and enters the forwarding state after another forward delay.
  - A newly elected RSTP root port rapidly enters the forwarding state if the following requirements are met:
    - The old root port on the device has stopped forwarding data.
    - The upstream designated port has started forwarding data.
  - A newly elected RSTP designated port rapidly enters the forwarding state if one of the following requirements is met:
    - The designated port is configured as an edge port which directly connects to a user terminal.
    - The designated port connects to a point-to-point link and receives a handshake response from the directly connected device.

RSTP BPDU processing

In RSTP, a non-root bridge actively sends RSTP BPDUs at the hello time through designated ports without waiting for the root bridge to send RSTP BPDUs. This enables RSTP to quickly detect link

failures. If a device fails to receive any RSTP BPDUs on a port within triple the hello time, the device considers that a link failure has occurred. After the stored configuration BPDU expires, the device floods RSTP BPDUs with the TC flag set to initiate a new RSTP calculation.

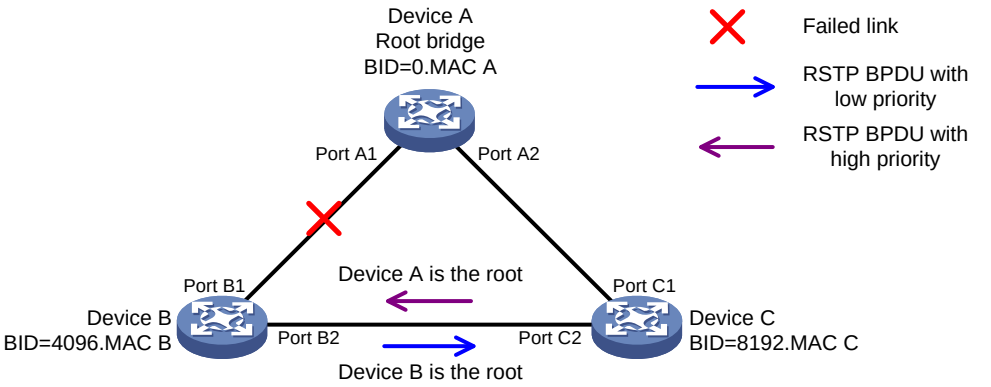
In RSTP, a port in blocking state can immediately respond to an RSTP BPDU with a lower priority than its own BPDU.

As shown in Figure 6, Device A is the root bridge. The priority of Device B is higher than the priority of Device C. Port C2 on Device C is blocked.

When the link between Device A and Device B fails, the following events occur:

1. Device B sends an RSTP BPDU with itself as the root bridge to Device C.
2. Device C compares the RSTP BPDU with its own BPDU.
3. Because the RSTP BPDU from Device B has a lower priority, Device C sends its own BPDU to Device B.
4. Device B considers that Port B2 is the root port and stops sending RSTP BPDUs to Device C.

Figure 6 BPDU processing in RSTP



About PVST

In an STP- or RSTP-enabled LAN, all bridges share one spanning tree. Traffic from all VLANs is forwarded along the spanning tree, and ports cannot be blocked on a per-VLAN basis to prune loops.

PVST allows every VLAN to have its own spanning tree, which increases usage of links and bandwidth. Because each VLAN runs RSTP independently, a spanning tree only serves its VLAN.

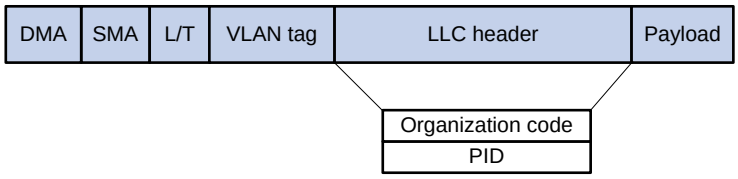
A PVST-enabled H3C device can communicate with a third-party device that is running Rapid PVST or PVST. The PVST-enabled H3C device supports fast network convergence like RSTP when connected to PVST-enabled H3C devices or third-party devices enabled with Rapid PVST.

PVST protocol frames

As shown in Figure 7, a PVST BPDU uses the same format as an RSTP BPDU except the following differences:

- The destination MAC address of a PVST BPDU is 01-00-0c-cc-cc-cd, which is a private MAC address.
- Each PVST BPDU carries a VLAN tag. The VLAN tag identifies the VLAN to which the PVST BPDU belongs.
- The organization code and PID fields are added to the LLC header of the PVST BPDU.

Figure 7 PVST BPDU format



A port's link type determines the type of BPDUs the port sends.

- An access port sends RSTP BPDUs.
- A trunk or hybrid port sends RSTP BPDUs in the default VLAN and sends PVST BPDUs in other VLANs.

How PVST works

PVST implements per-VLAN spanning tree calculation by mapping each VLAN to an MSTI. In PVST, each VLAN runs RSTP independently to maintain its own spanning tree without affecting the spanning trees of other VLANs. In this way, loops in each VLAN are eliminated and traffic of different VLANs is load shared over links. PVST uses RSTP BPDUs in the default VLAN and PVST BPDUs in other VLANs for spanning tree calculation.

PVST uses the same port roles and port states as RSTP for rapid transition. For more information, see "Basic concepts in RSTP."

About MSTP

MSTP features

Developed based on IEEE 802.1s, MSTP overcomes the limitations of STP, RSTP, and PVST. In addition to supporting rapid network convergence, it allows data flows of different VLANs to be forwarded along separate paths. This provides a better load sharing mechanism for redundant links.

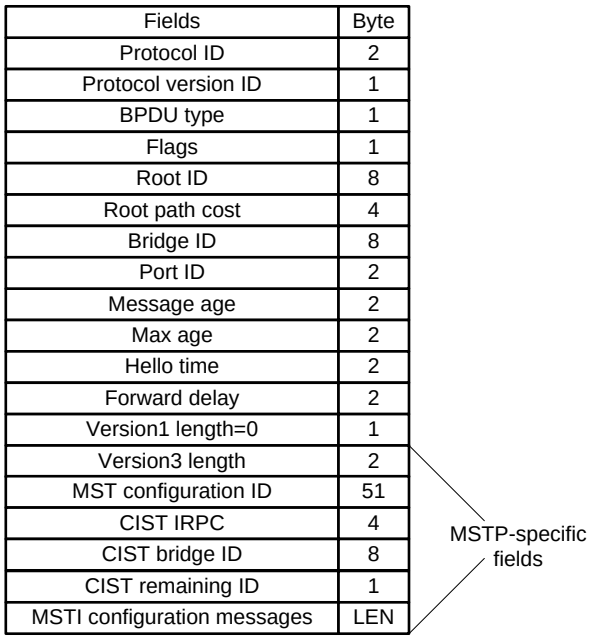
MSTP provides the following features:

- MSTP divides a switched network into multiple regions, each of which contains multiple spanning trees that are independent of one another.
- MSTP supports mapping VLANs to spanning tree instances by means of a VLAN-to-instance mapping table. MSTP can reduce communication overheads and resource usage by mapping multiple VLANs to one instance.
- MSTP prunes a loop network into a loop-free tree, which avoids proliferation and endless cycling of frames in a loop network. In addition, it supports load balancing of VLAN data by providing multiple redundant paths for data forwarding.
- MSTP is compatible with STP and RSTP, and partially compatible with PVST.

MSTP protocol frames

Figure 8 shows the format of an MSTP BPDU.

Figure 8 MSTP BPDU format



The first 13 fields of an MSTP BPDU are the same as an RSTP BPDU. The other six fields are unique to MSTP.

- **Protocol version ID**—The value is 0x03 for MSTP.
- **BPDU type**—The value is 0x02 for RSTP/MSTP BPDUs.
- **Root ID**—ID of the common root bridge.
- **Root path cost**—CIST external path cost.
- **Bridge ID**—ID of the regional root for the IST or an MSTI.
- **Port ID**—ID of the designated port in the CIST.
- **Version3 length**—Length of the MSTP-specific fields. Devices use this field for verification upon receiving an MSTP BPDU.
- **MST configuration ID**—Includes the format selector, configuration name, revision level, and configuration digest. The value for format selector is fixed at 0x00. The other parameters are used to identify the MST region for the originating bridge.
- **CIST IRPC**—Internal root path cost (IRPC) from the originating bridge to the root of the MST region.
- **CIST bridge ID**—ID of the bridge that sends the MSTP BPDU.
- **CIST remaining ID**—Remaining hop count. This field limits the scale of the MST region. The regional root sends a BPDU with the remaining hop count set to the maximum value. Each device that receives the BPDU decrements the hop count by one. When the hop count reaches zero, the BPDU is discarded. Devices beyond the maximum hops of the MST region cannot participate in spanning tree calculation. The default remaining hop count is 20.
- **MSTI configuration messages**—Contains MSTI configuration messages. Each MSTI configuration message is 16 bytes. This field can contain 0 to 64 MSTI configuration messages. The number of the MSTI configuration messages is determined by the number of MSTIs in the MST region.

Basic concepts in MSTP

Figure 9 shows a switched network that contains four MST regions, each MST region containing four MSTP devices. Figure 10 shows the networking topology of MST region 3.

Figure 9 Basic concepts in MSTP

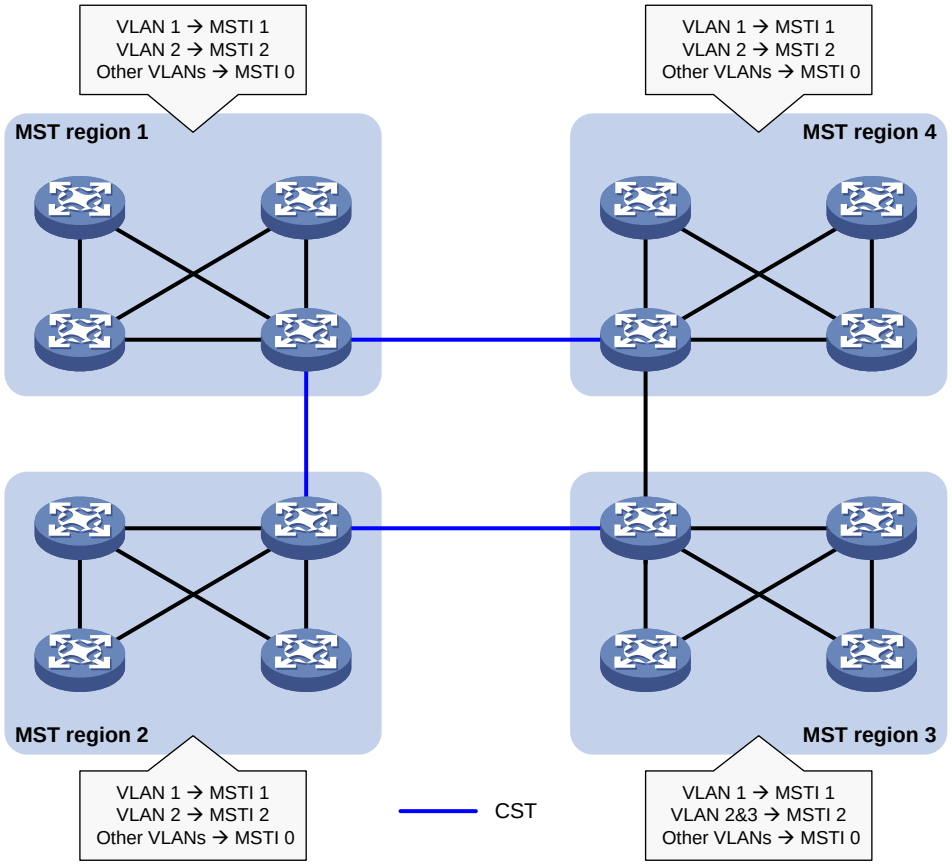
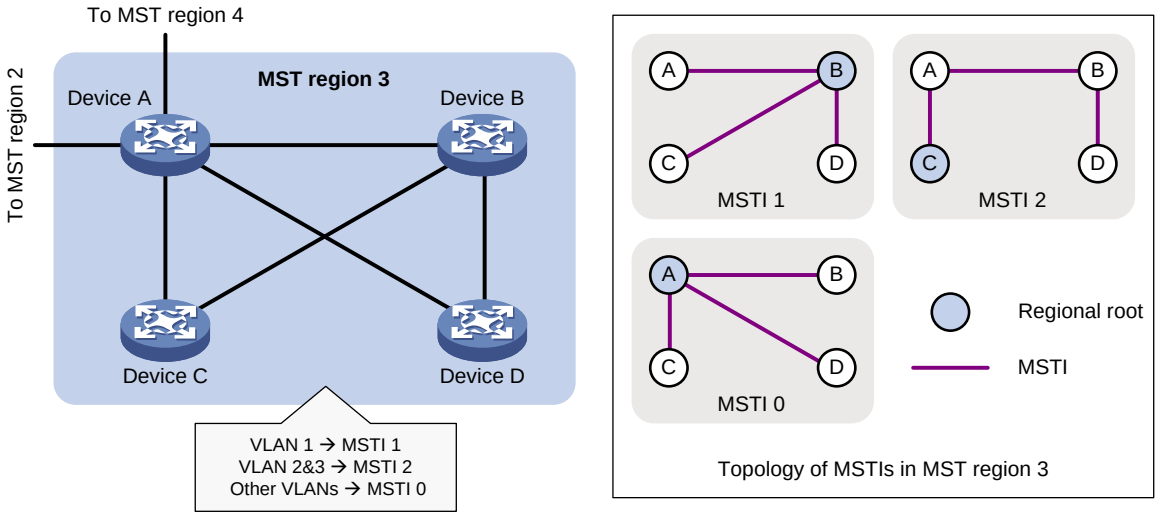


Figure 10 Network diagram and topology of MST region 3



MST region

A multiple spanning tree region (MST region) consists of multiple devices in a switched network and the network segments among them. All these devices have the following characteristics:

- A spanning tree protocol enabled
- Same region name
- Same VLAN-to-instance mapping configuration
- Same MSTP revision level
- Physically linked together

Multiple MST regions can exist in a switched network. You can assign multiple devices to the same MST region, as shown in Figure 9.

- The switched network contains four MST regions, MST region 1 through MST region 4.
- All devices in each MST region have the same MST region configuration.

MSTI

MSTP can generate multiple independent spanning trees in an MST region, and each spanning tree is mapped to the specific VLANs. Each spanning tree is referred to as a multiple spanning tree instance (MSTI).

In Figure 10, MST region 3 contains three MSTIs, MSTI 1, MSTI 2, and MSTI 0.

VLAN-to-instance mapping table

As an attribute of an MST region, the VLAN-to-instance mapping table describes the mapping relationships between VLANs and MSTIs.

In Figure 10, the VLAN-to-instance mapping table of MST region 3 is as follows:

- VLAN 1 to MSTI 1.
- VLAN 2 and VLAN 3 to MSTI 2.
- Other VLANs to MSTI 0.

MSTP achieves load balancing by means of the VLAN-to-instance mapping table.

CST

The common spanning tree (CST) is a single spanning tree that connects all MST regions in a switched network. If you regard each MST region as a device, the CST is a spanning tree calculated by these devices through STP or RSTP.

The blue lines in Figure 9 represent the CST.

IST

An internal spanning tree (IST) is a spanning tree that runs in an MST region. It is also called MSTI 0, a special MSTI to which all VLANs are mapped by default.

In Figure 9, MSTI 0 is the IST in MST region 3.

CIST

The common and internal spanning tree (CIST) is a single spanning tree that connects all devices in a switched network. It consists of the ISTs in all MST regions and the CST.

In Figure 9, the ISTs (MSTI 0) in all MST regions plus the inter-region CST constitute the CIST of the entire network.

Regional root

The root bridge of the IST or an MSTI within an MST region is the regional root of the IST or MSTI. Based on the topology, different spanning trees in an MST region might have different regional roots, as shown in MST region 3 in Figure 10.

- The regional root of MSTI 1 is Device B.
- The regional root of MSTI 2 is Device C.
- The regional root of MSTI 0 (also known as the IST) is Device A.

Common root bridge

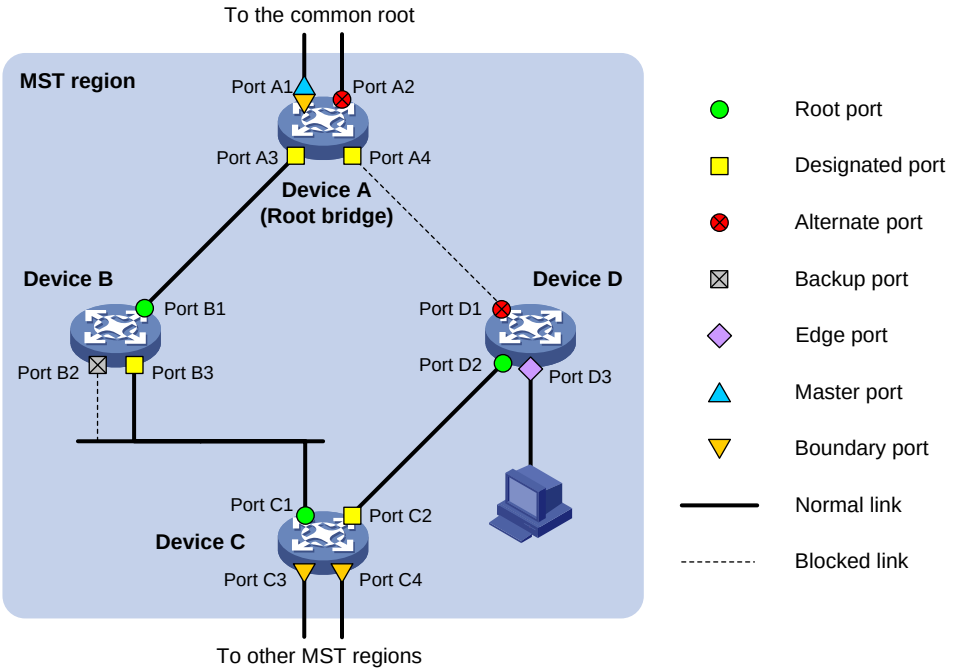
The common root bridge is the root bridge of the CIST.

In Figure 9, the common root bridge is a device in MST region 1.

Port roles

A port can play different roles in different MSTIs. As shown in Figure 11, an MST region contains Device A, Device B, Device C, and Device D. Port A1 and port A2 of Device A connect to the common root bridge. Port B2 and Port B3 of Device B form a loop. Port C3 and Port C4 of Device C connect to other MST regions. Port D3 of Device D directly connects to a host.

Figure 11 Port roles



MSTP calculation involves the following port roles:

- **Root port**—Forwards data for a non-root bridge to the root bridge. The root bridge does not have any root port.
- **Designated port**—Forwards data to the downstream network segment or device.
- **Alternate port**—Acts as the backup port for a root port or master port. When the root port or master port is blocked, the alternate port takes over.
- **Backup port**—Acts as the backup port of a designated port. When the designated port is invalid, the backup port becomes the new designated port. A loop occurs when two ports of the same spanning tree device are connected, so the device blocks one of the ports. The blocked port acts as the backup.
- **Edge port**—Directly connects to a user host rather than a network device or network segment.
- **Master port**—Acts as a port on the shortest path from the local MST region to the common root bridge. The master port is not always located on the regional root. It is a root port on the IST or CIST and still a master port on the other MSTIs.
- **Boundary port**—Connects an MST region to another MST region or to an STP/RSTP-running device. In MSTP calculation, a boundary port's role on an MSTI is consistent with its role on the

CIST. However, that is not true with master ports. A master port on MSTIs is a root port on the CIST.

Port states

In MSTP, a port can be in one of the following states:

- **Forwarding**—The port receives and sends BPDUs, learns MAC addresses, and forwards user traffic.
- **Learning**—The port receives and sends BPDUs, learns MAC addresses, but does not forward user traffic. Learning is an intermediate port state.
- **Discarding**—The port receives and sends BPDUs, but does not learn MAC addresses or forward user traffic.

NOTE:

When in different MSTIs, a port can be in different states.

A port state is not exclusively associated with a port role. Table 6 lists the port states that each port role supports. (A check mark [√] indicates that the port supports this state, while a dash [—] indicates that the port does not support this state.)

Table 6 Port states that different port roles support

Port role (right) Port state (below)	Root port/master port	Designated port	Alternate port	Backup port
Forwarding	√	√	—	—
Learning	√	√	—	—
Discarding	√	√	√	√

How MSTP works

MSTP divides an entire Layer 2 network into multiple MST regions, which are connected by a calculated CST. Inside an MST region, multiple spanning trees, called MSTIs, are calculated. Among these MSTIs, MSTI 0 is the IST.

Like STP, MSTP uses configuration BPDUs to calculate spanning trees. An important difference is that an MSTP BPDU carries the MSTP configuration of the bridge from which the BPDU is sent.

CIST calculation

During the CIST calculation, the following process takes place:

- The device with the highest priority is elected as the root bridge of the CIST.
- MSTP generates an IST within each MST region through calculation.
- MSTP regards each MST region as a single device and generates a CST among these MST regions through calculation.

The CST and ISTs constitute the CIST of the entire network.

MSTI calculation

Within an MST region, MSTP generates different MSTIs for different VLANs based on the VLAN-to-instance mappings. For each spanning tree, MSTP performs a separate calculation process similar to spanning tree calculation in STP. For more information, see "Calculation process of the STP algorithm."

In MSTP, a VLAN frame is forwarded along the following paths:

- Within an MST region, the frame is forwarded along the corresponding MSTI.
- Between two MST regions, the frame is forwarded along the CST.

MSTP implementation on devices

MSTP is compatible with STP and RSTP. Devices that are running MSTP and that are used for spanning tree calculation can identify STP and RSTP protocol frames.

In addition to basic MSTP features, the following features are provided for ease of management:

- Root bridge hold.
- Root bridge backup.
- Root guard.
- BPDU guard.
- Loop guard.
- TC-BPDU guard.
- Port role restriction.
- TC-BPDU transmission restriction.

Rapid transition mechanism

In STP, a port must wait twice the forward delay (30 seconds by default) before it transits from the blocking state to the forwarding state. The forward delay is related to the hello time and network diameter. If the forward delay is too short, loops might occur. This affects the stability of the network.

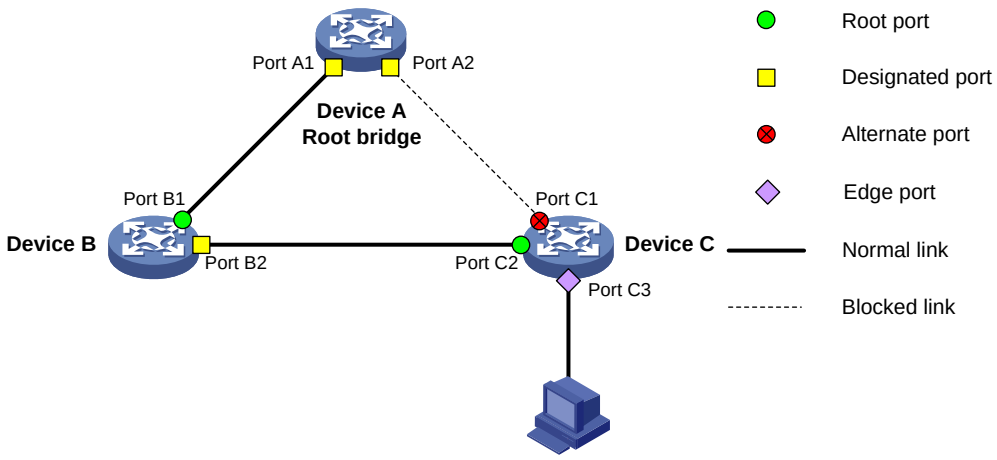
RSTP, PVST, and MSTP all use the rapid transition mechanism to speed up port state transition for edge ports, root ports, and designated ports. The rapid transition mechanism for designated ports is also known as the proposal/agreement (P/A)_transition.

Edge port rapid transition

As shown in Figure 12, Port C3 is an edge port connected to a host. When a network topology change occurs, the port can immediately transit from the blocking state to the forwarding state because no loop will be caused.

Because a device cannot determine whether a port is directly connected to a terminal, you must manually configure the port as an edge port.

Figure 12 Edge port rapid transition

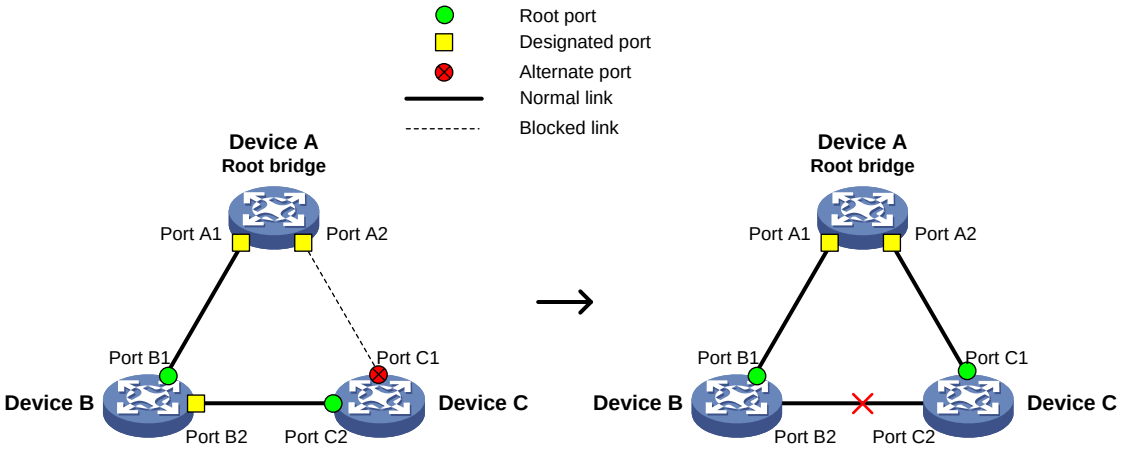


Root port rapid transition

When a root port is blocked, the bridge will elect the alternate port with the highest priority as the new root port. If the new root port's peer is in the forwarding state, the new root port immediately transits to the forwarding state.

As shown in Figure 13, Port C2 on Device C is a root port and Port C1 is an alternate port. When Port C2 transits to the blocking state, Port C1 is elected as the root port and immediately transits to the forwarding state.

Figure 13 Root port rapid transition



P/A transition

The P/A transition enables a designated port to rapidly transit to the forwarding state after a handshake with its peer. The P/A transition applies only to point-to-point links.

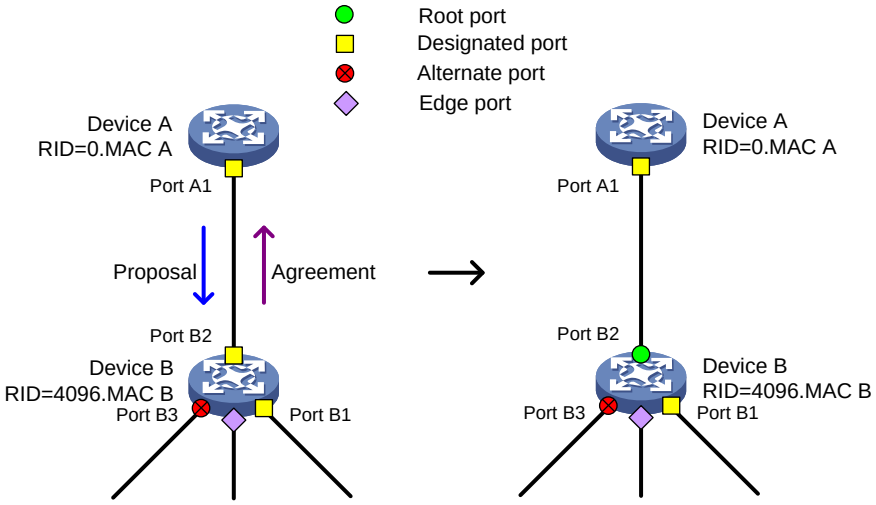
P/A transition for RSTP and PVST.

In RSTP or PVST, the ports on a new link or recovered link are designated ports in blocking state. When one of the designated ports transits to the discarding or learning state, it sets the proposal flag in its BPDU. Its peer bridge receives the BPDU and determines whether the receiving port is the root port. If it is the root port, the bridge blocks the other ports except edge ports. The bridge then replies an agreement BPDU to the designated port. The designated port immediately transits to the forwarding state upon receiving the agreement BPDU. If the designated port does not receive the agreement BPDU, it waits for twice the forward delay to transit to the forwarding state.

As shown in Figure 14, the P/A transition operates as follows:

1. Device A sends a proposal BPDU to Device B through Port A1.
2. Device B receives the proposal BPDU on Port B2. Port B2 is elected as the root port.
3. Device B blocks its designated port Port B1 and alternate port Port B3 to eliminate loops.
4. The root port Port B2 transits to the forwarding state and sends an agreement BPDU to Device A.
5. The designated port Port A1 on Device A immediately transits to the forwarding state after receiving the agreement BPDU.

Figure 14 P/A transition for RSTP and PVST



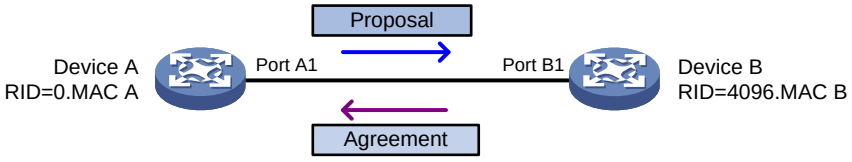
P/A transition for MSTP.

In MSTP, an upstream bridge sets both the proposal and agreement flags in its BPDU. If a downstream bridge receives the BPDU and its receiving port is elected as the root port, the bridge blocks all the other ports except edge ports. The downstream bridge then replies an agreement BPDU to the upstream bridge. The upstream port immediately transits to the forwarding state upon receiving the agreement BPDU. If the upstream port does not receive the agreement BPDU, it waits for twice the forward delay to transit to the forwarding state.

As shown in Figure 15, the P/A transition operates as follows:

1. Device A sets the proposal and agreement flags in its BPDU and sends it to Device B through Port A1.
2. Device B receives the BPDU. Port B1 of Device B is elected as the root port.
3. Device B then blocks all its ports except the edge ports.
4. The root port Port B1 of Device B transits to the forwarding state and sends an agreement BPDU to Device A.
5. Port A1 of Device A immediately transits to the forwarding state upon receiving the agreement BPDU.

Figure 15 P/A transition for MSTP



Protocols and standards

MSTP is documented in the following protocols and standards:

- IEEE 802.1d, *Media Access Control (MAC) Bridges*
- IEEE 802.1w, *Part 3: Media Access Control (MAC) Bridges—Amendment 2: Rapid Reconfiguration*
- IEEE 802.1s, *Virtual Bridged Local Area Networks—Amendment 3: Multiple Spanning Trees*

- IEEE 802.1Q-REV/D1.3, *Media Access Control (MAC) Bridges and Virtual Bridged Local Area Networks —Clause 13: Spanning tree Protocols*

Configuring spanning tree protocols

Restrictions and guidelines: spanning tree protocol configuration

Restrictions: Compatibility with other features

- If both MVRP and a spanning tree protocol are enabled on a device, MVRP packets are forwarded along MSTIs. To advertise a specific VLAN within the network through MVRP, make sure this VLAN is mapped to an MSTI when you configure the VLAN-to-instance mapping table. For more information about MVRP, see "Configuring MVRP."
- The spanning tree configurations are mutually exclusive with any of the following features on a port: RRPP, Smart Link, and L2PT. The S5000E-X, S5000X-EI, S5110V2-SI, S5000V3-EI, S5000V5-EI, and WAS6000 switch series do not support RRPP or Smart Link.

Restrictions: Interface configuration

- Some spanning tree features are supported in Layer 2 Ethernet interface view and Layer 2 aggregate interface view. Unless otherwise stated, these views are collectively referred to as interface view in this document. BPDU drop can be configured only in Layer 2 Ethernet interface view.
- Configurations made in system view take effect globally. Configurations made in Layer 2 Ethernet interface view take effect only on the interface. Configurations made in Layer 2 aggregate interface view take effect only on the aggregate interface. Configurations made on an aggregation member port can take effect only after the port is removed from the aggregation group.
- After you enable a spanning tree protocol on a Layer 2 aggregate interface, the system performs spanning tree calculation on the Layer 2 aggregate interface. It does not perform spanning tree calculation on the aggregation member ports. The spanning tree protocol enable state and forwarding state of each selected member port are consistent with those of the corresponding Layer 2 aggregate interface.
- The member ports of an aggregation group do not participate in spanning tree calculation. However, the ports still reserve their spanning tree configurations for participating in spanning tree calculation after leaving the aggregation group.

Spanning tree protocol tasks at a glance

STP tasks at a glance

Configuring the root bridge

To configure the root bridge in STP mode, perform the following tasks:

1. Setting the spanning tree mode

   Set the spanning tree mode to STP.
2. (Optional.) Configuring the root bridge or a secondary root bridge
3. (Optional.) Configuring the device priority
4. (Optional.) Configuring parameters that affects STP topology convergence

- Configuring the network diameter of a switched network
- Setting spanning tree timers
- Setting the timeout factor
- Configuring the BPDU transmission rate

5. (Optional.) Enabling outputting port state transition information
6. Enabling the spanning tree feature
7. (Optional.) Configuring advanced spanning tree features
   - Configuring TC Snooping
   - Configuring protection features
   - Disabling the device from reactivating edge ports shut down by BPDU guard
   - Enabling SNMP notifications for new-root election and topology change events

Configuring the leaf nodes

To configure the leaf nodes in STP mode, perform the following tasks:

1. Setting the spanning tree mode

   Set the spanning tree mode to STP.
2. (Optional.) Configuring the device priority
3. (Optional.) Configuring parameters that affects STP topology convergence
   - Setting the timeout factor
   - Configuring the BPDU transmission rate
   - Configuring path costs of ports
   - Configuring the port priority
4. (Optional.) Enabling outputting port state transition information
5. Enabling the spanning tree feature
6. (Optional.) Configuring advanced spanning tree features
   - Configuring TC Snooping
   - Configuring protection features
   - Disabling the device from reactivating edge ports shut down by BPDU guard
   - Enabling SNMP notifications for new-root election and topology change events

RSTP tasks at a glance

Configuring the root bridge

To configure the root bridge in RSTP mode, perform the following tasks:

1. Setting the spanning tree mode

   Set the spanning tree mode to RSTP.
2. (Optional.) Configuring the root bridge or a secondary root bridge
3. (Optional.) Configuring the device priority
4. (Optional.) Configuring parameters that affects RSTP topology convergence
   - Configuring the network diameter of a switched network
   - Setting spanning tree timers
   - Setting the timeout factor
   - Configuring the BPDU transmission rate
   - Configuring edge ports
   - Configuring the port link type

5. (Optional.) Enabling outputting port state transition information
6. Enabling the spanning tree feature
7. (Optional.) Configuring advanced spanning tree features
   - Performing mCheck
   - Configuring TC Snooping
   - Configuring protection features
   - Disabling the device from reactivating edge ports shut down by BPDU guard
   - Enabling SNMP notifications for new-root election and topology change events

Configuring the leaf nodes

To configure the leaf nodes in RSTP mode, perform the following tasks:

1. Setting the spanning tree mode

   Set the spanning tree mode to RSTP.
2. (Optional.) Configuring the device priority
3. (Optional.) Configuring parameters that affects RSTP topology convergence
   - Setting the timeout factor
   - Configuring the BPDU transmission rate
   - Configuring edge ports
   - Configuring path costs of ports
   - Configuring the port priority
   - Configuring the port link type
4. (Optional.) Enabling outputting port state transition information
5. Enabling the spanning tree feature
6. (Optional.) Configuring advanced spanning tree features
   - Performing mCheck
   - Configuring TC Snooping
   - Configuring protection features
   - Disabling the device from reactivating edge ports shut down by BPDU guard
   - Enabling SNMP notifications for new-root election and topology change events

PVST tasks at a glance

Configuring the root bridge

To configure the root bridge in PVST mode, perform the following tasks:

1. Setting the spanning tree mode

   Set the spanning tree mode to PVST.
2. (Optional.) Configuring the root bridge or a secondary root bridge
3. (Optional.) Configuring the device priority
4. (Optional.) Configuring parameters that affects PVST topology convergence
   - Configuring the network diameter of a switched network
   - Setting spanning tree timers
   - Setting the timeout factor
   - Configuring the BPDU transmission rate
   - Configuring edge ports
   - Configuring the port link type

5. (Optional.) Enabling outputting port state transition information
6. Enabling the spanning tree feature
7. (Optional.) Configuring advanced spanning tree features
   - Performing mCheck
   - Disabling inconsistent PVID protection
   - Configuring protection features
   - Enabling the device to log events of detecting or receiving TC BPDUs
   - Disabling the device from reactivating edge ports shut down by BPDU guard
   - Enabling SNMP notifications for new-root election and topology change events

Configuring the leaf nodes

To configure the leaf nodes in PVST mode, perform the following tasks:

1. Setting the spanning tree mode

   Set the spanning tree mode to PVST.
2. (Optional.) Configuring the device priority
3. (Optional.) Configuring parameters that affects PVST topology convergence
   - Setting the timeout factor
   - Configuring the BPDU transmission rate
   - Configuring edge ports
   - Configuring path costs of ports
   - Configuring the port priority
   - Configuring the port link type
4. (Optional.) Enabling outputting port state transition information
5. Enabling the spanning tree feature
6. (Optional.) Configuring advanced spanning tree features
   - Performing mCheck
   - Disabling inconsistent PVID protection
   - Configuring protection features
   - Enabling the device to log events of detecting or receiving TC BPDUs
   - Disabling the device from reactivating edge ports shut down by BPDU guard
   - Enabling SNMP notifications for new-root election and topology change events

MSTP tasks at a glance

Configuring the root bridge

To configure the root bridge in MSTP mode, perform the following tasks:

1. Setting the spanning tree mode

   Set the spanning tree mode to MSTP.
2. Configuring an MST region
3. (Optional.) Configuring the root bridge or a secondary root bridge
4. (Optional.) Configuring the device priority
5. (Optional.) Configuring parameters that affects MSTP topology convergence
   - Configuring the maximum hops of an MST region
   - Configuring the network diameter of a switched network
   - Setting spanning tree timers

- Setting the timeout factor
- Configuring the BPDU transmission rate
- Configuring edge ports
- Configuring the port link type

6. (Optional.) Configuring the mode a port uses to recognize and send MSTP frames
7. (Optional.) Enabling outputting port state transition information
8. Enabling the spanning tree feature
9. (Optional.) Configuring advanced spanning tree features
   - Performing mCheck
   - Configuring Digest Snooping
   - Configuring No Agreement Check
   - Configuring TC Snooping
   - Configuring protection features
   - Disabling the device from reactivating edge ports shut down by BPDU guard
   - Enabling SNMP notifications for new-root election and topology change events

Configuring the leaf nodes

To configure the leaf nodes in MSTP mode, perform the following tasks:

1. Setting the spanning tree mode

   Set the spanning tree mode to MSTP.
2. Configuring an MST region
3. (Optional.) Configuring the device priority
4. (Optional.) Configuring parameters that affects MSTP topology convergence
   - Setting the timeout factor
   - Configuring the BPDU transmission rate
   - Configuring edge ports
   - Configuring path costs of ports
   - Configuring the port priority
   - Configuring the port link type
5. (Optional.) Configuring the mode a port uses to recognize and send MSTP frames
6. (Optional.) Enabling outputting port state transition information
7. Enabling the spanning tree feature
8. (Optional.) Configuring advanced spanning tree features
   - Performing mCheck
   - Configuring Digest Snooping
   - Configuring No Agreement Check
   - Configuring TC Snooping
   - Configuring protection features
   - Disabling the device from reactivating edge ports shut down by BPDU guard
   - Enabling SNMP notifications for new-root election and topology change events

Setting the spanning tree mode

About spanning tree mode

The spanning tree modes include:

- **STP mode**—All ports of the device send STP BPDUs. Select this mode when the peer device of a port supports only STP.
- **RSTP mode**—All ports of the device send RSTP BPDUs. A port in this mode automatically transits to the STP mode when it receives STP BPDUs from the peer device. A port in this mode does not transit to the MSTP mode when it receives MSTP BPDUs from the peer device.
- **PVST mode**—All ports of the device send PVST BPDUs. Each VLAN maintains a spanning tree. In a network, the amount of spanning trees maintained by all devices equals the number of PVST-enabled VLANs multiplied by the number of PVST-enabled ports. If the amount of spanning trees exceeds the capacity of the network, device CPUs will be overloaded. Packet forwarding is interrupted, and the network becomes unstable. The device can maintain spanning trees for 128 VLANs.
- **MSTP mode**—All ports of the device send MSTP BPDUs. A port in this mode automatically transits to the STP mode when receiving STP BPDUs from the peer device. A port in this mode does not transit to the RSTP mode when receiving RSTP BPDUs from the peer device.

Restrictions and guidelines

The MSTP mode is compatible with the RSTP mode, and the RSTP mode is compatible with the STP mode.

Compatibility of the PVST mode depends on the link type of a port.

- On an access port, the PVST mode is compatible with other spanning tree modes in all VLANs.
- On a trunk port or hybrid port, the PVST mode is compatible with other spanning tree modes only in the default VLAN.

Procedure

1. Enter system view.

   system-view
2. Set the spanning tree mode.

   stp mode { **mstp** | **pvst** | **rstp** | **stp** }

   The default setting is the MSTP mode.

Configuring an MST region

About MST region

Spanning tree devices belong to the same MST region if they are both connected through a physical link and configured with the following details:

- Format selector (0 by default, not configurable).
- MST region name.
- MST region revision level.
- VLAN-to-instance mapping entries in the MST region.

The configuration of MST region-related parameters (especially the VLAN-to-instance mapping table) might cause MSTP to begin a new spanning tree calculation. To reduce the possibility of topology instability, the MST region configuration takes effect only after you activate it by doing one of the following:

- Use the **active region-configuration** command.

- Enable a spanning tree protocol by using the **stp global enable** command if the spanning tree protocol is disabled.

Restrictions and guidelines

In STP, RSTP, or PVST mode, MST region configurations do not take effect.

Procedure

1. Enter system view.
   system-view
2. Enter MST region view.
   stp region-configuration
3. Configure the MST region name.
   region-name *name*
   The default setting is the MAC address.
4. Configure the VLAN-to-instance mapping table. Choose one option as needed:
   - Map a list of VLANs to an MSTI.
     instance *instance-id* **vlan** *vlan-id-list*
   - Quickly create a VLAN-to-instance mapping table.
     vlan-mapping modulo *modulo*

   By default, all VLANs in an MST region are mapped to the CIST (or MSTI 0).
5. Configure the MSTP revision level of the MST region.
   revision-level *level*
   The default setting is 0.
6. (Optional.) Display the MST region configurations that are not activated yet.
   check region-configuration
7. Manually activate MST region configuration.
   active region-configuration

Configuring the root bridge or a secondary root bridge

Restrictions and guidelines

You can have the spanning tree protocol determine the root bridge of a spanning tree through calculation. You can also specify a device as the root bridge or as a secondary root bridge.

When you specify a device as the root bridge or as a secondary root bridge, follow these restrictions and guidelines:

- A device has independent roles in different spanning trees. It can act as the root bridge in one spanning tree and as a secondary root bridge in another. However, one device cannot be the root bridge and a secondary root bridge in the same spanning tree.
- If you specify the root bridge for a spanning tree, no new root bridge is elected according to the device priority settings. Once you specify a device as the root bridge or a secondary root bridge, you cannot change the priority of the device.
- You can configure a device as the root bridge by setting the device priority to 0. For the device priority configuration, see "Configuring the device priority."

Configuring the device as the root bridge of a spanning tree

1. Enter system view.
   system-view
2. Configure the device as the root bridge.
   - In STP/RSTP mode:
     stp root primary
   - In PVST mode:
     stp vlan *vlan-id-list* **root primary**
   - In MSTP mode:
     stp [**instance** *instance-list*] **root primary**

   By default, the device is not a root bridge.

Configuring the device as a secondary root bridge of a spanning tree

1. Enter system view.
   system-view
2. Configure the device as a secondary root bridge.
   - In STP/RSTP mode:
     stp root secondary
   - In PVST mode:
     stp vlan *vlan-id-list* **root secondary**
   - In MSTP mode:
     stp [**instance** *instance-list*] **root secondary**

   By default, the device is not a secondary root bridge.

Configuring the device priority

About device priority

Device priority is a factor in calculating the spanning tree. The priority of a device determines whether the device can be elected as the root bridge of a spanning tree. A lower value indicates a higher priority. You can set the priority of a device to a low value to specify the device as the root bridge of the spanning tree. A spanning tree device can have different priorities in different spanning trees.

During root bridge selection, if all devices in a spanning tree have the same priority, the one with the lowest MAC address is selected. You cannot change the priority of a device after it is configured as the root bridge or as a secondary root bridge.

Procedure

1. Enter system view.
   system-view
2. Configure the priority of the device.
   - In STP/RSTP mode:
     stp priority *priority*

- In PVST mode:
  stp vlan *vlan-id-list* **priority** *priority*
- In MSTP mode:
  stp [**instance** *instance-list*] **priority** *priority*

The default setting is 32768.

Configuring the maximum hops of an MST region

About the maximum hops of an MST region

Restrict the region size by setting the maximum hops of an MST region. The hop limit configured on the regional root bridge is used as the hop limit for the MST region.

Configuration BPDUs sent by the regional root bridge always have a hop count set to the maximum value. When a device receives this configuration BPDU, it decrements the hop count by one, and uses the new hop count in the BPDUs that it propagates. When the hop count of a BPDU reaches zero, it is discarded by the device that received it. Devices beyond the reach of the maximum hops can no longer participate in spanning tree calculations, so the size of the MST region is limited.

Restrictions and guidelines

Make this configuration only on the root bridge. All other devices in the MST region use the maximum hop value set for the root bridge.

You can configure the maximum hops of an MST region based on the STP network size. As a best practice, set the maximum hops to a value that is greater than the maximum hops of each edge device to the root bridge.

Procedure

1. Enter system view.
   system-view
2. Configure the maximum hops of the MST region.
   stp max-hops *hops*
   The default setting is 20.

Configuring the network diameter of a switched network

About network diameter

Any two terminal devices in a switched network can reach each other through a specific path, and there are a series of devices on the path. The switched network diameter is the maximum number of devices on the path for an edge device to reach another one in the switched network through the root bridge. The network diameter indicates the network size. The bigger the diameter, the larger the network size.

Based on the network diameter you configured, the system automatically sets an optimal hello time, forward delay, and max age for the device.

In STP, RSTP, or MSTP mode, each MST region is considered a device. The configured network diameter takes effect only on the CIST (or the common root bridge) but not on other MSTIs.

In PVST mode, the configured network diameter takes effect only on the root bridges of the specified VLANs.

Procedure

1. Enter system view.
   system-view
2. Configure the network diameter of the switched network.
   - In STP/RSTP/MSTP mode:
     stp bridge-diameter *diameter*
   - In PVST mode:
     stp vlan *vlan-id-list* **bridge-diameter** *diameter*

   The default setting is 7.

Setting spanning tree timers

About spanning tree timers

The following timers are used for spanning tree calculation:

- **Forward delay**—Delay time for port state transition. To prevent temporary loops on a network, the spanning tree feature sets an intermediate port state (the learning state) before it transits from the discarding state to the forwarding state. The feature also requires that the port transit its state after a forward delay timer. This ensures that the state transition of the local port stays synchronized with the peer.
- **Hello time**—Interval at which the device sends configuration BPDUs to detect link failures. If the device does not receive configuration BPDUs within the timeout period, it recalculates the spanning tree. The formula for calculating the timeout period is timeout period = timeout factor × 3 × hello time.
- **Max age**—In the CIST of an MSTP network, the device uses the max age timer to determine whether a configuration BPDU received by a port has expired. If it is expired, a new spanning tree calculation process starts. The max age timer does not take effect on MSTIs.

To ensure a fast topology convergence, make sure the timer settings meet the following formulas:

- 2 × (forward delay – 1 second) ≥ max age
- Max age ≥ 2 × (hello time + 1 second)

As a best practice, specify the network diameter and letting spanning tree protocols automatically calculate the timers based on the network diameter instead of manually setting the spanning tree timers. If the network diameter uses the default value, the timers also use their default values.

Set the timers only on the root bridge. The timer settings on the root bridge apply to all devices on the entire switched network.

Restrictions and guidelines

- The length of the forward delay is related to the network diameter of the switched network. The larger the network diameter is, the longer the forward delay time should be. As a best practice, use the automatically calculated value because inappropriate forward delay setting might cause temporary redundant paths or increase the network convergence time.
- An appropriate hello time setting enables the device to promptly detect link failures on the network without using excessive network resources. If the hello time is too long, the device mistakes packet loss for a link failure and triggers a new spanning tree calculation process. If the hello time is too short, the device frequently sends the same configuration BPDUs, which wastes device and network resources. As a best practice, use the automatically calculated value.
- If the max age timer is too short, the device frequently begins spanning tree calculations and might mistake network congestion as a link failure. If the max age timer is too long, the device might fail to promptly detect link failures and quickly launch spanning tree calculations, reducing

the auto-sensing capability of the network. As a best practice, use the automatically calculated value.

Procedure

1. Enter system view.
   system-view
2. Set the forward delay timer.
   - In STP/RSTP/MSTP mode:
     stp timer forward-delay *time*
   - In PVST mode:
     stp vlan *vlan-id-list* **timer forward-delay** *time*

   The default setting is 15 seconds.
3. Set the hello timer.
   - In STP/RSTP/MSTP mode:
     stp timer hello *time*
   - In PVST mode:
     stp vlan *vlan-id-list* **timer hello** *time*

   The default setting is 2 seconds.
4. Set the max age timer.
   - In STP/RSTP/MSTP mode:
     stp timer max-age *time*
   - In PVST mode:
     stp vlan *vlan-id-list* **timer max-age** *time*

     The default setting is 20 seconds.

Setting the timeout factor

About timeout factor

The timeout factor is a parameter used to decide the timeout period. The formula for calculating the timeout period is: *timeout period* = *timeout factor* × 3 × *hello time*.

In a stable network, each non-root-bridge device forwards configuration BPDUs to the downstream devices at the hello time interval to detect link failures. If a device does not receive a BPDU from the upstream device within nine times the hello time, it assumes that the upstream device has failed. Then, it starts a new spanning tree calculation process.

Restrictions and guidelines

As a best practice, set the timeout factor to 5, 6, or 7 in the following situations:

- To prevent undesired spanning tree calculations. An upstream device might be too busy to forward configuration BPDUs in time, for example, many Layer 2 interfaces are configured on the upstream device. In this case, the downstream device fails to receive a BPDU within the timeout period and then starts an undesired spanning tree calculation.
- To save network resources on a stable network.

Procedure

1. Enter system view.
   system-view
2. Set the timeout factor of the device.

stp timer-factor *factor*

The default setting is 3.

Configuring the BPDU transmission rate

About BPDU transmission rate

The maximum number of BPDUs a port can send within each hello time equals the BPDU transmission rate plus the hello timer value.

The higher the BPDU transmission rate, the more BPDUs are sent within each hello time, and the more system resources are used. By setting an appropriate BPDU transmission rate, you can limit the rate at which the port sends BPDUs. Setting an appropriate rate also prevents spanning tree protocols from using excessive network resources when the network topology changes.

Restrictions and guidelines

The BPDU transmission rate depends on the physical status of the port and the network structure. As a best practice, use the default setting.

Procedure

1. Enter system view.

   system-view
2. Enter interface view.

   interface *interface-type interface-number*
3. Configure the BPDU transmission rate of the ports.

   stp transmit-limit *limit*

   The default setting is 10.

Configuring edge ports

About edge port

If a port directly connects to a user terminal rather than another device or a shared LAN segment, this port is regarded as an edge port. When network topology change occurs, an edge port will not cause a temporary loop. Because a device does not determine whether a port is directly connected to a terminal, you must manually configure the port as an edge port. After that, the port can rapidly transit from the blocking state to the forwarding state.

Restrictions and guidelines

- If BPDU guard is disabled on a port configured as an edge port, the port becomes a non-edge port again if it receives a BPDU from another port. To restore the edge port, re-enable it.
- If a port directly connects to a user terminal, configure it as an edge port and enable BPDU guard for it. This enables the port to quickly transit to the forwarding state when ensuring network security.
- On a port, the loop guard feature and the edge port setting are mutually exclusive.

Procedure

1. Enter system view.

   system-view
2. Enter interface view.

   interface *interface-type interface-number*
3. Configure the port as an edge port.

`stp edged-port`

By default, all ports are non-edge ports.

Configuring path costs of ports

About path cost

Path cost is a parameter related to the link speed of a port. On a spanning tree device, a port can have different path costs in different MSTIs. Setting appropriate path costs allows VLAN traffic flows to be forwarded along different physical links, achieving VLAN-based load balancing.

You can have the device automatically calculate the default path cost, or you can configure the path cost for ports.

Specifying a standard for the default path cost calculation

About the standard for the default path cost calculation

You can specify a standard for the device to use in automatic calculation for the default path cost. The device supports the following standards:

- **dot1d-1998**—The device calculates the default path cost for ports based on IEEE 802.1d-1998.
- **dot1t**—The device calculates the default path cost for ports based on IEEE 802.1t.
- **legacy**—The device calculates the default path cost for ports based on a private standard.

Table 7 Mappings between the link speed (100M and below) and the path cost

Link speed	Port type	Path cost		
		IEEE 802.1d-1998	IEEE 802.1t	Private standard
0	N/A	65535	200000000	200000
10 Mbps	Single port	100	2000000	2000
	Aggregate interface containing two Selected ports		1000000	1800
	Aggregate interface containing three Selected ports		666666	1600
	Aggregate interface containing four Selected ports		500000	1400
100 Mbps	Single port	19	200000	200
	Aggregate interface containing two Selected ports		100000	180
	Aggregate interface containing three Selected ports		66666	160
	Aggregate interface containing four Selected ports		50000	140

Table 8 Mappings between the link speed (1000M) and the path cost

Link speed	Port type	Path cost		
		IEEE 802.1d-1998	IEEE 802.1t	Private standard
1000 Mbps	Single port	4	20000	20
	Aggregate interface containing two Selected ports		10000	18
	Aggregate interface containing three Selected ports		6666	16
	Aggregate interface containing four Selected ports		5000	14

Table 9 Mappings between the link speed (10G) and the path cost

Link speed	Port type	Path cost		
		IEEE 802.1d-1998	IEEE 802.1t	Private standard
10 Gbps	Single port	2	2000	2
	Aggregate interface containing two Selected ports		1000	1
	Aggregate interface containing three Selected ports		666	1
	Aggregate interface containing four Selected ports		500	1

Restrictions and guidelines

If you change the standard for the default path cost calculation, you restore the path costs to the default.

When the device calculates the path cost for an aggregate interface, IEEE 802.1t takes into account the number of Selected ports in its aggregation group. However, IEEE 802.1d-1998 does not take into account the number of Selected ports. The calculation formula of IEEE 802.1t is: Path cost = 200,000,000/link speed (in 100 kbps). The link speed is the sum of the link speed values of the Selected ports in the aggregation group.

Procedure

1. Enter system view.

   system-view

2. Specify a standard for the default path costs calculation.

   stp pathcost-standard { **dot1d-1998** | **dot1t** | **legacy** }

   By default, the device uses **legacy** to calculate the default path costs of its ports.

Configuring path costs of ports

Restrictions and guidelines

When the path cost of a port changes, the system recalculates the port role and initiates a state transition.

Procedure

1. Enter system view.
   system-view
2. Enter interface view.
   interface *interface-type interface-number*
3. Configure the path cost of the ports.
   - In STP/RSTP mode:
     stp cost *cost-value*
   - In PVST mode:
     stp vlan *vlan-id-list* **cost** *cost-value*
   - In MSTP mode:
     stp [**instance** *instance-list*] **cost** *cost-value*

   By default, the system automatically calculates the path cost of each port.

Configuring the port priority

About port priority

The priority of a port is a factor that determines whether the port can be elected as the root port of a device. If all other conditions are the same, the port with the highest priority is elected as the root port.

On a spanning tree device, a port can have different priorities and play different roles in different spanning trees. As a result, data of different VLANs can be propagated along different physical paths, implementing per-VLAN load balancing. You can set port priority values based on the actual networking requirements.

Restrictions and guidelines

When the priority of a port changes, the system recalculates the port role and initiates a state transition. Prepare for the network topology change before configuring the port priority.

Procedure

1. Enter system view.
   system-view
2. Enter interface view.
   interface *interface-type interface-number*
3. Configure the port priority.
   - In STP/RSTP mode:
     stp port priority *priority*
   - In PVST mode:
     stp vlan *vlan-id-list* **port priority** *priority*
   - In MSTP mode:
     stp [**instance** *instance-list*] **port priority** *priority*

The default setting is 128 for all ports.

Configuring the port link type

About port link type

A point-to-point link directly connects two devices. If two root ports or designated ports are connected over a point-to-point link, they can rapidly transit to the forwarding state after a proposal-agreement handshake process.

Restrictions and guidelines

- You can configure the link type as point-to-point for a Layer 2 aggregate interface or a port that operates in full duplex mode. As a best practice, use the default setting and let the device automatically detect the port link type.
- In PVST or MSTP mode, the **stp point-to-point force-false** or **stp point-to-point force-true** command configured on a port takes effect on all VLANs or all MSTIs.
- Before you set the link type of a port to point-to-point, make sure the port is connected to a point-to-point link. Otherwise, a temporary loop might occur.

Procedure

1. Enter system view.
   system-view
2. Enter interface view.
   interface *interface-type interface-number*
3. Configure the port link type.
   stp point-to-point { **auto** | **force-false** | **force-true** }
   By default, the link type is **auto** where the port automatically detects the link type.

Configuring the mode a port uses to recognize and send MSTP frames

About MSTP frame format

A port can receive and send MSTP frames in the following formats:

- **dot1s**—802.1s-compliant standard format
- **legacy**—Compatible format

By default, the frame format recognition mode of a port is **auto**. The port automatically distinguishes the two MSTP frame formats, and determines the format of frames that it will send based on the recognized format.

You can configure the MSTP frame format on a port. Then, the port sends only MSTP frames of the configured format to communicate with devices that send frames of the same format.

By default, a port in **auto** mode sends 802.1s MSTP frames. When the port receives an MSTP frame of a legacy format, the port starts to send frames only of the legacy format. This prevents the port from frequently changing the format of sent frames. To configure the port to send 802.1s MSTP frames, shut down and then bring up the port.

Restrictions and guidelines

When the number of existing MSTIs exceeds 48, the port can send only 802.1s MSTP frames.

Procedure

1. Enter system view.
   system-view
2. Enter interface view.
   interface *interface-type interface-number*
3. Configure the mode that the port uses to recognize/send MSTP frames.
   stp compliance { **auto** | **dot1s** | **legacy** }
   The default setting is **auto**.

Enabling outputting port state transition information

About outputting port state transition information

In a large-scale spanning tree network, you can enable devices to output the port state transition information. Then, you can monitor the port states in real time.

Procedure

1. Enter system view.
   system-view
2. Enable outputting port state transition information.
   - In STP/RSTP mode:
     stp port-log instance 0
   - In PVST mode:
     stp port-log vlan *vlan-id-list*
   - In MSTP mode:
     stp port-log { **all** | **instance** *instance-list* }
     The default differs depending on the software version, as shown below:

Hardware platform	Versions	Default setting
S5000V3-EI, S5000V5-EI, S5000E-X, S5000X-EI, WAS6000	All versions	Outputting port state transition information is disabled.
Other switch series	Versions earlier than Release 6350	Outputting port state transition information is disabled.
	Release 6350 and later	• If the device starts up with the initial configuration, outputting port state transition information is disabled. • If the device starts up with the factory defaults, outputting port state transition information is enabled.

For more information about initial configuration and factory defaults, see configuration file management in *Fundamentals Configuration Guide*.

Enabling the spanning tree feature

Restrictions and guidelines

You must enable the spanning tree feature for the device before any other spanning tree related configurations can take effect. In STP, RSTP, or MSTP mode, make sure the spanning tree feature is enabled globally and on the desired ports. In PVST mode, make sure the spanning tree feature is enabled globally, in the desired VLANs, and on the desired ports.

To exclude specific ports from spanning tree calculation and save CPU resources, disable the spanning tree feature for these ports with the **undo stp enable** command. Make sure no loops occur in the network after you disable the spanning tree feature on these ports.

Enabling the spanning tree feature in STP/RSTP/MSTP mode

1. Enter system view.

   system-view

2. Enable the spanning tree feature.

   stp global enable

   For the S5000V3-EI, S5000V5-EI, S5000E-X, S5000X-EI, and WAS6000 switch series, the spanning tree feature is globally disabled by default.

   For other switch series:

   - When the device starts up with initial settings, the spanning tree feature is globally disabled by default.
   - When the device starts up with factory defaults, the spanning tree feature is globally enabled by default.

   For more information about the initial settings and factory defaults, see *Fundamentals Configuration Guide*.

3. Enter interface view.

   interface *interface-type interface-number*

4. Enable the spanning tree feature for the port.

   stp enable

   By default, the spanning tree feature is enabled on all ports.

Enabling the spanning tree feature in PVST mode

1. Enter system view.

   system-view

2. Enable the spanning tree feature.

   stp global enable

   For the S5000V3-EI, S5000V5-EI, S5000E-X, S5000X-EI, and WAS6000 switch series, the spanning tree feature is globally disabled by default.

   For other switch series:

   - When the device starts up with initial settings, the spanning tree feature is globally disabled by default.

- When the device starts up with factory defaults, the spanning tree feature is globally enabled by default.

For more information about the initial settings and factory defaults, see *Fundamentals Configuration Guide*.

3. Enable the spanning tree feature in VLANs.

   stp vlan *vlan-id-list* **enable**

   By default, the spanning tree feature is enabled in VLANs.

4. Enter interface view.

   interface *interface-type interface-number*

5. Enable the spanning tree feature on the port.

   stp enable

   By default, the spanning tree feature is enabled on all ports.

Performing mCheck

About mCheck

The mCheck feature enables user intervention in the port state transition process.

When a port on an MSTP, RSTP, or PVST device connects to an STP device and receives STP BPDUs, the port automatically transits to the STP mode. However, the port cannot automatically transit back to the original mode when the following conditions exist:

- The peer STP device is shut down or removed.
- The port cannot detect the change.

To forcibly transit the port to operate in the original mode, you can perform an mCheck operation.

For example, Device A, Device B, and Device C are connected in sequence. Device A runs STP, Device B does not run any spanning tree protocol, and Device C runs RSTP, PVST, or MSTP. In this case, when Device C receives an STP BPDU transparently transmitted by Device B, the receiving port transits to the STP mode. If you configure Device B to run RSTP, PVST, or MSTP with Device C, you must perform mCheck operations on the ports interconnecting Device B and Device C.

Restrictions and guidelines

The mCheck operation takes effect on devices operating in MSTP, PVST, or RSTP mode.

Performing mCheck globally

1. Enter system view.

   system-view

2. Perform mCheck.

   stp global mcheck

Performing mCheck in interface view

1. Enter system view.

   system-view

2. Enter interface view.

interface *interface-type interface-number*

3. Perform mCheck.

   stp mcheck

Disabling inconsistent PVID protection

About inconsistent PVID protection

In PVST, if two connected ports use different PVIDs, PVST calculation errors might occur. By default, inconsistent PVID protection is enabled to avoid PVST calculation errors. If PVID inconsistency is detected on a port, the system blocks the port.

Restrictions and guidelines

If different PVIDs are required on two connected ports, disable inconsistent PVID protection on the devices that host the ports. To avoid PVST calculation errors, make sure the following requirements are met:

- Make sure the VLANs on one device do not use the same ID as the PVID of its peer port (except the default VLAN) on another device.
- If the local port or its peer is a hybrid port, do not configure the local and peer ports as untagged members of the same VLAN.
- Disable inconsistent PVID protection on both the local device and the peer device.

This feature takes effect only when the device is operating in PVST mode.

Procedure

1. Enter system view.

   system-view

2. Disable the inconsistent PVID protection feature.

   stp ignore-pvid-inconsistency

   By default, the inconsistent PVID protection feature is enabled.

Configuring Digest Snooping

About Digest Snooping

As defined in IEEE 802.1s, connected devices are in the same region only when they have the same MST region-related configurations, including:

- Region name.
- Revision level.
- VLAN-to-instance mappings.

A spanning tree device identifies devices in the same MST region by determining the configuration ID in BPDUs. The configuration ID includes the region name, revision level, and configuration digest. It is 16-byte long and is the result calculated through the HMAC-MD5 algorithm based on VLAN-to-instance mappings.

Because spanning tree implementations vary by vendor, the configuration digests calculated through private keys are different. The devices of different vendors in the same MST region cannot communicate with each other.

To enable communication between an H3C device and a third-party device in the same MST region, enable Digest Snooping on the H3C device port connecting them.

Restrictions and guidelines

CAUTION:

Use caution with global Digest Snooping in the following situations:

- When you modify the VLAN-to-instance mappings.
- When you restore the default MST region configuration.

If the local device has different VLAN-to-instance mappings than its neighboring devices, loops or traffic interruption will occur.

- Before you enable Digest Snooping, make sure associated devices of different vendors are connected and run spanning tree protocols.
- With Digest Snooping enabled, in-the-same-region verification does not require comparison of configuration digest. The VLAN-to-instance mappings must be the same on associated ports.
- To make Digest Snooping take effect, you must enable Digest Snooping both globally and on associated ports. As a best practice, enable Digest Snooping on all associated ports first and then enable it globally. This will make the configuration take effect on all configured ports and reduce impact on the network.
- To prevent loops, do not enable Digest Snooping on MST region edge ports.
- As a best practice, enable Digest Snooping first and then enable the spanning tree feature. To avoid traffic interruption, do not configure Digest Snooping when the network is already working well.

Prerequisites

Before configuring Digest Snooping, you need to make sure your H3C device and the third-party device both run spanning tree protocols properly.

Procedure

1. Enter system view.
   `system-view`
2. Enter interface view.
   `interface` *`interface-type interface-number`*
3. Enable Digest Snooping on the interface.
   `stp config-digest-snooping`
   By default, Digest Snooping is disabled on ports.
4. Return to system view.
   `quit`
5. Enable Digest Snooping globally.
   `stp global config-digest-snooping`
   By default, Digest Snooping is disabled globally.

Configuring No Agreement Check

About No Agreement Check

In RSTP and MSTP, the following types of messages are used for rapid state transition on designated ports:

- **Proposal**—Sent by designated ports to request rapid transition
- **Agreement**—Used to acknowledge rapid transition requests

Both RSTP and MSTP devices can perform rapid transition on a designated port only when the port receives an agreement packet from the downstream device. RSTP and MSTP devices have the following differences:

- For MSTP, the root port of the downstream device sends an agreement packet only after it receives an agreement packet from the upstream device.
- For RSTP, the downstream device sends an agreement packet whether or not an agreement packet from the upstream device is received.

Figure 16 Rapid state transition of an MSTP designated port

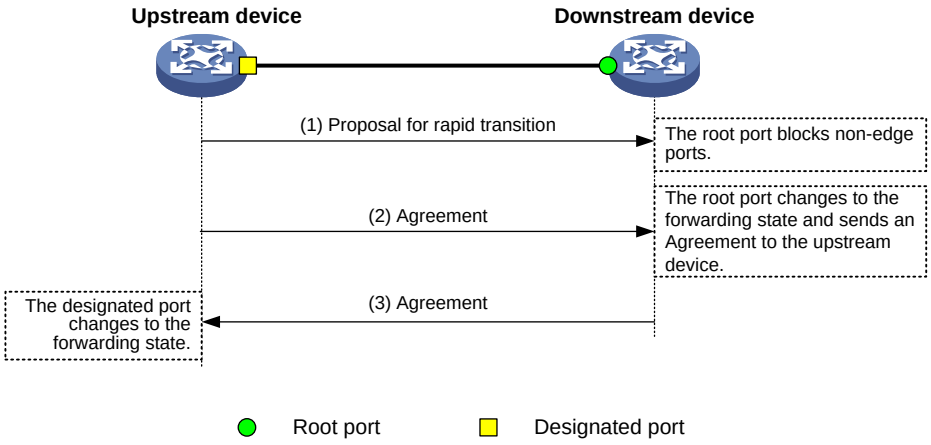
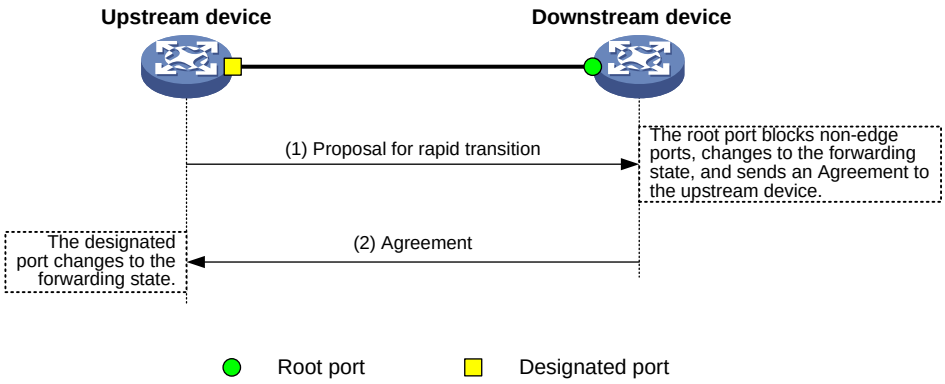


Figure 17 Rapid state transition of an RSTP designated port



If the upstream device is a third-party device, the rapid state transition implementation might be limited as follows:

- The upstream device uses a rapid transition mechanism similar to that of RSTP.
- The downstream device runs MSTP and does not operate in RSTP mode.

In this case, the following occurs:

1. The root port on the downstream device receives no agreement from the upstream device.
2. It sends no agreement to the upstream device.

As a result, the designated port of the upstream device can transit to the forwarding state only after a period twice the forward delay.

To enable the designated port of the upstream device to transit its state rapidly, enable No Agreement Check on the downstream device's port.

Restrictions and guidelines

Configure No Agreement Check on the root port of your device, because this feature takes effect only if it's configured on root ports.

Prerequisites

Before you configure the No Agreement Check feature, complete the following tasks:

- Connect a device to a third-party upstream device that supports spanning tree protocols through a point-to-point link.
- Configure the same region name, revision level, and VLAN-to-instance mappings on the two devices.

Procedure

Enable the No Agreement Check feature on the root port.

1. Enter system view.
   `system-view`
2. Enter interface view.
   `interface` *`interface-type interface-number`*
3. Enable No Agreement Check.
   `stp no-agreement-check`
   By default, No Agreement Check is disabled.

Configuring TC Snooping

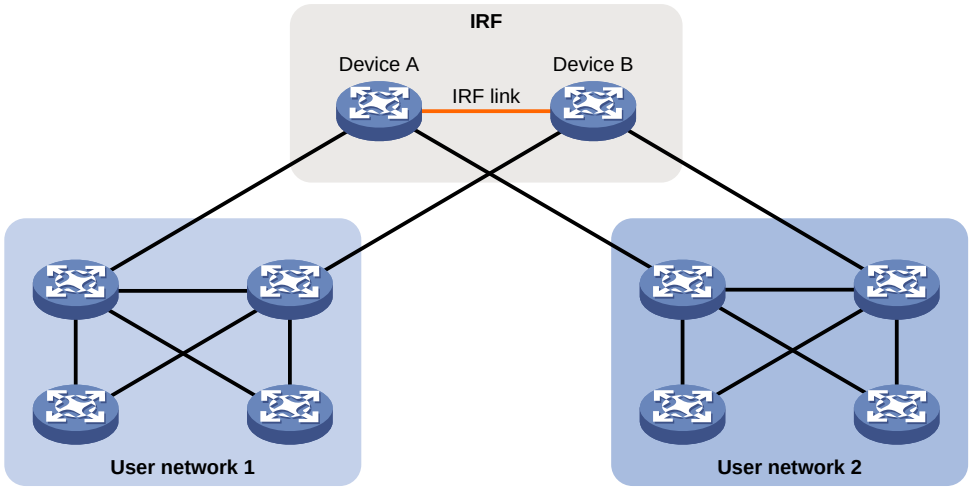
About TC Snooping

As shown in Figure 18, an IRF fabric connects to two user networks through double links.

- Device A and Device B form the IRF fabric.
- The spanning tree feature is disabled on Device A and Device B and enabled on all devices in user network 1 and user network 2.
- The IRF fabric transparently transmits BPDUs for both user networks and is not involved in the calculation of spanning trees.

When the network topology changes, it takes time for the IRF fabric to update its MAC address table and ARP table. During this period, traffic in the network might be interrupted.

Figure 18 TC Snooping application scenario



To avoid traffic interruption, you can enable TC Snooping on the IRF fabric. After receiving a TC-BPDU through a port, the IRF fabric updates MAC address table and ARP table entries associated with the port's VLAN. In this way, TC Snooping prevents topology change from interrupting traffic forwarding in the network. For more information about the MAC address table and the ARP table, see "Configuring the MAC address table" and *Layer 3—IP Services Configuration Guide*.

Restrictions and guidelines

- TC Snooping and the spanning tree feature are mutually exclusive. You must globally disable the spanning tree feature before enabling TC Snooping.
- The priority of BPDU tunneling is higher than that of TC Snooping. When BPDU tunneling is enabled on a port, the TC Snooping feature does not take effect on the port.
- TC Snooping does not support the PVST mode.

Procedure

1. Enter system view.

   `system-view`
2. Globally disable the spanning tree feature.

   `undo stp global enable`

   For the S5000V3-EI, S5000V5-EI, S5000E-X, S5000X-EI, and WAS6000 switch series, the spanning tree feature is globally disabled by default.

   For other switch series:

   - When the device starts up with initial settings, the spanning tree feature is globally disabled by default.
   - When the device starts up with factory defaults, the spanning tree feature is globally enabled by default.

   For more information about the initial settings and factory defaults, see *Fundamentals Configuration Guide*.
3. Enable TC Snooping.

   `stp tc-snooping`

   By default, TC Snooping is disabled.

Configuring protection features

Spanning tree protection tasks at a glance

All spanning tree protection tasks are optional.

- Configuring BPDU guard
- Enabling root guard
- Enabling loop guard
- Configuring port role restriction
- Configuring TC-BPDU transmission restriction
- Enabling TC-BPDU guard
- Enabling BPDU drop
- Enabling PVST BPDU guard
- Disabling dispute guard

Configuring BPDU guard

About BPDU guard

For access layer devices, the access ports can directly connect to the user terminals (such as PCs) or file servers. The access ports are configured as edge ports to allow rapid transition. When these ports receive configuration BPDUs, the system automatically sets the ports as non-edge ports and starts a new spanning tree calculation process. This causes a change of network topology. Under normal conditions, these ports should not receive configuration BPDUs. However, if someone uses configuration BPDUs maliciously to attack the devices, the network will become unstable.

The spanning tree protocol provides the BPDU guard feature to protect the system against such attacks. When ports with BPDU guard enabled receive configuration BPDUs on a device, the device performs the following operations:

- Shuts down these ports.
- Notifies the NMS that these ports have been shut down by the spanning tree protocol.

The device reactivates the ports that have been shut down when the port status detection timer expires. You can set this timer by using the **shutdown-interval** command. For more information about this command, see device management commands in *Fundamentals Command Reference*.

Restrictions and guidelines

You can configure the BPDU guard feature in system view or on a per-port basis. A port preferentially uses the port-specific BPDU guard setting. If the port-specific BPDU guard setting is not available, the port uses the global BPDU guard setting.

The global BPDU guard setting takes effect only on the edge ports configured by using the **stp edged-port** command. For the BPDU guard setting to take effect on non-edge ports, you must configure the feature on a per-port basis. The port-specific BPDU guard setting takes effect on both edge and non-edge ports.

Configure BPDU guard on ports which directly connect to a user terminal rather than other device or shared LAN segment.

BPDU guard does not take effect on loopback-testing-enabled ports. For more information about loopback testing, see Ethernet interface configuration in *Interface Configuration Guide*.

Enabling BPDU guard in system view

1. Enter system view.
   system-view
2. Enable BPDU guard globally.
   stp bpdu-protection
   By default, BPDU guard is globally disabled.

Configuring BPDU guard in interface view

1. Enter system view.
   system-view
2. Enter interface view.
   interface *interface-type interface-number*
3. Configure BPDU guard.
   stp port bpdu-protection { **enable** | **disable** }
   By default, the enabling status of BPDU guard on an interface is the same as that of global BPDU guard, and BPDU guard is not configured for non-edge ports.

Enabling root guard

About root guard

Configure root guard on a designated port.

The root bridge and secondary root bridge of a spanning tree should be located in the same MST region. Especially for the CIST, the root bridge and secondary root bridge are put in a high-bandwidth core region during network design. However, due to possible configuration errors or malicious attacks in the network, the legal root bridge might receive a configuration BPDU with a higher priority. Another device supersedes the current legal root bridge, causing an undesired change of the network topology. The traffic that should go over high-speed links is switched to low-speed links, resulting in network congestion.

To prevent this situation, MSTP provides the root guard feature. If root guard is enabled on a port of a root bridge, this port plays the role of designated port on all MSTIs. After this port receives a configuration BPDU with a higher priority from an MSTI, it performs the following operations:

- Immediately sets that port to the listening state in the MSTI.
- Does not forward the received user data.

This is equivalent to disconnecting the link connected to this port in the MSTI. If the port receives no BPDUs with a higher priority within twice the forwarding delay, it reverts to its original state.

Restrictions and guidelines

On a port, the loop guard feature and the root guard feature are mutually exclusive.

Procedure

1. Enter system view.

   system-view
2. Enter interface view.

   interface *interface-type interface-number*
3. Enable the root guard feature.

   stp root-protection

   By default, root guard is disabled.

Enabling loop guard

About loop guard

Configure loop guard on the root port and alternate ports of a device.

By continuing to receive BPDUs from the upstream device, a device can maintain the state of the root port and blocked ports. However, link congestion or unidirectional link failures might cause these ports to fail to receive BPDUs from the upstream devices. In this situation, the device reselects the following port roles:

- Those ports in forwarding state that failed to receive upstream BPDUs become designated ports.
- The blocked ports transit to the forwarding state.

As a result, loops occur in the switched network. The loop guard feature can suppress the occurrence of such loops.

The initial state of a loop guard-enabled port is **discarding** in every MSTI. When the port receives BPDUs, it transits its state. Otherwise, it stays in the discarding state to prevent temporary loops.

Restrictions and guidelines

Do not enable loop guard on a port that connects user terminals. Otherwise, the port stays in the discarding state in all MSTIs because it cannot receive BPDUs.

On a port, the loop guard feature is mutually exclusive with the root guard feature or the edge port setting.

A loop guard-enabled interface can receive BPDUs and transit from the discarding state to the forwarding state after two forward delays if one of the following events occurs:

- The state of the interface changes from down to up.
- The spanning tree feature is enabled on the up interface.

Procedure

1. Enter system view.
   system-view
2. Enter interface view.
   interface *interface-type interface-number*
3. Enable the loop guard feature.
   stp loop-protection
   By default, loop guard is disabled.

Configuring port role restriction

About port role restriction

Make this configuration on the port that connects to the user access network.

The bridge ID change of a device in the user access network might cause a change to the spanning tree topology in the core network. To avoid this problem, you can enable port role restriction on a port. With this feature enabled, when the port receives a superior BPDU, it becomes an alternate port rather than a root port.

Restrictions and guidelines

Use this feature with caution, because enabling port role restriction on a port might affect the connectivity of the spanning tree topology.

Procedure

1. Enter system view.
   system-view
2. Enter interface view.
   interface *interface-type interface-number*
3. Enable port role restriction.
   stp role-restriction
   By default, port role restriction is disabled.

Configuring TC-BPDU transmission restriction

About TC-BPDU transmission restriction

Make this configuration on the port that connects to the user access network.

The topology change to the user access network might cause the forwarding address changes to the core network. When the user access network topology is unstable, the user access network might affect the core network. To avoid this problem, you can enable TC-BPDU transmission restriction on

a port. With this feature enabled, when the port receives a TC-BPDU, it does not forward the TC-BPDU to other ports.

Restrictions and guidelines

Enabling TC-BPDU transmission restriction on a port might cause the previous forwarding address table to fail to be updated when the topology changes.

Procedure

1. Enter system view.
   system-view
2. Enter interface view.
   interface *interface-type interface-number*
3. Enable TC-BPDU transmission restriction.
   stp tc-restriction
   By default, TC-BPDU transmission restriction is disabled.

Enabling TC-BPDU guard

About TC-BPDU guard

When a device receives topology change (TC) BPDUs (the BPDUs that notify devices of topology changes), it flushes its forwarding address entries. If someone uses TC-BPDUs to attack the device, the device will receive a large number of TC-BPDUs within a short time. Then, the device is busy with forwarding address entry flushing. This affects network stability.

TC-BPDU guard allows you to set the maximum number of immediate forwarding address entry flushes performed within 10 seconds after the device receives the first TC-BPDU. For TC-BPDUs received in excess of the limit, the device performs a forwarding address entry flush when the time period expires. This prevents frequent flushing of forwarding address entries.

Restrictions and guidelines

As a best practice, enable TC-BPDU guard.

Procedure

1. Enter system view.
   system-view
2. Enable the TC-BPDU guard feature.
   stp tc-protection
   By default, TC-BPDU guard is enabled.
3. (Optional.) Configure the maximum number of forwarding address entry flushes that the device can perform every 10 seconds.
   stp tc-protection threshold *number*
   The default setting is 6.

Enabling BPDU drop

About BPDU drop

In a spanning tree network, every BPDU arriving at the device triggers an STP calculation process and is then forwarded to other devices in the network. Malicious attackers might use the vulnerability to attack the network by forging BPDUs. By continuously sending forged BPDUs, they can make all devices in the network continue performing STP calculations. As a result, problems such as CPU overload and BPDU protocol status errors occur.

To avoid this problem, you can enable BPDU drop on ports. A BPDU drop-enabled port does not receive any BPDUs and is invulnerable to forged BPDU attacks.

Restrictions and guidelines

This feature allows the device to drop BPDUs of STP, RSTP, MSTP, PVST, LACP, and LLDP. Make sure you are fully aware of the impact of this feature when you use it on a live network.

Procedure

1. Enter system view.
   system-view
2. Enter Layer 2 Ethernet interface view.
   interface *interface-type interface-number*
3. Enable BPDU drop on the interface.
   bpdu-drop any
   By default, BPDU drop is disabled.

Enabling PVST BPDU guard

About PVST BPDU guard

This feature takes effect only when the device is operating in MSTP mode.

An MSTP-enabled device forwards PVST BPDUs as data traffic because it cannot recognize PVST BPDUs. If a PVST-enabled device in another independent network receives the PVST BPDUs, a PVST calculation error might occur. To avoid PVST calculation errors, enable PVST BPDU guard on the MSTP-enabled device. The device shuts down a port if the port receives PVST BPDUs.

Procedure

1. Enter system view.
   system-view
2. Enable PVST BPDU guard.
   stp pvst-bpdu-protection
   By default, PVST BPDU guard is disabled.

Disabling dispute guard

About dispute guard

Dispute guard can be triggered by unidirectional link failures. If an upstream port receives inferior BPDUs from a downstream designated port in forwarding or learning state because of a unidirectional link failure, a loop appears. Dispute guard blocks the upstream designated port to prevent the loop.

As shown in Figure 19, in normal conditions, the spanning tree calculation result is as follows:

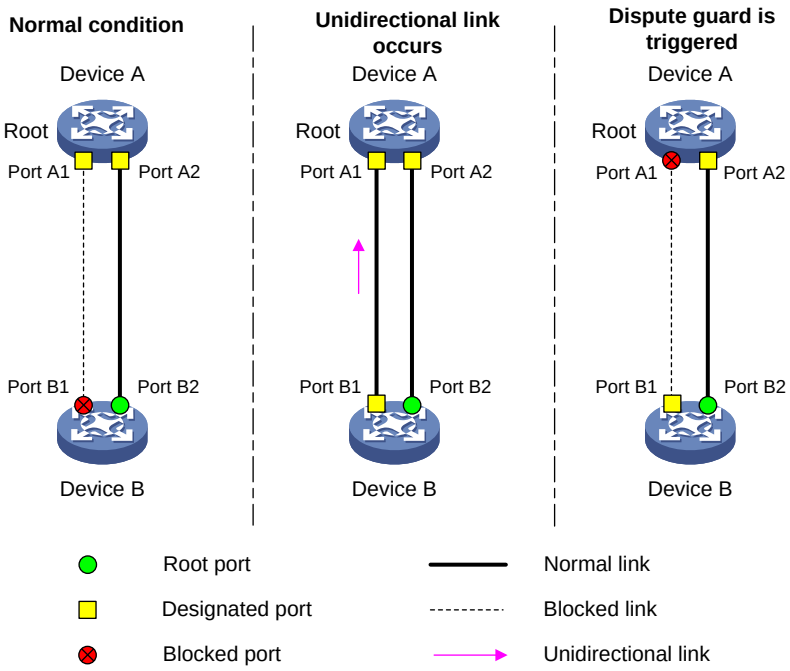
- Device A is the root bridge, and Port A1 is a designated port.
- Port B1 is blocked.

When the link between Port A1 and Port B1 fails in the direction of Port A1 to Port B1 and becomes unidirectional, the following events occur:

1. Port A1 can only receive BPDUs and cannot send BPDUs to Port B1.
2. Port B1 does not receive BPDUs from Port A1 for a certain period of time.
3. Device B determines itself as the root bridge.
4. Port B1 sends its BPDUs to Port A1.

5. Port A1 determines the received BPDUs are inferior to its own BPDUs. A dispute is detected.
6. Dispute guard is triggered and blocks Port A1 to prevent a loop.

Figure 19 Dispute guard triggering scenario

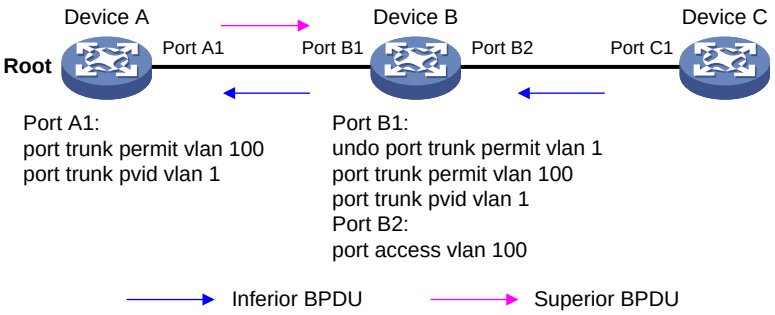


However, dispute guard might disrupt the network connectivity. You can disable dispute guard to avoid connectivity loss in VLAN networks. As shown in Figure 20, the spanning tree feature is disabled on Device B and enabled on Device A and device C. Device B transparently transmits BPDUs.

Device C cannot receive superior BPDUs of VLAN 1 from Device A because Port B1 of Device B is configured to deny packets of VLAN 1. Device C determines itself as the root bridge after a certain period of time. Then, Port C1 sends an inferior BPDU of VLAN 100 to Device A.

When Device A receives the inferior BPDU, dispute guard blocks Port A1, which causes traffic interruption. To ensure service continuity, you can disable dispute guard on Device A to prevent the link from being blocked.

Figure 20 Disabling dispute guard application scenario



Restrictions and guidelines

You can disable dispute guard if the network does not have unidirectional link failures.

Procedure

1. Enter system view.

system-view

2. Disable dispute guard.

   undo stp dispute-protection

   By default, dispute guard is enabled.

Enabling the device to log events of detecting or receiving TC BPDUs

About spanning tree TC BPDU event logging

This feature allows the device to generate logs when it detects or receives TC BPDUs. This feature applies only to PVST mode.

Procedure

1. Enter system view.

   system-view

2. Enable the device to log events of receiving or detecting TC BPDUs.

   stp log enable tc

   By default, the device does not generate logs when it detects or receives TC BPDUs.

Disabling the device from reactivating edge ports shut down by BPDU guard

About disabling the device from reactivating edge ports shut down by BPDU guard

BPDU guard shuts down edge ports that have received configuration BPDUs and notifies the NMS of the shutdown event.

The device reactivates the ports that have been shut down when the port status detection timer expires. You can set this timer by using the **shutdown-interval** command. For more information about this command, see device management commands in *Fundamentals Command Reference*.

Restrictions and guidelines

This feature prevents the device from reactivating edge ports shut down by BPDU guard after this feature is configured. The device does not bring up the shutdown ports if you execute the **undo stp port shutdown permanent** command. To bring up these ports, use the **undo shutdown** command.

Procedure

1. Enter system view.

   system-view

2. Disable the device from reactivating edge ports shut down by BPDU guard.

   stp port shutdown permanent

   By default, the device reactivates an edge port shut down by BPDU guard after the port status detection timer expires.

Enabling SNMP notifications for new-root election and topology change events

About spanning tree SNMP notifications

This task enables the device to generate logs and report new-root election events or spanning tree topology changes to SNMP. For the event notifications to be sent correctly, you must also configure SNMP on the device. For more information about SNMP configuration, see the network management and monitoring configuration guide for the device.

When you use the **snmp-agent trap enable stp** [**new-root** | **tc**] command, follow these guidelines:

- The **new-root** keyword applies only to STP, MSTP, and RSTP modes.
- The **tc** keyword applies only to PVST mode.
- In STP, MSTP, or RSTP mode, the **snmp-agent trap enable stp** command enables SNMP notifications for new-root election events.
- In PVST mode, the **snmp-agent trap enable stp** command enables SNMP notifications for spanning tree topology changes.

Procedure

1. Enter system view.

   system-view
2. Enable SNMP notifications for new-root election and topology change events.

   snmp-agent trap enable stp [**new-root** | **tc**]

   The default settings are as follows:
   - SNMP notifications are disabled for new-root election events.
   - In MSTP mode, SNMP notifications are enabled in MSTI 0 and disabled in other MSTIs for spanning tree topology changes.
   - In PVST mode, SNMP notifications are disabled for spanning tree topology changes in all VLANs.

Display and maintenance commands for the spanning tree protocols

Execute **display** commands in any view and **reset** command in user view.

Task	Command
Display the spanning tree status and statistics.	**display stp** [**instance** *instance-list* | **vlan** *vlan-id-list*] [**interface** *interface-list* | **slot** *slot-number*] [**brief**]
Display the port role calculation history for the specified MSTI or all MSTIs.	**display stp** [**instance** *instance-list* | **vlan** *vlan-id-list*] **history** [**slot** *slot-number*]
Display the incoming and outgoing TC/TCN BPDU statistics by all ports in the specified MSTI or all MSTIs.	**display stp** [**instance** *instance-list* | **vlan** *vlan-id-list*] **tc** [**slot** *slot-number*]

Task	Command
Display history about ports blocked by spanning tree protection features.	**display stp abnormal-port**
Display BPDU statistics on ports.	**display stp bpdu-statistics** [**interface** *interface-type interface-number* [**instance** *instance-list*]]
Display information about ports shut down by spanning tree protection features.	**display stp down-port**
Display the MST region configuration information that has taken effect.	**display stp region-configuration**
Display the root bridge information of all MSTIs.	**display stp root**
Clear the spanning tree statistics.	**reset stp** [**interface** *interface-list*]

Spanning tree configuration examples

Example: Configuring MSTP

Network configuration

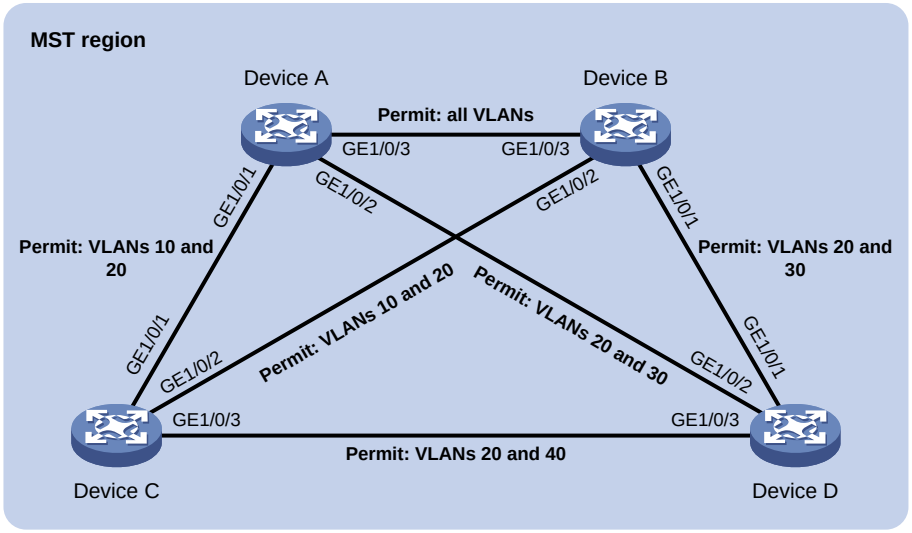
As shown in Figure 21, all devices on the network are in the same MST region. Device A and Device B work at the distribution layer. Device C and Device D work at the access layer.

Configure MSTP so that frames of different VLANs are forwarded along different spanning trees.

- VLAN 10 frames are forwarded along MSTI 1.
- VLAN 30 frames are forwarded along MSTI 3.
- VLAN 40 frames are forwarded along MSTI 4.
- VLAN 20 frames are forwarded along MSTI 0.

VLAN 10 and VLAN 30 are terminated on the distribution layer devices, and VLAN 40 is terminated on the access layer devices. The root bridges of MSTI 1 and MSTI 3 are Device A and Device B, respectively, and the root bridge of MSTI 4 is Device C.

Figure 21 Network diagram



Procedure

1. Configure VLANs and VLAN member ports. (Details not shown.)
   - Create VLAN 10, VLAN 20, and VLAN 30 on both Device A and Device B.
   - Create VLAN 10, VLAN 20, and VLAN 40 on Device C.
   - Create VLAN 20, VLAN 30, and VLAN 40 on Device D.
   - Configure the ports on these devices as trunk ports and assign them to related VLANs.
2. Configure Device A:

   # Enter MST region view, and configure the MST region name as **example**.

   ```
   <DeviceA> system-view
   [DeviceA] stp region-configuration
   [DeviceA-mst-region] region-name example
   ```

   # Map VLAN 10, VLAN 30, and VLAN 40 to MSTI 1, MSTI 3, and MSTI 4, respectively.

   ```
   [DeviceA-mst-region] instance 1 vlan 10
   [DeviceA-mst-region] instance 3 vlan 30
   [DeviceA-mst-region] instance 4 vlan 40
   ```

   # Configure the revision level of the MST region as 0.

   ```
   [DeviceA-mst-region] revision-level 0
   ```

   # Activate MST region configuration.

   ```
   [DeviceA-mst-region] active region-configuration
   [DeviceA-mst-region] quit
   ```

   # Configure the Device A as the root bridge of MSTI 1.

   ```
   [DeviceA] stp instance 1 root primary
   ```

   # Enable the spanning tree feature globally.

   ```
   [DeviceA] stp global enable
   ```

3. Configure Device B:

   # Enter MST region view, and configure the MST region name as **example**.

   ```
   <DeviceB> system-view
   [DeviceB] stp region-configuration
   [DeviceB-mst-region] region-name example
   ```

   # Map VLAN 10, VLAN 30, and VLAN 40 to MSTI 1, MSTI 3, and MSTI 4, respectively.

```
[DeviceB-mst-region] instance 1 vlan 10
[DeviceB-mst-region] instance 3 vlan 30
[DeviceB-mst-region] instance 4 vlan 40
```

Configure the revision level of the MST region as 0.

```
[DeviceB-mst-region] revision-level 0
```

Activate MST region configuration.

```
[DeviceB-mst-region] active region-configuration
[DeviceB-mst-region] quit
```

Configure Device B as the root bridge of MSTI 3.

```
[DeviceB] stp instance 3 root primary
```

Enable the spanning tree feature globally.

```
[DeviceB] stp global enable
```

4. Configure Device C:

Enter MST region view, and configure the MST region name as **example**.

```
<DeviceC> system-view
[DeviceC] stp region-configuration
[DeviceC-mst-region] region-name example
```

Map VLAN 10, VLAN 30, and VLAN 40 to MSTI 1, MSTI 3, and MSTI 4, respectively.

```
[DeviceC-mst-region] instance 1 vlan 10
[DeviceC-mst-region] instance 3 vlan 30
[DeviceC-mst-region] instance 4 vlan 40
```

Configure the revision level of the MST region as 0.

```
[DeviceC-mst-region] revision-level 0
```

Activate MST region configuration.

```
[DeviceC-mst-region] active region-configuration
[DeviceC-mst-region] quit
```

Configure the Device C as the root bridge of MSTI 4.

```
[DeviceC] stp instance 4 root primary
```

Enable the spanning tree feature globally.

```
[DeviceC] stp global enable
```

5. Configure Device D:

Enter MST region view, and configure the MST region name as **example**.

```
<DeviceD> system-view
[DeviceD] stp region-configuration
[DeviceD-mst-region] region-name example
```

Map VLAN 10, VLAN 30, and VLAN 40 to MSTI 1, MSTI 3, and MSTI 4, respectively.

```
[DeviceD-mst-region] instance 1 vlan 10
[DeviceD-mst-region] instance 3 vlan 30
[DeviceD-mst-region] instance 4 vlan 40
```

Configure the revision level of the MST region as 0.

```
[DeviceD-mst-region] revision-level 0
```

Activate MST region configuration.

```
[DeviceD-mst-region] active region-configuration
[DeviceD-mst-region] quit
```

Enable the spanning tree feature globally.

```
[DeviceD] stp global enable
```

Verifying the configuration

In this example, Device B has the lowest root bridge ID. As a result, Device B is elected as the root bridge in MSTI 0.

When the network is stable, you can use the **display stp brief** command to display brief spanning tree information on each device.

Display brief spanning tree information on Device A.

```
[DeviceA] display stp brief
 MST ID      Port                        Role  STP State     Protection
 0           GigabitEthernet1/0/1        ALTE  DISCARDING    NONE
 0           GigabitEthernet1/0/2        DESI  FORWARDING    NONE
 0           GigabitEthernet1/0/3        ROOT  FORWARDING    NONE
 1           GigabitEthernet1/0/1        DESI  FORWARDING    NONE
 1           GigabitEthernet1/0/3        DESI  FORWARDING    NONE
 3           GigabitEthernet1/0/2        DESI  FORWARDING    NONE
 3           GigabitEthernet1/0/3        ROOT  FORWARDING    NONE
```

Display brief spanning tree information on Device B.

```
[DeviceB] display stp brief
 MST ID      Port                        Role  STP State     Protection
 0           GigabitEthernet1/0/1        DESI  FORWARDING    NONE
 0           GigabitEthernet1/0/2        DESI  FORWARDING    NONE
 0           GigabitEthernet1/0/3        DESI  FORWARDING    NONE
 1           GigabitEthernet1/0/2        DESI  FORWARDING    NONE
 1           GigabitEthernet1/0/3        ROOT  FORWARDING    NONE
 3           GigabitEthernet1/0/1        DESI  FORWARDING    NONE
 3           GigabitEthernet1/0/3        DESI  FORWARDING    NONE
```

Display brief spanning tree information on Device C.

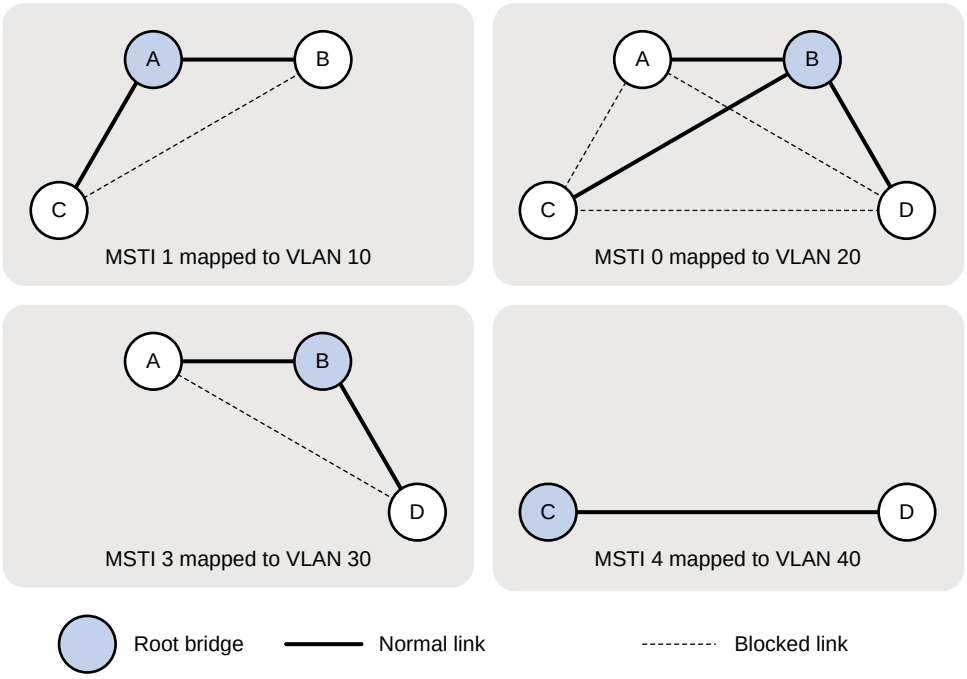
```
[DeviceC] display stp brief
 MST ID      Port                        Role  STP State     Protection
 0           GigabitEthernet1/0/1        DESI  FORWARDING    NONE
 0           GigabitEthernet1/0/2        ROOT  FORWARDING    NONE
 0           GigabitEthernet1/0/3        DESI  FORWARDING    NONE
 1           GigabitEthernet1/0/1        ROOT  FORWARDING    NONE
 1           GigabitEthernet1/0/2        ALTE  DISCARDING    NONE
 4           GigabitEthernet1/0/3        DESI  FORWARDING    NONE
```

Display brief spanning tree information on Device D.

```
[DeviceD] display stp brief
 MST ID      Port                        Role  STP State     Protection
 0           GigabitEthernet1/0/1        ROOT  FORWARDING    NONE
 0           GigabitEthernet1/0/2        ALTE  DISCARDING    NONE
 0           GigabitEthernet1/0/3        ALTE  DISCARDING    NONE
 3           GigabitEthernet1/0/1        ROOT  FORWARDING    NONE
 3           GigabitEthernet1/0/2        ALTE  DISCARDING    NONE
 4           GigabitEthernet1/0/3        ROOT  FORWARDING    NONE
```

Based on the output, you can draw each MSTI mapped to each VLAN, as shown in Figure 22.

Figure 22 MSTIs mapped to different VLANs



Example: Configuring PVST

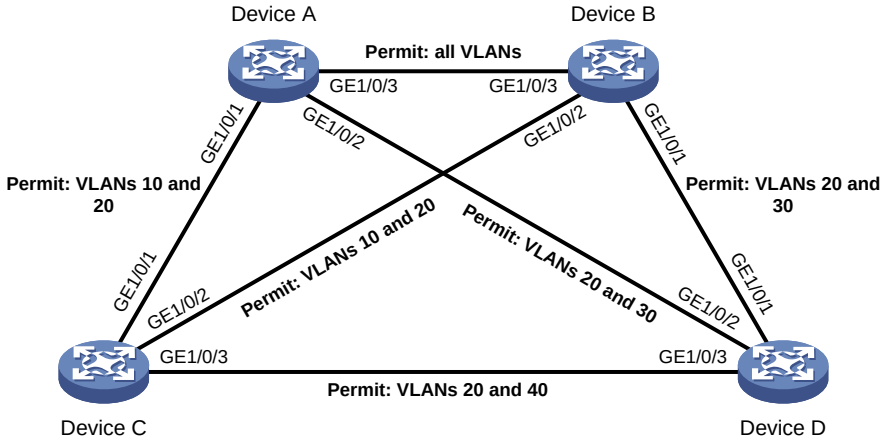
Network configuration

As shown in Figure 23, Device A and Device B work at the distribution layer, and Device C and Device D work at the access layer.

Configure PVST to meet the following requirements:

- Frames of a VLAN are forwarded along the spanning trees of the VLAN.
- VLAN 10, VLAN 20, and VLAN 30 are terminated on the distribution layer devices, and VLAN 40 is terminated on the access layer devices.
- The root bridge of VLAN 10 and VLAN 20 is Device A.
- The root bridge of VLAN 30 is Device B.
- The root bridge of VLAN 40 is Device C.

Figure 23 Network diagram



Procedure

1. Configure VLANs and VLAN member ports. (Details not shown.)
   - Create VLAN 10, VLAN 20, and VLAN 30 on both Device A and Device B.
   - Create VLAN 10, VLAN 20, and VLAN 40 on Device C.
   - Create VLAN 20, VLAN 30, and VLAN 40 on Device D.
   - Configure the ports on these devices as trunk ports and assign them to related VLANs.
2. Configure Device A:

   # Set the spanning tree mode to PVST.

   ```
   <DeviceA> system-view
   [DeviceA] stp mode pvst
   ```

   # Configure the device as the root bridge of VLAN 10 and VLAN 20.

   ```
   [DeviceA] stp vlan 10 20 root primary
   ```

   # Enable the spanning tree feature globally and in VLAN 10, VLAN 20, and VLAN 30.

   ```
   [DeviceA] stp global enable
   [DeviceA] stp vlan 10 20 30 enable
   ```
3. Configure Device B:

   # Set the spanning tree mode to PVST.

   ```
   <DeviceB> system-view
   [DeviceB] stp mode pvst
   ```

   # Configure the device as the root bridge of VLAN 30.

   ```
   [DeviceB] stp vlan 30 root primary
   ```

   # Enable the spanning tree feature globally and in VLAN 10, VLAN 20, and VLAN 30.

   ```
   [DeviceB] stp global enable
   [DeviceB] stp vlan 10 20 30 enable
   ```
4. Configure Device C:

   # Set the spanning tree mode to PVST.

   ```
   <DeviceC> system-view
   [DeviceC] stp mode pvst
   ```

   # Configure the device as the root bridge of VLAN 40.

   ```
   [DeviceC] stp vlan 40 root primary
   ```

   # Enable the spanning tree feature globally and in VLAN 10, VLAN 20, and VLAN 40.

   ```
   [DeviceC] stp global enable
   ```

```
[DeviceC] stp vlan 10 20 40 enable
```

5. Configure Device D:

Set the spanning tree mode to PVST.

```
<DeviceD> system-view
[DeviceD] stp mode pvst
```

Enable the spanning tree feature globally and in VLAN 20, VLAN 30, and VLAN 40.

```
[DeviceD] stp global enable
[DeviceD] stp vlan 20 30 40 enable
```

Verifying the configuration

When the network is stable, you can use the **`display stp brief`** command to display brief spanning tree information on each device.

Display brief spanning tree information on Device A.

```
[DeviceA] display stp brief
 VLAN ID     Port                          Role  STP State     Protection
 10          GigabitEthernet1/0/1          DESI  FORWARDING    NONE
 10          GigabitEthernet1/0/3          DESI  FORWARDING    NONE
 20          GigabitEthernet1/0/1          DESI  FORWARDING    NONE
 20          GigabitEthernet1/0/2          DESI  FORWARDING    NONE
 20          GigabitEthernet1/0/3          DESI  FORWARDING    NONE
 30          GigabitEthernet1/0/2          DESI  FORWARDING    NONE
 30          GigabitEthernet1/0/3          ROOT  FORWARDING    NONE
```

Display brief spanning tree information on Device B.

```
[DeviceB] display stp brief
 VLAN ID     Port                          Role  STP State     Protection
 10          GigabitEthernet1/0/2          DESI  FORWARDING    NONE
 10          GigabitEthernet1/0/3          ROOT  FORWARDING    NONE
 20          GigabitEthernet1/0/1          DESI  FORWARDING    NONE
 20          GigabitEthernet1/0/2          DESI  FORWARDING    NONE
 20          GigabitEthernet1/0/3          ROOT  FORWARDING    NONE
 30          GigabitEthernet1/0/1          DESI  FORWARDING    NONE
 30          GigabitEthernet1/0/3          DESI  FORWARDING    NONE
```

Display brief spanning tree information on Device C.

```
[DeviceC] display stp brief
 VLAN ID     Port                          Role  STP State     Protection
 10          GigabitEthernet1/0/1          ROOT  FORWARDING    NONE
 10          GigabitEthernet1/0/2          ALTE  DISCARDING    NONE
 20          GigabitEthernet1/0/1          ROOT  FORWARDING    NONE
 20          GigabitEthernet1/0/2          ALTE  DISCARDING    NONE
 20          GigabitEthernet1/0/3          DESI  FORWARDING    NONE
 40          GigabitEthernet1/0/3          DESI  FORWARDING    NONE
```

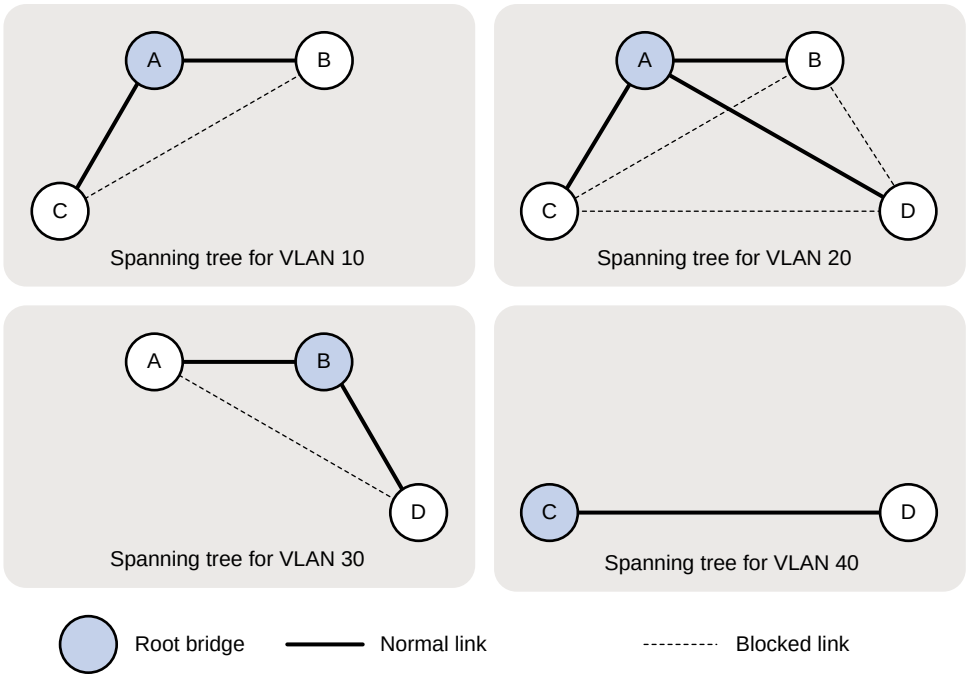
Display brief spanning tree information on Device D.

```
[DeviceD] display stp brief
 VLAN ID     Port                          Role  STP State     Protection
 20          GigabitEthernet1/0/1          ALTE  DISCARDING    NONE
 20          GigabitEthernet1/0/2          ROOT  FORWARDING    NONE
 20          GigabitEthernet1/0/3          ALTE  DISCARDING    NONE
 30          GigabitEthernet1/0/1          ROOT  FORWARDING    NONE
```

```
30          GigabitEthernet1/0/2          ALTE  DISCARDING    NONE
40          GigabitEthernet1/0/3          ROOT  FORWARDING    NONE
```

Based on the output, you can draw a topology for each VLAN spanning tree, as shown in Figure 24.

Figure 24 VLAN spanning tree topologies



Contents

Configuring loop detection

About loop detection

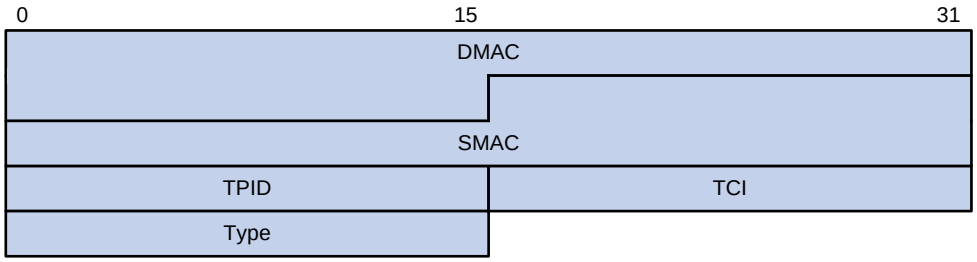
The loop detection mechanism performs periodic checking for Layer 2 loops. The mechanism immediately generates a log when a loop occurs so that you are promptly notified to adjust network connections and configurations. You can configure loop detection to shut down the looped port. Logs are maintained in the information center. For more information, see *Network Management and Monitoring Configuration Guide*.

Loop detection mechanism

The device detects loops by sending detection frames and then checking whether these frames return to any port on the device. If they do, the device considers that the port is on a looped link.

Loop detection usually works within a VLAN. If a detection frame is returned with a different VLAN tag than it was sent out with, an inter-VLAN loop has occurred. To remove the loop, examine the QinQ or VLAN mapping configuration for incorrect settings. For more information about QinQ and VLAN mapping, see "Configuring QinQ" and "Configuring VLAN mapping."

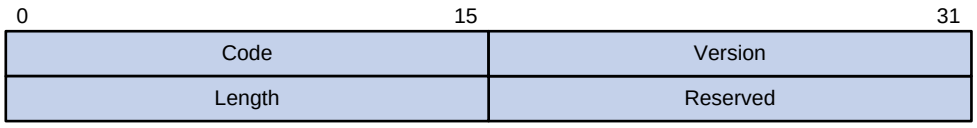
Figure 1 Ethernet frame header for loop detection



The Ethernet frame header of a loop detection packet contains the following fields:

- **DMAC**—Destination MAC address of the frame, which is the multicast MAC address 010f-e200-0007. When a loop detection-enabled device receives a frame with this destination MAC address, it performs the following operations:
  - Sends the frame to the CPU.
  - Floods the frame in the VLAN from which the frame was originally received.
- **SMAC**—Source MAC address of the frame, which is the bridge MAC address of the sending device.
- **TPID**—Type of the VLAN tag, with the value of 0x8100.
- **TCI**—Information of the VLAN tag, including the priority and VLAN ID.
- **Type**—Protocol type, with the value of 0x8918.

Figure 2 Inner frame header for loop detection



The inner frame header of a loop detection packet contains the following fields:

- **Code**—Protocol sub-type, which is 0x0001, indicating the loop detection protocol.

- **Version**—Protocol version, which is always 0x0000.
- **Length**—Length of the frame. The value includes the inner header, but excludes the Ethernet header.
- **Reserved**—This field is reserved.

Frames for loop detection are encapsulated as TLV triplets.

Table 1 TLVs supported by loop detection

TLV	Description	Remarks
End of PDU	End of a PDU.	Optional.
Device ID	Bridge MAC address of the sending device.	Required.
Port ID	ID of the PDU sending port.	Optional.
Port Name	Name of the PDU sending port.	Optional.
System Name	Device name.	Optional.
Chassis ID	Chassis ID of the sending port.	Optional.
Slot ID	Slot ID of the sending port.	Optional.
Sub Slot ID	Sub-slot ID of the sending port.	Optional.

Loop detection interval

Loop detection is a continuous process as the network changes. Loop detection frames are sent at the loop detection interval to determine whether loops occur on ports and whether loops are removed.

Loop protection actions

When the device detects a loop on a port, it generates a log but performs no action on the port by default. You can configure the device to take one of the following actions:

- **Block**—Disables the port from learning MAC addresses and blocks the port.
- **No-learning**—Disables the port from learning MAC addresses.
- **Shutdown**—Shuts down the port to disable it from receiving and sending any frames.

Port status auto recovery

When the device configured with the block or no-learning loop action detects a loop on a port, it performs the action and waits three loop detection intervals. If the device does not receive a loop detection frame within three loop detection intervals, it performs the following operations:

- Automatically sets the port to the forwarding state.
- Notifies the user of the event.

When the device configured with the shutdown action detects a loop on a port, the following events occur:

1. The device automatically shuts down the port.

2. The device automatically sets the port to the forwarding state after the detection timer set by using the **shutdown-interval** command expires. For more information about the **shutdown-interval** command, see *Fundamentals Command Reference*.
3. The device shuts down the port again if a loop is still detected on the port when the detection timer expires.

This process is repeated until the loop is removed.

NOTE:

Incorrect recovery can occur when loop detection frames are discarded to reduce the load. To avoid this, use the shutdown action, or manually remove the loop.

Loop detection tasks at a glance

To configure loop detection, perform the following tasks:

1. Enabling loop detection
   - Enabling loop detection globally
   - Enabling loop detection on a port
2. (Optional) Setting the loop protection action
   - Setting the global loop protection action
   - Setting the loop protection action on an interface
3. (Optional) Setting the loop detection interval
4. (Optional) Enabling LED flashing for loop detection

Enabling loop detection

Restrictions and guidelines for loop detection configuration

You can enable loop detection globally or on a per-port basis. When a port receives a detection frame in any VLAN, the loop protection action is triggered on that port, regardless of whether loop detection is enabled on it.

The loop detection feature is mutually exclusive with Layer 2 loop prevention features, including:

- The spanning tree feature.
- RRPP.
- ERPS.

To avoid unexpected network issues, do not use the loop detection feature and any of those Layer 2 loop prevention features together. For more information about the spanning tree feature, see "Configuring spanning tree protocols." For more information about RRPP and ERPS, see *High Availability Configuration Guide*.

Enabling loop detection globally

1. Enter system view.

   system-view
2. Globally enable loop detection.

   loopback-detection global enable vlan { *vlan-id--list* | **all** }

   By default, loop detection is globally disabled.

Enabling loop detection on a port

1. Enter system view.
   system-view
2. Enter Layer 2 Ethernet interface view or Layer 2 aggregate interface view.
   interface *interface-type interface-number*
3. Enable loop detection on the port.
   loopback-detection enable vlan { *vlan-id--list* | **all** }
   By default, loop detection is disabled on ports.

Setting the loop protection action

Restrictions and guidelines for loop protection action configuration

You can set the loop protection action globally or on a per-port basis. The global action applies to all ports. The per-port action applies to the individual ports. The per-port action takes precedence over the global action.

Setting the global loop protection action

1. Enter system view.
   system-view
2. Set the global loop protection action.
   loopback-detection global action shutdown
   By default, the device generates a log but performs no action on the port on which a loop is detected.

Setting the loop protection action on an interface

1. Enter system view.
   system-view
2. Enter interface view.
   interface *interface-type interface-number*
3. Set the loop protection action on the interface.
   loopback-detection action { **block** | **no-learning** | **shutdown** }
   By default, the device generates a log but performs no action on the port on which a loop is detected.
   Support for the keywords of this command varies by interface type. For more information, see *Layer 2—LAN Switching Command Reference*.

Setting the loop detection interval

About the loop detection interval

With loop detection enabled, the device sends loop detection frames at the loopback detection interval. A shorter interval offers more sensitive detection but consumes more resources. Consider the system performance and loop detection speed when you set the loop detection interval.

Procedure

1. Enter system view.
   system-view
2. Set the loop detection interval.
   loopback-detection interval-time *interval*
   The default setting is 30 seconds.

Enabling LED flashing for loop detection

About this task

If loop detection is enabled globally or on a per-port basis, LED flashing allows port LEDs in Link/Active mode to flash as follows when a loop is detected:

- The LED for a looped port turns to steady green.
- The LEDs for unlooped ports turn to flashing green.

Hardware and feature compatibility

This feature is supported only by the S5000V3-EI, S5000V5-EI, S5000E-X, S5000X-EI, and WAS6000 switch series.

Software version and feature compatibility

This feature is supported only in Release 6328 and later.

Restrictions and guidelines

The device flashes port LEDs for a loop only when LED flashing is enabled on all ports that form the loop on the device. As a best practice, enable LED flashing for loop detection on all physically up Layer 2 interfaces.

Procedure

1. Enter system view.
   system-view
2. Enter Layer 2 Ethernet interface view or Layer 2 aggregate interface view.
   interface *interface-type interface-number*
3. Enable LED flashing for loop detection.
   loopback-detection led-flashing enable
   By default, LED flashing is disabled for loop detection.

Display and maintenance commands for loop detection

Execute **display** commands in any view.

Task	Command
Display the loop detection configuration and status.	**display loopback-detection**

Loop detection configuration examples

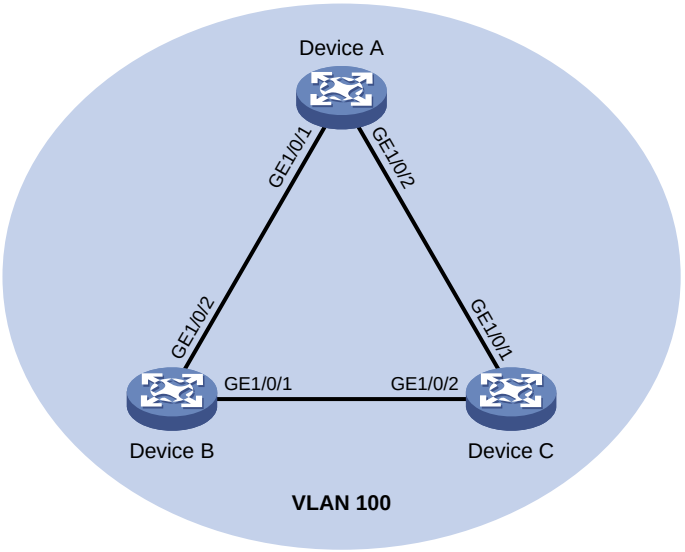
Example: Configuring basic loop detection functions

Network configuration

As shown in Figure 3, configure loop detection on Device A to meet the following requirements:

- Device A generates a log as a notification.
- Device A automatically shuts down the port on which a loop is detected.

Figure 3 Network diagram



Procedure

1. Configure Device A:

   # Create VLAN 100, and globally enable loop detection for the VLAN.

   ```
   <DeviceA> system-view
   [DeviceA] vlan 100
   [DeviceA-vlan100] quit
   [DeviceA] loopback-detection global enable vlan 100
   ```

   # Configure GigabitEthernet 1/0/1 and GigabitEthernet 1/0/2 as trunk ports, and assign them to VLAN 100.

   ```
   [DeviceA] interface GigabitEthernet 1/0/1
   [DeviceA-GigabitEthernet1/0/1] port link-type trunk
   [DeviceA-GigabitEthernet1/0/1] port trunk permit vlan 100
   [DeviceA-GigabitEthernet1/0/1] quit
   [DeviceA] interface gigabitethernet 1/0/2
   [DeviceA-GigabitEthernet1/0/2] port link-type trunk
   [DeviceA-GigabitEthernet1/0/2] port trunk permit vlan 100
   ```

```
[DeviceA-GigabitEthernet1/0/2] quit
```

Set the global loop protection action to shutdown.

```
[DeviceA] loopback-detection global action shutdown
```

Set the loop detection interval to 35 seconds.

```
[DeviceA] loopback-detection interval-time 35
```

2. Configure Device B:

Create VLAN 100.

```
<DeviceB> system-view
[DeviceB] vlan 100
[DeviceB–vlan100] quit
```

Configure GigabitEthernet 1/0/1 and GigabitEthernet 1/0/2 as trunk ports, and assign them to VLAN 100.

```
[DeviceB] interface gigabitethernet 1/0/1
[DeviceB-GigabitEthernet1/0/1] port link-type trunk
[DeviceB-GigabitEthernet1/0/1] port trunk permit vlan 100
[DeviceB-GigabitEthernet1/0/1] quit
[DeviceB] interface gigabitethernet 1/0/2
[DeviceB-GigabitEthernet1/0/2] port link-type trunk
[DeviceB-GigabitEthernet1/0/2] port trunk permit vlan 100
[DeviceB-GigabitEthernet1/0/2] quit
```

3. Configure Device C:

Create VLAN 100.

```
<DeviceC> system-view
[DeviceC] vlan 100
[DeviceC–vlan100] quit
```

Configure GigabitEthernet 1/0/1 and GigabitEthernet 1/0/2 as trunk ports, and assign them to VLAN 100.

```
[DeviceC] interface gigabitethernet 1/0/1
[DeviceC-GigabitEthernet1/0/1] port link-type trunk
[DeviceC-GigabitEthernet1/0/1] port trunk permit vlan 100
[DeviceC-GigabitEthernet1/0/1] quit
[DeviceC] interface gigabitethernet 1/0/2
[DeviceC-GigabitEthernet1/0/2] port link-type trunk
[DeviceC-GigabitEthernet1/0/2] port trunk permit vlan 100
[DeviceC-GigabitEthernet1/0/2] quit
```

Verifying the configuration

View the system logs on devices, for example, Device A.

```
[DeviceA]
%Feb 24 15:04:29:663 2013 DeviceA LPDT/4/LPDT_LOOPED:  A loop was detected on
GigabitEthernet1/0/1.
%Feb 24 15:04:29:664 2013 DeviceA LPDT/4/LPDT_VLAN_LOOPED: A loop was detected on
GigabitEthernet1/0/1 in VLAN 100.
%Feb 24 15:04:29:667 2013 DeviceA LPDT/4/LPDT_LOOPED: A loop was detected on
GigabitEthernet1/0/2.
%Feb 24 15:04:29:668 2013 DeviceA LPDT/4/LPDT_VLAN_LOOPED: A loop was detected on
GigabitEthernet1/0/2 in VLAN 100.
%Feb 24 15:04:44:243 2013 DeviceA LPDT/5/LPDT_VLAN_RECOVERED: A loop was removed on
GigabitEthernet1/0/1 in VLAN 100.
```

```
%Feb 24 15:04:44:243 2013 DeviceA LPDT/5/LPDT_RECOVERED: All loops were removed on
GigabitEthernet1/0/1.
%Feb 24 15:04:44:248 2013 DeviceA LPDT/5/LPDT_VLAN_RECOVERED: A loop was removed on
GigabitEthernet1/0/2 in VLAN 100.
%Feb 24 15:04:44:248 2013 DeviceA LPDT/5/LPDT_RECOVERED: All loops were removed on
GigabitEthernet1/0/2.
```

The output shows the following information:

- Device A detected loops on GigabitEthernet 1/0/1 and GigabitEthernet 1/0/2 within a loop detection interval.
- Loops on GigabitEthernet 1/0/1 and GigabitEthernet 1/0/2 were removed.

Use the **`display loopback-detection`** command to display the loop detection configuration and status on devices, for example, Device A.

```
[DeviceA] display loopback-detection
Loop detection is enabled.
Loop detection interval is 35 second(s).
Loop is detected on following interfaces:
 Interface                     Action mode     VLANs
 GigabitEthernet1/0/1          Shutdown        100
 GigabitEthernet1/0/2          Shutdown        100
```

The output shows that the device has removed the loops from GigabitEthernet 1/0/1 and GigabitEthernet 1/0/2 according to the shutdown action.

Display the status of GigabitEthernet 1/0/1 on devices, for example, Device A.

```
[DeviceA] display interface gigabitethernet 1/0/1
GigabitEthernet1/0/1 current state: DOWN (Loop detection down)
...
```

The output shows that GigabitEthernet 1/0/1 is already shut down by the loop detection module.

Display the status of GigabitEthernet 1/0/2 on devices, for example, Device A.

```
[DeviceA] display interface gigabitethernet 1/0/2
GigabitEthernet1/0/2 current state: DOWN (Loop detection down)
...
```

The output shows that GigabitEthernet 1/0/2 is already shut down by the loop detection module.

Contents

Configuring VLANs

About VLANs

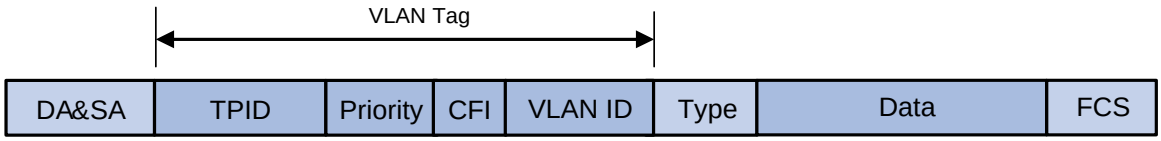
The Virtual Local Area Network (VLAN) technology divides a physical LAN into multiple logical LANs. It has the following benefits:

- **Security**—Hosts in the same VLAN can communicate with one another at Layer 2, but they are isolated from hosts in other VLANs at Layer 2.
- **Broadcast traffic isolation**—Each VLAN is a broadcast domain that limits the transmission of broadcast packets.
- **Flexibility**—A VLAN can be logically divided on a workgroup basis. Hosts in the same workgroup can be assigned to the same VLAN, regardless of their physical locations.

VLAN frame encapsulation

To identify Ethernet frames from different VLANs, IEEE 802.1Q inserts a four-byte VLAN tag between the destination and source MAC address (DA&SA) field and the Type field.

Figure 1 VLAN tag placement and format



A VLAN tag includes the following fields:

- **TPID**—16-bit tag protocol identifier that indicates whether a frame is VLAN-tagged. By default, the hexadecimal TPID value 8100 identifies a VLAN-tagged frame. A device vendor can set the TPID to a different value. For compatibility with a neighbor device, set the TPID value on the device to be the same as the neighbor device. For more information about setting the TPID value, see QinQ commands in *Layer 2—LAN Switching Command Reference*.
- **Priority**—3-bit long, identifies the 802.1p priority of the frame. For more information, see *ACL and QoS Configuration Guide*.
- **CFI**—1-bit long canonical format indicator that indicates whether the MAC addresses are encapsulated in the standard format when packets are transmitted across different media. Available values include:
  - **0 (default)**—The MAC addresses are encapsulated in the standard format.
  - **1**—The MAC addresses are encapsulated in a non-standard format.

  This field is always set to 0 for Ethernet.
- **VLAN ID**—12-bit long, identifies the VLAN to which the frame belongs. The VLAN ID range is 0 to 4095. VLAN IDs 0 and 4095 are reserved, and VLAN IDs 1 to 4094 are user configurable.

The way a network device handles an incoming frame depends on whether the frame has a VLAN tag and the value of the VLAN tag (if any).

Ethernet supports encapsulation formats Ethernet II, 802.3/802.2 LLC, 802.3/802.2 SNAP, and 802.3 raw. The Ethernet II encapsulation format is used here. For information about the VLAN tag fields in other frame encapsulation formats, see related protocols and standards.

For a frame that has multiple VLAN tags, the device handles it according to its outermost VLAN tag and transmits its inner VLAN tags as the payload.

VLAN types

The following VLAN types are available:

- Port-based VLAN.
- MAC-based VLAN.
- IP subnet-based VLAN.
- Protocol-based VLAN.

If all these types of VLANs are configured on a port, the port processes packets in the following descending order of priority by default:

- MAC-based VLAN.
- IP subnet-based VLAN.
- Protocol-based VLAN.
- Port-based VLAN.

Port-based VLANs

Port-based VLANs group VLAN members by port. A port forwards packets from a VLAN only after it is assigned to the VLAN.

Port link type

You can set the link type of a port to access, trunk, or hybrid. The port link type determines whether the port can be assigned to multiple VLANs. The link types use the following VLAN tag handling methods:

- **Access**—An access port can forward packets only from one VLAN and send these packets untagged. An access port is typically used in the following conditions:
  - Connecting to a terminal device that does not support VLAN packets.
  - In scenarios that do not distinguish VLANs.
- **Trunk**—A trunk port can forward packets from multiple VLANs. Except packets from the port VLAN ID (PVID), packets sent out of a trunk port are VLAN-tagged. Ports connecting network devices are typically configured as trunk ports.
- **Hybrid**—A hybrid port can forward packets from multiple VLANs. The tagging status of the packets forwarded by a hybrid port depends on the port configuration. In one-to-two VLAN mapping, hybrid ports are used to remove SVLAN tags for downlink traffic. For more information about one-to-two VLAN mapping, see "Configuring VLAN mapping."

PVID

The PVID identifies the default VLAN of a port. Untagged packets received on a port are considered as the packets from the port PVID.

An access port can join only one VLAN. The VLAN to which the access port belongs is the PVID of the port. A trunk or hybrid port supports multiple VLANs and the PVID configuration.

How ports of different link types handle frames

Actions	Access	Trunk	Hybrid
In the inbound direction for an untagged frame	Tags the frame with the PVID tag.	• If the PVID is permitted on the port, tags the frame with the PVID tag. • If not, drops the frame.	
In the inbound direction for a tagged frame	• Receives the frame if its VLAN ID is the same as	• Receives the frame if its VLAN is permitted on the port. • Drops the frame if its VLAN is not permitted on the port.	

Actions	Access	Trunk	Hybrid
	the PVID. • Drops the frame if its VLAN ID is different from the PVID.		
In the outbound direction	Removes the VLAN tag and sends the frame.	• Removes the tag and sends the frame if the frame carries the PVID tag and the port belongs to the PVID. • Sends the frame without removing the tag if its VLAN is carried on the port but is different from the PVID.	Sends the frame if its VLAN is permitted on the port. The tagging status of the frame depends on the **`port hybrid vlan`** command configuration.

MAC-based VLANs

The MAC-based VLAN feature assigns hosts to a VLAN based on their MAC addresses. This feature is also called user-based VLAN because VLAN configuration remains the same regardless of a user's physical location.

Static MAC-based VLAN assignment

Use static MAC-based VLAN assignment in networks that have a small number of VLAN users. To configure static MAC-based VLAN assignment on a port, perform the following tasks:

1. Create MAC-to-VLAN entries.
2. Enable the MAC-based VLAN feature on the port.
3. Assign the port to the MAC-based VLAN.

A port configured with static MAC-based VLAN assignment processes a received frame as follows before sending the frame out:

- For an untagged frame, the port determines its VLAN ID in the following workflow:
  a. The port first performs an exact match. It searches for MAC-to-VLAN entries whose masks are all Fs. If the source MAC address of the frame exactly matches the MAC address of a MAC-to-VLAN entry, the port tags the frame with the VLAN ID specific to this entry.
  b. If the exact match fails, the port performs a fuzzy as follows:
     – Searches for the MAC-to-VLAN entries whose masks are not all Fs.
     – Performs a logical AND operation on the source MAC address and each of these masks.

       If an AND operation result matches the MAC address in a MAC-to-VLAN entry, the port tags the frame with the VLAN ID specific to this entry.
  c. If no matching VLAN ID is found, the port determines the VLAN for the packet by using the following matching order:
     – IP subnet-based VLAN.
     – Protocol-based VLAN.
     – Port-based VLAN.

     When a match is found, the port tags the packet with the matching VLAN ID.
- For a tagged frame, the port determines whether the VLAN ID of the frame is permitted on the port.

- If the VLAN ID of the frame is permitted on the port, the port forwards the frame.
- If the VLAN ID of the frame is not permitted on the port, the port drops the frame.

Dynamic MAC-based VLAN assignment

When you cannot determine the target MAC-based VLANs of a port, use dynamic MAC-based VLAN assignment on the port. To use dynamic MAC-based VLAN assignment, perform the following tasks:

1. Create MAC-to-VLAN entries.
2. Enable the MAC-based VLAN feature on the port.
3. Enable dynamic MAC-based VLAN assignment on the port.

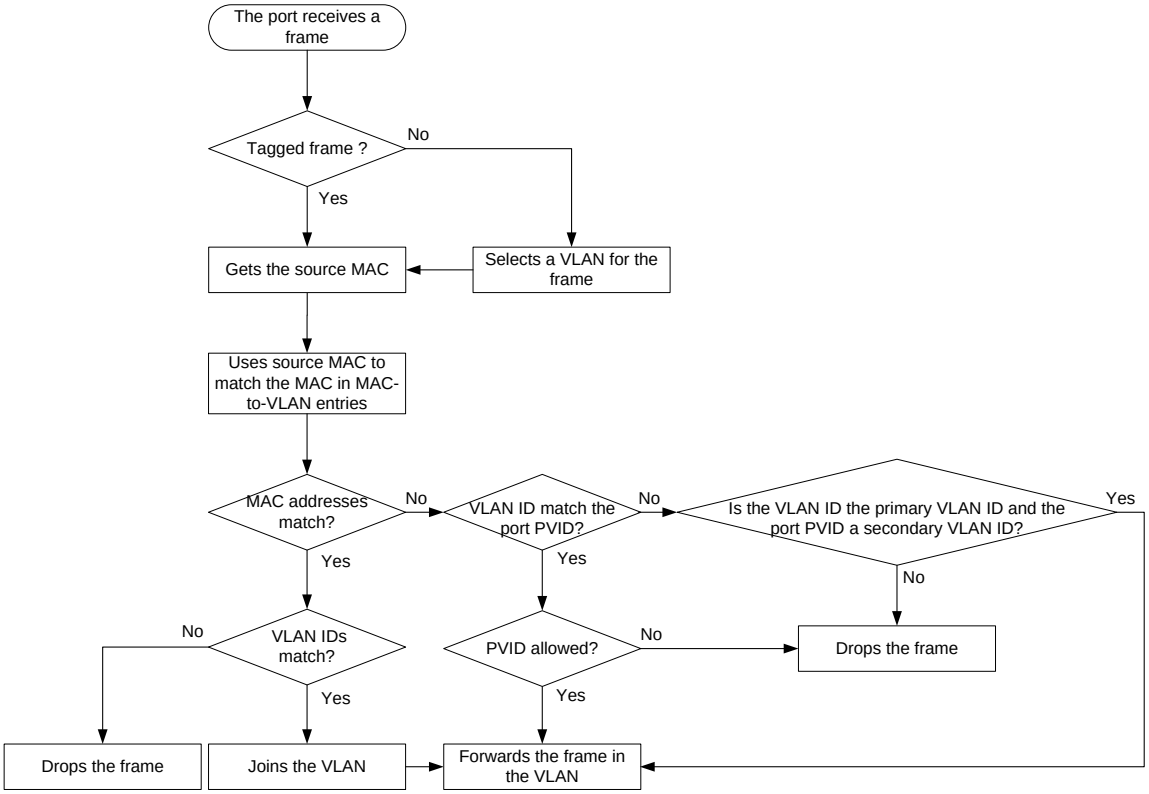
Dynamic MAC-based VLAN assignment uses the following workflow, as shown in Figure 2:

1. When a port receives a frame, it first determines whether the frame is tagged.
   - If the frame is tagged, the port gets the source MAC address of the frame.
   - If the frame is untagged, the port selects a VLAN for the frame by using the following matching order:
     - MAC-based VLAN (fuzzy and exact MAC address match).
     - IP subnet-based VLAN.
     - Protocol-based VLAN.
     - Port-based VLAN.

     After tagging the frame with the selected VLAN, the port gets the source MAC address of the frame.
2. The port uses the source MAC address and VLAN of the frame to match the MAC-to VLAN entries.
   - If the source MAC address of the frame exactly matches the MAC address in a MAC-to-VLAN entry, the port checks whether the VLAN ID of the frame matches the VLAN in the entry.
     - If the two VLAN IDs match, the port joins the VLAN and forwards the frame.
     - If the two VLAN IDs do not match, the port drops the frame.
   - If the source MAC address of the frame does not exactly match any MAC addresses in MAC-to-VLAN entries, the port checks whether the VLAN ID of the frame is its PVID.
     - If the VLAN ID of the frame is the PVID of the port, the port determines whether it allows the PVID.

       If the PVID is allowed, the port forwards the frame within the PVID. If the PVID is not allowed, the port drops the frame.
     - If the VLAN ID of the frame is not the PVID of the port, the port determines whether the VLAN ID is the primary VLAN ID and the port PVID is a secondary VLAN ID. If yes, the port forwards the frame. Otherwise, the port drops the frame.

Figure 2 Flowchart for processing a frame in dynamic MAC-based VLAN assignment



Server-assigned MAC-based VLAN

Use this feature with access authentication, such as MAC-based 802.1X authentication, to implement secure and flexible terminal access.

To implement server-assigned MAC-based VLAN, perform the following tasks:

1. Configure the server-assigned MAC-based VLAN feature on the access device.
2. Configure username-to-VLAN entries on the access authentication server.

When a user passes authentication of the access authentication server, the server assigns the authorization VLAN information for the user to the device. The device then performs the following operations:

1. Generates a MAC-to-VLAN entry by using the source MAC address of the user packet and the authorization VLAN information. The authorization VLAN is a MAC-based VLAN.

   The generated MAC-to-VLAN entry cannot conflict with the existing static MAC-to-VLAN entries. If a confliction exists, the dynamic MAC-to-VLAN entry cannot be generated.
2. Assigns the port that connects the user to the MAC-based VLAN.

When the user goes offline, the device automatically deletes the MAC-to-VLAN entry and removes the port from the MAC-based VLAN. For more information about 802.1X and MAC authentication, see *Security Configuration Guide*.

IP subnet-based VLANs

The IP subnet-based VLAN feature assigns untagged packets to VLANs based on their source IP addresses and subnet masks.

Use this feature when untagged packets from an IP subnet or IP address must be transmitted in a VLAN.

Protocol-based VLANs

The protocol-based VLAN feature assigns inbound packets to different VLANs based on their protocol types and encapsulation formats. The protocols available for VLAN assignment include IP, IPX, and AT. The encapsulation formats include Ethernet II, 802.3 raw, 802.2 LLC, and 802.2 SNAP.

This feature associates the available network service types with VLANs and facilitates network management and maintenance.

Layer 3 communication between VLANs

Hosts of different VLANs use VLAN interfaces to communicate at Layer 3. VLAN interfaces are virtual interfaces that do not exist as physical entities on devices. For each VLAN, you can create one VLAN interface and assign an IP address to it. The VLAN interface acts as the gateway of the VLAN to forward packets destined for another IP subnet at Layer 3.

Protocols and standards

IEEE 802.1Q, *IEEE Standard for Local and Metropolitan Area Networks: Virtual Bridged Local Area Networks*

Configuring a VLAN

Restrictions and guidelines

As the system default VLAN, VLAN 1 cannot be created or deleted.

Before you delete a dynamic VLAN or a VLAN locked by an application, you must first remove the configuration from the VLAN.

Creating VLANs

1. Enter system view.

   system-view

2. Create one or multiple VLANs.
   - Create a VLAN and enter its view.

     vlan *vlan-id*
   - Create multiple VLANs and enter VLAN view.

     Create VLANs.

     vlan { *vlan-id-list* | **all** }

     Enter VLAN view.

     vlan *vlan-id*

   By default, only the system default VLAN (VLAN 1) exists.

3. (Optional.) Set a name for the VLAN.

   name *text*

   By default, the name of a VLAN is **VLAN** *vlan-id.* The *vlan-id* argument specifies the VLAN ID in a four-digit format. If the VLAN ID has fewer than four digits, leading zeros are added. For example, the name of VLAN 100 is **VLAN 0100**.

4. (Optional.) Configure the description for the VLAN.

description *text*

By default, the description of a VLAN is **VLAN** *vlan-id.* The *vlan-id* argument specifies the VLAN ID in a four-digit format. If the VLAN ID has fewer than four digits, leading zeros are added. For example, the default description of VLAN 100 is **VLAN 0100**.

Configuring port-based VLANs

Restrictions and guidelines for port-based VLANs

- When you use the **undo vlan** command to delete the PVID of a port, either of the following events occurs depending on the port link type:
  - For an access port, the PVID of the port changes to VLAN 1.
  - For a hybrid or trunk port, the PVID setting of the port does not change.

  You can use a nonexistent VLAN as the PVID for a hybrid or trunk port, but not for an access port.
- As a best practice, set the same PVID for a local port and its peer.
- To prevent a port from dropping untagged packets or PVID-tagged packets, assign the port to its PVID.

Assigning an access port to a VLAN

About assigning an access port to a VLAN

You can assign an access port to a VLAN in VLAN view or interface view.

Assigning one or multiple access ports to a VLAN in VLAN view

1. Enter system view.
   system-view
2. Enter VLAN view.
   vlan *vlan-id*
3. Assign one or multiple access ports to the VLAN.
   port *interface-list*

   By default, all ports belong to VLAN 1.

Assigning an access port to a VLAN in interface view

1. Enter system view.
   system-view
2. Enter interface view.
   - Enter Layer 2 Ethernet interface view.
     interface *interface-type interface-number*
   - Enter Layer 2 aggregate interface view.
     interface bridge-aggregation *interface-number*
3. Set the port link type to access.
   port link-type access

   By default, all ports are access ports.
4. Assign the access port to a VLAN.
   port access vlan *vlan-id*

By default, all access ports belong to VLAN 1.

Assigning a trunk port to a VLAN

About assigning a trunk port to a VLAN

A trunk port supports multiple VLANs. You can assign it to a VLAN in interface view.

Restrictions and guidelines

To change the link type of a port from trunk to hybrid, set the link type to access first.

To enable a trunk port to transmit packets from its PVID, you must assign the trunk port to the PVID by using the **port trunk permit vlan** command.

Procedure

1. Enter system view.
   system-view
2. Enter interface view.
   - Enter Layer 2 Ethernet interface view.
     interface *interface-type interface-number*
   - Enter Layer 2 aggregate interface view.
     interface bridge-aggregation *interface-number*
3. Set the port link type to trunk.
   port link-type trunk
   By default, all ports are access ports.
4. Assign the trunk port to the specified VLANs.
   port trunk permit vlan { *vlan-id-list* | **all** }
   By default, a trunk port permits only VLAN 1.
5. (Optional.) Set the PVID for the trunk port.
   port trunk pvid vlan *vlan-id*
   The default setting is VLAN 1.

Assigning a hybrid port to a VLAN

About assigning a hybrid port to a VLAN

A hybrid port supports multiple VLANs. You can assign it to the specified VLANs in interface view. Make sure the VLANs have been created.

Restrictions and guidelines

To change the link type of a port from trunk to hybrid, set the link type to access first.

To enable a hybrid port to transmit packets from its PVID, you must assign the hybrid port to the PVID by using the **port hybrid vlan** command.

Procedure

1. Enter system view.
   system-view
2. Enter interface view.
   - Enter Layer 2 Ethernet interface view.
     interface *interface-type interface-number*

- Enter Layer 2 aggregate interface view.
  interface bridge-aggregation *interface-number*

3. Set the port link type to hybrid.
   port link-type hybrid
   By default, all ports are access ports.
4. Assign the hybrid port to the specified VLANs.
   port hybrid vlan *vlan-id-list* { **tagged** | **untagged** }
   By default, the hybrid port is an untagged member of the VLAN to which the port belongs when its link type is **access**.
5. (Optional.) Set the PVID for the hybrid port.
   port hybrid pvid vlan *vlan-id*
   By default, the PVID of a hybrid port is the ID of the VLAN to which the port belongs when its link type is **access**.

Configuring MAC-based VLANs

Restrictions and guidelines for MAC-based VLANs

- MAC-based VLANs are available only on hybrid ports.
- The MAC-based VLAN feature is mainly configured on downlink ports of user access devices. Do not use this feature with link aggregation.

Configuring static MAC-based VLAN assignment

1. Enter system view.
   system-view
2. Create a MAC-to-VLAN entry.
   mac-vlan mac-address *mac-address* [**mask** *mac-mask*] **vlan** *vlan-id* [**dot1p** *priority*]
   By default, no MAC-to-VLAN entries exist.
3. Enter Layer 2 Ethernet interface view.
   interface *interface-type interface-number*
4. Set the port link type to hybrid.
   port link-type hybrid
   By default, all ports are access ports.
5. Assign the hybrid port to the MAC-based VLANs.
   port hybrid vlan *vlan-id-list* { **tagged** | **untagged** }
   By default, a hybrid port is an untagged member of the VLAN to which the port belongs when its link type is **access**.
6. Enable the MAC-based VLAN feature.
   mac-vlan enable
   By default, this feature is disabled.
7. (Optional.) Configure the system to assign VLANs based on the MAC address preferentially.
   vlan precedence mac-vlan

By default, the system assigns VLANs based on the MAC address preferentially when both the MAC-based VLAN and IP subnet-based VLAN are configured on a port.

Configuring dynamic MAC-based VLAN assignment

About dynamic MAC-based VLAN assignment

For successful dynamic MAC-based VLAN assignment, use static VLANs when you create MAC-to-VLAN entries.

When a port joins a VLAN specified in the MAC-to-VLAN entry, one of the following events occurs depending on the port configuration:

- If the port has not been configured to allow packets from the VLAN to pass through, the port joins the VLAN as an untagged member.
- If the port has been configured to allow packets from the VLAN to pass through, the port configuration remains the same.

The 802.1p priority of the VLAN in a MAC-to-VLAN entry determines the transmission priority of the matching packets.

Restrictions and guidelines

- If you configure both static and dynamic MAC-based VLAN assignments on a port, dynamic MAC-based VLAN assignment takes effect.
- As a best practice to ensure correct operation of 802.1X and MAC authentication, do not use dynamic MAC-based VLAN assignment with 802.1X or MAC authentication.
- As a best practice, do not both configure dynamic MAC-based VLAN assignment and disable MAC address learning on a port. If the two features are configured together on a port, the port forwards only packets exactly matching the MAC-to-VLAN entries and drops inexactly matching packets.
- As a best practice, do not configure both dynamic MAC-based VLAN assignment and the MAC learning limit on a port.

  If the two features are configured together on a port and the port learns the configured maximum number of MAC address entries, the port processes packets as follows:
  - Forwards only packets matching the MAC address entries learnt by the port.
  - Drops unmatching packets.
- As a best practice, do not use dynamic MAC-based VLAN assignment with MSTP. In MSTP mode, if a port is blocked in the MSTI of its target VLAN, the port drops the received packets instead of delivering them to the CPU. As a result, the port will not be dynamically assigned to the target VLAN.
- As a best practice, do not use dynamic MAC-based VLAN assignment with PVST. In PVST mode, if the target VLAN of a port is not permitted on the port, the port is placed in blocked state. The port drops the received packets instead of delivering them to the CPU. As a result, the port will not be dynamically assigned to the target VLAN.
- As a best practice, do not configure both dynamic MAC-based VLAN assignment and automatic voice VLAN assignment mode on a port. They can have a negative impact on each other.

Procedure

1. Enter system view.

   system-view
2. Create a MAC-to-VLAN entry.

   mac-vlan mac-address *mac-address* **vlan** *vlan-id* [**dot1p** *priority*]

   By default, no MAC-to-VLAN entries exist.
3. Enter Layer 2 Ethernet interface view.

interface *interface-type interface-number*

4. Set the port link type to hybrid.

   port link-type hybrid

   By default, all ports are access ports.

5. Enable the MAC-based VLAN feature.

   mac-vlan enable

   By default, MAC-based VLAN is disabled.

6. Enable dynamic MAC-based VLAN assignment.

   mac-vlan trigger enable

   By default, dynamic MAC-based VLAN assignment is disabled.

   The VLAN assignment for a port is triggered only when the source MAC address of its receiving packet exactly matches the MAC address in a MAC-to-VLAN entry.

7. (Optional.) Configure the system to assign VLANs based on the MAC address preferentially.

   vlan precedence mac-vlan

   By default, the system assigns VLANs based on the MAC address preferentially when both the MAC-based VLAN and IP subnet-based VLAN are configured on a port.

8. (Optional.) Disable the port from forwarding packets that fail the exact MAC address match in its PVID.

   port pvid forbidden

   By default, when a port receives packets whose source MAC addresses fail the exact match, the port forwards them in its PVID.

Configuring server-assigned MAC-based VLAN

1. Enter system view.

   system-view

2. Enter Layer 2 Ethernet interface view.

   interface *interface-type interface-number*

3. Set the port link type to hybrid.

   port link-type hybrid

   By default, all ports are access ports.

4. Assign the hybrid port to the MAC-based VLANs.

   port hybrid vlan *vlan-id-list* { **tagged** | **untagged** }

   By default, a hybrid port is an untagged member of the VLAN to which the port belongs when its link type is **access**.

5. Enable the MAC-based VLAN feature.

   mac-vlan enable

   By default, MAC-based VLAN is disabled.

6. Configure 802.1X or MAC authentication.

   For more information, see *Security Command Reference*.

Configuring IP subnet-based VLANs

Restrictions and guidelines

This feature is available only on hybrid ports, and it processes only untagged packets.

Procedure

1. Enter system view.
   system-view
2. Enter VLAN view.
   vlan *vlan-id*
3. Associate the VLAN with an IP subnet or IP address.
   ip-subnet-vlan [*ip-subnet-index*] **ip** *ip-address* [*mask*]
   By default, a VLAN is not associated with an IP subnet or IP address.
   A multicast subnet or a multicast address cannot be associated with a VLAN.
4. Return to system view.
   quit
5. Enter interface view.
   - Enter Layer 2 Ethernet interface view.
     interface *interface-type interface-number*
   - Enter Layer 2 aggregate interface view.
     interface bridge-aggregation *interface-number*
6. Set the port link type to hybrid.
   port link-type hybrid
   By default, all ports are access ports.
7. Assign the hybrid port to the specified IP subnet-based VLANs.
   port hybrid vlan *vlan-id-list* { **tagged** | **untagged** }
   By default, a hybrid port is an untagged member of the VLAN to which the port belongs when its link type is **access**.
8. Associate the hybrid port with the specified IP subnet-based VLAN.
   port hybrid ip-subnet-vlan vlan *vlan-id*
   By default, a hybrid port is not associated with a subnet-based VLAN.

Configuring protocol-based VLANs

About protocol-based VLANs

A protocol-based VLAN has one or multiple protocol templates. A protocol template defines a protocol type and an encapsulation format as the match criteria to match inbound packets. Each protocol template has a unique index in the protocol-based VLAN. All protocol templates in a protocol-based VLAN have the same VLAN ID.

For a port to assign inbound packets to protocol-based VLANs, perform the following tasks:

- Assign the port to the protocol-based VLANs.
- Associate the port with the protocol templates of the protocol-based VLANs.

When an untagged packet arrives at the port, the port processes the packet as follows:

- If the protocol type and encapsulation format in the packet match a protocol template, the port tags the packet with the VLAN tag specific to the protocol template.
- If no protocol templates are matched, the port tags the packet with its PVID.

Hardware and feature compatibility

S5110V2-SI, S5000V3-EI, S5000V5-EI, S5000E-X, S5000X-EI, and WAS6000 switches do not support protocol-based VLAN.

Restrictions and guidelines

The voice VLAN in automatic mode processes only tagged voice traffic. Do not configure a VLAN as both a protocol-based VLAN and a voice VLAN.

Procedure

1. Enter system view.
   system-view
2. Enter VLAN view.
   vlan *vlan-id*
3. Associate the VLAN with a protocol template.
   protocol-vlan [*protocol-index*] { **at** | **ipv4** | **ipv6** | **ipx** { **ethernetii** | **llc** | **raw** | **snap** } | **mode** { **ethernetii etype** *etype-id* | **llc** { **dsap** *dsap-id* [**ssap** *ssap-id*] | **ssap** *ssap-id* } | **snap etype** *etype-id* } }
   By default, a VLAN is not associated with a protocol template.
4. Exit VLAN view.
   quit
5. Enter interface view.
   - Enter Layer 2 Ethernet interface view.
     interface *interface-type interface-number*
   - Enter Layer 2 aggregate interface view.
     interface bridge-aggregation *interface-number*
6. Set the port link type to hybrid.
   port link-type hybrid
   By default, all ports are access ports.
7. Assign the hybrid port to the specified protocol-based VLANs.
   port hybrid vlan *vlan-id-list* { **tagged** | **untagged** }
   By default, a hybrid port is an untagged member of the VLAN to which the port belongs when its link type is **access**.
8. Associate the hybrid port with the specified protocol-based VLAN.
   port hybrid protocol-vlan vlan *vlan-id* { *protocol-index* [**to** *protocol-end*] | **all** }
   By default, a hybrid port is not associated with a protocol-based VLAN.

Configuring a VLAN group

About a VLAN group

A VLAN group includes a set of VLANs.

On an authentication server, a VLAN group name represents a group of authorization VLANs. When an 802.1X or MAC authentication user passes authentication, the authentication server assigns a VLAN group name to the device. The device then uses the received VLAN group name to match the locally configured VLAN group names. If a match is found, the device selects a VLAN from the group and assigns the VLAN to the user. For more information about 802.1X and MAC authentication, see *Security Configuration Guide*.

Procedure

1. Enter system view.
   system-view

2. Create a VLAN group and enter its view.
   vlan-group *group-name*
3. Add VLANs to the VLAN group.
   vlan-list *vlan-id-list*
   By default, no VLANs exist in a VLAN group.
   You can add multiple VLAN lists to a VLAN group.

Configuring VLAN interfaces

Restrictions and guidelines

You cannot create VLAN interfaces for secondary VLANs that have the following characteristics:

- Associated with the same primary VLAN.
- Enabled with Layer 3 communication in VLAN interface view of the primary VLAN interface.

For more information about secondary VLANs, see "Configuring private VLAN."

VLAN interfaces configuration tasks at a glance

To configure VLAN interfaces, perform the following tasks:

1. Creating a VLAN interface
2. (Optional.) Restoring the default settings for the VLAN interface

Prerequisites

Before you create a VLAN interface for a VLAN, create the VLAN first.

Creating a VLAN interface

1. Enter system view.
   system-view
2. Create a VLAN interface and enter its view.
   interface vlan-interface *interface-number*
3. Assign an IP address to the VLAN interface.
   ip address *ip-address* { *mask* | *mask-length* } [**sub**]
   By default, no IP address is assigned to a VLAN interface.
4. (Optional.) Configure the description for the VLAN interface.
   description *text*
   The default setting is the VLAN interface name. For example, **Vlan-interface1 Interface**.
5. (Optional.) Set the MTU for the VLAN interface.
   mtu *size*
   By default, the MTU of a VLAN interface is 1500 bytes.
6. (Optional.) Set the expected bandwidth for the interface.
   bandwidth *bandwidth-value*
   By default, the expected bandwidth (in kbps) is the interface baud rate divided by 1000.
7. Bring up the VLAN interface.

undo shutdown

By default, a VLAN interface is not manually shut down. The status of the VLAN interface depends on the status of member ports of the VLAN.

Restoring the default settings for the VLAN interface

Restrictions and guidelines

This feature might fail to restore the default settings for some commands for reasons such as command dependencies or system restrictions. Use the **display this** command in interface view to identify these commands, and then use their **undo** forms or follow the command reference to restore their default settings. If your restoration attempt still fails, follow the error message instructions to resolve the problem.

Procedure

1. Enter system view.
   system-view
2. Enter a VLAN interface view.
   interface vlan-interface *interface-number*
3. Restore the default settings for the VLAN interface.
   default

CAUTION:

This feature might interrupt ongoing network services. Make sure you are fully aware of the impact of this feature when you use it on a live network.

Display and maintenance commands for VLANs

Execute **display** commands in any view and **reset** commands in user view.

Task	Command
Display VLAN interface information.	**display interface** [**vlan-interface** [*interface-number*]] [**brief** [**description** | **down**]]
Display information about IP subnet-based VLANs that are associated with the specified ports.	**display ip-subnet-vlan interface** { *interface-type interface-number1* [**to** *interface-type interface-number2*] | **all** }
Display information about IP subnet-based VLANs.	**display ip-subnet-vlan vlan** { *vlan-id1* [**to** *vlan-id2*] | **all** }
Display MAC-to-VLAN entries.	**display mac-vlan** { **all** | **dynamic** | **mac-address** *mac-address* [**mask** *mac-mask*] | **static** | **vlan** *vlan-id* }
Display all ports that are enabled with the MAC-based VLAN feature.	**display mac-vlan interface**
Display hybrid ports or trunk ports on the device.	**display port** { **hybrid** | **trunk** }
Display information about protocol-based VLANs that are	**display protocol-vlan interface** { *interface-type interface-number1* [**to**

associated with the specified ports.	*interface-type interface-number2*] | **all** }
Display information about protocol-based VLANs.	**display protocol-vlan vlan** { *vlan-id1* [**to** *vlan-id2*] | **all** }
Display VLAN information.	**display vlan** [*vlan-id1* [**to** *vlan-id2*] | **all** | **dynamic** | **reserved** | **static**]
Display brief VLAN information.	**display vlan brief**
Display VLAN group information.	**display vlan-group** [*group-name*]
Clear statistics on a VLAN interface.	**reset counters interface** [**vlan-interface** [*interface-number*]]

VLAN configuration examples

Example: Configuring port-based VLANs

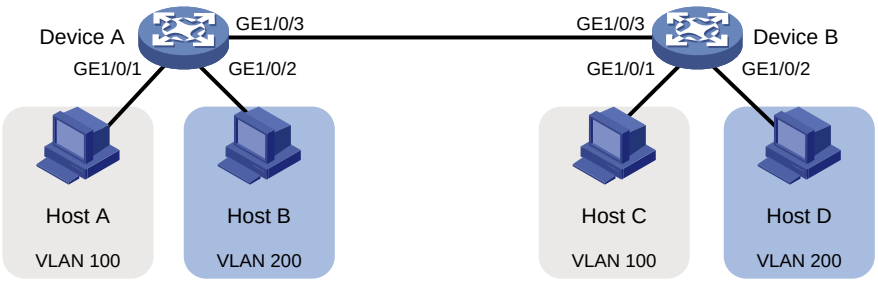
Network configuration

As shown in Figure 3:

- Host A and Host C belong to Department A. VLAN 100 is assigned to Department A.
- Host B and Host D belong to Department B. VLAN 200 is assigned to Department B.

Configure port-based VLANs so that only hosts in the same department can communicate with each other.

Figure 3 Network diagram



Procedure

1. Configure Device A:

   # Create VLAN 100, and assign GigabitEthernet 1/0/1 to VLAN 100.

   ```
   <DeviceA> system-view
   [DeviceA] vlan 100
   [DeviceA-vlan100] port gigabitethernet 1/0/1
   [DeviceA-vlan100] quit
   ```

   # Create VLAN 200, and assign GigabitEthernet 1/0/2 to VLAN 200.

   ```
   [DeviceA] vlan 200
   [DeviceA-vlan200] port gigabitethernet 1/0/2
   [DeviceA-vlan200] quit
   ```

   # Configure GigabitEthernet 1/0/3 as a trunk port, and assign the port to VLANs 100 and 200.

   ```
   [DeviceA] interface gigabitethernet 1/0/3
   [DeviceA-GigabitEthernet1/0/3] port link-type trunk
   ```

```
[DeviceA-GigabitEthernet1/0/3] port trunk permit vlan 100 200
Please wait... Done.
```

2. Configure Device B in the same way Device A is configured. (Details not shown.)
3. Configure hosts:
   a. Configure Host A and Host C to be on the same IP subnet. For example, 192.168.100.0/24.
   b. Configure Host B and Host D to be on the same IP subnet. For example, 192.168.200.0/24.

Verifying the configuration

Verify that Host A and Host C can ping each other, but they both fail to ping Host B and Host D. (Details not shown.)

Verify that Host B and Host D can ping each other, but they both fail to ping Host A and Host C. (Details not shown.)

Verify that VLANs 100 and 200 are correctly configured on Device A.

```
[DeviceA-GigabitEthernet1/0/3] display vlan 100
 VLAN ID: 100
 VLAN type: Static
 Route interface: Not configured
 Description: VLAN 0100
 Name: VLAN 0100
 Tagged ports:
    GigabitEthernet1/0/3
 Untagged ports:
    GigabitEthernet1/0/1
[DeviceA-GigabitEthernet1/0/3] display vlan 200
 VLAN ID: 200
 VLAN type: Static
 Route interface: Not configured
 Description: VLAN 0200
 Name: VLAN 0200
 Tagged ports:
    GigabitEthernet1/0/3
 Untagged ports:
    GigabitEthernet1/0/2
```

Example: Configuring MAC-based VLANs

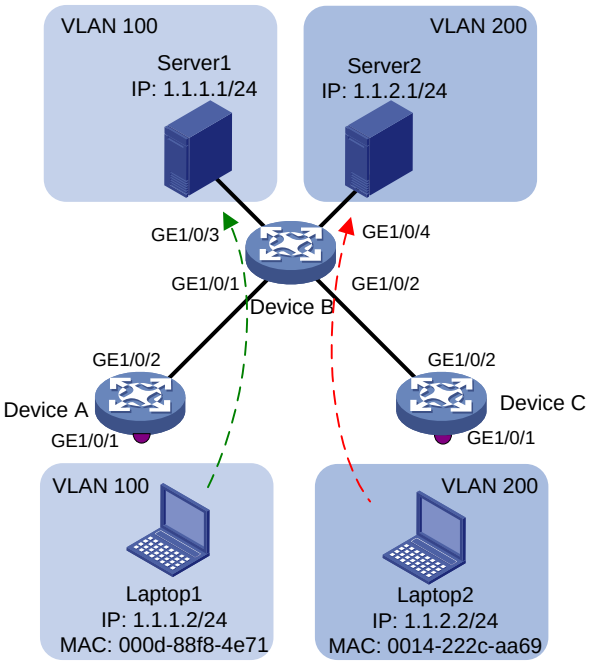
Network configuration

As shown in Figure 4:

- GigabitEthernet 1/0/1 of Device A and Device C are each connected to a meeting room. Laptop 1 and Laptop 2 are used for meetings and might be used in either of the two meeting rooms.
- One department uses VLAN 100 and owns Laptop 1. The other department uses VLAN 200 and owns Laptop 2.

Configure MAC-based VLANs, so that Laptop 1 and Laptop 2 can access Server 1 and Server 2, respectively, no matter which meeting room they are used in.

Figure 4 Network diagram



Procedure

1. Configure Device A:

   # Create VLANs 100 and 200.

   ```
   <DeviceA> system-view
   [DeviceA] vlan 100
   [DeviceA-vlan100] quit
   [DeviceA] vlan 200
   [DeviceA-vlan200] quit
   ```

   # Associate the MAC addresses of Laptop 1 and Laptop 2 with VLANs 100 and 200, respectively.

   ```
   [DeviceA] mac-vlan mac-address 000d-88f8-4e71 vlan 100
   [DeviceA] mac-vlan mac-address 0014-222c-aa69 vlan 200
   ```

   # Configure GigabitEthernet 1/0/1 as a hybrid port, and assign it to VLANs 100 and 200 as an untagged VLAN member.

   ```
   [DeviceA] interface gigabitethernet 1/0/1
   [DeviceA-GigabitEthernet1/0/1] port link-type hybrid
   [DeviceA-GigabitEthernet1/0/1] port hybrid vlan 100 200 untagged
   ```

   # Enable the MAC-based VLAN feature on GigabitEthernet 1/0/1.

   ```
   [DeviceA-GigabitEthernet1/0/1] mac-vlan enable
   [DeviceA-GigabitEthernet1/0/1] quit
   ```

   # Configure the uplink port (GigabitEthernet 1/0/2) as a trunk port, and assign it to VLANs 100 and 200.

   ```
   [DeviceA] interface gigabitethernet 1/0/2
   [DeviceA-GigabitEthernet1/0/2] port link-type trunk
   [DeviceA-GigabitEthernet1/0/2] port trunk permit vlan 100 200
   [DeviceA-GigabitEthernet1/0/2] quit
   ```

2. Configure Device B:

   # Create VLAN 100, and assign GigabitEthernet 1/0/3 to VLAN 100.

```
<DeviceB> system-view
[DeviceB] vlan 100
[DeviceB-vlan100] port gigabitethernet 1/0/3
[DeviceB-vlan100] quit
```

Create VLAN 200 and assign GigabitEthernet 1/0/4 to VLAN 200.

```
[DeviceB] vlan 200
[DeviceB-vlan200] port gigabitethernet 1/0/4
[DeviceB-vlan200] quit
```

Configure GigabitEthernet 1/0/1 as a trunk port, and assign the port to VLANs 100 and 200.

```
[DeviceB] interface gigabitethernet 1/0/1
[DeviceB-GigabitEthernet1/0/1] port link-type trunk
[DeviceB-GigabitEthernet1/0/1] port trunk permit vlan 100 200
[DeviceB-GigabitEthernet1/0/1] quit
```

Configure GigabitEthernet 1/0/2 as a trunk port, and assign the port to VLANs 100 and 200.

```
[DeviceB] interface gigabitethernet 1/0/2
[DeviceB-GigabitEthernet1/0/2] port link-type trunk
[DeviceB-GigabitEthernet1/0/2] port trunk permit vlan 100 200
[DeviceB-GigabitEthernet1/0/2] quit
```

3. Configure Device C in the same way as the Device A is configured. (Details not shown.)

Verifying the configuration

Verify that Laptop 1 can access only Server 1, and Laptop 2 can access only Server 2. (Details not shown.)

Verify the MAC-to-VLAN entries on Device A and Device C, for example, on Device A.

```
[DeviceA] display mac-vlan all
  The following MAC VLAN addresses exist:
  S:Static  D:Dynamic
  MAC address      Mask             VLAN ID   Dot1p      State
  000d-88f8-4e71   ffff-ffff-ffff   100       0          S
  0014-222c-aa69   ffff-ffff-ffff   200       0          S

  Total MAC VLAN address count: 2
```

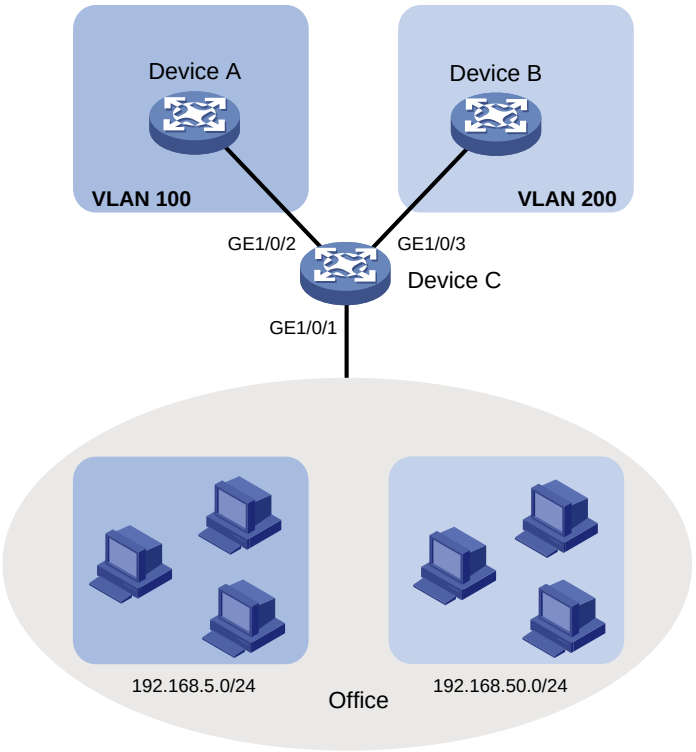
Example: Configuring IP subnet-based VLANs

Network configuration

As shown in Figure 5, the hosts in the office belong to different IP subnets.

Configure Device C to transmit packets from 192.168.5.0/24 and 192.168.50.0/24 in VLANs 100 and 200, respectively.

Figure 5 Network diagram



Procedure

1. Configure Device C:

   # Associate IP subnet 192.168.5.0/24 with VLAN 100.

   ```
   <DeviceC> system-view
   [DeviceC] vlan 100
   [DeviceC-vlan100] ip-subnet-vlan ip 192.168.5.0 255.255.255.0
   [DeviceC-vlan100] quit
   ```

   # Associate IP subnet 192.168.50.0/24 with VLAN 200.

   ```
   [DeviceC] vlan 200
   [DeviceC-vlan200] ip-subnet-vlan ip 192.168.50.0 255.255.255.0
   [DeviceC-vlan200] quit
   ```

   # Configure GigabitEthernet 1/0/2 as a hybrid port, and assign it to VLAN 100 as a tagged VLAN member.

   ```
   [DeviceC] interface gigabitethernet 1/0/2
   [DeviceC-GigabitEthernet1/0/2] port link-type hybrid
   [DeviceC-GigabitEthernet1/0/2] port hybrid vlan 100 tagged
   [DeviceC-GigabitEthernet1/0/2] quit
   ```

   # Configure GigabitEthernet 1/0/3 as a hybrid port, and assign it to VLAN 200 as a tagged VLAN member.

   ```
   [DeviceC] interface gigabitethernet 1/0/3
   [DeviceC-GigabitEthernet1/0/3] port link-type hybrid
   [DeviceC-GigabitEthernet1/0/3] port hybrid vlan 200 tagged
   [DeviceC-GigabitEthernet1/0/3] quit
   ```

   # Configure GigabitEthernet 1/0/1 as a hybrid port, and assign it to VLANs 100 and 200 as an untagged VLAN member.

```
[DeviceC] interface gigabitethernet 1/0/1
[DeviceC-GigabitEthernet1/0/1] port link-type hybrid
[DeviceC-GigabitEthernet1/0/1] port hybrid vlan 100 200 untagged
```

Associate GigabitEthernet 1/0/1 with the IP subnet-based VLANs 100 and 200.

```
[DeviceC-GigabitEthernet1/0/1] port hybrid ip-subnet-vlan vlan 100
[DeviceC-GigabitEthernet1/0/1] port hybrid ip-subnet-vlan vlan 200
[DeviceC-GigabitEthernet1/0/1] quit
```

2. Configure Device A and Device B to forward packets from VLANs 100 and 200, respectively. (Details not shown.)

Verifying the configuration

Verify the IP subnet-based VLAN configuration on Device C.

```
[DeviceC] display ip-subnet-vlan vlan all
 VLAN ID: 100
  Subnet index      IP address      Subnet mask
  0                 192.168.5.0     255.255.255.0

 VLAN ID: 200
  Subnet index      IP address      Subnet mask
  0                 192.168.50.0    255.255.255.0
```

Verify the IP subnet-based VLAN configuration on GigabitEthernet 1/0/1 of Device C.

```
[DeviceC] display ip-subnet-vlan interface gigabitethernet 1/0/1
 Interface: GigabitEthernet1/0/1
  VLAN ID   Subnet index    IP address       Subnet mask       Status
  100       0               192.168.5.0      255.255.255.0     Active
  200       0               192.168.50.0     255.255.255.0     Active
```

Example: Configuring protocol-based VLANs

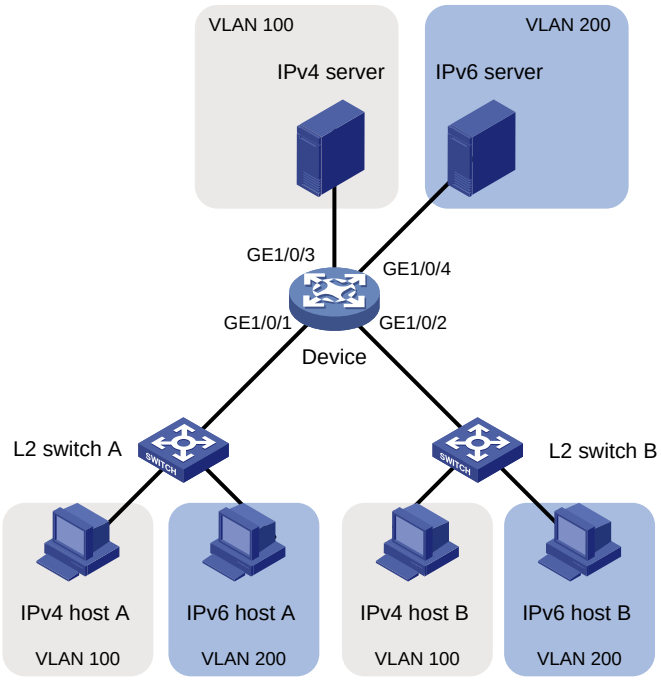
Network configuration

As shown in Figure 6:

- The majority of hosts in a lab environment run the IPv4 protocol.
- The other hosts run the IPv6 protocol for teaching purposes.

To isolate IPv4 and IPv6 traffic at Layer 2, configure protocol-based VLANs to associate the IPv4 and ARP protocols with VLAN 100, and associate the IPv6 protocol with VLAN 200.

Figure 6 Network diagram



Procedure

In this example, L2 Switch A and L2 Switch B use the factory configuration.

1. Configure Device:

   # Create VLAN 100, and configure the description for VLAN 100 as **protocol VLAN for IPv4**.

   ```
   <Device> system-view
   [Device] vlan 100
   [Device-vlan100] description protocol VLAN for IPv4
   ```

   # Assign GigabitEthernet 1/0/3 to VLAN 100.

   ```
   [Device-vlan100] port gigabitethernet 1/0/3
   [Device-vlan100] quit
   ```

   # Create VLAN 200, and configure the description for VLAN 200 as **protocol VLAN for IPv6**.

   ```
   [Device] vlan 200
   [Device-vlan200] description protocol VLAN for IPv6
   ```

   # Assign GigabitEthernet 1/0/4 to VLAN 200.

   ```
   [Device-vlan200] port gigabitethernet 1/0/4
   ```

   # Configure VLAN 200 as a protocol-based VLAN, and create an IPv6 protocol template with the index 1 for VLAN 200.

   ```
   [Device-vlan200] protocol-vlan 1 ipv6
   [Device-vlan200] quit
   ```

   # Configure VLAN 100 as a protocol-based VLAN. Create an IPv4 protocol template with the index 1, and create an ARP protocol template with the index 2. (In Ethernet II encapsulation, the protocol type ID for ARP is 0806 in hexadecimal notation.)

   ```
   [Device] vlan 100
   [Device-vlan100] protocol-vlan 1 ipv4
   [Device-vlan100] protocol-vlan 2 mode ethernetii etype 0806
   [Device-vlan100] quit
   ```

Configure GigabitEthernet 1/0/1 as a hybrid port, and assign it to VLANs 100 and 200 as an untagged VLAN member.

```
[Device] interface gigabitethernet 1/0/1
[Device-GigabitEthernet1/0/1] port link-type hybrid
[Device-GigabitEthernet1/0/1] port hybrid vlan 100 200 untagged
```

Associate GigabitEthernet 1/0/1 with the IPv4 and ARP protocol templates of VLAN 100 and the IPv6 protocol template of VLAN 200.

```
[Device-GigabitEthernet1/0/1] port hybrid protocol-vlan vlan 100 1 to 2
[Device-GigabitEthernet1/0/1] port hybrid protocol-vlan vlan 200 1
[Device-GigabitEthernet1/0/1] quit
```

Configure GigabitEthernet 1/0/2 as a hybrid port, and assign it to VLANs 100 and 200 as an untagged VLAN member.

```
[Device] interface gigabitethernet 1/0/2
[Device-GigabitEthernet1/0/2] port link-type hybrid
[Device-GigabitEthernet1/0/2] port hybrid vlan 100 200 untagged
```

Associate GigabitEthernet 1/0/2 with the IPv4 and ARP protocol templates of VLAN 100 and the IPv6 protocol template of VLAN 200.

```
[Device-GigabitEthernet1/0/2] port hybrid protocol-vlan vlan 100 1 to 2
[Device-GigabitEthernet1/0/2] port hybrid protocol-vlan vlan 200 1
[Device-GigabitEthernet1/0/2] quit
```

2. Configure hosts and servers:
   a. Configure IPv4 Host A, IPv4 Host B, and IPv4 server to be on the same network segment (192.168.100.0/24, for example). (Details not shown.)
   b. Configure IPv6 Host A, IPv6 Host B, and IPv6 server to be on the same network segment (2001::1/64, for example). (Details not shown.)

Verifying the configuration

1. Verify the following:
   - The hosts and the server in VLAN 100 can successfully ping one another. (Details not shown.)
   - The hosts and the server in VLAN 200 can successfully ping one another. (Details not shown.)
   - The hosts or the server in VLAN 100 cannot ping the hosts or server in VLAN 200. (Details not shown.)
2. Verify the protocol-based VLAN configuration:

Display protocol-based VLANs on Device.

```
[Device] display protocol-vlan vlan all
 VLAN ID: 100
  Protocol index  Protocol type
  1               IPv4
  2               Ethernet II Etype 0x0806

 VLAN ID: 200
  Protocol index  Protocol type
  1               IPv6
```

Display protocol-based VLANs on the ports of Device.

```
[Device] display protocol-vlan interface all
 Interface: GigabitEthernet1/0/1
  VLAN ID  Protocol index  Protocol type            Status
```

```
 100      1               IPv4                       Active
 100      2               Ethernet II Etype 0x0806   Active
 200      1               IPv6                       Active

Interface: GigabitEthernet 1/0/2
 VLAN ID  Protocol index  Protocol type              Status
 100      1               IPv4                       Active
 100      2               Ethernet II Etype 0x0806   Active
 200      1               IPv6                       Active
```

Configuring private VLAN

About private VLAN

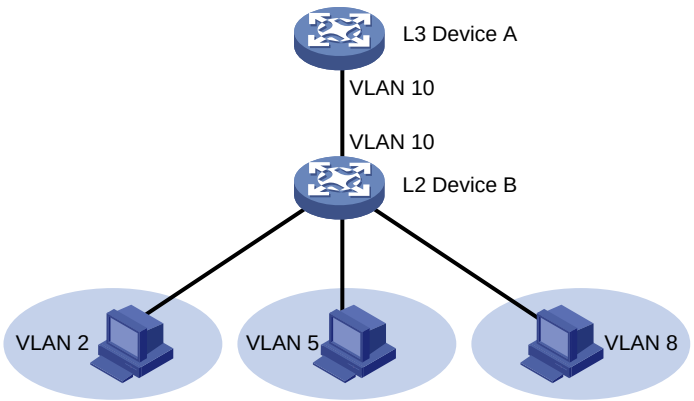
VLAN technology provides a method for isolating traffic from customers. At the access layer of a network, customer traffic must be isolated for security or accounting purposes. If VLANs are assigned on a per-user basis, a large number of VLANs will be required.

The private VLAN feature saves VLAN resources. It uses a two-tier VLAN structure as follows:

- **Primary VLAN**—Used for connecting the upstream device. A primary VLAN can be associated with multiple secondary VLANs. The upstream device identifies only the primary VLAN.
- **Secondary VLANs**—Used for connecting users. Secondary VLANs are isolated at Layer 2. To implement Layer 3 communication between secondary VLANs associated with the primary VLAN, enable local proxy ARP or ND on the upstream device (for example, L3 Device A in Figure 7).

As shown in Figure 7, the private VLAN feature is enabled on L2 Device B. VLAN 10 is the primary VLAN. VLANs 2, 5, and 8 are secondary VLANs that are associated with VLAN 10. L3 Device A is only aware of VLAN 10.

Figure 7 Private VLAN example



If the private VLAN feature is configured on a Layer 3 device, use one of the following methods on the Layer 3 device to enable Layer 3 communication. Layer 3 communication might be required between secondary VLANs that are associated with the same primary VLAN, or between secondary VLANs and other networks.

- Method 1:
  - **a.** Create VLAN interfaces for the secondary VLANs.
  - **b.** Assign IP addresses to the secondary VLAN interfaces.
- Method 2:
  - **a.** Enable Layer 3 communication between the secondary VLANs that are associated with the primary VLAN.
  - **b.** Create the VLAN interface for the primary VLAN and assign an IP address to it. (Do not create secondary VLAN interfaces if you use this method.)
  - **c.** Enable local proxy ARP or ND on the primary VLAN interface.

Restrictions: Hardware compatibility with private VLAN

S5110V2-SI, S5000V3-EI, S5000V5-EI, S5000E-X, S5000X-EI, and WAS6000 switches do not support private VLAN.

Restrictions and guidelines: Private VLAN configuration

- Make sure the following requirements are met:
  - For a promiscuous port:
    - The primary VLAN is the PVID of the port.
    - The port is an untagged member of the primary VLAN and secondary VLANs.
  - For a host port:
    - The PVID of the port is a secondary VLAN.
    - The port is an untagged member of the primary VLAN and the secondary VLAN.
  - A trunk promiscuous or trunk secondary port must be a tagged member of the primary VLANs and the secondary VLANs.
- VLAN 1 (system default VLAN) does not support the private VLAN configuration.

Private VLAN tasks at a glance

To configure a private VLAN, perform the following tasks:

1. Creating a primary VLAN
2. Creating secondary VLANs
3. Associating the primary VLAN with secondary VLANs
4. Configuring the uplink port
5. Configuring a downlink port
6. (Optional.) Configuring Layer 3 communication for secondary VLANs

Creating a primary VLAN

1. Enter system view.
   system-view
2. Create a VLAN and enter VLAN view.
   vlan *vlan-id*
3. Configure the VLAN as a primary VLAN.
   private-vlan primary
   By default, a VLAN is not a primary VLAN.

Creating secondary VLANs

1. Enter system view.

system-view

2. Create one or multiple secondary VLANs.
   vlan { *vlan-id-list* | **all** }

Associating the primary VLAN with secondary VLANs

1. Enter system view.
   system-view
2. Create enter VLAN view of the primary VLAN.
   vlan *vlan-id*
3. Associate the primary VLAN with the secondary VLANs.
   private-vlan secondary *vlan-id-list*
   By default, a primary VLAN is not associated with any secondary VLANs.

Configuring the uplink port

About the uplink port

Configure the uplink port (for example, the port connecting L2 Device B to L3 Device A in Figure 7) as follows:

- If the port allows only one primary VLAN, configure the port as a promiscuous port of the primary VLAN. The promiscuous port can be automatically assigned to the primary VLAN and its associated secondary VLANs.
- If the port allows multiple primary VLANs, configure the port as a trunk promiscuous port of the primary VLANs. The trunk promiscuous port can be automatically assigned to the primary VLANs and their associated secondary VLANs.

Procedure

1. Enter system view.
   system-view
2. Enter interface view of the uplink port.
   interface *interface-type interface-number*
3. Configure the uplink port as a promiscuous or trunk promiscuous port of the specified VLANs.
   - Configure the uplink port as a promiscuous port of the specified VLAN.
     port private-vlan *vlan-id* **promiscuous**
   - Configure the uplink port as a trunk promiscuous port of the specified VLANs.
     port private-vlan *vlan-id-list* **trunk promiscuous**

   By default, a port is not a promiscuous or trunk promiscuous port of any VLANs.

Configuring a downlink port

About the downlink port

Configure a downlink port as follows:

- If a downlink port allows only one secondary VLAN (for example, the port connecting L2 Device B to a host in Figure 7), configure the port as a host port. The host port can be automatically assigned to the secondary VLAN and its associated primary VLAN.
- If a downlink port allows multiple secondary VLANs, configure the port as a trunk secondary port. The trunk secondary port can be automatically assigned to the secondary VLANs and their associated primary VLANs.

Procedure

1. Enter system view.
   system-view
2. Enter interface view of the downlink port.
   interface *interface-type interface-number*
3. Assign the downlink port to secondary VLANs.
   a. Set the link type of the port.
      port link-type { **access** | **hybrid | trunk** }
   b. Assign the access port to the specified VLAN.
      port access vlan *vlan-id*
   c. Assign the trunk port to the specified VLANs.
      port trunk permit vlan { *vlan-id-list* | **all** }
   d. Assign the hybrid port to the specified VLANs.
      port hybrid vlan *vlan-id-list* { **tagged** | **untagged** }

   Select substep b, c, or d depending on the port link type.
4. Configure the downlink port as a host or trunk secondary port.
   - Configure the downlink port as a host port.
     port private-vlan host
   - Configure the downlink port as a trunk secondary port of the specified VLANs.
     port private-vlan *vlan-id-list* **trunk secondary**

   By default, a port is not a host or trunk secondary port.
5. Return to system view.
   quit
6. Enter VLAN view of a secondary VLAN.
   vlan *vlan-id*
7. (Optional.) Enable Layer 2 communication for ports in the same secondary VLAN. Choose one command as needed:
   undo private-vlan isolated
   private-vlan community

   By default, ports in the same secondary VLAN can communicate with each other at Layer 2.

Configuring Layer 3 communication for secondary VLANs

1. Enter system view.
   system-view
2. Enter VLAN interface view of the primary VLAN interface.
   interface vlan-interface *interface-number*

3. Enable Layer 3 communication between secondary VLANs that are associated with the primary VLAN.

   private-vlan secondary *vlan-id-list*

   By default, secondary VLANs cannot communicate with each other at Layer 3.
4. Assign an IP address to the primary VLAN interface.

   IPv4:

   ip address *ip-address* { *mask-length* | *mask* } [**sub**]

   IPv6:

   ipv6 address { *ipv6-address prefix-length* | *ipv6-address*/*prefix-length* }

   By default, no IP address is configured for a VLAN interface.
5. Enable local proxy ARP or ND.

   IPv4:

   local-proxy-arp enable

   By default, local proxy ARP is disabled.

   For more information about local proxy ARP, see *Layer 3—IP Services Configuration Guide*.

   IPv6:

   local-proxy-nd enable

   By default, local proxy ND is disabled.

   For more information about local proxy ND, see *Layer 3—IP Services Configuration Guide*.

Display and maintenance commands for the private VLAN

Execute **display** commands in any view.

Task	Command
Display information about primary VLANs and the secondary VLANs associated with each primary VLAN.	**display private-vlan** [*primary-vlan-id*]

Private VLAN configuration examples

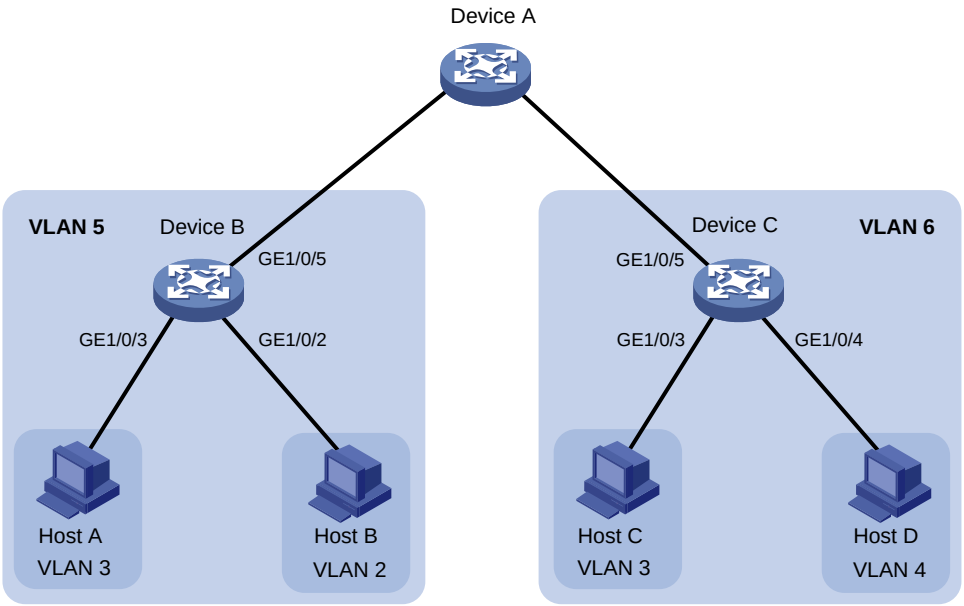
Example: Configuring promiscuous ports

Network configuration

As shown in Figure 8, configure the private VLAN feature to meet the following requirements:

- On Device B, VLAN 5 is a primary VLAN that is associated with secondary VLANs 2 and 3. GigabitEthernet 1/0/5 is in VLAN 5. GigabitEthernet 1/0/2 is in VLAN 2. GigabitEthernet 1/0/3 is in VLAN 3.
- On Device C, VLAN 6 is a primary VLAN that is associated with secondary VLANs 3 and 4. GigabitEthernet 1/0/5 is in VLAN 6. GigabitEthernet 1/0/3 is in VLAN 3. GigabitEthernet 1/0/4 is in VLAN 4.
- Device A is aware of only VLAN 5 on Device B and VLAN 6 on Device C.

Figure 8 Network diagram



Procedure

This example describes the configurations on Device B and Device C.

1. Configure Device B:

Configure VLAN 5 as a primary VLAN.

```
<DeviceB> system-view
[DeviceB] vlan 5
[DeviceB-vlan5] private-vlan primary
[DeviceB-vlan5] quit
```

Create VLANs 2 and 3.

```
[DeviceB] vlan 2 to 3
```

Associate secondary VLANs 2 and 3 with primary VLAN 5.

```
[DeviceB] vlan 5
[DeviceB-vlan5] private-vlan secondary 2 to 3
[DeviceB-vlan5] quit
```

Configure the uplink port (GigabitEthernet 1/0/5) as a promiscuous port of VLAN 5.

```
[DeviceB] interface gigabitethernet 1/0/5
[DeviceB-GigabitEthernet1/0/5] port private-vlan 5 promiscuous
[DeviceB-GigabitEthernet1/0/5] quit
```

Assign downlink port GigabitEthernet 1/0/2 to VLAN 2, and configure the port as a host port.

```
[DeviceB] interface gigabitethernet 1/0/2
[DeviceB-GigabitEthernet1/0/2] port access vlan 2
[DeviceB-GigabitEthernet1/0/2] port private-vlan host
[DeviceB-GigabitEthernet1/0/2] quit
```

Assign downlink port GigabitEthernet 1/0/3 to VLAN 3, and configure the port as a host port.

```
[DeviceB] interface gigabitethernet 1/0/3
[DeviceB-GigabitEthernet1/0/3] port access vlan 3
[DeviceB-GigabitEthernet1/0/3] port private-vlan host
[DeviceB-GigabitEthernet1/0/3] quit
```

2. Configure Device C:

Configure VLAN 6 as a primary VLAN.

```
<DeviceC> system-view
[DeviceC] vlan 6
[DeviceC–vlan6] private-vlan primary
[DeviceC–vlan6] quit
```

Create VLANs 3 and 4.

```
[DeviceC] vlan 3 to 4
```

Associate secondary VLANs 3 and 4 with primary VLAN 6.

```
[DeviceC] vlan 6
[DeviceC-vlan6] private-vlan secondary 3 to 4
[DeviceC-vlan6] quit
```

Configure the uplink port (GigabitEthernet 1/0/5) as a promiscuous port of VLAN 6.

```
[DeviceC] interface gigabitethernet 1/0/5
[DeviceC-GigabitEthernet1/0/5] port private-vlan 6 promiscuous
[DeviceC-GigabitEthernet1/0/5] quit
```

Assign downlink port GigabitEthernet 1/0/3 to VLAN 3, and configure the port as a host port.

```
[DeviceC] interface gigabitethernet 1/0/3
[DeviceC-GigabitEthernet1/0/3] port access vlan 3
[DeviceC-GigabitEthernet1/0/3] port private-vlan host
[DeviceC-GigabitEthernet1/0/3] quit
```

Assign downlink port GigabitEthernet 1/0/4 to VLAN 4, and configure the port as a host port.

```
[DeviceC] interface gigabitethernet 1/0/4
[DeviceC-GigabitEthernet1/0/4] port access vlan 4
[DeviceC-GigabitEthernet1/0/4] port private-vlan host
[DeviceC-GigabitEthernet1/0/4] quit
```

Verifying the configuration

Verify the private VLAN configurations on the devices, for example, on Device B.

```
[DeviceB] display private-vlan
 Primary VLAN ID: 5
 Secondary VLAN ID: 2-3

 VLAN ID: 5
 VLAN type: Static
 Private VLAN type: Primary
 Route interface: Not configured
 Description: VLAN 0005
 Name: VLAN 0005
 Tagged ports:   None
 Untagged ports:
    GigabitEthernet1/0/2
    GigabitEthernet1/0/3
    GigabitEthernet1/0/5

 VLAN ID: 2
 VLAN type: Static
 Private VLAN type: Secondary
```

```
Route interface: Not configured
Description: VLAN 0002
Name: VLAN 0002
Tagged ports:   None
Untagged ports:
   GigabitEthernet1/0/2
   GigabitEthernet1/0/5

VLAN ID: 3
VLAN type: Static
Private VLAN type: Secondary
Route interface: Not configured
Description: VLAN 0003
Name: VLAN 0003
Tagged Ports:   None
Untagged Ports:
   GigabitEthernet1/0/3
   GigabitEthernet1/0/5
```

The output shows that:

- The promiscuous port (GigabitEthernet 1/0/5) is an untagged member of primary VLAN 5 and secondary VLANs 2 and 3.
- Host port GigabitEthernet 1/0/2 is an untagged member of primary VLAN 5 and secondary VLAN 2.
- Host port GigabitEthernet 1/0/3 is an untagged member of primary VLAN 5 and secondary VLAN 3.

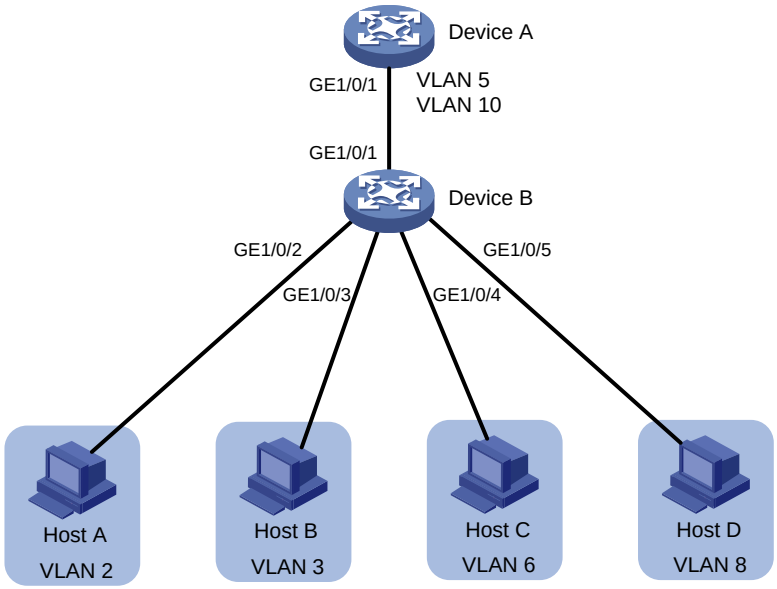
Example: Configuring trunk promiscuous ports

Network configuration

As shown in Figure 9, configure the private VLAN feature to meet the following requirements:

- VLANs 5 and 10 are primary VLANs on Device B. The uplink port (GigabitEthernet 1/0/1) on Device B permits the packets from VLANs 5 and 10 to pass through tagged.
- On Device B, downlink port GigabitEthernet 1/0/2 permits secondary VLAN 2. Downlink port GigabitEthernet 1/0/3 permits secondary VLAN 3. Secondary VLANs 2 and 3 are associated with primary VLAN 5.
- On Device B, downlink port GigabitEthernet 1/0/4 permits secondary VLAN 6. Downlink port GigabitEthernet 1/0/5 permits secondary VLAN 8. Secondary VLANs 6 and 8 are associated with primary VLAN 10.
- Device A is aware of only VLANs 5 and 10 on Device B.

Figure 9 Network diagram



Procedure

1. Configure Device B:

   # Configure VLANs 5 and 10 as primary VLANs.

```
<DeviceB> system-view
[DeviceB] vlan 5
[DeviceB-vlan5] private-vlan primary
[DeviceB-vlan5] quit
[DeviceB] vlan 10
[DeviceB-vlan10] private-vlan primary
[DeviceB-vlan10] quit
```

   # Create VLANs 2, 3, 6, and 8.

```
[DeviceB] vlan 2 to 3
[DeviceB] vlan 6
[DeviceB-vlan6] quit
[DeviceB] vlan 8
[DeviceB-vlan8] quit
```

   # Associate secondary VLANs 2 and 3 with primary VLAN 5.

```
[DeviceB] vlan 5
[DeviceB-vlan5] private-vlan secondary 2 to 3
[DeviceB-vlan5] quit
```

   # Associate secondary VLANs 6 and 8 with primary VLAN 10.

```
[DeviceB] vlan 10
[DeviceB-vlan10] private-vlan secondary 6 8
[DeviceB-vlan10] quit
```

   # Configure the uplink port (GigabitEthernet 1/0/1) as a trunk promiscuous port of VLANs 5 and 10.

```
[DeviceB] interface gigabitethernet 1/0/1
[DeviceB-GigabitEthernet1/0/1] port private-vlan 5 10 trunk promiscuous
[DeviceB-GigabitEthernet1/0/1] quit
```

Assign downlink port GigabitEthernet 1/0/2 to VLAN 2, and configure the port as a host port.

```
[DeviceB] interface gigabitethernet 1/0/2
[DeviceB-GigabitEthernet1/0/2] port access vlan 2
[DeviceB-GigabitEthernet1/0/2] port private-vlan host
[DeviceB-GigabitEthernet1/0/2] quit
```

Assign downlink port GigabitEthernet 1/0/3 to VLAN 3, and configure the port as a host port.

```
[DeviceB] interface gigabitethernet 1/0/3
[DeviceB-GigabitEthernet1/0/3] port access vlan 3
[DeviceB-GigabitEthernet1/0/3] port private-vlan host
[DeviceB-GigabitEthernet1/0/3] quit
```

Assign downlink port GigabitEthernet 1/0/4 to VLAN 6, and configure the port as a host port.

```
[DeviceB] interface gigabitethernet 1/0/4
[DeviceB-GigabitEthernet1/0/4] port access vlan 6
[DeviceB-GigabitEthernet1/0/4] port private-vlan host
[DeviceB-GigabitEthernet1/0/4] quit
```

Assign downlink port GigabitEthernet 1/0/5 to VLAN 8, and configure the port as a host port.

```
[DeviceB] interface gigabitethernet 1/0/5
[DeviceB-GigabitEthernet1/0/5] port access vlan 8
[DeviceB-GigabitEthernet1/0/5] port private-vlan host
[DeviceB-GigabitEthernet1/0/5] quit
```

2. Configure Device A:

Create VLANs 5 and 10.

```
[DeviceA] vlan 5
[DeviceA-vlan5] quit
[DeviceA] vlan 10
[DeviceA-vlan10] quit
```

Configure GigabitEthernet 1/0/1 as a hybrid port, and assign it to VLANs 5 and 10 as a tagged VLAN member.

```
[DeviceA] interface gigabitethernet 1/0/1
[DeviceA-GigabitEthernet1/0/1] port link-type hybrid
[DeviceA-GigabitEthernet1/0/1] port hybrid vlan 5 10 tagged
[DeviceA-GigabitEthernet1/0/1] quit
```

Verifying the configuration

Verify the primary VLAN configurations on Device B. The following output uses primary VLAN 5 as an example.

```
[DeviceB] display private-vlan 5
 Primary VLAN ID: 5
 Secondary VLAN ID: 2-3

 VLAN ID: 5
 VLAN type: Static
 Private VLAN type: Primary
 Route interface: Not configured
 Description: VLAN 0005
 Name: VLAN 0005
 Tagged ports:
    GigabitEthernet1/0/1
 Untagged ports:
```

```
    GigabitEthernet1/0/2
    GigabitEthernet1/0/3

 VLAN ID: 2
 VLAN type: Static
 Private VLAN type: Secondary
 Route interface: Not configured
 Description: VLAN 0002
 Name: VLAN 0002
 Tagged ports:
    GigabitEthernet1/0/1
 Untagged ports:
    GigabitEthernet1/0/2

 VLAN ID: 3
 VLAN type: Static
 Private VLAN type: Secondary
 Route interface: Not configured
 Description: VLAN 0003
 Name: VLAN 0003
 Tagged ports:
    GigabitEthernet1/0/1
 Untagged ports:
    GigabitEthernet1/0/3
```

The output shows that:

- The trunk promiscuous port (GigabitEthernet 1/0/1) is a tagged member of primary VLAN 5 and secondary VLANs 2 and 3.
- Host port GigabitEthernet 1/0/2 is an untagged member of primary VLAN 5 and secondary VLAN 2.
- Host port GigabitEthernet 1/0/3 is an untagged member of primary VLAN 5 and secondary VLAN 3.

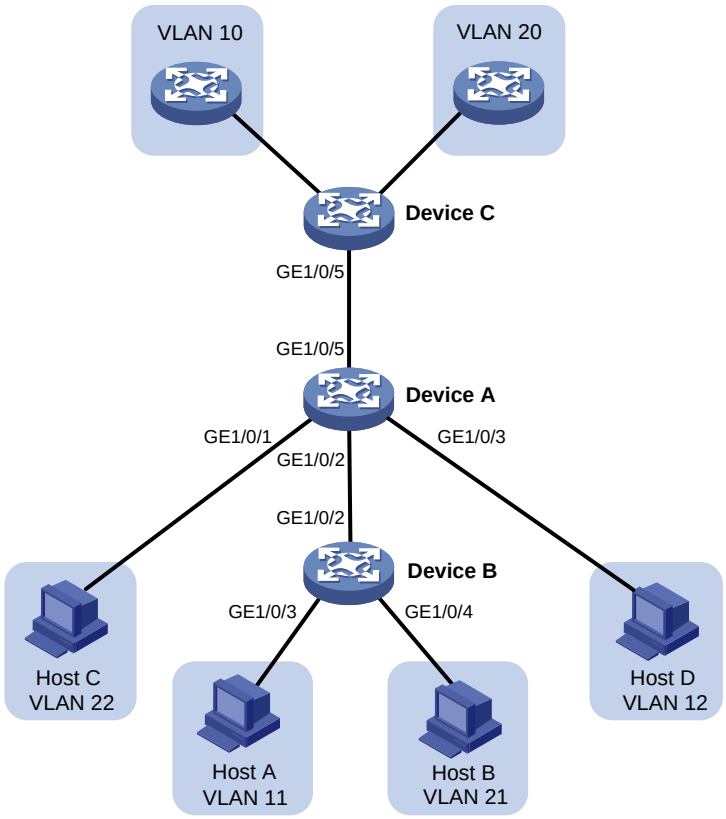
Example: Configuring trunk promiscuous and trunk secondary ports

Network configuration

As shown in Figure 10, configure the private VLAN feature to meet the following requirements:

- VLANs 10 and 20 are primary VLANs on Device A. The uplink port (GigabitEthernet 1/0/5) on Device A permits the packets from VLANs 10 and 20 to pass through tagged.
- VLANs 11, 12, 21, and 22 are secondary VLANs on Device A.
  - Downlink port GigabitEthernet 1/0/2 permits the packets from secondary VLANs 11 and 21 to pass through tagged.
  - Downlink port GigabitEthernet 1/0/1 permits secondary VLAN 22.
  - Downlink port GigabitEthernet 1/0/3 permits secondary VLAN 12.
- Secondary VLANs 11 and 12 are associated with primary VLAN 10.
- Secondary VLANs 21 and 22 are associated with primary VLAN 20.

Figure 10 Network diagram



Procedure

1. Configure Device A:

Configure VLANs 10 and 20 as primary VLANs.

```
<DeviceA> system-view
[DeviceA] vlan 10
[DeviceA-vlan10] private-vlan primary
[DeviceA-vlan10] quit
[DeviceA] vlan 20
[DeviceA-vlan20] private-vlan primary
[DeviceA-vlan20] quit
```

Create VLANs 11, 12, 21, and 22.

```
[DeviceA] vlan 11 to 12
[DeviceA] vlan 21 to 22
```

Associate secondary VLANs 11 and 12 with primary VLAN 10.

```
[DeviceA] vlan 10
[DeviceA-vlan10] private-vlan secondary 11 12
[DeviceA-vlan10] quit
```

Associate secondary VLANs 21 and 22 with primary VLAN 20.

```
[DeviceA] vlan 20
[DeviceA-vlan20] private-vlan secondary 21 22
[DeviceA-vlan20] quit
```

Configure the uplink port (GigabitEthernet 1/0/5) as a trunk promiscuous port of VLANs 10 and 20.

```
[DeviceA] interface gigabitethernet 1/0/5
[DeviceA-GigabitEthernet1/0/5] port private-vlan 10 20 trunk promiscuous
[DeviceA-GigabitEthernet1/0/5] quit
```

Assign downlink port GigabitEthernet 1/0/1 to VLAN 22 and configure the port as a host port.

```
[DeviceA] interface gigabitethernet 1/0/1
[DeviceA-GigabitEthernet1/0/1] port access vlan 22
[DeviceA-GigabitEthernet1/0/1] port private-vlan host
[DeviceA-GigabitEthernet1/0/1] quit
```

Assign downlink port GigabitEthernet 1/0/3 to VLAN 12 and configure the port as a host port.

```
[DeviceA] interface gigabitethernet 1/0/3
[DeviceA-GigabitEthernet1/0/3] port access vlan 12
[DeviceA-GigabitEthernet1/0/3] port private-vlan host
[DeviceA-GigabitEthernet1/0/3] quit
```

Configure downlink port GigabitEthernet 1/0/2 as a trunk secondary port of VLANs 11 and 21.

```
[DeviceA] interface gigabitethernet 1/0/2
[DeviceA-GigabitEthernet1/0/2] port private-vlan 11 21 trunk secondary
[DeviceA-GigabitEthernet1/0/2] quit
```

2. Configure Device B:

Create VLANs 11 and 21.

```
<DeviceB> system-view
[DeviceB] vlan 11
[DeviceB-vlan11] quit
[DeviceB] vlan 21
[DeviceB-vlan21] quit
```

Configure GigabitEthernet 1/0/2 as a hybrid port, and assign it to VLANs 11 and 21 as a tagged VLAN member.

```
[DeviceB] interface gigabitethernet 1/0/2
[DeviceB-GigabitEthernet1/0/2] port link-type hybrid
[DeviceB-GigabitEthernet1/0/2] port hybrid vlan 11 21 tagged
[DeviceB-GigabitEthernet1/0/2] quit
```

Assign GigabitEthernet 1/0/3 to VLAN 11.

```
[DeviceB] interface gigabitethernet 1/0/3
[DeviceB-GigabitEthernet1/0/3] port access vlan 11
[DeviceB-GigabitEthernet1/0/3] quit
```

Assign GigabitEthernet 1/0/4 to VLAN 21.

```
[DeviceB] interface gigabitethernet 1/0/4
[DeviceB-GigabitEthernet1/0/4] port access vlan 21
[DeviceB-GigabitEthernet1/0/4] quit
```

3. Configure Device C:

Create VLANs 10 and 20.

```
<DeviceC> system-view
[DeviceC] vlan 10
[DeviceC-vlan10] quit
[DeviceC] vlan 20
[DeviceC-vlan20] quit
```

Configure GigabitEthernet 1/0/5 as a hybrid port, and assign it to VLANs 10 and 20 as a tagged VLAN member.

```
[DeviceC] interface gigabitethernet 1/0/5
```

```
[DeviceC-GigabitEthernet1/0/5] port link-type hybrid
[DeviceC-GigabitEthernet1/0/5] port hybrid vlan 10 20 tagged
[DeviceC-GigabitEthernet1/0/5] quit
```

Verifying the configuration

Verify the primary VLAN configurations on Device A. The following output uses primary VLAN 10 as an example.

```
[DeviceA] display private-vlan 10
 Primary VLAN ID: 10
 Secondary VLAN ID: 11-12

 VLAN ID: 10
 VLAN type: Static
 Private-vlan type: Primary
 Route interface: Not configured
 Description: VLAN 0010
 Name: VLAN 0010
 Tagged ports:
    GigabitEthernet1/0/2
    GigabitEthernet1/0/5
 Untagged ports:
    GigabitEthernet1/0/3

 VLAN ID: 11
 VLAN type: Static
 Private-vlan type: Secondary
 Route interface: Not configured
 Description: VLAN 0011
 Name: VLAN 0011
 Tagged ports:
    GigabitEthernet1/0/2
    GigabitEthernet1/0/5
 Untagged ports: None

 VLAN ID: 12
 VLAN type: Static
 Private-vlan type: Secondary
 Route interface: Not configured
 Description: VLAN 0012
 Name: VLAN 0012
 Tagged ports:
    GigabitEthernet1/0/5
 Untagged ports:
    GigabitEthernet1/0/3
```

The output shows that:

- The trunk promiscuous port (GigabitEthernet 1/0/5) is a tagged member of primary VLAN 10 and secondary VLANs 11 and 12.
- The trunk secondary port (GigabitEthernet 1/0/2) is a tagged member of primary VLAN 10 and secondary VLAN 11.

- The host port (GigabitEthernet 1/0/3) is an untagged member of primary VLAN 10 and secondary VLAN 12.

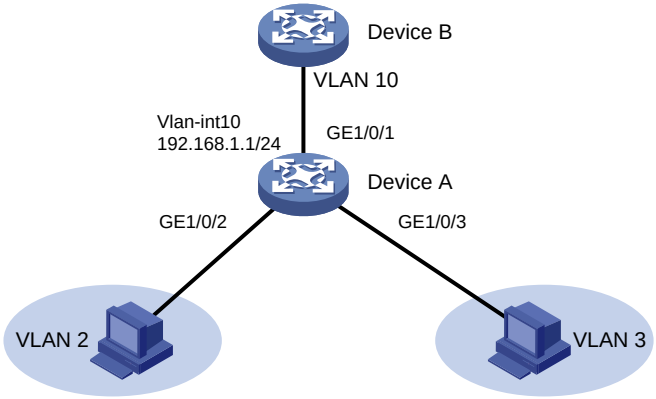
Example: Configuring Layer 3 communication for secondary VLANs

Network configuration

As shown in Figure 11, configure the private VLAN feature to meet the following requirements:

- Primary VLAN 10 on Device A is associated with secondary VLANs 2 and 3. The IP address of VLAN-interface 10 is 192.168.1.1/24.
- GigabitEthernet 1/0/1 belongs to VLAN 10. GigabitEthernet 1/0/2 and GigabitEthernet 1/0/3 belong to VLAN 2 and VLAN 3, respectively.
- Secondary VLANs are isolated at Layer 2 but interoperable at Layer 3.

Figure 11 Network diagram



Procedure

Create VLAN 10 and configure it as a primary VLAN.

```
<DeviceA> system-view
[DeviceA] vlan 10
[DeviceA-vlan10] private-vlan primary
[DeviceA-vlan10] quit
```

Create VLANs 2 and 3.

```
<DeviceA> system-view
[DeviceA] vlan 2 to 3
```

Associate primary VLAN 10 with secondary VLANs 2 and 3.

```
[DeviceA] vlan 10
[DeviceA-vlan10] private-vlan primary
[DeviceA-vlan10] private-vlan secondary 2 3
[DeviceA-vlan10] quit
```

Configure the uplink port (GigabitEthernet 1/0/1) as a promiscuous port of VLAN 10.

```
[DeviceA] interface gigabitethernet 1/0/1
[DeviceA-GigabitEthernet1/0/1] port private-vlan 10 promiscuous
[DeviceA-GigabitEthernet1/0/1] quit
```

Assign downlink port GigabitEthernet 1/0/2 to VLAN 2, and configure the port as a host port.

```
[DeviceA] interface gigabitethernet 1/0/2
```

```
[DeviceA-GigabitEthernet1/0/2] port access vlan 2
[DeviceA-GigabitEthernet1/0/2] port private-vlan host
[DeviceA-GigabitEthernet1/0/2] quit
```

Assign downlink port GigabitEthernet 1/0/3 to VLAN 3, and configure the port as a host port.

```
[DeviceA] interface gigabitethernet 1/0/3
[DeviceA-GigabitEthernet1/0/3] port access vlan 3
[DeviceA-GigabitEthernet1/0/3] port private-vlan host
[DeviceA-GigabitEthernet1/0/3] quit
```

Enable Layer 3 communication between secondary VLANs 2 and 3 that are associated with primary VLAN 10.

```
[DeviceA] interface vlan-interface 10
[DeviceA-Vlan-interface10] private-vlan secondary 2 3
```

Assign IP address 192.168.1.1/24 to VLAN-interface 10.

```
[DeviceA-Vlan-interface10] ip address 192.168.1.1 255.255.255.0
```

Enable local proxy ARP on VLAN-interface 10.

```
[DeviceA-Vlan-interface10] local-proxy-arp enable
[DeviceA-Vlan-interface10] quit
```

Verifying the configuration

Display the configuration of primary VLAN 10.

```
[DeviceA] display private-vlan 10
 Primary VLAN ID: 10
 Secondary VLAN ID: 2-3

 VLAN ID: 10
 VLAN type: Static
 Private VLAN type: Primary
 Route interface: Configured
 IPv4 address: 192.168.1.1
 IPv4 subnet mask: 255.255.255.0
 Description: VLAN 0010
 Name: VLAN 0010
 Tagged ports:   None
 Untagged ports:
    GigabitEthernet1/0/1
    GigabitEthernet1/0/2
    GigabitEthernet1/0/3

 VLAN ID: 2
 VLAN type: Static
 Private VLAN type: Secondary
 Route interface: Configured
 IPv4 address: 192.168.1.1
 IPv4 subnet mask: 255.255.255.0
 Description: VLAN 0002
 Name: VLAN 0002
 Tagged ports:   None
 Untagged ports:
```

```
   GigabitEthernet1/0/1
   GigabitEthernet1/0/2

VLAN ID: 3
VLAN type: Static
Private VLAN type: Secondary
Route interface: Configured
IPv4 address: 192.168.1.1
IPv4 subnet mask: 255.255.255.0
Description: VLAN 0003
Name: VLAN 0003
Tagged ports:   None
Untagged ports:
   GigabitEthernet1/0/1
   GigabitEthernet1/0/3
```

The **Route interface** field in the output is **Configured**, indicating that secondary VLANs 2 and 3 are interoperable at Layer 3.

Configuring voice VLANs

About voice VLANs

A voice VLAN is used for transmitting voice traffic. The device can configure QoS parameters for voice packets to ensure higher transmission priority of the voice packets.

Common voice devices include IP phones and integrated access devices (IADs). This chapter uses IP phones as an example.

Working mechanism

When an IP phone accesses a device, the device performs the following operations:

1. Identifies the IP phone in the network and obtains the MAC address of the IP phone.
2. Advertises the voice VLAN information to the IP phone.

After receiving the voice VLAN information, the IP phone performs automatic configuration. Voice packets sent from the IP phone can then be transmitted within the voice VLAN.

Methods of identifying IP phones

Devices can use the OUI addresses or LLDP to identify IP phones.

Identifying IP phones through OUI addresses

A device identifies voice packets based on their source MAC addresses. A packet whose source MAC address complies with an Organizationally Unique Identifier (OUI) address of the device is regarded as a voice packet.

You can use system default OUI addresses (see Table 1) or configure OUI addresses for the device. You can manually remove or add the system default OUI addresses.

Table 1 Default OUI addresses

Number	OUI address	Vendor
1	0001-e300-0000	Siemens phone
2	0003-6b00-0000	Cisco phone
3	0004-0d00-0000	Avaya phone
4	000f-e200-0000	H3C Aolynk phone
5	0060-b900-0000	Philips/NEC phone
6	00d0-1e00-0000	Pingtel phone
7	00e0-7500-0000	Polycom phone
8	00e0-bb00-0000	3Com phone

Typically, an OUI address refers to the first 24 bits of a MAC address (in binary notation) and is a globally unique identifier that IEEE assigns to a vendor. However, OUI addresses in this chapter are addresses that the system uses to identify voice packets. They are the logical AND results of the *mac-address* and *oui-mask* arguments in the **voice-vlan mac-address** command.

Automatically identifying IP phones through LLDP

If IP phones support LLDP, configure LLDP for automatic IP phone discovery on the device. The device can then automatically discover the peer through LLDP, and exchange LLDP TLVs with the peer.

If the LLDP System Capabilities TLV received on a port indicates that the peer can act as a telephone, the device performs the following operations:

1. Sends an LLDP TLV with the voice VLAN configuration to the peer.
2. Assigns the receiving port to the voice VLAN.
3. Increases the transmission priority of the voice packets sent from the IP phone.
4. Adds the MAC address of the IP phone to the MAC address table to ensure that the IP phone can pass authentication.

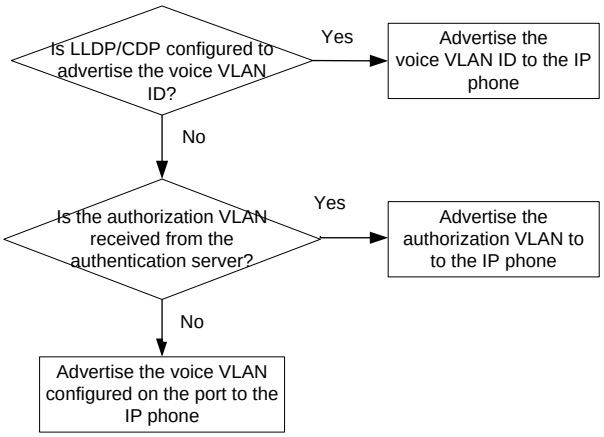
Use LLDP instead of the OUI list to identify IP phones if the network has more IP phone categories than the maximum number of OUI addresses supported on the device. LLDP has higher priority than the OUI list.

For more information about LLDP, see "Configuring LLDP."

Advertising the voice VLAN information to IP phones

Figure 12 shows the workflow of advertising the voice VLAN information to IP phones.

Figure 12 Workflow of advertising the voice VLAN information to IP phones



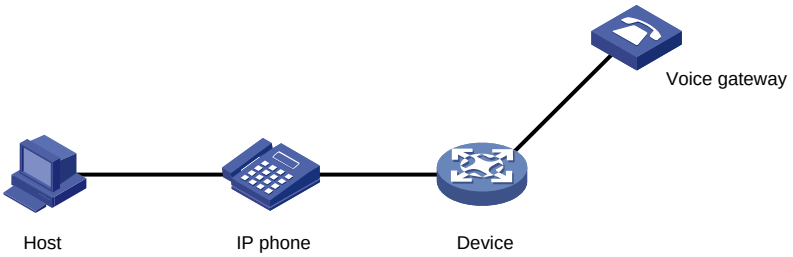
IP phone access methods

Connecting the host and the IP phone in series

As shown in Figure 13, the host is connected to the IP phone, and the IP phone is connected to the device. In this scenario, the following requirements must be met:

- The host and the IP phone use different VLANs.
- The IP phone is able to send out VLAN-tagged packets, so that the device can differentiate traffic from the host and the IP phone.
- The port connecting to the IP phone forwards packets from the voice VLAN and the PVID.

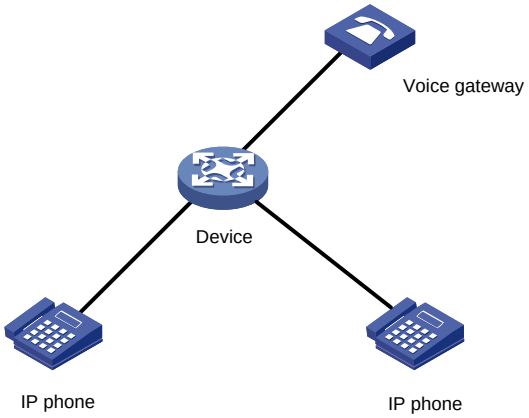
Figure 13 Connecting the host and IP phone in series



Connecting the IP phone to the device

As shown in Figure 14, IP phones are connected to the device without the presence of the host. Use this connection method when IP phones sends out untagged voice packets. In this scenario, you must configure the voice VLAN as the PVID of the access port of the IP phone, and configure the port to forward the packets from the PVID.

Figure 14 Connecting the IP phone to the device



Voice VLAN assignment modes

A port can be assigned to a voice VLAN automatically or manually.

Automatic mode

Use automatic mode when PCs and IP phones are connected in series to access the network through the device, as shown in Figure 13. Ports on the device transmit both voice traffic and data traffic.

When an IP phone is powered on, it sends out protocol packets. After receiving these protocol packets, the device uses the source MAC address of the protocol packets to match its OUI addresses. If the match succeeds, the device performs the following operations:

- Assigns the receiving port of the protocol packets to the voice VLAN.
- Issues ACL rules to set the packet precedence.
- Starts the voice VLAN aging timer.

If no voice packet is received from the port before the aging timer expires, the device will remove the port from the voice VLAN. The aging timer is also configurable.

When the IP phone reboots, the port is reassigned to the voice VLAN to ensure the correct operation of the existing voice connections. The reassignment occurs automatically without being triggered by voice traffic as long as the voice VLAN operates correctly.

Manual mode

Use manual mode when only IP phones access the network through the device, as shown in Figure 14. In this mode, ports are assigned to a voice VLAN that transmits voice traffic exclusively. No data traffic affects the voice traffic transmission.

You must manually assign the port that connects to the IP phone to a voice VLAN. The device uses the source MAC address of the received voice packets to match its OUI addresses. If the match succeeds, the device issues ACL rules to set the packet precedence.

To remove the port from the voice VLAN, you must manually remove it.

Cooperation of voice VLAN assignment modes and IP phones

Some IP phones send out VLAN-tagged packets, and others send out only untagged packets. For correct packet processing, ports of different link types must meet specific configuration requirements in different voice VLAN assignment modes.

If an IP phone sends out tagged voice traffic, and its access port is configured with 802.1X authentication, guest VLAN, Auth-Fail VLAN, or critical VLAN, VLAN IDs must be different for the following VLANs:

- Voice VLAN.
- PVID of the access port.
- 802.1X guest, Auth-Fail, or critical VLAN.

If an IP phone sends out untagged voice traffic, the PVID of the access port must be the voice VLAN. In this scenario, 802.1X authentication is not supported.

Access ports do not transmit tagged packets.

Configuration requirements for transmitting tagged voice traffic

Port link type	Voice VLAN assignment mode	Configuration requirements
Trunk	Automatic	The PVID of the port cannot be the voice VLAN.
	Manual	The PVID of the port cannot be the voice VLAN. The port must forward packets from the voice VLAN.
Hybrid	Automatic	The PVID of the port cannot be the voice VLAN.
	Manual	The PVID of the port cannot be the voice VLAN. The port must forward packets from the voice VLAN with VLAN tags.

Configuration requirements for transmitting untagged voice traffic

When IP phones send out untagged packets, you must set the voice VLAN assignment mode to manual.

Table 2 Configuration requirements for ports in manual mode to support untagged voice traffic

Port link type	Configuration requirements
Access	The voice VLAN must be the PVID of the port.
Trunk	The voice VLAN must be the PVID of the port.

Port link type	Configuration requirements
	The port must forward packets from the voice VLAN.
Hybrid	The voice VLAN must be the PVID of the port. The port must forward packets from the voice VLAN without VLAN tags.

Security mode and normal mode of voice VLANs

Depending on the filtering mechanisms to incoming packets, a voice VLAN-enabled port can operate in one of the following modes:

- **Normal mode**—The port receives voice-VLAN-tagged packets and forwards them in the voice VLAN without examining their MAC addresses. If the PVID of the port is the voice VLAN and the port operates in manual VLAN assignment mode, the port forwards all the received untagged packets in the voice VLAN.

  In this mode, voice VLANs are vulnerable to traffic attacks. Malicious users might send a large number of forged voice-VLAN-tagged or untagged packets to affect voice communication.
- **Security mode**—The port uses the source MAC addresses of voice packets to match the OUI addresses of the device. Packets that fail the match will be dropped.

In a safe network, you can configure the voice VLANs to operate in normal mode. This mode reduces system resource consumption in source MAC address checking.

In either mode, the device modifies the transmission priority only for voice VLAN packets whose source MAC addresses match OUI addresses of the device.

As a best practice, do not transmit both voice traffic and non-voice traffic in a voice VLAN. If you must transmit different traffic in a voice VLAN, make sure the voice VLAN security mode is disabled.

Table 3 Packet processing on a voice VLAN-enabled port in normal or security mode

Voice VLAN mode	Packet type	Packet processing
Normal	• Untagged packets • Packets with the voice VLAN tags	The port does not examine their source MAC addresses. Both voice traffic and non-voice traffic can be transmitted in the voice VLAN.
	Packets with other VLAN tags	The port forwards or drops them depending on whether the port permits packets from these VLANs to pass through.
Security	• Untagged packets • Packets with the voice VLAN tags	• If the source MAC address of a packet matches an OUI address on the device, the packet is forwarded in the voice VLAN. • If the source MAC address of a packet does not match an OUI address on the device, the packet is dropped.
	Packets with other VLAN tags	The port forwards or drops them depending on whether the port permits packets from these VLANs to pass through.

Restrictions: Hardware compatibility with voice VLAN

S5110V2-SI, S5000V3-EI, S5000V5-EI, S5000E-X, S5000X-EI, and WAS6000 switches do not support voice VLAN.

Restrictions and guidelines: Voice VLAN configuration

The aging timer of a voice VLAN starts only when the dynamic MAC address entry of the voice VLAN ages out. The aging period for the voice VLAN equals the sum of the voice VLAN aging timer and the aging timer for its dynamic MAC address entry. For more information about the aging timer for dynamic MAC address entries, see "Configuring the MAC address table."

As a best practice, do not both configure voice VLAN and disable MAC address learning on a port. If the two features are configured together on a port, the port forwards only packets exactly matching the OUI addresses and drops inexactly matching packets.

As a best practice, do not configure both voice VLAN and the MAC learning limit on a port. If the two features are configured together on a port and the port learns the configured maximum number of MAC address entries, the port processes packets as follows:

- Forwards only packets matching the MAC address entries learnt by the port and OUI addresses.
- Drops unmatching packets.

Voice VLAN tasks at a glance

To configure a voice VLAN, perform the following tasks:

1. Configuring voice VLAN assignment modes for a port

   Use one of the following methods:

   - Configuring a port to operate in automatic voice VLAN assignment mode
   - Configuring a port to operate in manual voice VLAN assignment mode
2. (Optional.) Enabling LLDP for automatic IP phone discovery
3. (Optional.) Use one of the following methods:
   - Configuring LLDP to advertise a voice VLAN
   - Configuring CDP to advertise a voice VLAN

Configuring voice VLAN assignment modes for a port

Configuring a port to operate in automatic voice VLAN assignment mode

Restrictions and guidelines

- Do not configure a VLAN as both a voice VLAN and a protocol-based VLAN.
  - A voice VLAN in automatic mode on a hybrid port processes only tagged incoming voice traffic.
  - A protocol-based VLAN on a hybrid port processes only untagged incoming packets. For more information about protocol-based VLANs, see "Configuring protocol-based VLANs."
- As a best practice, do not use this mode with MSTP. In MSTP mode, if a port is blocked in the MSTI of the target voice VLAN, the port drops the received packets instead of delivering them to the CPU. As a result, the port will not be dynamically assigned to the voice VLAN.

- As a best practice, do not use this mode with PVST. In PVST mode, if the target voice VLAN is not permitted on a port, the port is placed in blocked state. The port drops the received packets instead of delivering them to the CPU. As a result, the port will not be dynamically assigned to the voice VLAN.
- As a best practice, do not configure both dynamic MAC-based VLAN assignment and automatic voice VLAN assignment mode on a port. They can have a negative impact on each other.

Procedure

1. Enter system view.
   system-view
2. (Optional.) Set the voice VLAN aging timer.
   voice-vlan aging *minutes*
   By default, the aging timer of a voice VLAN is 1440 minutes.
   The voice VLAN aging timer takes effect only on ports in automatic voice VLAN assignment mode.
3. (Optional.) Enable the voice VLAN security mode.
   voice-vlan security enable
   By default, the voice VLAN security mode is enabled.
4. (Optional.) Add an OUI address for voice packet identification.
   voice-vlan mac-address *oui* **mask** *oui-mask* [**description** *text*]
   By default, system default OUI addresses exist. For more information, see Table 1.
5. Enter Layer 2 Ethernet interface view.
   interface *interface-type interface-number*
6. Configure the link type of the port.
   - **port link-type trunk**
   - **port link-type hybrid**
7. Configure the port to operate in automatic voice VLAN assignment mode.
   voice-vlan mode auto
   By default, the automatic voice VLAN assignment mode is enabled.
8. Enable the voice VLAN feature on the port.
   voice-vlan *vlan-id* **enable**
   By default, the voice VLAN feature is disabled.
   Before you execute this command, make sure the specified VLAN already exists.

Configuring a port to operate in manual voice VLAN assignment mode

Restrictions and guidelines

- You can configure different voice VLANs for different ports on the same device. Make sure the following requirements are met:
  - One port can be configured with only one voice VLAN.
  - Voice VLANs must be existing static VLANs.
- Do not enable voice VLAN on the member ports of a link aggregation group. For more information about link aggregation, see "Configuring Ethernet link aggregation."
- To make a voice VLAN take effect on a port operating in manual mode, you must manually assign the port to the voice VLAN.

Procedure

1. Enter system view.
   system-view
2. (Optional.) Enable the voice VLAN security mode.
   voice-vlan security enable
   By default, the voice VLAN security mode is enabled.
3. (Optional.) Add an OUI address for voice packet identification.
   voice-vlan mac-address *oui* **mask** *oui-mask* [**description** *text*]
   By default, system default OUI addresses exist. For more information, see Table 1.
4. Enter Layer 2 Ethernet interface view.
   interface *interface-type interface-number*
5. Configure the port to operate in manual voice VLAN assignment mode.
   undo voice-vlan mode auto
   By default, a port operates in automatic voice VLAN assignment mode.
6. Assign the access, trunk, or hybrid port to the voice VLAN.
   - For the access port, see "Assigning an access port to a VLAN."
   - For the trunk port, see "Assigning a trunk port to a VLAN."
   - For the hybrid port, see "Assigning a hybrid port to a VLAN."

   After you assign an access port to the voice VLAN, the voice VLAN becomes the PVID of the port.
7. (Optional.) Configure the voice VLAN as the PVID of the trunk or hybrid port.
   - For the trunk port, see "Assigning a trunk port to a VLAN."
   - For the hybrid port, see "Assigning a hybrid port to a VLAN."

   This step is required for untagged incoming voice traffic and prohibited for tagged incoming voice traffic.
8. Enable the voice VLAN feature on the port.
   voice-vlan *vlan-id* **enable**
   By default, the voice VLAN feature is disabled.
   Before you execute this command, make sure the specified VLAN already exists.

Enabling LLDP for automatic IP phone discovery

Restrictions and guidelines

- Before you enable this feature, enable LLDP both globally and on access ports.
- Use this feature only with the automatic voice VLAN assignment mode.
- If you use this feature together with CDP compatibility, voice VLAN settings will be deleted when the CDP neighbors are deleted, which causes IP phones automatically discovered through LLDP to go offline. Do not use this feature together with CDP compatibility.
- After you enable this feature on the device, each port of the device can be connected to a maximum of five IP phones.

Procedure

1. Enter system view.
   system-view
2. Enable LLDP for automatic IP phone discovery.

voice-vlan track lldp

By default, this feature is disabled.

Configuring LLDP or CDP to advertise a voice VLAN

Configuring LLDP to advertise a voice VLAN

About configuring LLDP to advertise a voice VLAN

For IP phones that support LLDP, the device advertises the voice VLAN information to the IP phones through the LLDP-MED TLVs.

Prerequisites

Before you configure this feature, enable LLDP both globally and on access ports.

Procedure

1. Enter system view.
   system-view
2. Enter Layer 2 Ethernet interface view.
   interface *interface-type interface-number*
3. Configure an advertised voice VLAN ID.
   lldp tlv-enable med-tlv network-policy *vlan-id*

   By default, no advertised voice VLAN ID is configured.

   For more information about the command, see *Layer 2—LAN Switching Command Reference*.
4. (Optional.) Display the voice VLAN advertised by LLDP.
   display lldp local-information

   For more information about the command, see *Layer 2—LAN Switching Command Reference*.

Configuring CDP to advertise a voice VLAN

About configuring CDP to advertise a voice VLAN

If an IP phone supports CDP but does not support LLDP, it will send out CDP packets to the device to request the voice VLAN ID. If the IP phone does not receive the voice VLAN ID within a time period, it will send out untagged packets. The device cannot differentiate untagged voice packets from other types of packets.

You can configure CDP compatibility on the device to enable it to perform the following operations:

- Receive and identify CDP packets from the IP phone.
- Send CDP packets to the IP phone. The voice VLAN information is carried in the CDP packets.

After receiving the advertised VLAN information, the IP phone performs automatic voice VLAN configuration. Packets from the IP phone will be transmitted in the dedicated voice VLAN.

LLDP packets sent from the device carry the priority information. CDP packets sent from the device do not carry the priority information.

Prerequisites

Before you configure this feature, enable LLDP globally and on access ports.

Procedure

1. Enter system view.
   system-view
2. Enable CDP compatibility.
   lldp compliance cdp
   By default, CDP compatibility is disabled.
3. Enter Layer 2 Ethernet interface view.
   interface *interface-type interface-number*
4. Configure CDP-compatible LLDP to operate in TxRx mode.
   lldp compliance admin-status cdp txrx
   By default, CDP-compatible LLDP operates in Disable mode.
5. Configure an advertised voice VLAN ID.
   cdp voice-vlan *vlan-id*
   By default, no advertised voice VLAN ID is configured.
   For more information about the command, see *Layer 2—LAN Switching Command Reference*.

Display and maintenance commands for voice VLANs

Execute **display** commands in any view.

Task	Command
Display OUI addresses on a device.	**display voice-vlan mac-address**
Display the voice VLAN state.	**display voice-vlan state**

Voice VLAN configuration examples

Example: Configuring automatic voice VLAN assignment mode

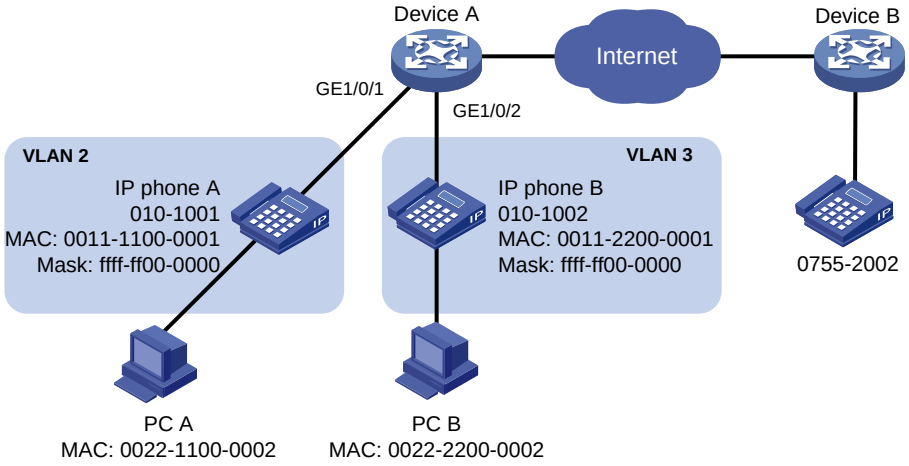
Network configuration

As shown in Figure 15, Device A transmits traffic from IP phones and hosts.

For correct voice traffic transmission, perform the following tasks on Device A:

- Configure voice VLANs 2 and 3 to transmit voice packets from IP phone A and IP phone B, respectively.
- Configure GigabitEthernet 1/0/1 and GigabitEthernet 1/0/2 to operate in automatic voice VLAN assignment mode.
- Add MAC addresses of IP phones A and B to the device for voice packet identification. The mask of the two MAC addresses is FFFF-FF00-0000.
- Set an aging timer for voice VLANs.

Figure 15 Network diagram



Procedure

1. Configure voice VLANs:

   # Create VLANs 2 and 3.

   ```
   <DeviceA> system-view
   [DeviceA] vlan 2 to 3
   ```

   # Set the voice VLAN aging timer to 30 minutes.

   ```
   [DeviceA] voice-vlan aging 30
   ```

   # Enable security mode for voice VLANs.

   ```
   [DeviceA] voice-vlan security enable
   ```

   # Add MAC addresses of IP phones A and B to the device with mask FFFF-FF00-0000.

   ```
   [DeviceA] voice-vlan mac-address 0011-1100-0001 mask ffff-ff00-0000 description IP phone A
   [DeviceA] voice-vlan mac-address 0011-2200-0001 mask ffff-ff00-0000 description IP phone B
   ```

2. Configure GigabitEthernet 1/0/1:

   # Configure GigabitEthernet 1/0/1 as a hybrid port.

   ```
   [DeviceA] interface gigabitethernet 1/0/1
   [DeviceA-GigabitEthernet1/0/1] port link-type hybrid
   ```

   # Configure GigabitEthernet 1/0/1 to operate in automatic voice VLAN assignment mode.

   ```
   [DeviceA-GigabitEthernet1/0/1] voice-vlan mode auto
   ```

   # Enable voice VLAN on GigabitEthernet 1/0/1 and configure VLAN 2 as the voice VLAN for it.

   ```
   [DeviceA-GigabitEthernet1/0/1] voice-vlan 2 enable
   [DeviceA-GigabitEthernet1/0/1] quit
   ```

3. Configure GigabitEthernet 1/0/2:

   # Configure GigabitEthernet 1/0/2 as a hybrid port.

   ```
   [DeviceA] interface gigabitethernet 1/0/2
   [DeviceA-GigabitEthernet1/0/2] port link-type hybrid
   ```

   # Configure GigabitEthernet 1/0/2 to operate in automatic voice VLAN assignment mode.

   ```
   [DeviceA-GigabitEthernet1/0/2] voice-vlan mode auto
   ```

   # Enable voice VLAN on GigabitEthernet 1/0/2 and configure VLAN 3 as the voice VLAN for it.

   ```
   [DeviceA-GigabitEthernet1/0/2] voice-vlan 3 enable
   [DeviceA-GigabitEthernet1/0/2] quit
   ```

Verifying the configuration

Display the OUI addresses supported on Device A.

```
[DeviceA] display voice-vlan mac-address
OUI Address     Mask            Description
0001-e300-0000  ffff-ff00-0000  Siemens phone
0003-6b00-0000  ffff-ff00-0000  Cisco phone
0004-0d00-0000  ffff-ff00-0000  Avaya phone
000f-e200-0000  ffff-ff00-0000  H3C Aolynk phone
0011-1100-0000  ffff-ff00-0000  IP phone A
0011-2200-0000  ffff-ff00-0000  IP phone B
0060-b900-0000  ffff-ff00-0000  Philips/NEC phone
00d0-1e00-0000  ffff-ff00-0000  Pingtel phone
00e0-7500-0000  ffff-ff00-0000  Polycom phone
00e0-bb00-0000  ffff-ff00-0000  3Com phone
```

Display the voice VLAN state.

```
[DeviceA] display voice-vlan state
 Current voice VLANs: 2
 Voice VLAN security mode: Security
 Voice VLAN aging time: 30 minutes
 Voice VLAN enabled ports and their modes:
 Port                      VLAN        Mode        CoS         DSCP
 GE1/0/1                   2           Auto        6           46
 GE1/0/2                   3           Auto        6           46
```

Example: Configuring manual voice VLAN assignment mode

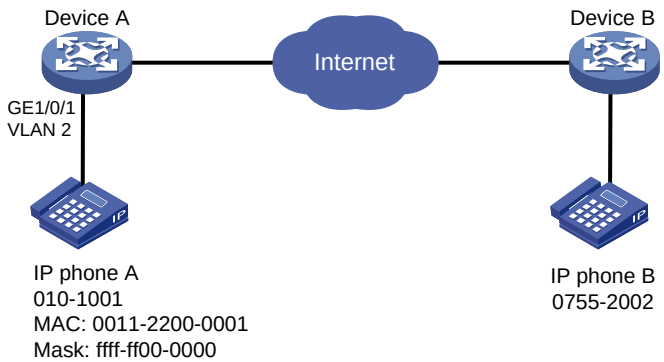
Network configuration

As shown in Figure 16, IP phone A send untagged voice traffic.

To enable GigabitEthernet 1/0/1 to transmit only voice packets, perform the following tasks on Device A:

- Create VLAN 2. This VLAN will be used as a voice VLAN.
- Configure GigabitEthernet 1/0/1 to operate in manual voice VLAN assignment mode and add it to VLAN 2.
- Add the OUI address of IP phone A to the OUI list of Device A.

Figure 16 Network diagram



Procedure

Enable security mode for voice VLANs.

```
<DeviceA> system-view
[DeviceA] voice-vlan security enable
```

Add MAC address 0011-2200-0001 with mask FFFF-FF00-0000.

```
[DeviceA] voice-vlan mac-address 0011-2200-0001 mask ffff-ff00-0000 description test
```

Create VLAN 2.

```
[DeviceA] vlan 2
[DeviceA-vlan2] quit
```

Configure GigabitEthernet 1/0/1 to operate in manual voice VLAN assignment mode.

```
[DeviceA] interface gigabitethernet 1/0/1
[DeviceA-GigabitEthernet1/0/1] undo voice-vlan mode auto
```

Configure GigabitEthernet 1/0/1 as a hybrid port.

```
[DeviceA-GigabitEthernet1/0/1] port link-type hybrid
```

Set the PVID of GigabitEthernet 1/0/1 to VLAN 2.

```
[DeviceA-GigabitEthernet1/0/1] port hybrid pvid vlan 2
```

Assign GigabitEthernet 1/0/1 to VLAN 2 as an untagged VLAN member.

```
[DeviceA-GigabitEthernet1/0/1] port hybrid vlan 2 untagged
```

Enable voice VLAN and configure VLAN 2 as the voice VLAN on GigabitEthernet 1/0/1.

```
[DeviceA-GigabitEthernet1/0/1] voice-vlan 2 enable
[DeviceA-GigabitEthernet1/0/1] quit
```

Verifying the configuration

Display the OUI addresses supported on Device A.

```
[DeviceA] display voice-vlan mac-address
OUI Address     Mask            Description
0001-e300-0000  ffff-ff00-0000  Siemens phone
0003-6b00-0000  ffff-ff00-0000  Cisco phone
0004-0d00-0000  ffff-ff00-0000  Avaya phone
000f-e200-0000  ffff-ff00-0000  H3C Aolynk phone
0011-2200-0000  ffff-ff00-0000  test
0060-b900-0000  ffff-ff00-0000  Philips/NEC phone
00d0-1e00-0000  ffff-ff00-0000  Pingtel phone
00e0-7500-0000  ffff-ff00-0000  Polycom phone
00e0-bb00-0000  ffff-ff00-0000  3Com phone
```

Display the voice VLAN state.

```
[DeviceA] display voice-vlan state
 Current voice VLANs: 1
 Voice VLAN security mode: Security
 Voice VLAN aging time: 1440 minutes
 Voice VLAN enabled ports and their modes:
 Port                        VLAN        Mode        CoS         DSCP
 GE1/0/1                     2           Manual      6           46
```

Contents

Configuring MVRP

About MVRP

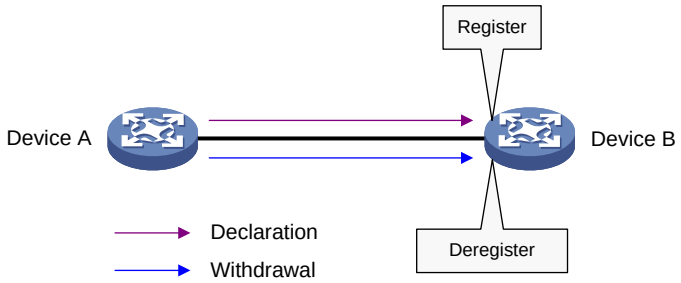
Multiple Registration Protocol (MRP) is an attribute registration protocol used to transmit attribute values. Multiple VLAN Registration Protocol (MVRP) is a typical MRP application. It synchronizes VLAN information among devices and greatly reduces the workload of network administrators.

MRP implementation

An MRP-enabled port is called an MRP participant. An MVRP-enabled port is called an MVRP participant.

As shown in Figure 1, an MRP participant sends declarations and withdrawals to notify other participants to register and deregister its attribute values. It also registers and deregisters the attribute values of other participants according to the received declarations and withdrawals. MRP rapidly propagates the configuration information of an MRP participant throughout the LAN.

Figure 1 MRP implementation



For example, MRP registers and deregisters VLAN attributes as follows:

- When a port receives a declaration for a VLAN, the port registers the VLAN and joins the VLAN.
- When a port receives a withdrawal for a VLAN, the port deregisters the VLAN and leaves the VLAN.

MRP allows devices in the same LAN to transmit attribute values on a per MSTI basis. Figure 1 shows a simple MRP implementation on an MSTI. In a network with multiple MSTIs, MRP performs attribute registration and deregistration on a per MSTI basis. For more information about MSTIs, see "Configuring spanning tree protocols."

MRP messages

MRP messages include the following types:

- **Declaration**—Includes Join and New messages.
- **Withdrawal**—Includes Leave and LeaveAll messages.

Join message

An MRP participant sends a Join message to request the peer participant to register attributes in the Join message.

When receiving a Join message from the peer participant, an MRP participant performs the following tasks:

- Registers the attributes in the Join message.

- Propagates the Join message to all other participants on the device.

After receiving the Join message, other participants send the Join message to their respective peer participants.

Join messages sent from a local participant to its peer participant include the following types:

- **JoinEmpty**—Declares an unregistered attribute. For example, when an MRP participant joins an unregistered static VLAN, it sends a JoinEmpty message.

  VLANs created manually and locally are called static VLANs. VLANs learned through MRP are called dynamic VLANs.
- **JoinIn**—Declares a registered attribute. A JoinIn message is used in one of the following situations:
  - An MRP participant joins an existing static VLAN and sends a JoinIn message after registering the VLAN.
  - The MRP participant receives a Join message propagated by another participant on the device and sends a JoinIn message after registering the VLAN.

New message

Similar to a Join message, a New message enables MRP participants to register attributes.

When the MSTP topology changes, an MRP participant sends a New message to the peer participant to declare the topology change.

Upon receiving a New message from the peer participant, an MRP participant performs the following tasks:

- Registers the attributes in the message.
- Propagates the New message to all other participants on the device.

After receiving the New message, other participants send the New message to their respective peer participants.

Leave message

An MRP participant sends a Leave message to the peer participant when it wants the peer participant to deregister attributes that it has deregistered.

When the peer participant receives the Leave message, it performs the following tasks:

- Deregisters the attribute in the Leave message.
- Propagates the Leave message to all other participants on the device.

After a participant on the device receives the Leave message, it determines whether to send the Leave message to its peer participant depending on the attribute status on the device.

- If the VLAN in the Leave message is a dynamic VLAN not registered by any participants on the device, both of the following events occur:
  - The VLAN is deleted on the device.
  - The participant sends the Leave message to its peer participant.
- If the VLAN in the Leave message is a static VLAN, the participant will not send the Leave message to its peer participant.

LeaveAll message

Each MRP participant starts its LeaveAll timer when starting up. When the timer expires, the MRP participant sends LeaveAll messages to the peer participant.

Upon sending or receiving a LeaveAll message, the local participant starts the Leave timer. The local participant determines whether to send a Join message depending on its attribute status. A participant can re-register the attributes in the received Join message before the Leave timer expires.

When the Leave timer expires, a participant deregisters all attributes that have not been re-registered to periodically clear useless attributes in the network.

MRP timers

MRP uses the following timers to control message transmission.

Periodic timer

The Periodic timer controls the transmission of MRP messages. An MRP participant starts its own Periodic timer upon startup, and stores MRP messages to be sent before the Periodic timer expires. When the Periodic timer expires, MRP sends stored MRP messages in as few MRP frames as possible and restarts the Periodic timer. This mechanism reduces the number of MRP frames sent.

You can enable or disable the Periodic timer. When the Periodic timer is disabled, MRP does not periodically send MRP messages. Instead, an MRP participant sends MRP messages when the LeaveAll timer expires or the participant receives a LeaveAll message from the peer participant.

Join timer

The Join timer controls the transmission of Join messages. An MRP participant starts the Join timer after sending a Join message to the peer participant. Before the Join timer expires, the participant does not resend the Join message when the following conditions exist:

- The participant receives a JoinIn message from the peer participant.
- The received JoinIn message has the same attributes as the sent Join message.

When both the Join timer and the Periodic timer expire, the participant resends the Join message.

Leave timer

The Leave timer controls the deregistration of attributes.

An MRP participant starts the Leave timer in one of the following conditions:

- The participant receives a Leave message from its peer participant.
- The participant receives or sends a LeaveAll message.

The MRP participant does not deregister the attributes in the Leave or LeaveAll message if the following conditions exist:

- The participant receives a Join message before the Leave timer expires.
- The Join message includes the attributes that have been encapsulated in the Leave or LeaveAll message.

If the participant does not receive a Join message for these attributes before the Leave timer expires, MRP deregisters the attributes.

LeaveAll timer

After startup, an MRP participant starts its own LeaveAll timer. When the LeaveAll timer expires, the MRP participant sends out a LeaveAll message and restarts the LeaveAll timer.

Upon receiving the LeaveAll message, other participants restart their LeaveAll timer. The value of the LeaveAll timer is randomly selected between the LeaveAll timer and 1.5 times the LeaveAll timer. This mechanism provides the following benefits:

- Effectively reduces the number of LeaveAll messages in the network.
- Prevents the LeaveAll timer of a particular participant from always expiring first.

MVRP registration modes

VLAN information propagated by MVRP includes dynamic VLAN information from other devices and local static VLAN information.

Based on how an MVRP participant handles registration of dynamic VLANs, MVRP has the following registration modes:

- **Normal**—An MVRP participant in normal registration mode registers and deregisters dynamic VLANs.
- **Fixed**—An MVRP participant in fixed registration mode disables deregistering dynamic VLANs and drops received MVRP frames. The MVRP participant does not deregister dynamic VLANs or register new dynamic VLANs.
- **Forbidden**—An MVRP participant in forbidden registration mode disables registering dynamic VLANs and drops received MVRP frames. When you set the forbidden registration mode for a port, VLAN 1 of the port retains and all dynamically registered VLANs of the port will be deleted.

Protocols and standards

IEEE 802.1ak, *IEEE Standard for Local and Metropolitan Area Networks: Virtual Bridged Local Area Networks – Amendment 07: Multiple Registration Protocol*

Restrictions and guidelines: MVRP configuration

When you configure MVRP, follow these restrictions and guidelines:

- MVRP can work with STP, RSTP, or MSTP. Ports blocked by STP, RSTP, or MSTP can receive and send MVRP frames. Do not configure MVRP with other link layer topology protocols, such as PVST, RRPP, and Smart Link.

  For more information about STP, RSTP, MSTP, and PVST, see "Configuring spanning tree protocols." For more information about RRPP and Smart Link, see *High Availability Configuration Guide*.
- Do not configure both MVRP and remote port mirroring on a port. Otherwise, MVRP might register the remote probe VLAN with incorrect ports, which would cause the monitor port to receive undesired copies. For more information about port mirroring, see *Network Management and Monitoring Configuration Guide*.
- Enabling MVRP on a Layer 2 aggregate interface takes effect on the aggregate interface and all Selected member ports in the link aggregation group.
- MVRP configuration made on an aggregation group member port takes effect only after the port is removed from the aggregation group.

MVRP tasks at a glance

To configure MVRP, perform the following tasks:

1. Enabling MVRP
2. Setting an MVRP registration mode
3. (Optional.) Setting MRP timers
4. (Optional.) Enabling GVRP compatibility

Prerequisites

Before you configure MVRP, complete the following tasks:

- Map each MSTI used by MVRP to an existing VLAN on each device in the network.
- Set the port link type of MVRP participants to trunk because MVRP takes effect only on trunk ports. For more information about trunk ports, see "Configuring VLANs."

Enabling MVRP

1. Enter system view.
   system-view
2. Enable MVRP globally.
   mvrp global enable
   By default, MVRP is globally disabled.
   For MVRP to take effect on a port, enable MVRP both on the port and globally.
3. Enter Layer 2 Ethernet interface view or Layer 2 aggregate interface view.
   interface *interface-type interface-number*
4. Configure the port as a trunk port.
   port link-type trunk
   By default, each port is an access port. For more information about the **port link-type trunk** command, see *Layer 2—LAN Switching Command Reference*.
5. Configure the trunk port to permit the specified VLANs.
   port trunk permit vlan { *vlan-id-list* | **all** }
   By default, a trunk port permits only VLAN 1.
   Make sure the trunk port permits all registered VLANs.
   For more information about the **port trunk permit vlan** command, see *Layer 2—LAN Switching Command Reference*.
6. Enable MVRP on the port.
   mvrp enable
   By default, MVRP is disabled on a port.

Setting an MVRP registration mode

1. Enter system view.
   system-view
2. Enter Layer 2 Ethernet interface view or Layer 2 aggregate interface view.
   interface *interface-type interface-number*
3. Set an MVRP registration mode for the port.
   mvrp registration { **fixed** | **forbidden** | **normal** }
   The default setting is normal registration mode.

Setting MRP timers

Restrictions and guidelines

When you set MVRP timers, follow these restrictions and guidelines:

- Follow the value range requirements for Join, Leave, and LeaveAll timers and their dependencies as described in Table 1. If you set a timer to a value beyond the allowed value range, your configuration fails. You can set a timer by tuning the value of any other timer. The value of each timer must be an integer multiple of 20 centiseconds.

Table 1 Dependencies of the Join, Leave, and LeaveAll timers

Timer	Lower limit	Upper limit
Join	20 centiseconds	Half the Leave timer
Leave	Twice the Join timer	LeaveAll timer
LeaveAll	Leave timer on each port	32760 centiseconds

- To avoid frequent VLAN registrations and deregistrations, use the same MRP timers throughout the network.
- Each port maintains its own Periodic, Join, and LeaveAll timers, and each attribute of a port maintains a Leave timer.
- As a best practice, restore the timers in the order of Join, Leave, and LeaveAll when you restore these timers to their default values.
- You can restore the Periodic timer to its default value at any time.

Procedure

1. Enter system view.
   `system-view`
2. Enter Layer 2 Ethernet interface view or Layer 2 aggregate interface view.
   `interface` *`interface-type interface-number`*
3. Set the LeaveAll timer.
   `mrp timer leaveall` *`timer-value`*
   The default setting is 1000 centiseconds.
4. Set the Join timer.
   `mrp timer join` *`timer-value`*
   The default setting is 20 centiseconds.
5. Set the Leave timer.
   `mrp timer leave` *`timer-value`*
   The default setting is 60 centiseconds.
6. Set the Periodic timer.
   `mrp timer periodic` *`timer-value`*
   The default setting is 100 centiseconds.

Enabling GVRP compatibility

About GVRP compatibility

Perform this task to enable the device to receive and send both MVRP and GVRP frames when the peer device supports GVRP. For more information about GVRP, see the IEEE 802.1Q standard.

Restrictions and guidelines

When you enable GVRP compatibility, follow these restrictions and guidelines:

- GVRP compatibility enables MVRP to work with STP or RSTP, but not MSTP.
- When the system is busy, disable the Period timer to prevent the participant from frequently registering or deregistering attributes.

Procedure

1. Enter system view.

system-view

2. Enable GVRP compatibility.

   mvrp gvrp-compliance enable

   By default, GVRP compatibility is disabled.

Display and maintenance commands for MVRP

Execute **display** commands in any view and **reset** commands in user view.

Task	Command
Display MVRP running status.	**display mvrp running-status** [**interface** *interface-list*]
Display the MVRP state of a port in a VLAN.	**display mvrp state interface** *interface-type interface-number* **vlan** *vlan-id*
Display MVRP statistics.	**display mvrp statistics** [**interface** *interface-list*]
Clear MVRP statistics.	**reset mvrp statistics** [**interface** *interface-list*]

MVRP configuration examples

Example: Configuring basic MVRP functions

Network configuration

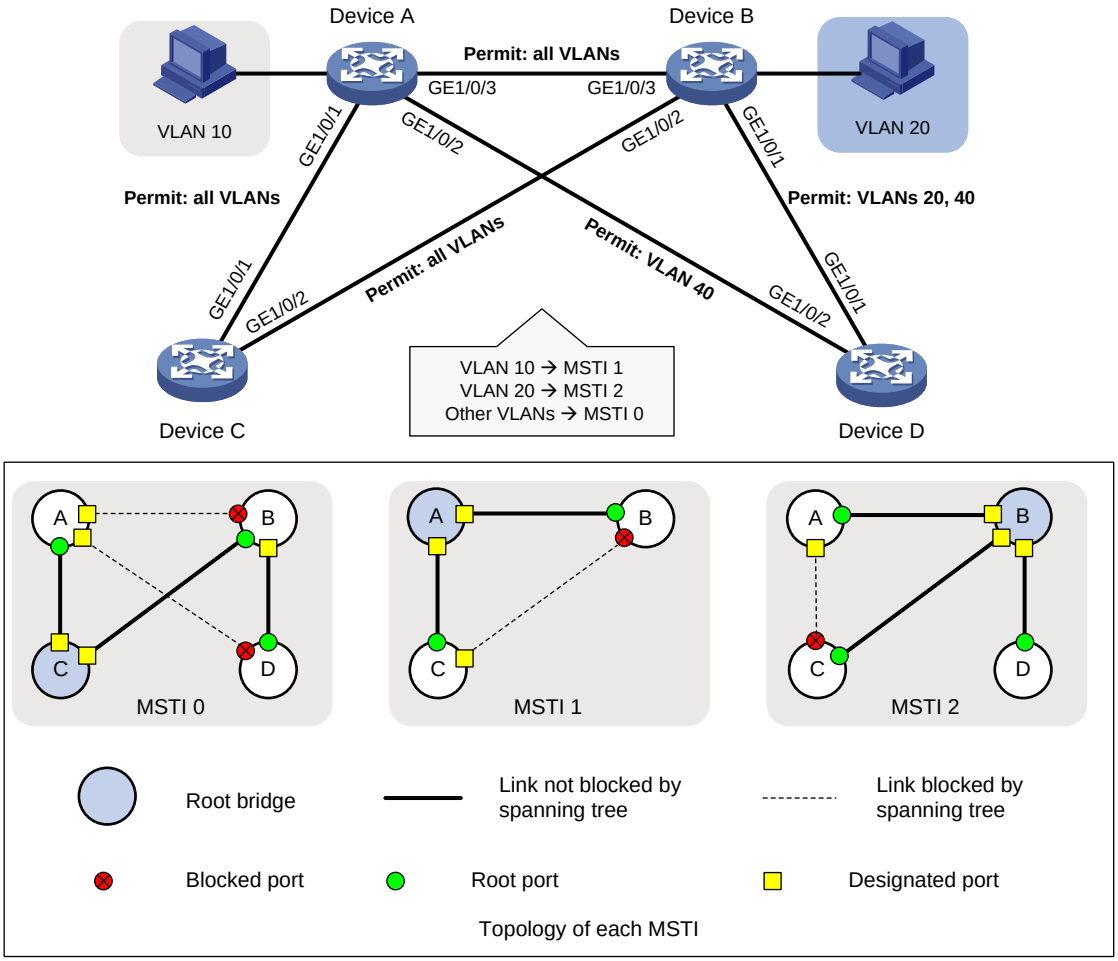
As shown in Figure 2:

- Create VLAN 10 on Device A and VLAN 20 on Device B.
- Configure MSTP, map VLAN 10 to MSTI 1, map VLAN 20 to MSTI 2, and map the other VLANs to MSTI 0.

Configure MVRP on Device A, Device B, Device C, and Device D to meet the following requirements:

- The devices can register and deregister dynamic VLANs.
- The devices can keep identical VLAN configurations for each MSTI.

Figure 2 Network diagram



Procedure

1. Configure Device A:

Enter MST region view.

```
<DeviceA> system-view
[DeviceA] stp region-configuration
```

Configure the MST region name, VLAN-to-instance mappings, and revision level.

```
[DeviceA-mst-region] region-name example
[DeviceA-mst-region] instance 1 vlan 10
[DeviceA-mst-region] instance 2 vlan 20
[DeviceA-mst-region] revision-level 0
```

Manually activate the MST region configuration.

```
[DeviceA-mst-region] active region-configuration
[DeviceA-mst-region] quit
```

Configure Device A as the primary root bridge of MSTI 1.

```
[DeviceA] stp instance 1 root primary
```

Globally enable the spanning tree feature.

```
[DeviceA] stp global enable
```

Globally enable MVRP.

```
[DeviceA] mvrp global enable
```

Configure GigabitEthernet 1/0/1 as a trunk port, and configure it to permit all VLANs.

```
[DeviceA] interface gigabitethernet 1/0/1
[DeviceA-GigabitEthernet1/0/1] port link-type trunk
[DeviceA-GigabitEthernet1/0/1] port trunk permit vlan all
```

Enable MVRP on GigabitEthernet 1/0/1.

```
[DeviceA-GigabitEthernet1/0/1] mvrp enable
[DeviceA-GigabitEthernet1/0/1] quit
```

Configure GigabitEthernet 1/0/2 as a trunk port, and configure it to permit VLAN 40.

```
[DeviceA] interface gigabitethernet 1/0/2
[DeviceA-GigabitEthernet1/0/2] port link-type trunk
[DeviceA-GigabitEthernet1/0/2] port trunk permit vlan 40
```

Enable MVRP on GigabitEthernet 1/0/2.

```
[DeviceA-GigabitEthernet1/0/2] mvrp enable
[DeviceA-GigabitEthernet1/0/2] quit
```

Configure GigabitEthernet 1/0/3 as a trunk port, and configure it to permit all VLANs.

```
[DeviceA] interface gigabitethernet 1/0/3
[DeviceA-GigabitEthernet1/0/3] port link-type trunk
[DeviceA-GigabitEthernet1/0/3] port trunk permit vlan all
```

Enable MVRP on GigabitEthernet 1/0/3.

```
[DeviceA-GigabitEthernet1/0/3] mvrp enable
[DeviceA-GigabitEthernet1/0/3] quit
```

Create VLAN 10.

```
[DeviceA] vlan 10
[DeviceA-vlan10] quit
```

2. Configure Device B:

Enter MST region view.

```
<DeviceB> system-view
[DeviceB] stp region-configuration
```

Configure the MST region name, VLAN-to-instance mappings, and revision level.

```
[DeviceB-mst-region] region-name example
[DeviceB-mst-region] instance 1 vlan 10
[DeviceB-mst-region] instance 2 vlan 20
[DeviceB-mst-region] revision-level 0
```

Manually activate the MST region configuration.

```
[DeviceB-mst-region] active region-configuration
[DeviceB-mst-region] quit
```

Configure Device B as the primary root bridge of MSTI 2.

```
[DeviceB] stp instance 2 root primary
```

Globally enable the spanning tree feature.

```
[DeviceB] stp global enable
```

Globally enable MVRP.

```
[DeviceB] mvrp global enable
```

Configure GigabitEthernet 1/0/1 as a trunk port, and configure it to permit VLANs 20 and 40.

```
[DeviceB] interface gigabitethernet 1/0/1
[DeviceB-GigabitEthernet1/0/1] port link-type trunk
[DeviceB-GigabitEthernet1/0/1] port trunk permit vlan 20 40
```

Enable MVRP on GigabitEthernet 1/0/1.

```
[DeviceB-GigabitEthernet1/0/1] mvrp enable
[DeviceB-GigabitEthernet1/0/1] quit
```

Configure GigabitEthernet 1/0/2 as a trunk port, and configure it to permit all VLANs.

```
[DeviceB] interface gigabitethernet 1/0/2
[DeviceB-GigabitEthernet1/0/2] port link-type trunk
[DeviceB-GigabitEthernet1/0/2] port trunk permit vlan all
```

Enable MVRP on GigabitEthernet 1/0/2.

```
[DeviceB-GigabitEthernet1/0/2] mvrp enable
[DeviceB-GigabitEthernet1/0/2] quit
```

Configure GigabitEthernet 1/0/3 as a trunk port, and configure it to permit all VLANs.

```
[DeviceB] interface gigabitethernet 1/0/3
[DeviceB-GigabitEthernet1/0/3] port link-type trunk
[DeviceB-GigabitEthernet1/0/3] port trunk permit vlan all
```

Enable MVRP on GigabitEthernet 1/0/3.

```
[DeviceB-GigabitEthernet1/0/3] mvrp enable
[DeviceB-GigabitEthernet1/0/3] quit
```

Create VLAN 20.

```
[DeviceB] vlan 20
[DeviceB-vlan20] quit
```

3. Configure Device C:

Enter MST region view.

```
<DeviceC> system-view
[DeviceC] stp region-configuration
```

Configure the MST region name, VLAN-to-instance mappings, and revision level.

```
[DeviceC-mst-region] region-name example
[DeviceC-mst-region] instance 1 vlan 10
[DeviceC-mst-region] instance 2 vlan 20
[DeviceC-mst-region] revision-level 0
```

Manually activate the MST region configuration.

```
[DeviceC-mst-region] active region-configuration
[DeviceC-mst-region] quit
```

Configure Device C as the root bridge of MSTI 0.

```
[DeviceC] stp instance 0 root primary
```

Globally enable the spanning tree feature.

```
[DeviceC] stp global enable
```

Globally enable MVRP.

```
[DeviceC] mvrp global enable
```

Configure GigabitEthernet 1/0/1 as a trunk port, and configure it to permit all VLANs.

```
[DeviceC] interface gigabitethernet 1/0/1
[DeviceC-GigabitEthernet1/0/1] port link-type trunk
[DeviceC-GigabitEthernet1/0/1] port trunk permit vlan all
```

Enable MVRP on GigabitEthernet 1/0/1.

```
[DeviceC-GigabitEthernet1/0/1] mvrp enable
[DeviceC-GigabitEthernet1/0/1] quit
```

Configure GigabitEthernet 1/0/2 as a trunk port, and configure it to permit all VLANs.

```
[DeviceC] interface gigabitethernet 1/0/2
[DeviceC-GigabitEthernet1/0/2] port link-type trunk
```

```
[DeviceC-GigabitEthernet1/0/2] port trunk permit vlan all
```

Enable MVRP on GigabitEthernet 1/0/2.

```
[DeviceC-GigabitEthernet1/0/2] mvrp enable
[DeviceC-GigabitEthernet1/0/2] quit
```

4. Configure Device D:

Enter MST region view.

```
<DeviceD> system-view
[DeviceD] stp region-configuration
```

Configure the MST region name, VLAN-to-instance mappings, and revision level.

```
[DeviceD-mst-region] region-name example
[DeviceD-mst-region] instance 1 vlan 10
[DeviceD-mst-region] instance 2 vlan 20
[DeviceD-mst-region] revision-level 0
```

Manually activate the MST region configuration.

```
[DeviceD-mst-region] active region-configuration
[DeviceD-mst-region] quit
```

Globally enable the spanning tree feature.

```
[DeviceD] stp global enable
```

Globally enable MVRP.

```
[DeviceD] mvrp global enable
```

Configure GigabitEthernet 1/0/1 as a trunk port, and configure it to permit VLANs 20 and 40.

```
[DeviceD] interface gigabitethernet 1/0/1
[DeviceD-GigabitEthernet1/0/1] port link-type trunk
[DeviceD-GigabitEthernet1/0/1] port trunk permit vlan 20 40
```

Enable MVRP on GigabitEthernet 1/0/1.

```
[DeviceD-GigabitEthernet1/0/1] mvrp enable
[DeviceD-GigabitEthernet1/0/1] quit
```

Configure GigabitEthernet 1/0/2 as a trunk port, and configure it to permit VLAN 40.

```
[DeviceD] interface gigabitethernet 1/0/2
[DeviceD-GigabitEthernet1/0/2] port link-type trunk
[DeviceD-GigabitEthernet1/0/2] port trunk permit vlan 40
```

Enable MVRP on GigabitEthernet 1/0/2.

```
[DeviceD-GigabitEthernet1/0/2] mvrp enable
[DeviceD-GigabitEthernet1/0/2] quit
```

Verifying the configuration

1. Verify the normal registration mode configuration.

Display local VLAN information on Device A.

```
[DeviceA] display mvrp running-status
 -------[MVRP Global Info]-------
 Global Status     : Enabled
 Compliance-GVRP   : False

 ----[GigabitEthernet1/0/1]----
 Config  Status                 : Enabled
 Running Status                 : Enabled
 Join Timer                     : 20 (centiseconds)
 Leave Timer                    : 60 (centiseconds)
```

```
Periodic Timer                : 100 (centiseconds)
LeaveAll Timer                : 1000 (centiseconds)
Registration Type             : Normal
Registered VLANs :
 1(default)
Declared VLANs :
 1(default), 10, 20
Propagated VLANs :
 1(default)

----[GigabitEthernet1/0/2]----
Config  Status                : Enabled
Running Status                : Enabled
Join Timer                    : 20 (centiseconds)
Leave Timer                   : 60 (centiseconds)
Periodic Timer                : 100 (centiseconds)
LeaveAll Timer                : 1000 (centiseconds)
Registration Type             : Normal
Registered VLANs :
 None
Declared VLANs :
 1(default)
Propagated VLANs :
 None

----[GigabitEthernet1/0/3]----
Config  Status                : Enabled
Running Status                : Enabled
Join Timer                    : 20 (centiseconds)
Leave Timer                   : 60 (centiseconds)
Periodic Timer                : 100 (centiseconds)
LeaveAll Timer                : 1000 (centiseconds)
Registration Type             : Normal
Registered VLANs :
 20
Declared  VLANs :
 1(default), 10
Propagated VLANs :
 20
```

The output shows that the following events have occurred:

- GigabitEthernet 1/0/1 has registered VLAN 1, declared VLAN 1, VLAN 10, and VLAN 20, and propagated VLAN 1 through MVRP.
- GigabitEthernet 1/0/2 has declared VLAN 1, and registered and propagated no VLANs.
- GigabitEthernet 1/0/3 has registered VLAN 20, declared VLAN 1 and VLAN 10, and propagated VLAN 20 through MVRP.

Display local VLAN information on Device B.

```
[DeviceB] display mvrp running-status
 -------[MVRP Global Info]-------
```

```
Global Status     : Enabled
Compliance-GVRP   : False

----[GigabitEthernet1/0/1]----
Config  Status                 : Enabled
Running Status                 : Enabled
Join Timer                     : 20 (centiseconds)
Leave Timer                    : 60 (centiseconds)
Periodic Timer                 : 100 (centiseconds)
LeaveAll Timer                 : 1000 (centiseconds)
Registration Type              : Normal
Registered VLANs :
 1(default)
Declared VLANs :
 1(default), 20
Propagated VLANs :
 1(default)

----[GigabitEthernet1/0/2]----
Config  Status                 : Enabled
Running Status                 : Enabled
Join Timer                     : 20 (centiseconds)
Leave Timer                    : 60 (centiseconds)
Periodic Timer                 : 100 (centiseconds)
LeaveAll Timer                 : 1000 (centiseconds)
Registration Type              : Normal
Registered VLANs :
 1(default), 10
Declared VLANs :
 1(default), 20
Propagated VLANs :
 1(default)

----[GigabitEthernet1/0/3]----
Config  Status                 : Enabled
Running Status                 : Enabled
Join Timer                     : 20 (centiseconds)
Leave Timer                    : 60 (centiseconds)
Periodic Timer                 : 100 (centiseconds)
LeaveAll Timer                 : 1000 (centiseconds)
Registration Type              : Normal
Registered VLANs :
 1(default), 10
Declared VLANs :
 20
Propagated VLANs :
 10
```

The output shows that the following events have occurred:

- GigabitEthernet 1/0/1 has registered VLAN 1, declared VLAN 1 and VLAN 20, and propagated VLAN 1 through MVRP.
- GigabitEthernet 1/0/2 has registered VLAN 1 and VLAN 10, declared VLAN 1 and VLAN 20, and propagated VLAN 1.
- GigabitEthernet 1/0/3 has registered VLAN 1 and VLAN 10, declared VLAN 20, and propagated VLAN 10 through MVRP.

Display local VLAN information on Device C.

```
[DeviceC] display mvrp running-status
 -------[MVRP Global Info]-------
 Global Status     : Enabled
 Compliance-GVRP   : False

 ----[GigabitEthernet1/0/1]----
 Config  Status                 : Enabled
 Running Status                 : Enabled
 Join Timer                     : 20 (centiseconds)
 Leave Timer                    : 60 (centiseconds)
 Periodic Timer                 : 100 (centiseconds)
 LeaveAll Timer                 : 1000 (centiseconds)
 Registration Type              : Normal
 Registered VLANs :
  1(default), 10, 20
 Declared VLANs :
  1(default)
 Propagated VLANs :
  1(default), 10

 ----[GigabitEthernet1/0/2]----
 Config  Status                 : Enabled
 Running Status                 : Enabled
 Join Timer                     : 20 (centiseconds)
 Leave Timer                    : 60 (centiseconds)
 Periodic Timer                 : 100 (centiseconds)
 LeaveAll Timer                 : 1000 (centiseconds)
 Registration Type              : Normal
 Registered VLANs :
  1(default), 20
 Declared VLANs :
  1(default), 10
 Propagated VLANs :
  1(default), 20
```

The output shows that the following events have occurred:

- GigabitEthernet 1/0/1 has registered VLAN 1, VLAN 10, and VLAN 20, declared VLAN 1, and propagated VLAN 1 and VLAN 10 through MVRP.
- GigabitEthernet 1/0/2 has registered VLAN 1 and VLAN 20, declared VLAN 1 and VLAN 10, and propagated VLAN 1 and VLAN 20 through MVRP.

Display local VLAN information on Device D.

```
[DeviceD] display mvrp running-status
 -------[MVRP Global Info]-------
```

```
Global Status     : Enabled
Compliance-GVRP   : False

----[GigabitEthernet1/0/1]----
Config  Status                 : Enabled
Running Status                 : Enabled
Join Timer                     : 20 (centiseconds)
Leave Timer                    : 60 (centiseconds)
Periodic Timer                 : 100 (centiseconds)
LeaveAll Timer                 : 1000 (centiseconds)
Registration Type              : Normal
Registered VLANs :
 1(default), 20
Declared VLANs :
 1(default)
Propagated VLANs :
 1(default), 20

----[GigabitEthernet1/0/2]----
Config  Status                 : Enabled
Running Status                 : Enabled
Join Timer                     : 20 (centiseconds)
Leave Timer                    : 60 (centiseconds)
Periodic Timer                 : 100 (centiseconds)
LeaveAll Timer                 : 1000 (centiseconds)
Registration Type              : Normal
Registered VLANs :
 1(default)
Declared  VLANs :
 None
Propagated VLANs :
 None
```

The output shows that the following events have occurred:

- GigabitEthernet 1/0/1 has registered and propagated VLAN 10 and VLAN 20, and declared VLAN 1 through MVRP.
- GigabitEthernet 1/0/2 has registered VLAN 1, and declared and propagated no VLANs through MVRP.

2. Verify the configuration after changing the registration mode.

When the network is stable, set the MVRP registration mode to **fixed** on the port of Device B connected to Device A. Then, verify that dynamic VLANs on the port will not be deregistered.

Set the MVRP registration mode to **fixed** on GigabitEthernet 1/0/3 of Device B.

```
[DeviceB] interface gigabitethernet 1/0/3
[DeviceB-GigabitEthernet1/0/3] mvrp registration fixed
[DeviceB-GigabitEthernet1/0/3] quit
```

Display local MVRP VLAN information on GigabitEthernet 1/0/3.

```
[DeviceB] display mvrp running-status interface gigabitethernet 1/0/3
 -------[MVRP Global Info]-------
 Global Status     : Enabled
```

```
 Compliance-GVRP   : False

 ----[GigabitEthernet1/0/3]----
 Config  Status                 : Enabled
 Running Status                 : Enabled
 Join Timer                     : 20 (centiseconds)
 Leave Timer                    : 60 (centiseconds)
 Periodic Timer                 : 100 (centiseconds)
 LeaveAll Timer                 : 1000 (centiseconds)
 Registration Type              : Fixed
 Registered VLANs :
  1(default), 10
 Declared VLANs :
  20
 Propagated VLANs :
  10
```

The output shows that VLAN information on GigabitEthernet 1/0/3 is not changed after you set its MVRP registration mode to **fixed**.

Delete VLAN 10 on Device A.

```
[DeviceA] undo vlan 10
```

Display local MVRP VLAN information on GigabitEthernet 1/0/3 of Device B.

```
[DeviceB] display mvrp running-status interface gigabitethernet 1/0/3
 -------[MVRP Global Info]-------
 Global Status     : Enabled
 Compliance-GVRP   : False

 ----[GigabitEthernet1/0/3]----
 Config  Status                 : Enabled
 Running Status                 : Enabled
 Join Timer                     : 20 (centiseconds)
 Leave Timer                    : 60 (centiseconds)
 Periodic Timer                 : 100 (centiseconds)
 LeaveAll Timer                 : 1000 (centiseconds)
 Registration Type              : Fixed
 Registered VLANs :
  1(default), 10
 Declared VLANs :
  20
 Propagated VLANs :
  10
```

The output shows that dynamic VLAN information on GigabitEthernet 1/0/3 is not changed after you set its MVRP registration mode to **fixed**.

Contents

Configuring QinQ

This document uses the following terms:

- **CVLAN**—Customer network VLANs, also called inner VLANs, refer to VLANs that a customer uses on the private network.
- **SVLAN**—Service provider network VLANs, also called outer VLANs, refer to VLANs that a service provider uses to transmit VLAN tagged traffic for customers.

About QinQ

802.1Q-in-802.1Q (QinQ) adds an 802.1Q tag to 802.1Q tagged customer traffic. It enables a service provider to extend Layer 2 connections across an Ethernet network between customer sites.

QinQ benefits

QinQ provides the following benefits:

- Enables a service provider to use a single SVLAN to convey multiple CVLANs for a customer.
- Enables customers to plan CVLANs without conflicting with SVLANs.
- Enables customers to keep their VLAN assignment schemes unchanged when the service provider changes its VLAN assignment scheme.
- Allows different customers to use overlapping CVLAN IDs. Devices in the service provider network make forwarding decisions based on SVLAN IDs instead of CVLAN IDs.

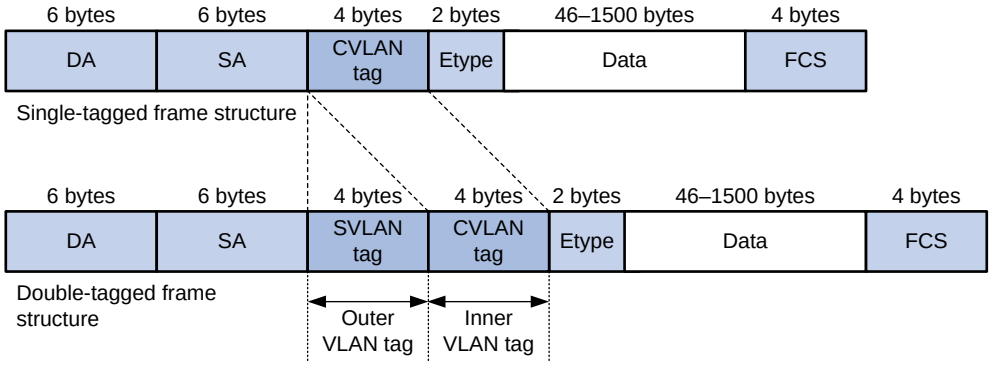
How QinQ works

As shown in Figure 1, a QinQ frame transmitted over the service provider network carries the following tags:

- **CVLAN tag**—Identifies the VLAN to which the frame belongs when it is transmitted in the customer network.
- **SVLAN tag**—Identifies the VLAN to which the QinQ frame belongs when it is transmitted in the service provider network. The service provider allocates the SVLAN tag to the customer.

The devices in the service provider network forward a tagged frame according to its SVLAN tag only. The CVLAN tag is transmitted as part of the frame's payload.

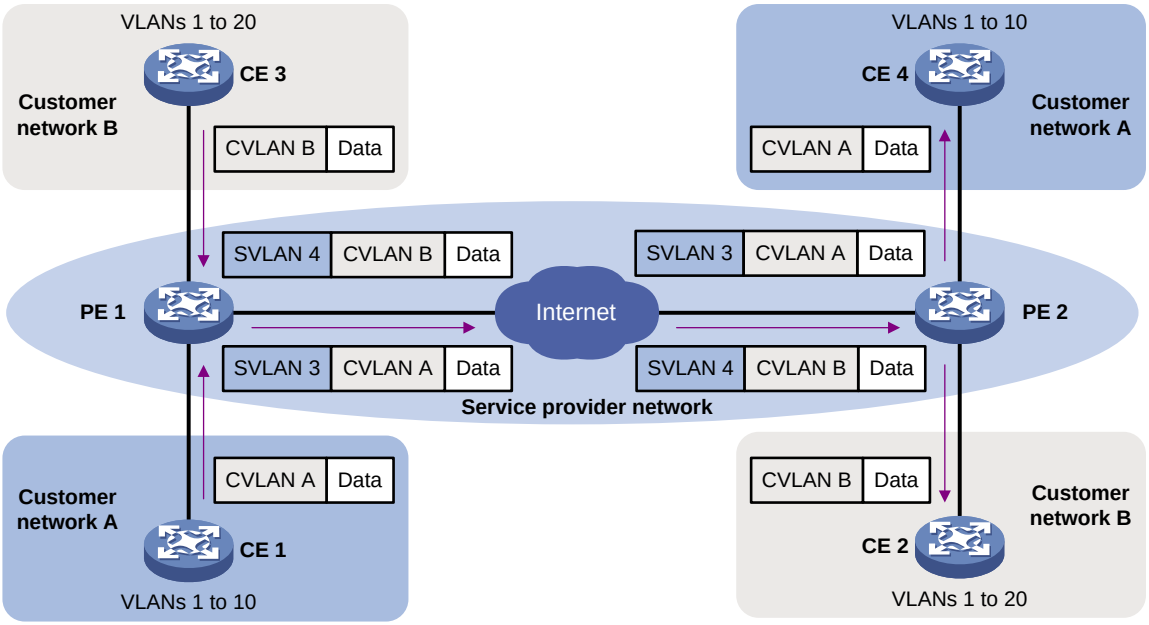
Figure 1 Single-tagged Ethernet frame header and double-tagged Ethernet frame header



As shown in Figure 2, customer A has remote sites CE 1 and CE 4. Customer B has remote sites CE 2 and CE 3. The CVLANs of the two customers overlap. The service provider assigns SVLANs 3 and 4 to customers A and B, respectively.

When a tagged Ethernet frame from CE 1 arrives at PE 1, the PE tags the frame with SVLAN 3. The double-tagged Ethernet frame travels over the service provider network until it arrives at PE 2. PE 2 removes the SVLAN tag of the frame, and then sends the frame to CE 4.

Figure 2 Typical QinQ application scenario



QinQ implementations

QinQ is enabled on a per-port basis. The link type of a QinQ-enabled port can be access, hybrid, or trunk. The QinQ tagging behaviors are the same across these types of ports.

A QinQ-enabled port tags all incoming frames (tagged or untagged) with the PVID tag.

- If an incoming frame already has one tag, it becomes a double-tagged frame.
- If the frame does not have any 802.1Q tags, it becomes a frame tagged with the PVID.

QinQ provides the most basic VLAN manipulation method to tag all incoming frames (tagged or untagged) with the PVID tag. To perform advanced VLAN manipulations, use VLAN mappings or QoS policies as follows:

- To add different SVLANs for different CVLAN tags, use one-to-two VLAN mappings.
- To use criteria other than the CVLAN ID to match packets for SVLAN tagging, use the QoS nest action. The QoS nest action can also be used with other actions in the same traffic behavior.

For more information about VLAN mappings, see "Configuring VLAN mapping." For more information about QoS, see *ACL and QoS Configuration Guide*.

Protocols and standards

- IEEE 802.1Q, *IEEE Standard for Local and Metropolitan Area Networks-Virtual Bridged Local Area Networks*
- IEEE 802.1ad, *IEEE Standard for Local and Metropolitan Area Networks-Virtual Bridged Local Area Networks-Amendment 4: Provider Bridges*

Restrictions: Hardware compatibility with QinQ

The S5110V2-SI, S5000V3-EI, S5000V5-EI, S5000E-X, S5000X-EI, and WAS6000 switch series do not support QinQ.

Restrictions and guidelines: QinQ configuration

When you configure QinQ, follow these restrictions and guidelines:

- The inner 802.1Q tag of QinQ frames is treated as part of the payload. As a best practice to ensure correct transmission of QinQ frames, set the MTU to a minimum of 1504 bytes for each port on their forwarding path. This value is the sum of the default Ethernet interface MTU (1500 bytes) and the length (4 bytes) of a VLAN tag.
- You can use a VLAN mapping and QinQ on a port for VLAN tag manipulation. If their settings conflict, the VLAN mapping has higher priority.
- Do not enable QinQ and apply a QoS policy containing a nesting action on the same interface. Otherwise, QinQ or the QoS policy might not take effect.

Enabling QinQ

About enabling QinQ

Enable QinQ on customer-side ports of PEs. A QinQ-enabled port tags an incoming frame with its PVID.

Restrictions and guidelines

Before you enable or disable QinQ on a port, you must remove any VLAN mappings on the port. For more information about VLAN mapping, see *Layer 2—LAN Switching Configuration Guide*.

Procedure

1. Enter system view.

   system-view
2. Enter Layer 2 Ethernet interface view or Layer 2 aggregate interface view.

   interface *interface-type interface-number*
3. Set the port link type.

   port link-type { **access** | **hybrid** | **trunk** }

   By default, the link type of a port is **access**.
4. Configure the port to allow packets from its PVID to pass through.
   - Assign the access port to the specified VLAN.

     port access vlan *vlan-id*

     By default, all access ports belong to VLAN 1.

     The PVID of an access port is the VLAN to which the port belongs. The port sends packets from the VLAN untagged.
   - Configure the hybrid port to send packets from its PVID untagged.

     port hybrid vlan *vlan-id-list* **untagged**

     By default, the hybrid port is an untagged member of the VLAN to which the port belongs when its link type is access.
   - Configure trunk port to allow packets from its PVID to pass through.

     port trunk permit vlan { *vlan-id-list* | **all** }

By default, a trunk port allows packets only from VLAN 1 to pass through.

5. Enable QinQ on the port.

   qinq enable

   By default, QinQ is disabled on the port.

Configuring transmission for transparent VLANs

About transparent VLAN

You can exclude a VLAN (for example, the management VLAN) from the QinQ tagging action on a customer-side port. This VLAN is called a transparent VLAN.

Restrictions and guidelines

- Do not configure any other VLAN manipulation actions for the transparent VLAN on the port.
- Make sure all ports on the traffic path permit the transparent VLAN to pass through.
- If you use both transparent VLANs and VLAN mappings on an interface, the transparent VLANs cannot be the following VLANs:
  - Original or translated VLANs of one-to-one, one-to-two, and many-to-one VLAN mappings.
  - Original or translated outer VLANs of two-to-two VLAN mappings.

Procedure

1. Enter system view.

   system-view

2. Enter Layer 2 Ethernet interface view or Layer 2 aggregate interface view.

   interface *interface-type interface-number*

3. Set the port link type.

   port link-type { **hybrid** | **trunk** }

   By default, the link type of a port is **access**.

4. Configure the port to allow packets from the transparent VLANs to pass through.
   - Configure the hybrid port to allow packets from the transparent VLANs to pass through.

     port hybrid vlan *vlan-id-list* { **tagged** | **untagged** }

     By default, a hybrid port is an untagged member of the VLAN to which the port belongs when its link type is **access**.
   - Configure the trunk port to allow packets from the transparent VLANs to pass through.

     port trunk permit vlan { *vlan-id-list* | **all** }

     By default, a trunk port allows packets only from VLAN 1 to pass through.

5. Specify transparent VLANs for the port.

   qinq transparent-vlan *vlan-id-list*

   By default, transparent transmission is not configured for any VLANs.

Configuring the TPID for VLAN tags

About TPID

TPID identifies a frame as an 802.1Q tagged frame. The TPID value varies by vendor. On an H3C device, the TPID in the 802.1Q tag added on a QinQ-enabled port is 0x8100 by default, in

compliance with IEEE 802.1Q. In a multi-vendor network, make sure the TPID setting is the same between directly connected devices so 802.1Q tagged frames can be identified correctly.

TPID settings include CVLAN TPID and SVLAN TPID.

A QinQ-enabled port uses the CVLAN TPID to match incoming tagged frames. An incoming frame is handled as untagged if its TPID is different from the CVLAN TPID.

SVLAN TPIDs are configurable on a per-port basis. A service provider-side port uses the SVLAN TPID to replace the TPID in outgoing frames' SVLAN tags and match incoming tagged frames. An incoming frame is handled as untagged if the TPID in its outer VLAN tag is different from the SVLAN TPID.

For example, a PE device is connected to a customer device that uses the TPID 0x8200 and to a provider device that uses the TPID 0x9100. For correct packet processing, you must set the CVLAN TPID and SVLAN TPID to 0x8200 and 0x9100 on the PE, respectively.

The TPID field is at the same position as the EtherType field in an untagged Ethernet frame. To ensure correct packet type identification, do not set the TPID value to any of the values listed in Table 1.

Table 1 Reserved EtherType values

Protocol type	Value
ARP	0x0806
PUP	0x0200
RARP	0x8035
IP	0x0800
IPv6	0x86dd
PPPoE	0x8863/0x8864
MPLS	0x8847/0x8848
IPX/SPX	0x8137
IS-IS	0x8000
LACP	0x8809
LLDP	0x88cc
802.1X	0x888e
802.1ag	0x8902
Cluster	0x88a7
Reserved	0xfffd/0xfffe/0xffff

Restrictions and guidelines

The TPID value in CVLAN tags is typically configured on PEs. The TPID value in SVLAN tags is typically configured on the service provider-side ports of PEs.

Configuring the TPID for CVLAN tags

1. Enter system view.
   ```
   system-view
   ```
2. Set the TPID for CVLAN tags.

qinq ethernet-type customer-tag *hex-value*

By default, the TPID is 0x8100 for CVLAN tags.

Configuring the TPID for SVLAN tags

1. Enter system view.
   system-view
2. Enter Layer 2 Ethernet interface view or Layer 2 aggregate interface view.
   interface *interface-type interface-number*
3. Set the TPID for SVLAN tags.
   qinq ethernet-type service-tag *hex-value*
   By default, the TPID is 0x8100 for SVLAN tags.

Display and maintenance commands for QinQ

Execute **display** commands in any view.

Task	Command
Display QinQ-enabled ports.	**display qinq** [**interface** *interface-type interface-number*]

QinQ configuration examples

Example: Configuring basic QinQ

Network configuration

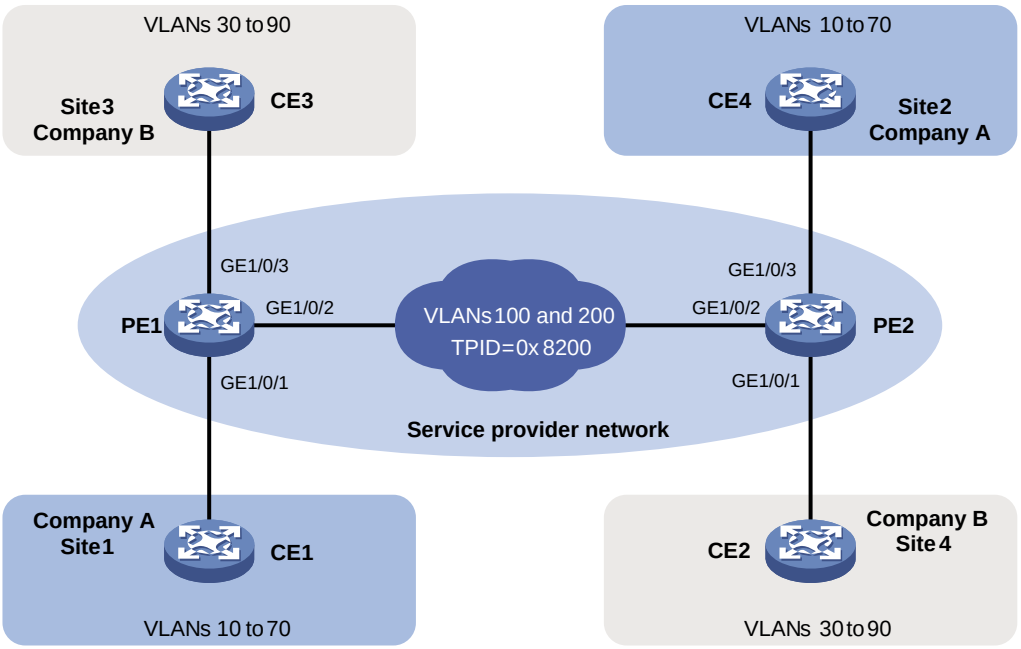
As shown in Figure 3:

- The service provider assigns VLAN 100 to Company A's VLANs 10 through 70.
- The service provider assigns VLAN 200 to Company B's VLANs 30 through 90.
- The devices between PE 1 and PE 2 in the service provider network use a TPID value of 0x8200.

Configure QinQ on PE 1 and PE 2 to transmit traffic in VLANs 100 and 200 for Company A and Company B, respectively.

For the QinQ frames to be identified correctly, set the SVLAN TPID to 0x8200 on the service provider-side ports of PE 1 and PE 2.

Figure 3 Network diagram



Procedure

1. Configure PE 1:

Configure GigabitEthernet 1/0/1 as a trunk port, and assign it to VLAN 100.

```
<PE1> system-view
[PE1] interface gigabitethernet 1/0/1
[PE1-GigabitEthernet1/0/1] port link-type trunk
[PE1-GigabitEthernet1/0/1] port trunk permit vlan 100
```

Set the PVID of GigabitEthernet 1/0/1 to VLAN 100.

```
[PE1-GigabitEthernet1/0/1] port trunk pvid vlan 100
```

Enable QinQ on GigabitEthernet 1/0/1.

```
[PE1-GigabitEthernet1/0/1] qinq enable
[PE1-GigabitEthernet1/0/1] quit
```

Configure GigabitEthernet 1/0/2 as a trunk port, and assign it to VLANs 100 and 200.

```
[PE1] interface gigabitethernet 1/0/2
[PE1-GigabitEthernet1/0/2] port link-type trunk
[PE1-GigabitEthernet1/0/2] port trunk permit vlan 100 200
```

Set the TPID value in the SVLAN tags to 0x8200 on GigabitEthernet 1/0/2.

```
[PE1-GigabitEthernet1/0/2] qinq ethernet-type service-tag 8200
[PE1-GigabitEthernet1/0/2] quit
```

Configure GigabitEthernet 1/0/3 as a trunk port, and assign it to VLAN 200.

```
[PE1] interface gigabitethernet 1/0/3
[PE1-GigabitEthernet1/0/3] port link-type trunk
[PE1-GigabitEthernet1/0/3] port trunk permit vlan 200
```

Set the PVID of GigabitEthernet 1/0/3 to VLAN 200.

```
[PE1-GigabitEthernet1/0/3] port trunk pvid vlan 200
```

Enable QinQ on GigabitEthernet 1/0/3.

```
[PE1-GigabitEthernet1/0/3] qinq enable
```

```
[PE1-GigabitEthernet1/0/3] quit
```

2. Configure PE 2:

   # Configure GigabitEthernet 1/0/1 as a trunk port, and assign it to VLAN 200.

```
<PE2> system-view
[PE2] interface gigabitethernet 1/0/1
[PE2-GigabitEthernet1/0/1] port link-type trunk
[PE2-GigabitEthernet1/0/1] port trunk permit vlan 200
```

   # Set the PVID of GigabitEthernet 1/0/1 to VLAN 200.

```
[PE2-GigabitEthernet1/0/1] port trunk pvid vlan 200
```

   # Enable QinQ on GigabitEthernet 1/0/1.

```
[PE2-GigabitEthernet1/0/1] qinq enable
[PE2-GigabitEthernet1/0/1] quit
```

   # Configure GigabitEthernet 1/0/2 as a trunk port, and assign it to VLANs 100 and 200.

```
[PE2] interface gigabitethernet 1/0/2
[PE2-GigabitEthernet1/0/2] port link-type trunk
[PE2-GigabitEthernet1/0/2] port trunk permit vlan 100 200
```

   # Set the TPID value in the SVLAN tags to 0x8200 on GigabitEthernet 1/0/2.

```
[PE2-GigabitEthernet1/0/2] qinq ethernet-type service-tag 8200
[PE2-GigabitEthernet1/0/2] quit
```

   # Configure GigabitEthernet 1/0/3 as a trunk port, and assign it to VLAN 100.

```
[PE2] interface gigabitethernet 1/0/3
[PE2-GigabitEthernet1/0/3] port link-type trunk
[PE2-GigabitEthernet1/0/3] port trunk permit vlan 100
```

   # Set the PVID of GigabitEthernet 1/0/3 to VLAN 100.

```
[PE2-GigabitEthernet1/0/3] port trunk pvid vlan 100
```

   # Enable QinQ on GigabitEthernet 1/0/3.

```
[PE2-GigabitEthernet1/0/3] qinq enable
[PE2-GigabitEthernet1/0/3] quit
```

3. Configure the devices between PE 1 and PE 2:

   # Set the MTU to a minimum of 1504 bytes for each port on the path of QinQ frames. (Details not shown.)

   # Configure all ports on the forwarding path to allow frames from VLANs 100 and 200 to pass through without removing the VLAN tag. (Details not shown.)

Example: Configuring VLAN transparent transmission

Network configuration

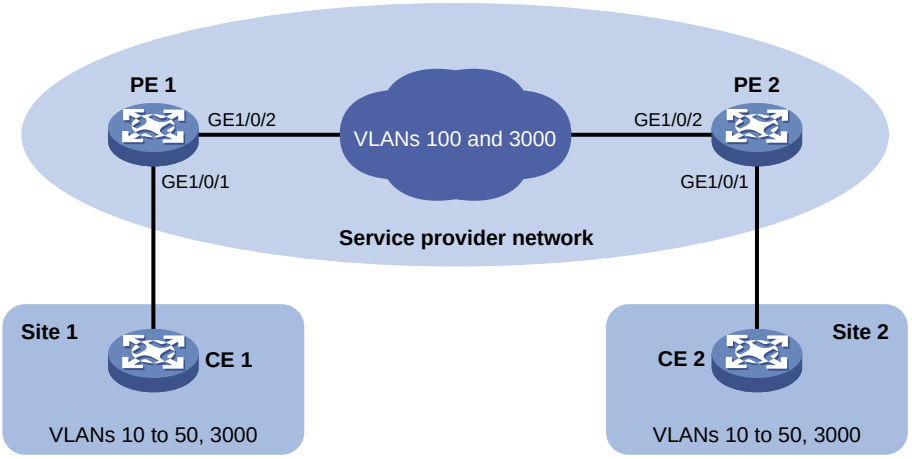
As shown in Figure 4:

- The service provider assigns VLAN 100 to a company's VLANs 10 through 50.
- VLAN 3000 is the dedicated VLAN of the company on the service provider network.

Configure QinQ on PE 1 and PE 2 to provide Layer 2 connectivity for CVLANs 10 through 50 over the service provider network.

Configure VLAN transparent transmission for VLAN 3000 on PE 1 and PE 2 to enable the hosts in VLAN 3000 to communicate without using an SVLAN.

Figure 4 Network diagram



Procedure

1. Configure PE 1:

Configure GigabitEthernet 1/0/1 as a trunk port, and assign it to VLAN 100 and VLAN 3000.

```
<PE1> system-view
[PE1] interface gigabitethernet 1/0/1
[PE1-GigabitEthernet1/0/1] port link-type trunk
[PE1-GigabitEthernet1/0/1] port trunk permit vlan 100 3000
```

Set the PVID of GigabitEthernet 1/0/1 to VLAN 100.

```
[PE1-GigabitEthernet1/0/1] port trunk pvid vlan 100
```

Enable QinQ on GigabitEthernet 1/0/1.

```
[PE1-GigabitEthernet1/0/1] qinq enable
```

Enable transparent transmission for VLAN 3000 on GigabitEthernet 1/0/1.

```
[PE1-GigabitEthernet1/0/1] qinq transparent-vlan 3000
[PE1-GigabitEthernet1/0/1] quit
```

Configure GigabitEthernet 1/0/2 as a trunk port, and assign it to VLANs 100 and 3000.

```
[PE1] interface gigabitethernet 1/0/2
[PE1-GigabitEthernet1/0/2] port link-type trunk
[PE1-GigabitEthernet1/0/2] port trunk permit vlan 100 3000
[PE1-GigabitEthernet1/0/2] quit
```

2. Configure PE 2:

Configure GigabitEthernet 1/0/1 as a trunk port, and assign it to VLAN 100 and VLAN 3000.

```
<PE2> system-view
[PE2] interface gigabitethernet 1/0/1
[PE2-GigabitEthernet1/0/1] port link-type trunk
[PE2-GigabitEthernet1/0/1] port trunk permit vlan 100 3000
```

Set the PVID of GigabitEthernet 1/0/1 to VLAN 100.

```
[PE1-GigabitEthernet1/0/1] port trunk pvid vlan 100
```

Enable QinQ on GigabitEthernet 1/0/1.

```
[PE2-GigabitEthernet1/0/1] qinq enable
```

Enable transparent transmission for VLAN 3000 on GigabitEthernet 1/0/1.

```
[PE2-GigabitEthernet1/0/1] qinq transparent-vlan 3000
[PE2-GigabitEthernet1/0/1] quit
```

Configure GigabitEthernet 1/0/2 as a trunk port, and assign it to VLANs 100 and 3000.

```
[PE2] interface gigabitethernet 1/0/2
[PE2-GigabitEthernet1/0/2] port link-type trunk
[PE2-GigabitEthernet1/0/2] port trunk permit vlan 100 3000
```

3. Configure the devices between PE 1 and PE 2:

Set the MTU to a minimum of 1504 bytes for each port on the path of QinQ frames. (Details not shown.)

Configure all ports on the forwarding path to allow frames from VLANs 100 and 3000 to pass through without removing the VLAN tag. (Details not shown.)

Contents

Configuring VLAN mapping

About VLAN mapping

VLAN mapping re-marks VLAN traffic with new VLAN IDs.

VLAN mapping types

H3C provides the following types of VLAN mapping:

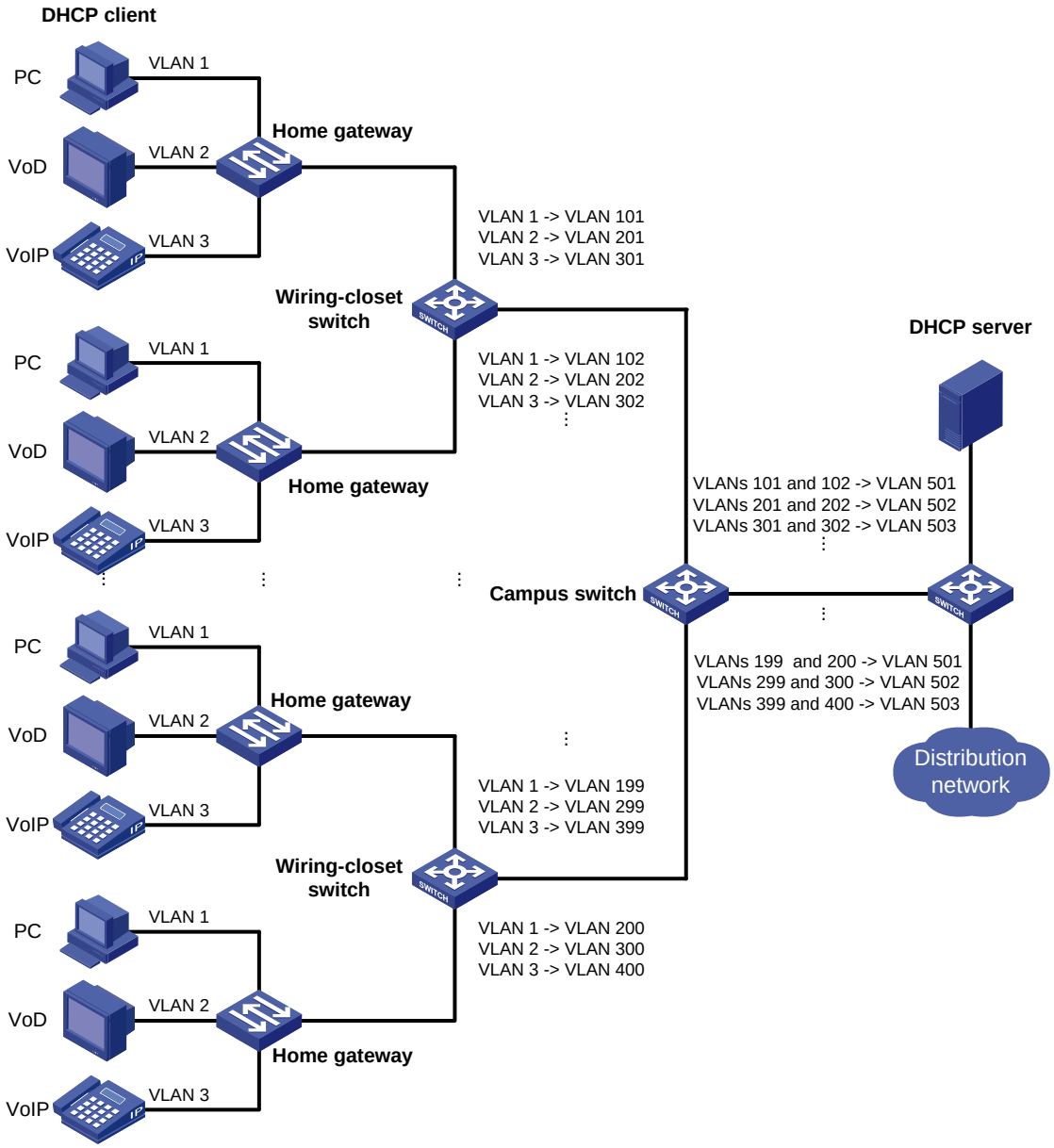
- **One-to-one VLAN mapping**—Replaces one VLAN tag with another.
- **Many-to-one VLAN mapping**—Replaces multiple VLAN tags with the same VLAN tag.
- **One-to-two VLAN mapping**—Tags single-tagged packets with an outer VLAN tag.

VLAN mapping application scenarios

One-to-one and many-to-one VLAN mapping

One-to-one and many-to-one VLAN mapping are typically used by a community for broadband Internet access, as shown in Figure 1.

Figure 1 Application scenario of one-to-one and many-to-one VLAN mapping



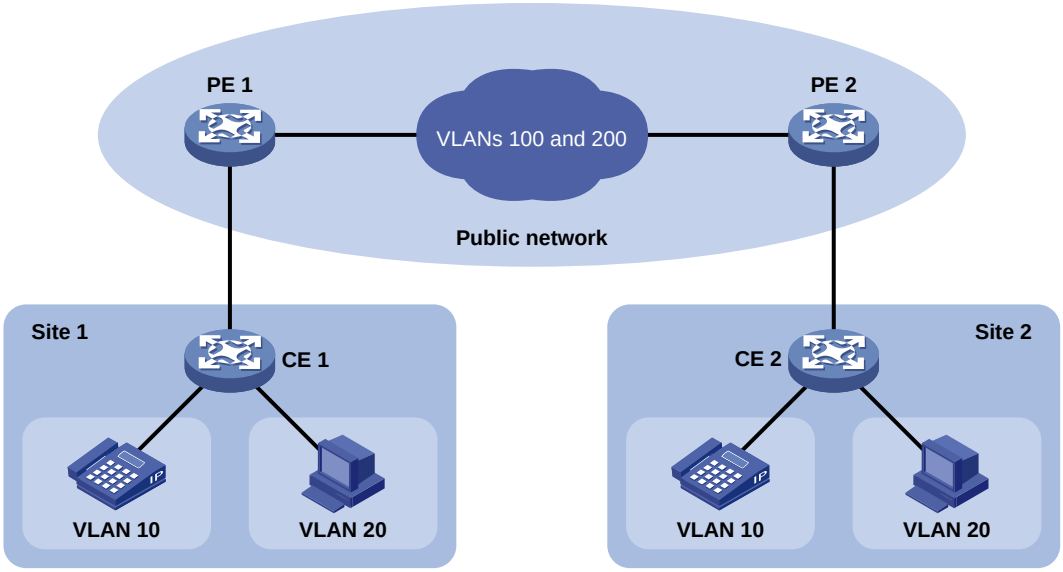
As shown in Figure 1, the network is implemented as follows:

- Each home gateway uses different VLANs to transmit the PC, VoD, and VoIP services.
- To further subclassify each type of traffic by customer, configure one-to-one VLAN mapping on the wiring-closet switches. This feature assigns a separate VLAN to each type of traffic from each customer. The required total number of VLANs in the network can be very large.
- To prevent the maximum number of VLANs from being exceeded on the distribution layer device, configure many-to-one VLAN mapping on the campus switch. This feature assigns the same VLAN to the same type of traffic from different customers.

One-to-two VLAN mapping

As shown in Figure 2, one-to-two VLAN mapping is used to transmit different types of CVLAN packets with different SVLAN tags over the service provider network.

Figure 2 Application scenario of one-to-two VLAN mapping



As shown in Figure 2, users of Site 1 and Site 2 are in VLAN 10 and VLAN 20. The service provider assigns VLAN 100 and VLAN 200 to the customer network. When packets from Site 1 arrive at PE 1, PE 1 adds an SVLAN tag to the packets based on the packet type.

One-to-two VLAN mapping enables the customer to plan CVLANs without conflicting with SVLANs. The service provider can distinguish traffic of the customer network with different SVLANs, and apply transmission policies to the customer traffic.

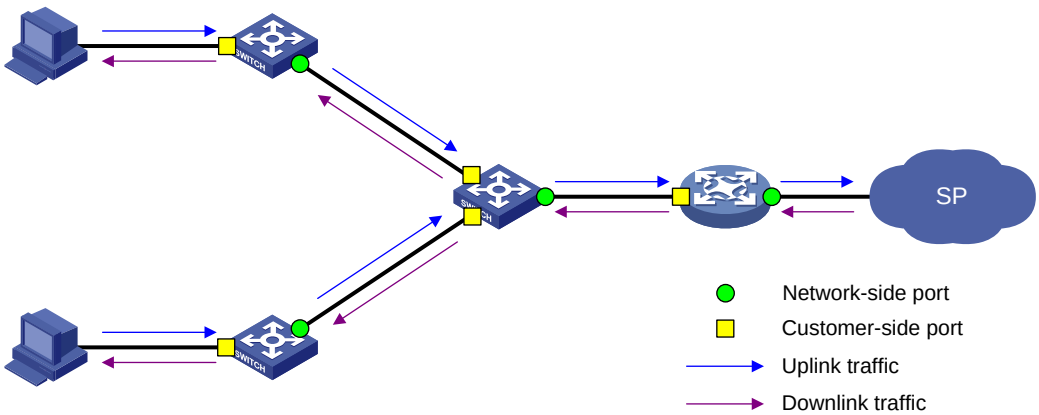
VLAN mapping implementations

Figure 3 shows a simplified network that illustrates basic VLAN mapping terms.

Basic VLAN mapping terms include the following:

- **Uplink traffic**—Traffic transmitted from the customer network to the service provider network.
- **Downlink traffic**—Traffic transmitted from the service provider network to the customer network.
- **Network-side port**—A port connected to or closer to the service provider network.
- **Customer-side port**—A port connected to or closer to the customer network.

Figure 3 Basic VLAN mapping terms

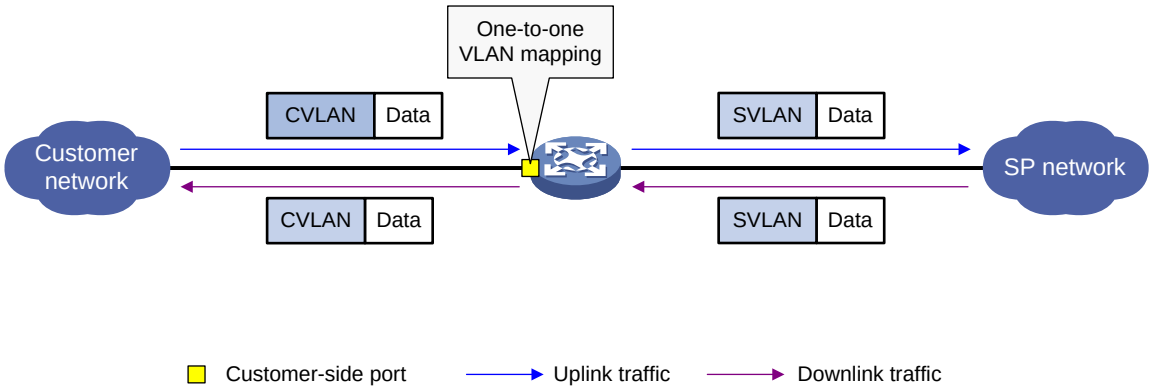


One-to-one VLAN mapping

As shown in Figure 4, one-to-one VLAN mapping is implemented on the customer-side port and replaces VLAN tags as follows:

- Replaces the CVLAN with the SVLAN for the uplink traffic.
- Replaces the SVLAN with the CVLAN for the downlink traffic.

Figure 4 One-to-one VLAN mapping implementation



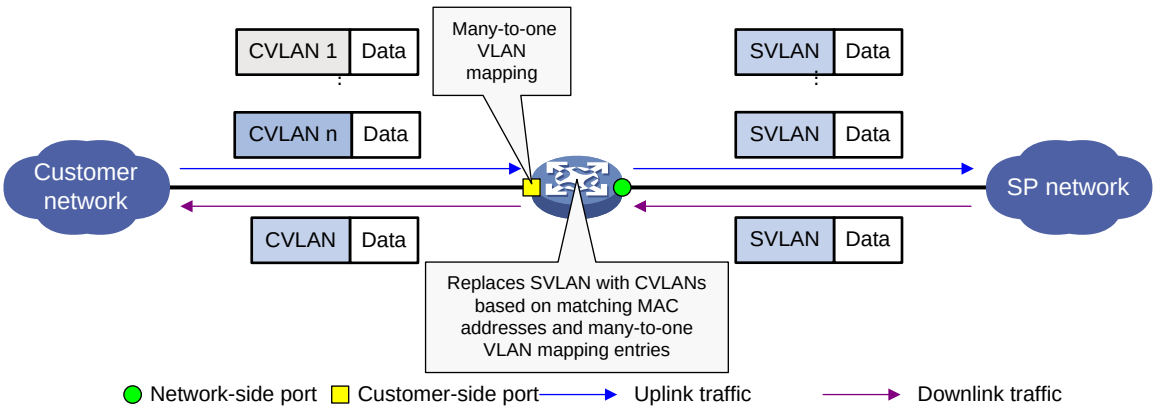
Many-to-one VLAN mapping

As shown in Figure 5, many-to-one VLAN mapping is implemented on both the customer-side and network-side ports, as follows:

- For the uplink traffic, the customer-side many-to-one VLAN mapping replaces multiple CVLANs with the same SVLAN.
- For the downlink traffic, the device performs the following operations:
  - **a.** Searches the MAC address table for an entry that matches the destination MAC address of the downlink packets.
  - **b.** Replaces the SVLAN tag with a CVLAN tag based on the matching many-to-one mapping entry.

For more information about the MAC address table, see "Configuring the MAC address table."

Figure 5 Many-to-one VLAN mapping implementation



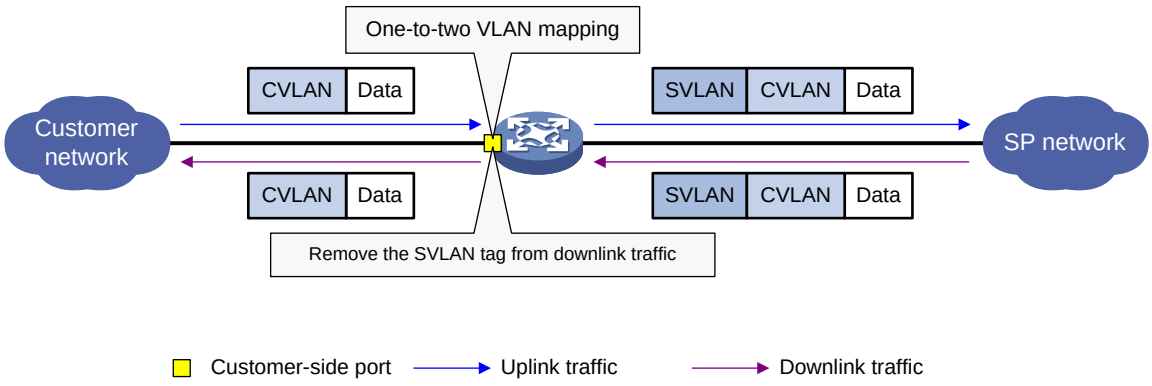
One-to-two VLAN mapping

As shown in Figure 6, one-to-two VLAN mapping is implemented on the customer-side port to add the SVLAN tag for the uplink traffic.

For the downlink traffic to be correctly sent to the customer network, make sure the SVLAN tag is removed on the customer-side port before transmission. Use one of the following methods to remove the SVLAN tag from the downlink traffic:

- Configure the customer-side port as a hybrid port and assign the port to the SVLAN as an untagged member.
- Configure the customer-side port as a trunk port and set the port PVID to the SVLAN.

Figure 6 One-to-two VLAN mapping implementation



Restrictions and guidelines: VLAN mapping configuration

To add VLAN tags to packets, you can configure both VLAN mapping and QinQ. VLAN mapping takes effect if a configuration conflict occurs. For more information about QinQ, see "Configuring QinQ."

To add or replace VLAN tags for packets, you can configure both VLAN mapping and a QoS policy. VLAN mapping takes effect if a configuration conflict occurs. For information about QoS policies, see *ACL and QoS Configuration Guide*.

VLAN mapping tasks at a glance

Use different VLAN mapping methods on the devices depending on their role and placement on the network.

To configure VLAN mapping, perform the following tasks:

- Configuring one-to-one VLAN mapping

  Configure one-to-one VLAN mapping on the wiring-closet switch, as shown in Figure 1.
- Configuring many-to-one VLAN mapping

  Configure many-to-one VLAN mapping on the campus switch, as shown in Figure 1.
- Configuring one-to-two VLAN mapping

  Configure one-to-two VLAN mapping on PE 1 and PE 4, as shown in Figure 2, through which traffic from customer networks enters the service provider networks.

Prerequisites

Before you configure VLAN mapping, create original and translated VLANs.

Configuring one-to-one VLAN mapping

About one-to-one VLAN mapping

Configure one-to-one VLAN mapping on the customer-side ports of wiring-closet switches (see Figure 1) to isolate traffic of the same service type from different homes.

Procedure

1. Enter system view.
   system-view
2. Enter interface view.
   - Enter Layer 2 Ethernet interface view.
     interface *interface-type interface-number*
   - Enter Layer 2 aggregate interface view.
     interface bridge-aggregation *interface-number*
3. Set the link type of the port.
   port link-type { **hybrid** | **trunk** }
   By default, the link type of a port is **access**.
4. Assign the port to the original VLAN and the translated VLAN.
   - Assign the trunk port to the original VLAN and the translated VLAN.
     port trunk permit vlan *vlan-id-list*
     By default, a trunk port is assigned to VLAN 1.
   - Assign the hybrid port to the original VLAN and the translated VLAN as a tagged member.
     port hybrid vlan *vlan-id-list* **tagged**
     By default, a hybrid port is an untagged member of the VLAN to which the port belongs when its link type is access.
5. Configure a one-to-one VLAN mapping.
   vlan mapping *vlan-id* **translated-vlan** *vlan-id*
   By default, no VLAN mapping is configured on an interface.

Configuring many-to-one VLAN mapping

About many-to-one VLAN mapping

To conserve VLAN resources, configure many-to-one VLAN mapping on campus switches (see Figure 1) to transmit the same type of traffic from different users in one VLAN.

Feature and software version compatibility

This feature is supported only in R6350 and higher versions.

Restrictions and guidelines for many-to-one VLAN mapping

To ensure correct traffic forwarding from the service provider network to the customer network, do not configure many-to-one VLAN mappings together with the following features:

- Disabling MAC address learning.
- Setting the MAC learning limit.

For more information about MAC address learning, see "Configuring the MAC address table."

To establish network connectivity successfully in a many-to-one VLAN mapping environment, make sure ARP requests are sent from the customer side to trigger connection to the network side.

Many-to-one VLAN mapping tasks at a glance

1. Configuring the customer-side port
2. Configuring the network-side port

Configuring the customer-side port

1. Enter system view.

   system-view
2. Enter interface view.
   - Enter Layer 2 Ethernet interface view.

     interface *interface-type interface-number*
   - Enter Layer 2 aggregate interface view.

     interface bridge-aggregation *interface-number*
3. Set the link type of the port to hybrid or trunk.

   port link-type { **hybrid** | **trunk** }

   By default, the link type of a port is **access**.
4. Assign the port to the original VLANs.
   - Assign the trunk port to the original VLANs.

     port trunk permit vlan *vlan-id-list*

     By default, a trunk port is assigned to VLAN 1.
   - Assign the hybrid port to the original VLANs as a tagged member.

     port hybrid vlan *vlan-id-list* **tagged**

     By default, a hybrid port is an untagged member of the VLAN to which the port belonged when its link type was access.
5. Configure a many-to-one VLAN mapping.

   vlan mapping uni { **range** *vlan-range-list* | **single** *vlan-id-list* } **translated-vlan** *vlan-id*

   By default, no VLAN mapping is configured on an interface.

Configuring the network-side port

1. Enter system view.

   system-view
2. Enter interface view.
   - Enter Layer 2 Ethernet interface view.

     interface *interface-type interface-number*
   - Enter Layer 2 aggregate interface view.

     interface bridge-aggregation *interface-number*
3. Set the link type of the port to hybrid or trunk.

   port link-type { **hybrid** | **trunk** }

   By default, the link type of a port is **access**.
4. Assign the port to the translated VLAN.
   - Assign the trunk port to the translated VLAN.

     port trunk permit vlan *vlan-id-list*

     By default, a trunk port is assigned to VLAN 1.
   - Assign the hybrid port to the translated VLAN as a tagged member.

     port hybrid vlan *vlan-id-list* **tagged**

By default, a hybrid port is an untagged member of the VLAN to which the port belonged when its link type was access.

Configuring one-to-two VLAN mapping

About one-to-two VLAN mapping

Configure one-to-two VLAN mapping on the customer-side ports of edge devices from which customer traffic enters SP networks, for example, on PEs 1 and 4 in Figure 2. One-to-two VLAN mapping enables the edge devices to add an SVLAN tag to each incoming packet.

Restrictions and guidelines

Only one SVLAN tag can be added to packets from the same CVLAN. To add different SVLAN tags to different CVLAN packets on a port, set the port link type to hybrid and configure multiple one-to-two VLAN mappings.

The MTU of an interface is 1500 bytes by default. After a VLAN tag is added to a packet, the packet length is added by 4 bytes. As a best practice, set the MTU to a minimum of 1504 bytes for ports on the forwarding path of the packet in the service provider network.

Procedure

1. Enter system view.
   system-view
2. Enter interface view.
   - Enter Layer 2 Ethernet interface view.
     interface *interface-type interface-number*
   - Enter Layer 2 aggregate interface view.
     interface bridge-aggregation *interface-number*
3. Set the link type of the port.
   port link-type { **hybrid** | **trunk** }
   By default, the link type of a port is **access**.
4. Configure the port to allow packets from the SVLAN to pass through untagged.
   - Configure the SVLAN as the PVID of the trunk port and assign the trunk port to the SVLAN.
     port trunk pvid vlan *vlan-id*
     port trunk permit vlan { *vlan-id-list* | **all** }
   - Assign the hybrid port to the SVLAN as an untagged member.
     port hybrid vlan *vlan-id-list* **untagged**
5. Configure a one-to-two VLAN mapping.
   vlan mapping nest { **range** *vlan-range-list* | **single** *vlan-id-list* } **nested-vlan** *vlan-id*
   By default, no VLAN mapping is configured on an interface.

Display and maintenance commands for VLAN mapping

Execute **display** commands in any view.

Task	Command
Display VLAN mapping information.	**display vlan mapping** [**interface** *interface-type interface-number*]

VLAN mapping configuration examples

Example: Configuring one-to-one VLAN mapping

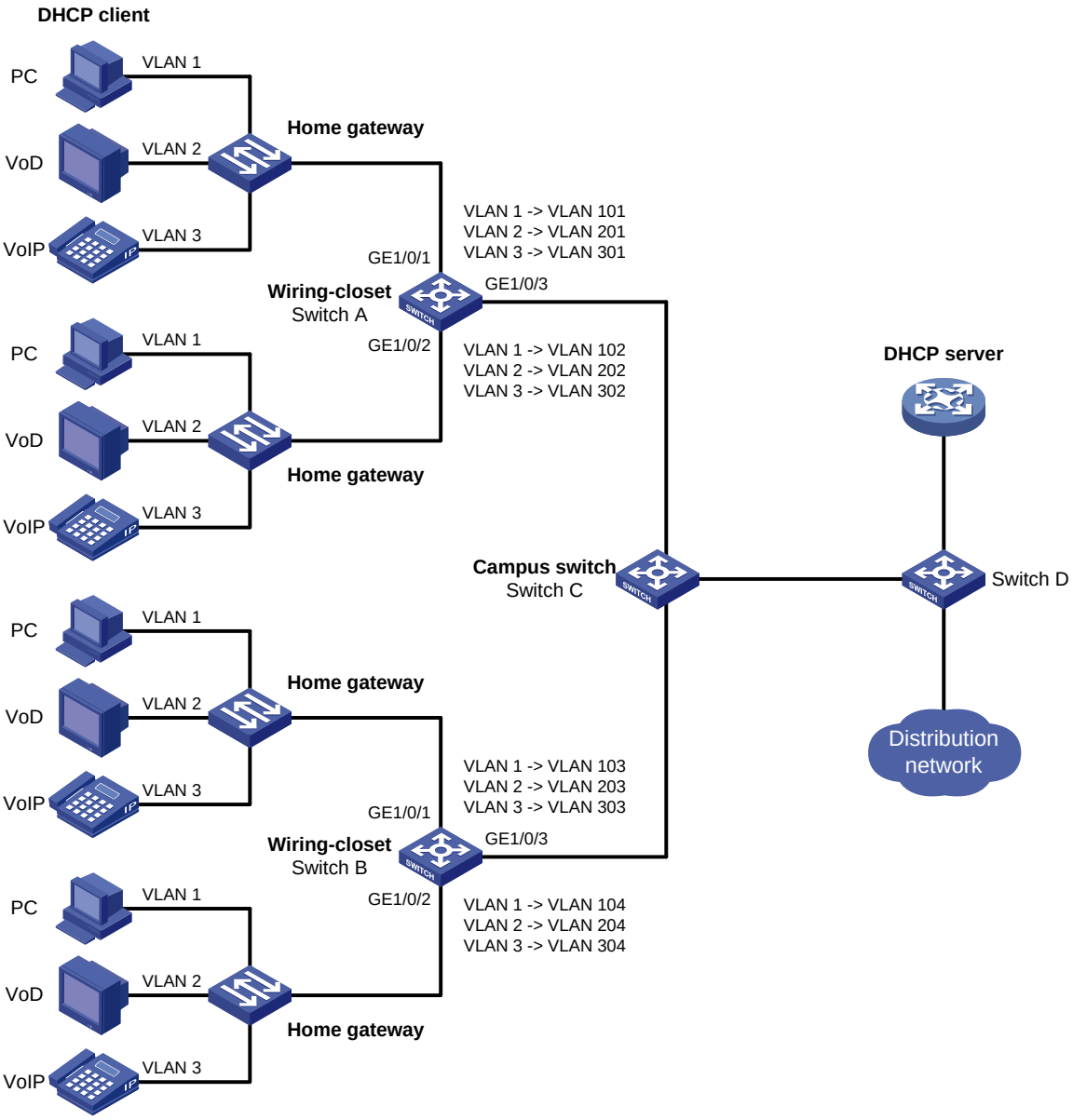
Network configuration

As shown in Figure 7:

- Each household subscribes to PC, VoD, and VoIP services.
- On the home gateways, VLANs 1, 2, and 3 are assigned to PC, VoD, and VoIP traffic, respectively.

To isolate traffic of the same service type from different households, configure one-to-one VLAN mappings on the wiring-closet switches. This feature assigns one VLAN to each type of traffic from each household.

Figure 7 Network diagram



Procedure

1. Configure Switch A:

   # Create the original VLANs.

   ```
   <SwitchA> system-view
   [SwitchA] vlan 2 to 3
   ```

   # Create the translated VLANs.

   ```
   [SwitchA] vlan 101 to 102
   [SwitchA] vlan 201 to 202
   [SwitchA] vlan 301 to 302
   ```

   # Configure customer-side port GigabitEthernet 1/0/1 as a trunk port.

   ```
   <SwitchA> system-view
   [SwitchA] interface gigabitethernet 1/0/1
   [SwitchA-GigabitEthernet1/0/1] port link-type trunk
   ```

   # Assign GigabitEthernet 1/0/1 to all original VLANs and translated VLANs.

```
[SwitchA-GigabitEthernet1/0/1] port trunk permit vlan 1 2 3 101 201 301
```

Configure one-to-one VLAN mappings on GigabitEthernet 1/0/1 to map VLANs 1, 2, and 3 to VLANs 101, 201, and 301, respectively.

```
[SwitchA-GigabitEthernet1/0/1] vlan mapping 1 translated-vlan 101
[SwitchA-GigabitEthernet1/0/1] vlan mapping 2 translated-vlan 201
[SwitchA-GigabitEthernet1/0/1] vlan mapping 3 translated-vlan 301
[SwitchA-GigabitEthernet1/0/1] quit
```

Configure customer-side port GigabitEthernet 1/0/2 as a trunk port.

```
[SwitchA] interface gigabitethernet 1/0/2
[SwitchA-GigabitEthernet1/0/2] port link-type trunk
```

Assign GigabitEthernet 1/0/2 to all original VLANs and translated VLANs.

```
[SwitchA-GigabitEthernet1/0/2] port trunk permit vlan 1 2 3 102 202 302
```

Configure one-to-one VLAN mappings on GigabitEthernet 1/0/2 to map VLANs 1, 2, and 3 to VLANs 102, 202, and 302, respectively.

```
[SwitchA-GigabitEthernet1/0/2] vlan mapping 1 translated-vlan 102
[SwitchA-GigabitEthernet1/0/2] vlan mapping 2 translated-vlan 202
[SwitchA-GigabitEthernet1/0/2] vlan mapping 3 translated-vlan 302
[SwitchA-GigabitEthernet1/0/2] quit
```

Configure the network-side port (GigabitEthernet 1/0/3) as a trunk port.

```
[SwitchA] interface gigabitethernet 1/0/3
[SwitchA-GigabitEthernet1/0/3] port link-type trunk
```

Assign GigabitEthernet 1/0/3 to the translated VLANs.

```
[SwitchA-GigabitEthernet1/0/3] port trunk permit vlan 101 201 301 102 202 302
[SwitchA-GigabitEthernet1/0/3] quit
```

2. Configure Switch B in the same way Switch A is configured. (Details not shown.)

Verifying the configuration

Verify VLAN mapping information on the wiring-closet switches, for example, Switch A.

```
[SwitchA] display vlan mapping
Interface GigabitEthernet1/0/1:
  Outer VLAN    Inner VLAN    Translated Outer VLAN    Translated Inner VLAN
  1             N/A           101                      N/A
  2             N/A           201                      N/A
  3             N/A           301                      N/A
Interface GigabitEthernet1/0/2:
  Outer VLAN    Inner VLAN    Translated Outer VLAN    Translated Inner VLAN
  1             N/A           102                      N/A
  2             N/A           202                      N/A
  3             N/A           302                      N/A
```

Example: Configuring many-to-one VLAN mapping

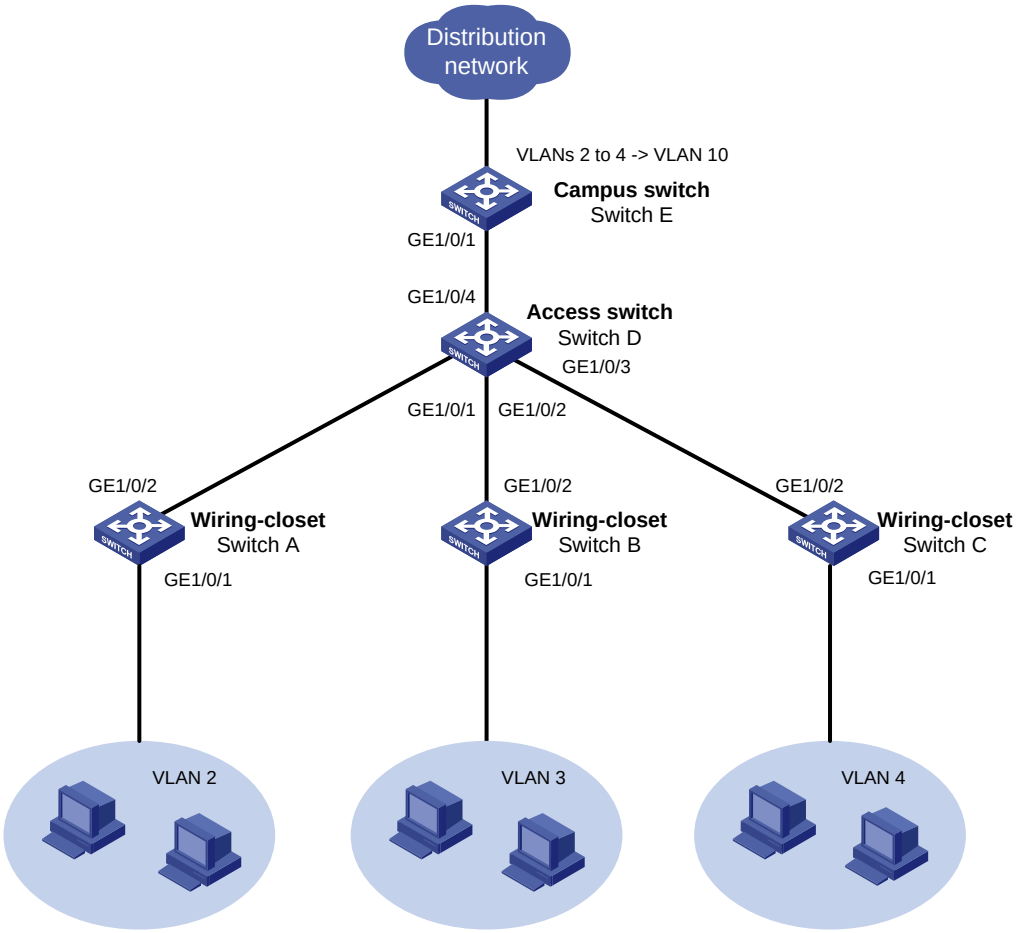
Network configuration

As shown in Figure 8:

- Create VLAN 2, VLAN 3, and VLAN 4 on the wiring-closet switches to isolate traffic of the same service type from different households.

- Configure many-to-one VLAN mappings on the campus switch to assigns one VLAN to transport all types of traffic from different households. In this example, map VLANs 2 through 4 to VLAN 10.

Figure 8 Network diagram



Procedure

1. Configure Switch A:

   # Create VLAN 2.

   ```
   <SwitchA> system-view
   [SwitchA] vlan 2
   [SwitchA-vlan2] quit
   ```

   # Assign ports GigabitEthernet 1/0/1 and GigabitEthernet 1/0/2 to VLAN 2.

   ```
   [SwitchA] interface range gigabitethernet 1/0/1 to gigabitethernet 1/0/2
   [SwitchA-if-range] port access vlan 2
   [SwitchA-if-range] quit
   ```

2. Configure Switch B and Switch C in the same way Switch A is configured. (Details not shown.)
3. Configure Switch D:

   # Create VLANs 2, 3, and 4.

   ```
   <SwitchD> system-view
   [SwitchD] vlan 2 to 4
   ```

   # Assign ports GigabitEthernet 1/0/1 to VLAN 2, GigabitEthernet 1/0/2 to VLAN 3, and GigabitEthernet 1/0/3 to VLAN 4.

```
[SwitchD] interface gigabitethernet 1/0/1
[SwitchD-GigabitEthernet1/0/1] port access vlan 2
[SwitchD-GigabitEthernet1/0/1] quit
[SwitchD] interface gigabitethernet 1/0/2
[SwitchD-GigabitEthernet1/0/2] port access vlan 3
[SwitchD-GigabitEthernet1/0/2] quit
[SwitchD] interface gigabitethernet 1/0/3
[SwitchD-GigabitEthernet1/0/3] port access vlan 4
[SwitchD-GigabitEthernet1/0/3] quit
```

Configure port GigabitEthernet 1/0/4 as a trunk port.

```
[SwitchD] interface gigabitethernet 1/0/4
[SwitchD-GigabitEthernet1/0/4] port link-type trunk
```

Assign GigabitEthernet 1/0/4 to VLANs 2 through VLAN 4.

```
[SwitchD-GigabitEthernet1/0/4] port trunk permit vlan 2 to 4
[SwitchD-GigabitEthernet1/0/4] quit
```

4. Configure Switch E:

Create VLANs 2, 3, and 4 (the original VLANs in the VLAN mapping to be created).

```
<SwitchE> system-view
[SwitchE] vlan 2 to 4
```

Configure the customer-side port (GigabitEthernet 1/0/1) as a trunk port.

```
<SwitchE> system-view
[SwitchE] interface gigabitethernet 1/0/1
[SwitchE-GigabitEthernet1/0/1] port link-type trunk
```

Assign GigabitEthernet 1/0/1 to the original VLANs.

```
[SwitchE-GigabitEthernet1/0/1] port trunk permit vlan 2 to 4
```

Configure many-to-one VLAN mapping on GigabitEthernet 1/0/1, which replaces VLAN tag 2 through VLAN tag 4 with VLAN tag 10.

```
[SwitchE-GigabitEthernet1/0/1] vlan mapping uni range 2 to 4 translated-vlan 10
[SwitchE-GigabitEthernet1/0/1] quit
```

Verifying the configuration

Verify VLAN mapping information on Switch E.

```
[SwitchE] display vlan mapping
Interface GigabitEthernet1/0/1:
  Outer VLAN    Inner VLAN    Translated Outer VLAN    Translated Inner VLAN
  2-4           N/A           10                       N/A
```

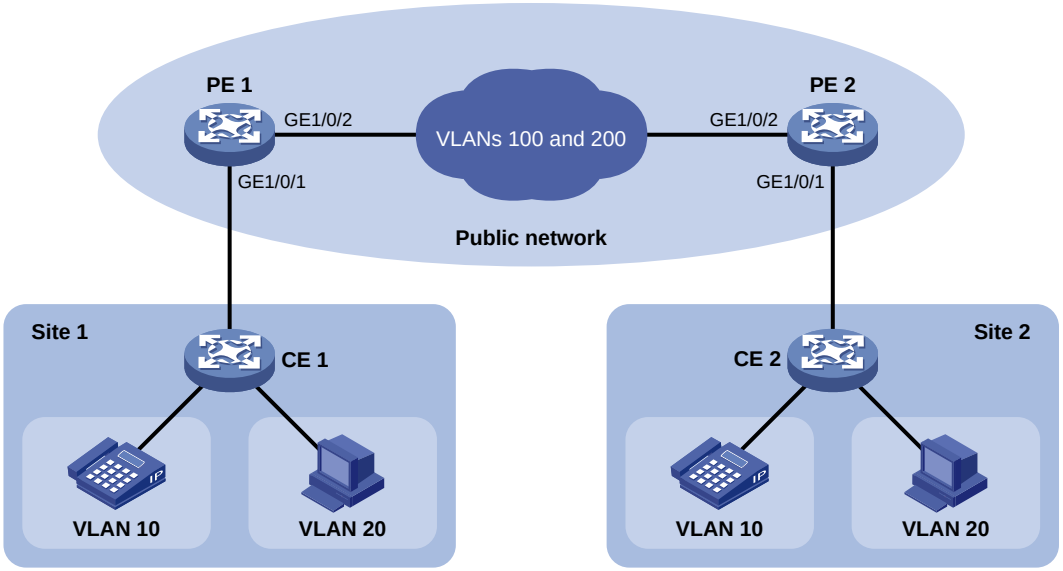
Example: Configuring one-to-two VLAN mapping

Network configuration

As shown in Figure 9, Site 1 and Site 2 of a company use VLAN 10 and VLAN 20 to transmit VoIP and PC traffic, respectively. The service provider assigns VLAN 100 and VLAN 200 to the customer network.

Configure one-to-two VLAN mappings to enable the service provider network to transmit VoIP and PC traffic with SVLAN 100 and SVLAN 200, respectively.

Figure 9 Network diagram



Procedure

1. Configure PE 1:

Create VLANs 10, 20, 100, and 200.

```
<PE1> system-view
[PE1] vlan 10
[PE1-vlan10] quit
[PE1] vlan 20
[PE1-vlan20] quit
[PE1] vlan 100
[PE1-vlan100] quit
[PE1] vlan 200
[PE1-vlan200] quit
```

Configure a one-to-two VLAN mapping on the customer-side port (GigabitEthernet 1/0/1) to add SVLAN tag 100 to packets from CVLAN 10.

```
[PE1] interface gigabitethernet 1/0/1
[PE1-GigabitEthernet1/0/1] vlan mapping nest single 10 nested-vlan 100
```

Configure a one-to-two VLAN mapping on GigabitEthernet 1/0/1 to add SVLAN tag 200 to packets from CVLAN 20.

```
[PE1-GigabitEthernet1/0/1] vlan mapping nest single 20 nested-vlan 200
```

Configure GigabitEthernet 1/0/1 as a hybrid port.

```
[PE1-GigabitEthernet1/0/1] port link-type hybrid
```

Assign GigabitEthernet 1/0/1 to VLANs 100 and 200 as an untagged member.

```
[PE1-GigabitEthernet1/0/1] port hybrid vlan 100 200 untagged
[PE1-GigabitEthernet1/0/1] quit
```

Configure the network-side port (GigabitEthernet 1/0/2) as a trunk port, and assign the port to VLANs 100 and 200.

```
[PE1] interface gigabitethernet 1/0/2
[PE1-GigabitEthernet1/0/2] port link-type trunk
[PE1-GigabitEthernet1/0/2] port trunk permit vlan 100 200
[PE1-GigabitEthernet1/0/2] quit
```

2. Configure PE 2 in the same way PE 1 is configured. (Details not shown.)

Verifying the configuration

Verify VLAN mapping information on PE 1.

```
[PE1] display vlan mapping
Interface GigabitEthernet1/0/1:
  Outer VLAN    Inner VLAN    Translated Outer VLAN    Translated Inner VLAN
  10             N/A           100                      10
  20             N/A           200                      20
```

Verify VLAN mapping information on PE 2.

```
[PE2] display vlan mapping
Interface GigabitEthernet1/0/2:
  Outer VLAN    Inner VLAN    Translated Outer VLAN    Translated Inner VLAN
  10             N/A           100                      10
  20             N/A           200                      20
```

Contents

Configuring LLDP

About LLDP

The Link Layer Discovery Protocol (LLDP) is a standard link layer protocol that allows network devices from different vendors to discover neighbors and exchange system and configuration information.

In an LLDP-enabled network, a device advertises local device information in LLDP Data Units (LLDPDUs) to the directly connected devices. The information distributed through LLDP is stored by its recipients in standard MIBs, making it possible for the information to be accessed by a Network Management System (NMS) through SNMP.

Information that can be distributed through LLDP includes (but is not limited to):

- Major capabilities of the system.
- Management IP address of the system.
- Device ID.
- Port ID.

LLDP agents and bridge modes

An LLDP agent is a mapping of a protocol entity that implements LLDP. Multiple LLDP agents can run on the same interface.

LLDP agents are classified into the following types:

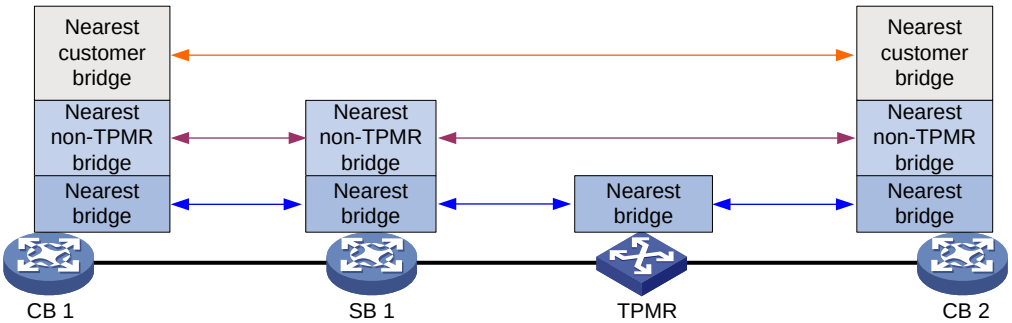
- Nearest bridge agent.
- Nearest customer bridge agent.
- Nearest non-TPMR bridge agent.

  A Two-port MAC Relay (TPMR) is a type of bridge that has only two externally-accessible bridge ports. It supports a subset of the features of a MAC bridge. A TPMR is transparent to all frame-based media-independent protocols except for the following protocols:

  - Protocols destined for the TPMR.
  - Protocols destined for reserved MAC addresses that the relay feature of the TPMR is configured not to forward.

LLDP exchanges packets between neighbor agents and creates and maintains neighbor information for them. Figure 1 shows the neighbor relationships for these LLDP agents.

Figure 1 LLDP neighbor relationships



The types of supported LLDP agents vary with the bridge mode in which LLDP operates. LLDP supports the following bridge modes: customer bridge (CB) and service bridge (SB).

- **Customer bridge mode**—LLDP supports nearest bridge agent, nearest non-TPMR bridge agent, and nearest customer bridge agent. LLDP processes the LLDP frames with destination MAC addresses for these agents and transparently transmits the LLDP frames with other destination MAC addresses in VLANs.
- **Service bridge mode**—LLDP supports nearest bridge agent and nearest non-TPMR bridge agent. LLDP processes the LLDP frames with destination MAC addresses for these agents and transparently transmits the LLDP frames with other destination MAC addresses in VLANs.

LLDP frame formats

LLDP sends device information in LLDP frames. LLDP frames are encapsulated in Ethernet II or Subnetwork Access Protocol (SNAP) format.

LLDP frame encapsulated in Ethernet II

Figure 2 Ethernet II-encapsulated LLDP frame

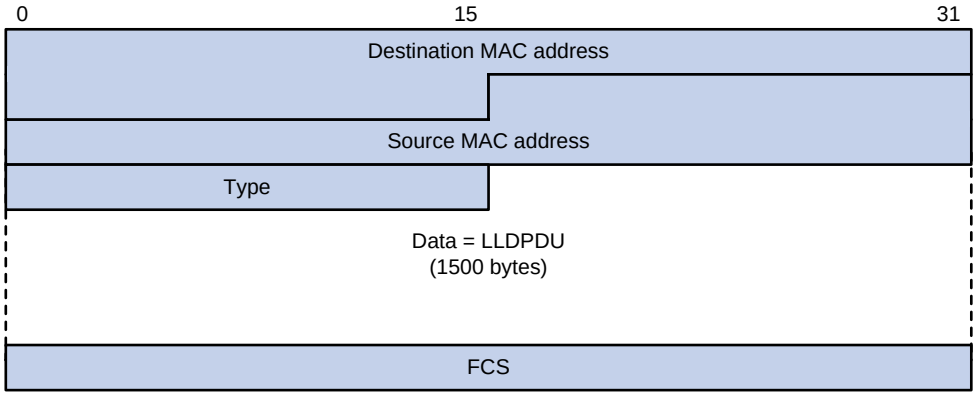


Table 1 Fields in an Ethernet II-encapsulated LLDP frame

Field	Description
Destination MAC address	MAC address to which the LLDP frame is advertised. LLDP specifies different multicast MAC addresses as destination MAC addresses for LLDP frames destined for agents of different types. This helps distinguish between LLDP frames sent and received by different agent types on the same interface. The destination MAC address is fixed to one of the following multicast MAC addresses: • 0x0180-c200-000E for LLDP frames destined for nearest bridge agents. • 0x0180-c200-0000 for LLDP frames destined for nearest customer bridge agents. • 0x0180-c200-0003 for LLDP frames destined for nearest non-TPMR bridge agents.
Source MAC address	MAC address of the sending port.
Type	Ethernet type for the upper-layer protocol. This field is 0x88CC for LLDP.
Data	LLDPDU.
FCS	Frame check sequence, a 32-bit CRC value used to determine the validity of the received Ethernet frame.

LLDP frame encapsulated in SNAP

Figure 3 SNAP-encapsulated LLDP frame

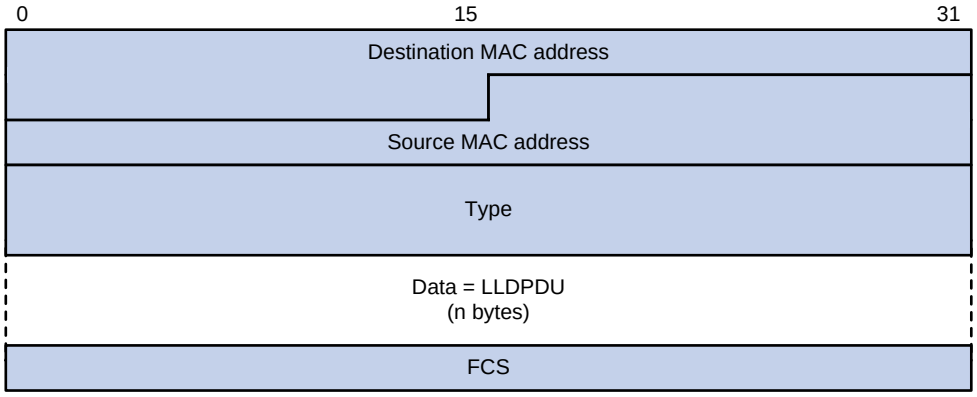


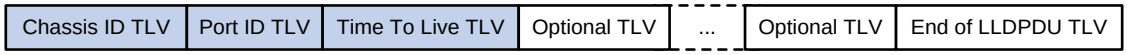
Table 2 Fields in a SNAP-encapsulated LLDP frame

Field	Description
Destination MAC address	MAC address to which the LLDP frame is advertised. It is the same as that for Ethernet II-encapsulated LLDP frames.
Source MAC address	MAC address of the sending port.
Type	SNAP type for the upper-layer protocol. This field is 0xAAAA-0300-0000-88CC for LLDP.
Data	LLDPDU.
FCS	Frame check sequence, a 32-bit CRC value used to determine the validity of the received Ethernet frame.

LLDPDUs

Each LLDP frame contains one LLDPDU. Each LLDPDU is a sequence of type-length-value (TLV) structures.

Figure 4 LLDPDU encapsulation format



As shown in Figure 4, each LLDPDU starts with the following mandatory TLVs: Chassis ID TLV, Port ID TLV, and Time to Live TLV. The mandatory TLVs are followed by a maxiumu of 29 optional TLVs.

TLVs

A TLV is an information element that contains the type, length, and value fields.

LLDPDU TLVs include the following categories:

- Basic management TLVs.
- Organizationally (IEEE 802.1 and IEEE 802.3) specific TLVs.
- LLDP-MED (media endpoint discovery) TLVs.

Basic management TLVs are essential to device management.

Organizationally specific TLVs and LLDP-MED TLVs are used for enhanced device management. They are defined by standardization or other organizations and are optional for LLDPDUs.

Basic management TLVs

Table 3 lists the basic management TLV types. Some of them are mandatory for LLDPDUs.

Table 3 Basic management TLVs

Type	Description	Remarks
Chassis ID	Specifies the bridge MAC address of the sending device.	Mandatory.
Port ID	Specifies the ID of the sending port: • If the LLDPDU carries LLDP-MED TLVs, the port ID TLV carries the MAC address of the sending port. • Otherwise, the port ID TLV carries the port name.	
Time to Live	Specifies the life of the transmitted information on the receiving device.	
End of LLDPDU	Marks the end of the TLV sequence in the LLDPDU.	
Port Description	Specifies the description for the sending port.	Optional.
System Name	Specifies the assigned name of the sending device.	
System Description	Specifies the description for the sending device.	
System Capabilities	Identifies the primary features of the sending device and the enabled primary features.	
Management Address	Specifies the following elements: • The management address of the local device. • The interface number and object identifier (OID) associated with the address.	

IEEE 802.1 organizationally specific TLVs

Table 4 lists the IEEE 802.1 organizationally specific TLVs.

The device can receive protocol identity TLVs and VID usage digest TLVs, but it cannot send these TLVs.

Table 4 IEEE 802.1 organizationally specific TLVs

Type	Description
Port VLAN ID (PVID)	Specifies the port PVID.
Port And Protocol VLAN ID (PPVID)	Indicates whether the device supports protocol VLANs and, if so, what VLAN IDs these protocols will be associated with.
VLAN Name	Specifies the textual name of any VLAN to which the port belongs.
Protocol Identity	Indicates protocols supported on the port.
DCBX	Data center bridging exchange protocol. DCBX TLVs are not supported in the current software version.
EVB module	Edge Virtual Bridging module, including EVB TLV and CDCP TLV. For more information, see *EVB Configuration Guide*. EVB module TLVs are not supported in the current software version.
Link Aggregation	Indicates whether the port supports link aggregation, and if yes, whether link aggregation is enabled.
Management VID	Management VLAN ID.

Type	Description
VID Usage Digest	VLAN ID usage digest.
ETS Configuration	Enhanced Transmission Selection configuration.
ETS Recommendation	ETS recommendation.
PFC	Priority-based Flow Control.
APP	Application protocol.
QCN	Quantized Congestion Notification. QCN TLVs are not supported in the current software version.

IEEE 802.3 organizationally specific TLVs

Table 5 shows the IEEE 802.3 organizationally specific TLVs.

The Power Stateful Control TLV is defined in IEEE P802.3at D1.0 and is not supported in later versions. The device sends this type of TLVs only after receiving them.

Table 5 IEEE 802.3 organizationally specific TLVs

Type	Description
MAC/PHY Configuration/Status	Contains the bit-rate and duplex capabilities of the port, support for autonegotiation, enabling status of autonegotiation, and the current rate and duplex mode.
Power Via MDI	Contains the power supply capabilities of the port: • Port class (PSE or PD). • Power supply mode. • Whether PSE power supply is supported. • Whether PSE power supply is enabled. • Whether pair selection can be controlled. • Power supply type. • Power source. • Power priority. • PD requested power. • PSE allocated power.
Maximum Frame Size	Indicates the supported maximum frame size.
Power Stateful Control	Indicates the power state control configured on the sending port, including the following: • Power supply mode of the PSE/PD. • PSE/PD priority. • PSE/PD power.
Energy-Efficient Ethernet	Indicates Energy Efficient Ethernet (EEE).

LLDP-MED TLVs

LLDP-MED TLVs provide multiple advanced applications for voice over IP (VoIP), such as basic configuration, network policy configuration, and address and directory management. LLDP-MED TLVs provide a cost-effective and easy-to-use solution for deploying voice devices in Ethernet. LLDP-MED TLVs are shown in Table 6.

If the MAC/PHY configuration/status TLV is not advertisable, none of the LLDP-MED TLVs will be advertised even if they are advertisable.

If the LLDP-MED capabilities TLV is not advertisable, the other LLDP-MED TLVs will not be advertised even if they are advertisable.

Table 6 LLDP-MED TLVs

Type	Description
LLDP-MED Capabilities	Allows a network device to advertise the LLDP-MED TLVs that it supports.
Network Policy	Allows a network device or terminal device to advertise the VLAN ID of a port, the VLAN type, and the Layer 2 and Layer 3 priorities for specific applications.
Extended Power-via-MDI	Allows a network device or terminal device to advertise power supply capability. This TLV is an extension of the Power Via MDI TLV.
Hardware Revision	Allows a terminal device to advertise its hardware version.
Firmware Revision	Allows a terminal device to advertise its firmware version.
Software Revision	Allows a terminal device to advertise its software version.
Serial Number	Allows a terminal device to advertise its serial number.
Manufacturer Name	Allows a terminal device to advertise its vendor name.
Model Name	Allows a terminal device to advertise its model name.
Asset ID	Allows a terminal device to advertise its asset ID. The typical case is that the user specifies the asset ID for the endpoint to facilitate directory management and asset tracking.
Location Identification	Allows a network device to advertise the appropriate location identifier information for a terminal device to use in the context of location-based applications.

H3C-proprietary TLVs

H3C-proprietary TLVs are used to meet specific transmission requirements on network management. Devices of other vendors cannot identify H3C-proprietary TLVs carried in LLDPDUS.

Only actual power TLVs are supported in the current software version. This type of TLVs provides PoE power information on an interface.

Management address

The network management system uses the management address of a device to identify and manage the device for topology maintenance and network management. The management address is encapsulated in the management address TLV.

LLDP operating modes

An LLDP agent can operate in one of the following modes:

- **TxRx mode**—An LLDP agent in this mode can send and receive LLDP frames.
- **Tx mode**—An LLDP agent in this mode can only send LLDP frames.
- **Rx mode**—An LLDP agent in this mode can only receive LLDP frames.
- **Disable mode**—An LLDP agent in this mode cannot send or receive LLDP frames.

Each time the operating mode of an LLDP agent changes, its LLDP protocol state machine reinitializes. A configurable reinitialization delay prevents frequent initializations caused by frequent changes to the operating mode. If you configure the reinitialization delay, an LLDP agent must wait the specified amount of time to initialize LLDP after the LLDP operating mode changes.

Transmitting and receiving LLDP frames

Transmitting LLDP frames

An LLDP agent operating in TxRx mode or Tx mode sends LLDP frames to its directly connected devices both periodically and when the local configuration changes. To prevent LLDP frames from overwhelming the network during times of frequent changes to local device information, LLDP uses the token bucket mechanism to rate limit LLDP frames. For more information about the token bucket mechanism, see *ACL and QoS Configuration Guide*.

LLDP automatically enables the fast LLDP frame transmission mechanism in either of the following cases:

- A new LLDP frame is received and carries device information new to the local device.
- The LLDP operating mode of the LLDP agent changes from Disable or Rx to TxRx or Tx.

The fast LLDP frame transmission mechanism successively sends the specified number of LLDP frames at a configurable fast LLDP frame transmission interval. The mechanism helps LLDP neighbors discover the local device as soon as possible. Then, the normal LLDP frame transmission interval resumes.

Receiving LLDP frames

An LLDP agent operating in TxRx mode or Rx mode confirms the validity of TLVs carried in every received LLDP frame. If the TLVs are valid, the LLDP agent saves the information and starts an aging timer. The initial value of the aging timer is equal to the TTL value in the Time To Live TLV carried in the LLDP frame. When the LLDP agent receives a new LLDP frame, the aging timer restarts. When the aging timer decreases to zero, all saved information ages out.

Collaboration with Track

You can configure a track entry and associate it with an LLDP interface. The LLDP module checks the neighbor availability of the LLDP interface and reports the check result to the Track module. The Track module changes the track entry status accordingly so the associated application module can take correct actions.

The Track module changes the track entry status based on the neighbor availability of a monitored LLDP interface as follows:

- If the neighbor of the LLDP interface is available, the Track module sets the track entry to Positive state.
- If the neighbor of the LLDP interface is unavailable, the Track module sets the track entry to Negative state.

For more information about collaboration between Track and LLDP, see the track configuration in *High Availability Configuration Guide.*

Protocols and standards

- IEEE 802.1AB-2005, *Station and Media Access Control Connectivity Discovery*
- IEEE 802.1AB-2009, *Station and Media Access Control Connectivity Discovery*
- ANSI/TIA-1057, *Link Layer Discovery Protocol for Media Endpoint Devices*

- IEEE Std 802.1Qaz-2011, *Media Access Control (MAC) Bridges and Virtual Bridged Local Area Networks-Amendment 18: Enhanced Transmission Selection for Bandwidth Sharing Between Traffic Classes*

Restrictions and guidelines: LLDP configuration

When you configure LLDP, follow these restrictions and guidelines:

- Some of the LLDP configuration tasks are available in different interface views (see Table 7).

  Table 7 Support of LLDP configuration tasks in different views

Tasks	Supported views
Enabling LLDP	Layer 2 Ethernet interface view Management Ethernet interface view Layer 2 aggregate interface view
Setting the LLDP operating mode	
Configuring the advertisable TLVs	
Configuring advertisement of the management address TLV	
Setting the encapsulation format for LLDP frames	
Enabling LLDP polling	
Configuring LLDP trapping and LLDP-MED trapping	

- To use LLDP together with OpenFlow, you must enable LLDP globally on OpenFlow switches. To prevent LLDP from affecting topology discovery of OpenFlow controllers, disable LLDP on ports of OpenFlow instances. For more information about OpenFlow, see *OpenFlow Configuration Guide*.

LLDP tasks at a glance

To configure LLDP, perform the following tasks:

1. Enabling LLDP
2. Setting the LLDP bridge mode
3. Setting the LLDP operating mode
4. (Optional.) Setting the LLDP reinitialization delay
5. (Optional.) Configuring LLDP packet-related settings
   - Configuring the advertisable TLVs
   - Configuring advertisement of the management address TLV
   - Setting the encapsulation format for LLDP frames
   - Setting LLDP frame transmission parameters
   - Configuring the type of port ID TLVs advertised by LLDP
6. (Optional.) Enabling displaying LLDP local information about all interfaces
7. (Optional.) Enabling LLDP polling
8. (Optional.) Disabling LLDP PVID inconsistency check
9. (Optional.) Configuring CDP compatibility
10. (Optional.) Configuring LLDP trapping and LLDP-MED trapping
11. (Optional.) Configuring MAC address learning for DCN
    - (Optional.) Setting the source MAC address of LLDP frames

- (Optional.) Enabling generation of ARP or ND entries for received management address TLVs

Enabling LLDP

Restrictions and guidelines

For LLDP to take effect on specific ports, you must enable LLDP both globally and on these ports.

Procedure

1. Enter system view.
   `system-view`
2. Enable LLDP globally.
   `lldp global enable`
   By default:
   - If the device starts up with the initial configuration, LLDP is disabled globally.
   - If the device starts up with the factory defaults, LLDP is enabled globally.

   For more information about device startup with the initial configuration or factory defaults, see *Fundamentals Configuration Guide*.
3. Enter interface view.
   `interface` *`interface-type interface-number`*
4. Enable LLDP.
   `lldp enable`
   By default, LLDP is enabled on a port.

Setting the LLDP bridge mode

1. Enter system view.
   `system-view`
2. Set the LLDP bridge mode.
   - Set the LLDP bridge mode to service bridge.
     `lldp mode service-bridge`
     By default, LLDP operates in customer bridge mode.
   - Set the LLDP bridge mode to customer bridge.
     `undo lldp mode`

   By default, LLDP operates in customer bridge mode.

Setting the LLDP operating mode

1. Enter system view.
   `system-view`
2. Enter interface view.
   `interface` *`interface-type interface-number`*
3. Set the LLDP operating mode.
   - In Layer 2 Ethernet interface view or management Ethernet interface view:

lldp [**agent** { **nearest-customer** | **nearest-nontpmr** }] **admin-status** { **disable** | **rx** | **tx** | **txrx** }

In Ethernet interface view, if you do not specify an agent type, the command sets the operating mode for the nearest bridge agent.

- In Layer 2 aggregate interface view:

  lldp agent { **nearest-customer** | **nearest-nontpmr** } **admin-status** { **disable** | **rx** | **tx** | **txrx** }

  In aggregate interface view, you can set the operating mode only for the nearest customer bridge agent and nearest non-TPMR bridge agent.

By default:

- The nearest bridge agent operates in TxRx mode.
- The nearest customer bridge agent and nearest non-TPMR bridge agent operate in Disable mode.

Setting the LLDP reinitialization delay

About LLDP reinitialization delay

When the LLDP operating mode changes on a port, the port initializes the protocol state machines after an LLDP reinitialization delay. By adjusting the delay, you can avoid frequent initializations caused by frequent changes to the LLDP operating mode on a port.

Procedure

1. Enter system view.

   system-view

2. Set the LLDP reinitialization delay.

   lldp timer reinit-delay *delay*

   The default LLDP reinitialization delay is 2 seconds.

Configuring the advertisable TLVs

1. Enter system view.

   system-view

2. Enter interface view.

   interface *interface-type interface-number*

3. Configure the advertisable TLVs.

   - In Layer 2 Ethernet interface view:

     lldp tlv-enable { **basic-tlv** { **all** | **port-description** | **system-capability** | **system-description** | **system-name** | **management-address-tlv** [**ipv6**] [*ip-address* | **interface loopback** *interface-number*] } | **dot1-tlv** { **all** | **port-vlan-id** | **link-aggregation** | **protocol-vlan-id** [*vlan-id*] | **vlan-name** [*vlan-id*] | **management-vid** [*mvlan-id*] } | **dot3-tlv** { **all** | **link-aggregation** | **mac-physic** | **max-frame-size** | **power** } | **med-tlv** { **all** | **capability** | **inventory** | **network-policy** [*vlan-id*] | **power-over-ethernet** | **location-id** { **civic-address** *device-type country-code* { *ca-type ca-value* }&<1-10> | **elin-address** *tel-number* } } }

     lldp tlv-enable private-tlv actual-power

Non-PoE devices do not support the **lldp tlv-enable private-tlv actual-power** command.

The **lldp tlv-enable private-tlv actual-power** command is available only in Release 6343P08 and later.

By default, the nearest bridge agent advertises all supported TLVs except the following TLVs:

- Location identification TLVs.
- Port and protocol VLAN ID TLVs.
- VLAN name TLVs.
- Management VLAN ID TLVs.

lldp agent nearest-nontpmr tlv-enable { **basic-tlv** { **all** | **port-description** | **system-capability** | **system-description** | **system-name** | **management-address-tlv** [**ipv6**] [*ip-address*] } | **dot1-tlv** { **all** | **port-vlan-id** | **link-aggregation** } | **dot3-tlv** { **all** | **link-aggregation** } }

lldp tlv-enable dot1-tlv { **protocol-vlan-id** [*vlan-id*] | **vlan-name** [*vlan-id*] | **management-vid** [*mvlan-id*] }

lldp agent nearest-nontpmr tlv-enable private-tlv actual-power

Non-PoE devices do not support the **lldp tlv-enable private-tlv actual-power** command.

The **lldp tlv-enable private-tlv actual-power** command is available only in Release 6343P08 and later.

By default, the nearest non-TPMR bridge agent does not advertise any TLVs.

lldp agent nearest-customer tlv-enable { **basic-tlv** { **all** | **port-description** | **system-capability** | **system-description** | **system-name** | **management-address-tlv** [**ipv6**] [*ip-address*] } | **dot1-tlv** { **all** | **port-vlan-id** | **link-aggregation** } | **dot3-tlv** { **all** | **link-aggregation** } }

lldp tlv-enable dot1-tlv { **protocol-vlan-id** [*vlan-id*] | **vlan-name** [*vlan-id*] | **management-vid** [*mvlan-id*] }

lldp agent nearest-customer tlv-enable private-tlv actual-power

Non-PoE devices do not support the **lldp agent nearest-customer tlv-enable private-tlv actual-power** command.

The **lldp agent nearest-customer tlv-enable private-tlv actual-power** command is available only in Release 6343P08 and later.

By default, the nearest customer bridge agent advertises all the supported basic management TLVs and IEEE 802.1 organizationally specific TLVs.

- In management Ethernet interface view:

lldp tlv-enable { **basic-tlv** { **all** | **port-description** | **system-capability** | **system-description** | **system-name** | **management-address-tlv** [**ipv6**] [*ip-address*] } | **dot1-tlv** { **all** | **link-aggregation** } | **dot3-tlv** { **all** | **link-aggregation** | **mac-physic** | **max-frame-size** | **power** } | **med-tlv** { **all** | **capability** | **inventory** | **power-over-ethernet** | **location-id** { **civic-address** *device-type country-code* { *ca-type ca-value* }&<1-10> | **elin-address** *tel-number* } } }

By default, the nearest bridge agent advertises the following TLVs:

- Link aggregation TLVs in the 802.1 organizationally specific TLV set.
- All supported 802.3 organizationally specific TLVs.

- All supported LLDP-MED TLVs except the network policy TLVs.

lldp agent { **nearest-nontpmr** | **nearest-customer** } **tlv-enable** { **basic-tlv** { **all** | **port-description** | **system-capability** | **system-description** | **system-name** | **management-address-tlv** [**ipv6**] [*ip-address*] } | **dot1-tlv** { **all** | **link-aggregation** } | **dot3-tlv** { **all** | **link-aggregation** } }

By default:

- The nearest non-TPMR bridge agent does not advertise anyTLVs.
- The nearest customer bridge agent advertises all supported basic management TLVs and link aggregation TLVs in the IEEE 802.1 organizationally specific TLV set.

- In Layer 2 aggregate interface view:

lldp tlv-enable dot1-tlv { **protocol-vlan-id** [*vlan-id*] | **vlan-name** [*vlan-id*] | **management-vid** [*mvlan-id*]

lldp agent nearest-nontpmr tlv-enable { **basic-tlv** { **all** | **management-address-tlv** [**ipv6**] [*ip-address*] | **port-description** | **system-capability** | **system-description** | **system-name** } | **dot1-tlv** { **all** | **port-vlan-id** } }

By default, the nearest non-TPMR bridge agent does not advertise any TLVs.

lldp agent nearest-customer tlv-enable { **basic-tlv** { **all** | **management-address-tlv** [**ipv6**] [*ip-address*] | **port-description** | **system-capability** | **system-description** | **system-name** } | **dot1-tlv** { **all** | **port-vlan-id** } }

By default, the nearest customer bridge agent advertises all supported basic management TLVs and the following IEEE 802.1 organizationally specific TLVs:

- Port and protocol VLAN ID TLVs.
- VLAN name TLVs.
- Management VLAN ID TLVs.

The nearest bridge agent is not supported.

Configuring advertisement of the management address TLV

About advertisement of the management address TLV

LLDP encodes management addresses in numeric or string format in management address TLVs.

If a neighbor encodes its management address in string format, set the encoding format of the management address to **string** on the connecting port. This guarantees normal communication with the neighbor.

You can configure advertisement of the management address TLV globally or on a per-interface basis. The device selects the management address TLV advertisement setting for an interface in the following order:

1. Interface-based setting, configured by using the **lldp tlv-enable** command with the **management-address-tlv** keyword.
2. Global setting, configured by using the **lldp global tlv-enable basic-tlv management-address-tlv** command.
3. Default setting for the interface.

   By default:

- The nearest bridge agent and nearest customer bridge agent advertise the management address TLV.
- The nearest non-TPMR bridge agent does not advertise the management address TLV.

Procedure

1. Enter system view.

   system-view

2. Enable advertisement of the management address TLV globally and set the management address to be advertised.

   lldp [**agent** { **nearest-customer** | **nearest-nontpmr** }] **global tlv-enable basic-tlv management-address-tlv** [**ipv6**] { *ip-address* | **interface loopback** *interface-number* | **interface m-gigabitethernet** *interface-number* | **interface vlan-interface** *interface-number* }

   By default, advertisement of the management address TLV is disabled globally.

3. Enter interface view.

   interface *interface-type interface-number*

4. Enable advertisement of the management address TLV on the interface and set the management address to be advertised.

   - In Layer 2 Ethernet interface view or management Ethernet interface view:

     lldp tlv-enable basic-tlv management-address-tlv [**ipv6**] [*ip-address* | **interface loopback** *interface-number*]

     lldp agent { **nearest-customer** | **nearest-nontpmr** } **tlv-enable basic-tlv management-address-tlv** [**ipv6**] [*ip-address*]

   - In Layer 2 aggregate interface view:

     lldp agent { **nearest-customer** | **nearest-nontpmr** } **tlv-enable basic-tlv management-address-tlv** [**ipv6**] [*ip-address*]

   By default:

   - The nearest bridge agent and nearest customer bridge agent advertise the management address TLVs.
   - The nearest non-TPMR bridge agent does not advertise the management address TLV.

   The device supports only the numeric encoding format for IPv6 management addresses.

5. Set the encoding format of the management address to string.

   - In Layer 2 Ethernet interface view or management Ethernet interface view:

     lldp [**agent** { **nearest-customer** | **nearest-nontpmr** }] **management-address-format string**

   - In Layer 2 aggregate interface view:

     lldp agent { **nearest-customer** | **nearest-nontpmr** } **management-address-format string**

   The default management address encoding format is numeric.

Setting the encapsulation format for LLDP frames

About setting the LLDP frame encapsulation format

Earlier versions of LLDP require the same encapsulation format on both ends to process LLDP frames. To successfully communicate with a neighboring device running an earlier version of LLDP, the local device must be set with the same encapsulation format.

Procedure

1. Enter system view.
   system-view
2. Enter interface view.
   interface *interface-type interface-number*
3. Set the encapsulation format for LLDP frames to SNAP.
   - In Layer 2 Ethernet interface view or management Ethernet interface view:
     lldp [**agent** { **nearest-customer** | **nearest-nontpmr** }] **encapsulation snap**
   - In Layer 2 aggregate interface view:
     lldp agent { **nearest-customer** | **nearest-nontpmr** } **encapsulation snap**

   By default, the Ethernet II encapsulation format is used.

Setting LLDP frame transmission parameters

About setting LLDP frame transmission parameters

The Time to Live TLV carried in an LLDPDU determines how long the device information carried in the LLDPDU can be saved on a recipient device.

By setting the TTL multiplier, you can configure the TTL of locally sent LLDPDUs. The TTL is expressed by using the following formula:

TTL = Min (65535, (TTL multiplier × LLDP frame transmission interval + 1))

As the expression shows, the TTL can be up to 65535 seconds. TTLs greater than 65535 will be rounded down to 65535 seconds.

Procedure

1. Enter system view.
   system-view
2. Set the TTL multiplier.
   lldp hold-multiplier *value*

   The default setting is 4.
3. Set the LLDP frame transmission interval.
   lldp timer tx-interval *interval*

   The default setting is 30 seconds.
4. Set the token bucket size for sending LLDP frames.
   lldp max-credit *credit-value*

   The default setting is 5.
5. Set the number of LLDP frames sent each time fast LLDP frame transmission is triggered.
   lldp fast-count *count*

   The default setting is 4.
6. Set the fast LLDP frame transmission interval.
   lldp timer fast-interval *interval*

   The default setting is 1 second.

Configuring the type of port ID TLVs advertised by LLDP

About this task

This task enables an H3C device to advertise only port ID TLVs that contain interface names. By default, an H3C device advertises port ID TLVs that contain interface MAC addresses or interface names. The media devices from some vendors can obtain interface information from H3C devices only through LLDP. For the media devices to obtain interface names, you must configure H3C devices to generate port ID TLVs based on interface names.

Software version and feature compatibility

This feature is supported only in Release 6331 and later.

Restrictions and guidelines

Perform this task only when LLDP neighbors must obtain interface names from LLDPDUs. Do not perform this task in any other scenarios.

You can configure the port ID TLV type in system view or interface view. The interface-specific setting takes precedence over the global setting.

Configuring the type of port ID TLVs advertised by LLDP globally

1. Enter system view.

   system-view

2. Configure the type of port ID TLVs advertised by LLDP.

   lldp [**agent** { **nearest-customer** | **nearest-nontpmr** }] **global tlv-config basic-tlv port-id** *type-id*

   By default, an interface advertises port ID TLVs that contain interface MAC addresses if it receives LLDP-MED TLVs and advertises port ID TLVs that contain interface names if no LLDP-MED TLVs are received.

Configuring the type of port ID TLVs advertised by LLDP on an interface

1. Enter system view.

   system-view

2. Enter interface view.

   interface *interface-type interface-number*

3. Configure the type of port ID TLVs advertised by LLDP.

   - In Layer 2 Ethernet interface view or management Ethernet interface view:

     lldp [**agent** { **nearest-customer** | **nearest-nontpmr** }] **tlv-config basic-tlv port-id** *type-id*

   - In Layer 2 aggregate interface view:

     lldp agent { **nearest-customer** | **nearest-nontpmr** } **tlv-config basic-tlv port-id** *type-id*

   By default, the global port ID TLV type configuration takes effect.

Enabling displaying LLDP local information about all interfaces

About this task

This task enables the **display lldp local-information** command to display LLDP local information about all interfaces.

By default, the **display lldp local-information** command displays information about physically up interfaces. The media devices from some vendors can obtain interface information from H3C devices only through LLDP. For the media devices to obtain all interface information, enable the **display lldp local-information** command to display LLDP local information about all interfaces.

Software version and feature compatibility

This feature is supported only in Release 6331 and later.

Restrictions and guidelines

Perform this task only when LLDP neighbors can obtain interface information from the device through LLDP.

Procedure

1. Enter system view.

   system-view

2. Enable displaying LLDP local information about all interfaces.

   lldp local-information all-interface

   By default, the **display lldp local-information** command displays information about physically up interfaces.

Enabling LLDP polling

About LLDP polling

With LLDP polling enabled, a device periodically searches for local configuration changes. When the device detects a configuration change, it sends LLDP frames to inform neighboring devices of the change.

Procedure

1. Enter system view.

   system-view

2. Enter interface view.

   interface *interface-type interface-number*

3. Enable LLDP polling and set the polling interval.

   - In Layer 2 Ethernet interface view or management Ethernet interface view:

     lldp [**agent** { **nearest-customer** | **nearest-nontpmr** }] **check-change-interval** *interval*

   - In Layer 2 aggregate interface view:

     lldp agent { **nearest-customer** | **nearest-nontpmr** } **check-change-interval** *interval*

   By default, LLDP polling is disabled.

Disabling LLDP PVID inconsistency check

About LLDP PVID inconsistency check

By default, when the system receives an LLDP packet, it compares the PVID value contained in the packet with the PVID configured on the receiving interface. If the two PVIDs do not match, a log message will be printed to notify the user.

You can disable PVID inconsistency check if different PVIDs are required on a link.

Procedure

1. Enter system view.

   `system-view`

2. Disable LLDP PVID inconsistency check.

   `lldp ignore-pvid-inconsistency`

   By default, LLDP PVID inconsistency check is enabled.

Configuring CDP compatibility

About CDP compatibility

To enable your device to exchange information with a directly connected Cisco device that supports only CDP, you must enable CDP compatibility.

CDP compatibility enables your device to receive and recognize CDP packets from the neighboring CDP device and send CDP packets to the neighboring device. The CDP packets sent to the neighboring CDP device carry the following information:

- Device ID.
- ID of the port connecting to the neighboring device.
- Port IP address.
- TTL.

The port IP address is the primary IP address of a VLAN interface in up state. The VLAN ID of the VLAN interface must be the lowest among the VLANs permitted on the port. If no VLAN interfaces of the permitted VLANs are assigned an IP address or all VLAN interfaces are down, no port IP address will be advertised.

You can view the neighboring CDP device information that can be recognized by the device in the output of the **`display lldp neighbor-information`** command. For more information about the **`display lldp neighbor-information`** command, see LLDP commands in *Layer 2—LAN Switching Command Reference*.

To make your device work with Cisco IP phones, you must enable CDP compatibility.

If your LLDP-enabled device cannot recognize CDP packets, it does not respond to the requests of Cisco IP phones for the voice VLAN ID configured on the device. As a result, a requesting Cisco IP phone sends voice traffic without any tag to your device. Your device cannot differentiate the voice traffic from other types of traffic.

CDP compatibility enables your device to receive and recognize CDP packets from a Cisco IP phone and respond with CDP packets carrying TLVs with the configured voice VLAN. If no voice VLAN is configured for CDP packets, CDP packets carry the voice VLAN of the port or the voice VLAN assigned by the RADIUS server. The assigned voice VLAN has a higher priority. According to TLVs with the voice VLAN configuration, the IP phone automatically configures the voice VLAN. As a result, the voice traffic is confined in the configured voice VLAN and is differentiated from other types of traffic.

For more information about voice VLANs, see "Configuring voice VLANs."

When the device is connected to a Cisco IP phone that has a host attached to its data port, the host must access the network through the Cisco IP phone. If the data port goes down, the IP phone will send a CDP packet to the device so the device can log out the user.

CDP-compatible LLDP operates in one of the following modes:

- **TxRx**—CDP packets can be transmitted and received.
- **Rx**—CDP packets can be received but cannot be transmitted.
- **Disable**—CDP packets cannot be transmitted or received.

Restrictions and guidelines

Voice VLANs are not available on the S5110V2-SI, S5000V3-EI, S5000V5-EI, S5000E-X, S5000X-EI, and WAS6000 switch series.

When you configure CDP compatibility for LLDP, follow these restrictions and guidelines:

- To make CDP-compatible LLDP take effect on a port, follow these steps:
  a. Enable CDP-compatible LLDP globally.
  b. Configure CDP-compatible LLDP to operate in TxRx mode on the port.
- The maximum TTL value that CDP allows is 255 seconds. To make CDP-compatible LLDP work correctly with Cisco IP phones, configure the LLDP frame transmission interval to be no more than 1/3 of the TTL value.

Prerequisites

Before you configure CDP compatibility, complete the following tasks:

- Globally enable LLDP.
- Enable LLDP on the port connecting to a CDP device.
- Configure LLDP to operate in TxRx mode on the port.

Procedure

1. Enter system view.
   `system-view`
2. Enable CDP compatibility globally.
   `lldp compliance cdp`
   By default, CDP compatibility is disabled globally.
3. Enter Layer 2 Ethernet interface view or management Ethernet interface view.
   `interface` *`interface-type interface-number`*
4. Configure CDP-compatible LLDP to operate in TxRx mode.
   `lldp compliance admin-status cdp txrx`
   By default, CDP-compatible LLDP operates in **`disable`** mode.
5. Set the voice VLAN ID carried in CDP packets.
   `cdp voice-vlan` *`vlan-id`*
   By default, no voice VLAN ID is configured to be carried in CDP packets.

Configuring LLDP trapping and LLDP-MED trapping

About LLDP trapping and LLDP-MED trapping

LLDP trapping or LLDP-MED trapping notifies the network management system of events such as newly detected neighboring devices and link failures.

To prevent excessive LLDP traps from being sent when the topology is unstable, set a trap transmission interval for LLDP.

Procedure

1. Enter system view.

   system-view

2. Enter interface view.

   interface *interface-type interface-number*

3. Enable LLDP trapping.

   - In Layer 2 Ethernet interface view or management Ethernet interface view:

     lldp [**agent** { **nearest-customer** | **nearest-nontpmr** }] **notification remote-change enable**

   - In Layer 2 aggregate interface view:

     lldp agent { **nearest-customer** | **nearest-nontpmr** } **notification remote-change enable**

   By default, LLDP trapping is disabled.

4. (In Layer 2 Ethernet interface view or management Ethernet interface view.) Enable LLDP-MED trapping.

   lldp notification med-topology-change enable

   By default, LLDP-MED trapping is disabled.

5. Return to system view.

   quit

6. (Optional.) Set the LLDP trap transmission interval.

   lldp timer notification-interval *interval*

   The default setting is 30 seconds.

Configuring MAC address learning for DCN

Setting the source MAC address of LLDP frames

About setting the source MAC address of LLDP frames

In Layer 2 Ethernet interface view, this feature must be configured with generation of ARP or ND entries for received management address TLVs to meet the following requirements:

- The source MAC address of outgoing LLDP frames is the MAC address of a VLAN interface instead of the MAC address of the egress interface.
- The neighbor device can generate correct ARP or ND entries for the local device.

In Layer 2 Ethernet interface view, this feature sets the source MAC address of outgoing LLDP frames to the MAC address of a VLAN interface to which the specified VLAN ID belongs. The source MAC address of outgoing LLDP frames is the MAC address of the Layer 2 Ethernet interface in the following situations:

- The specified VLAN or the corresponding VLAN interface does not exist.
- The VLAN interface to which the VLAN ID belongs is physically down.

Restrictions and guidelines

In Layer 2 Ethernet interface view, you must configure this feature so the interface can use the MAC address of a VLAN interface instead of its own MAC address as the source MAC address of LLDP

frames. This ensures that the neighbor device can generate correct ARP or ND entries for the local device.

Procedure

1. Enter system view.

   system-view

2. Enter Layer 2 Ethernet interface view.

   interface *interface-type interface-number*

3. Set the source MAC address of LLDP frames to the MAC address of a VLAN interface.

   lldp source-mac vlan *vlan-id*

   By default, the source MAC address of LLDP frames is the MAC address of the egress interface.

Enabling generation of ARP or ND entries for received management address TLVs

About generation of ARP or ND entries for received management address TLVs

This feature enables the device to generate an ARP or ND entry after receiving an LLDP frame containing a management address TLV on an interface. The ARP or ND entry maps the advertised management address to the source MAC address of the frame.

You can enable generation of both ARP and ND entries on an interface. If the management address TLV contains an IPv4 address, the device generates an ARP entry. If the management address TLV contains an IPv6 address, the device generates an ND entry.

In Layer 2 Ethernet interface view, this feature sets the Layer 2 Ethernet interface to the output interface in the generated entries. The VLAN to which the entries belong is the VLAN specified by this feature. The device cannot generate ARP or ND entries in one of the following situations:

- The specified VLAN or the corresponding VLAN interface does not exist.
- The VLAN interface to which the VLAN ID belongs is physically down.

Restrictions and guidelines

In Layer 2 Ethernet interface view, you must configure the interface to use the MAC address of a VLAN interface instead of its own MAC address as the source MAC address of LLDP frames. This ensures that the neighbor device can generate correct ARP or ND entries.

Procedure

1. Enter system view.

   system-view

2. Enter Layer 2 Ethernet interface view.

   interface *interface-type interface-number*

3. Enable generation of ARP or ND entries for management address TLVs received on the interface.

   lldp management-address { **arp-learning** | **nd-learning** } **vlan** *vlan-id*

   By default, generation of ARP or ND entries for received management address TLVs is disabled on an interface.

   In Layer 2 Ethernet interface view, the **vlan** *vlan-id* option specifies the ID of the VLAN to which the generated ARP or ND entry belongs. To prevent the ARP or ND entries from overwriting each other, do not specify the same VLAN ID for different Layer 2 Ethernet interfaces.

   You can enable generation of both ARP and ND entries on an interface.

Display and maintenance commands for LLDP

Execute **display** commands in any view.

Task	Command
Display local LLDP information.	**display lldp local-information** [**global** | **interface** *interface-type interface-number*]
Display the information contained in the LLDP TLVs sent from neighboring devices.	**display lldp neighbor-information** [[[**interface** *interface-type interface-number*] [**agent** { **nearest-bridge** | **nearest-customer** | **nearest-nontpmr** }] [**verbose**]] | **list** [**system-name** *system-name*]]
Display LLDP statistics.	**display lldp statistics** [**global** | [**interface** *interface-type interface-number*] [**agent** { **nearest-bridge** | **nearest-customer** | **nearest-nontpmr** }]]
Display LLDP status of a port.	**display lldp status** [**interface** *interface-type interface-number*] [**agent** { **nearest-bridge** | **nearest-customer** | **nearest-nontpmr** }]
Display types of advertisable optional LLDP TLVs.	**display lldp tlv-config** [**interface** *interface-type interface-number*] [**agent** { **nearest-bridge** | **nearest-customer** | **nearest-nontpmr** }]
Clear LLDP statistics on ports.	**reset lldp statistics** [**interface** *interface-type interface number*] [**agent** { **nearest-bridge** | **nearest-customer** | **nearest-nontpmr** }]

LLDP configuration examples

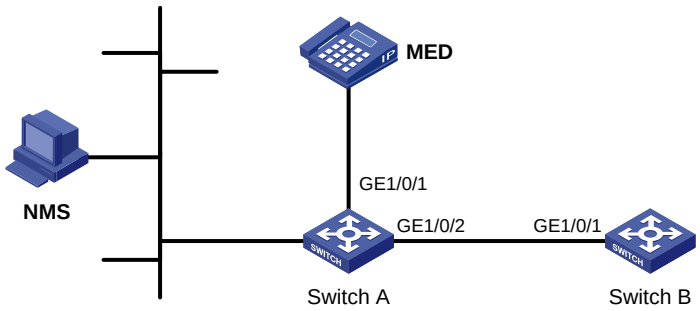
Example: Configuring basic LLDP functions

Network configuration

As shown in Figure 5, enable LLDP globally on Switch A and Switch B to perform the following tasks:

- Monitor the link between Switch A and Switch B on the NMS.
- Monitor the link between Switch A and the MED device on the NMS.

Figure 5 Network diagram



Procedure

1. Configure Switch A:

   # Enable LLDP globally.

   ```
   <SwitchA> system-view
   [SwitchA] lldp global enable
   ```

   # Enable LLDP on GigabitEthernet 1/0/1. By default, LLDP is enabled on ports.

   ```
   [SwitchA] interface gigabitethernet 1/0/1
   [SwitchA-GigabitEthernet1/0/1] lldp enable
   ```

   # Set the LLDP operating mode to Rx on GigabitEthernet 1/0/1.

   ```
   [SwitchA-GigabitEthernet1/0/1] lldp admin-status rx
   [SwitchA-GigabitEthernet1/0/1] quit
   ```

   # Enable LLDP on GigabitEthernet 1/0/2. By default, LLDP is enabled on ports.

   ```
   [SwitchA] interface gigabitethernet1/2
   [SwitchA-GigabitEthernet1/0/2] lldp enable
   ```

   # Set the LLDP operating mode to Rx on GigabitEthernet 1/0/2.

   ```
   [SwitchA-GigabitEthernet1/0/2] lldp admin-status rx
   [SwitchA-GigabitEthernet1/0/2] quit
   ```

2. Configure Switch B:

   # Enable LLDP globally.

   ```
   <SwitchB> system-view
   [SwitchB] lldp global enable
   ```

   # Enable LLDP on GigabitEthernet 1/0/1. By default, LLDP is enabled on ports.

   ```
   [SwitchB] interface gigabitethernet 1/0/1
   [SwitchB-GigabitEthernet1/0/1] lldp enable
   ```

   # Set the LLDP operating mode to Tx on GigabitEthernet 1/0/1.

   ```
   [SwitchB-GigabitEthernet1/0/1] lldp admin-status tx
   [SwitchB-GigabitEthernet1/0/1] quit
   ```

Verifying the configuration

Verify the following items:

- GigabitEthernet 1/0/1 of Switch A connects to a MED device.
- GigabitEthernet 1/0/2 of Switch A connects to a non-MED device.
- Both ports operate in Rx mode, and they can receive LLDP frames but cannot send LLDP frames.

```
[SwitchA] display lldp status
Global status of LLDP: Enable
Bridge mode of LLDP: customer-bridge
The current number of LLDP neighbors: 2
The current number of CDP neighbors: 0
LLDP neighbor information last changed time: 0 days, 0 hours, 4 minutes, 40 seconds
Transmit interval              : 30s
Fast transmit interval         : 1s
Transmit credit max            : 5
Hold multiplier                : 4
Reinit delay                   : 2s
Trap interval                  : 30s
Fast start times               : 4
```

```
LLDP status information of port 1 [GigabitEthernet1/0/1]:
LLDP agent nearest-bridge:
Port status of LLDP            : Enable
Admin status                   : Rx_Only
Trap flag                      : No
MED trap flag                  : No
Polling interval               : 0s
Number of LLDP neighbors       : 1
Number of MED neighbors        : 1
Number of CDP neighbors        : 0
Number of sent optional TLV    : 21
Number of received unknown TLV : 0

LLDP agent nearest-customer:
Port status of LLDP            : Enable
Admin status                   : Disable
Trap flag                      : No
MED trap flag                  : No
Polling interval               : 0s
Number of LLDP neighbors       : 0
Number of MED neighbors        : 0
Number of CDP neighbors        : 0
Number of sent optional TLV    : 16
Number of received unknown TLV : 0

LLDP status information of port 2 [GigabitEthernet1/0/2]:
LLDP agent nearest-bridge:
Port status of LLDP            : Enable
Admin status                   : Rx_Only
Trap flag                      : No
MED trap flag                  : No
Polling interval               : 0s
Number of LLDP neighbors       : 1
Number of MED neighbors        : 0
Number of CDP neighbors        : 0
Number of sent optional TLV    : 21
Number of received unknown TLV : 3

LLDP agent nearest-nontpmr:
Port status of LLDP            : Enable
Admin status                   : Disable
Trap flag                      : No
MED trap flag                  : No
Polling interval               : 0s
Number of LLDP neighbors       : 0
Number of MED neighbors        : 0
Number of CDP neighbors        : 0
```

```
Number of sent optional TLV    : 1
Number of received unknown TLV : 0

LLDP agent nearest-customer:
Port status of LLDP            : Enable
Admin status                   : Disable
Trap flag                      : No
MED trap flag                  : No
Polling interval               : 0s
Number of LLDP neighbors       : 0
Number of MED neighbors        : 0
Number of CDP neighbors        : 0
Number of sent optional TLV    : 16
Number of received unknown TLV : 0
```

Remove the link between Switch A and Switch B.

Verify that GigabitEthernet 1/0/2 of Switch A does not connect to any neighboring devices.

```
[SwitchA] display lldp status
Global status of LLDP: Enable
The current number of LLDP neighbors: 1
The current number of CDP neighbors: 0
LLDP neighbor information last changed time: 0 days, 0 hours, 5 minutes, 20 seconds
Transmit interval              : 30s
Fast transmit interval         : 1s
Transmit credit max            : 5
Hold multiplier                : 4
Reinit delay                   : 2s
Trap interval                  : 30s
Fast start times               : 4

LLDP status information of port 1 [GigabitEthernet1/0/1]:
LLDP agent nearest-bridge:
Port status of LLDP            : Enable
Admin status                   : Rx_Only
Trap flag                      : No
MED trap flag                  : No
Polling interval               : 0s
Number of LLDP neighbors       : 1
Number of MED neighbors        : 1
Number of CDP neighbors        : 0
Number of sent optional TLV    : 0
Number of received unknown TLV : 5

LLDP agent nearest-nontpmr:
Port status of LLDP            : Enable
Admin status                   : Disable
Trap flag                      : No
MED trap flag                  : No
Polling interval               : 0s
```

```
Number of LLDP neighbors       : 0
Number of MED neighbors        : 0
Number of CDP neighbors        : 0
Number of sent optional TLV    : 1
Number of received unknown TLV : 0

LLDP status information of port 2 [GigabitEthernet1/0/2]:
LLDP agent nearest-bridge:
Port status of LLDP            : Enable
Admin status                   : Rx_Only
Trap flag                      : No
MED trap flag                  : No
Polling interval               : 0s
Number of LLDP neighbors       : 0
Number of MED neighbors        : 0
Number of CDP neighbors        : 0
Number of sent optional TLV    : 0
Number of received unknown TLV : 0

LLDP agent nearest-nontpmr:
Port status of LLDP            : Enable
Admin status                   : Disable
Trap flag                      : No
MED trap flag                  : No
Polling interval               : 0s
Number of LLDP neighbors       : 0
Number of MED neighbors        : 0
Number of CDP neighbors        : 0
Number of sent optional TLV    : 1
Number of received unknown TLV : 0

LLDP agent nearest-customer:
Port status of LLDP            : Enable
Admin status                   : Disable
Trap flag                      : No
MED trap flag                  : No
Polling interval               : 0s
Number of LLDP neighbors       : 0
Number of MED neighbors        : 0
Number of CDP neighbors        : 0
Number of sent optional TLV    : 16
Number of received unknown TLV : 0
```

Example: Configuring CDP-compatible LLDP

IMPORTANT:

This example is not available on the S5000E-X, S5000X-EI, S5110V2-SI, S5000V3-EI, S5000V5-EI,

and WAS6000 switch series.

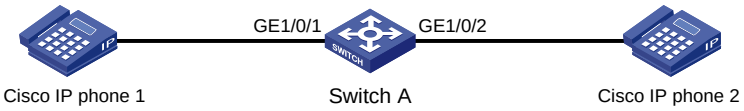
Network configuration

As shown in Figure 6, GigabitEthernet 1/0/1 and GigabitEthernet 1/0/2 of Switch A are each connected to a Cisco IP phone, which sends tagged voice traffic.

Configure voice VLAN 2 on Switch A. Enable CDP compatibility of LLDP on Switch A to allow the Cisco IP phones to automatically configure the voice VLAN. The voice VLAN feature performs the following operations:

- Confines the voice traffic to the voice VLAN.
- Isolates the voice traffic from other types of traffic.

Figure 6 Network diagram



Procedure

1. Configure a voice VLAN on Switch A:

Create VLAN 2.

```
<SwitchA> system-view
[SwitchA] vlan 2
[SwitchA-vlan2] quit
```

Set the link type of GigabitEthernet 1/0/1 and GigabitEthernet 1/0/2 to trunk, and enable voice VLAN on them.

```
[SwitchA] interface gigabitethernet 1/0/1
[SwitchA-GigabitEthernet1/0/1] port link-type trunk
[SwitchA-GigabitEthernet1/0/1] voice-vlan 2 enable
[SwitchA-GigabitEthernet1/0/1] quit
[SwitchA] interface gigabitethernet 1/0/2
[SwitchA-GigabitEthernet1/0/2] port link-type trunk
[SwitchA-GigabitEthernet1/0/2] voice-vlan 2 enable
[SwitchA-GigabitEthernet1/0/2] quit
```

2. Configure CDP-compatible LLDP on Switch A:

Enable LLDP globally, and enable CDP compatibility globally.

```
[SwitchA] lldp global enable
[SwitchA] lldp compliance cdp
```

Enable LLDP on GigabitEthernet 1/0/1. By default, LLDP is enabled on ports.

```
[SwitchA] interface gigabitethernet 1/0/1
[SwitchA-GigabitEthernet1/0/1] lldp enable
```

Configure LLDP to operate in TxRx mode on GigabitEthernet 1/0/1.

```
[SwitchA-GigabitEthernet1/0/1] lldp admin-status txrx
```

Configure CDP-compatible LLDP to operate in TxRx mode on GigabitEthernet 1/0/1.

```
[SwitchA-GigabitEthernet1/0/1] lldp compliance admin-status cdp txrx
[SwitchA-GigabitEthernet1/0/1] quit
```

Enable LLDP on GigabitEthernet 1/0/2. By default, LLDP is enabled on ports.

```
[SwitchA] interface gigabitethernet 1/0/2
[SwitchA-GigabitEthernet1/0/2] lldp enable
```

Configure LLDP to operate in TxRx mode on GigabitEthernet 1/0/2.

```
[SwitchA-GigabitEthernet1/0/2] lldp admin-status txrx
```

Configure CDP-compatible LLDP to operate in TxRx mode on GigabitEthernet 1/0/2.

```
[SwitchA-GigabitEthernet1/0/2] lldp compliance admin-status cdp txrx
[SwitchA-GigabitEthernet1/0/2] quit
```

Verifying the configuration

Verify that Switch A has completed the following operations:

- Discovering the IP phones connected to GigabitEthernet 1/0/1 and GigabitEthernet 1/0/2.
- Obtaining IP phone information.

```
[SwitchA] display lldp neighbor-information

CDP neighbor-information of port 1[GigabitEthernet1/0/1]:
LLDP agent nearest-bridge:
 CDP neighbor index  : 1
 Chassis ID          : SEP00141CBCDBFE
 Port ID             : Port 1

CDP neighbor-information of port 2[GigabitEthernet1/0/2]:
LLDP agent nearest-bridge:
 CDP neighbor index  : 2
 Chassis ID          : SEP00141CBCDBFF
 Port ID             : Port 1
```

Contents

Configuring L2PT

About L2PT

Layer 2 Protocol Tunneling (L2PT) can transparently send Layer 2 protocol packets from geographically dispersed customer networks across a service provider network or drop them.

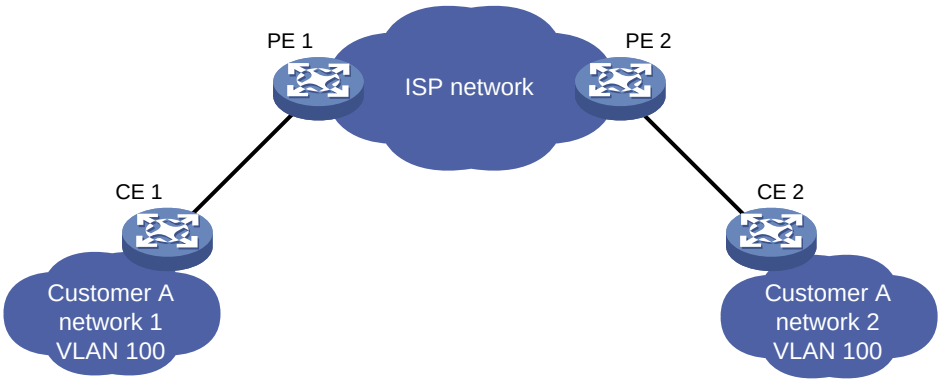
L2PT application scenario

Dedicated lines are used in a service provider network to build user-specific Layer 2 networks. As a result, a customer network contains sites located at different sides of the service provider network.

As shown in Figure 1, Customer A's network is divided into network 1 and network 2, which are connected by the service provider network. For Customer A's network to implement Layer 2 protocol calculations, the Layer 2 protocol packets must be transmitted across the service provider network.

Upon receiving a Layer 2 protocol packet, the PEs cannot determine whether the packet is from the customer network or the service provider network. They must deliver the packet to the CPU for processing. In this case, the Layer 2 protocol calculation in Customer A's network is mixed with the Layer 2 protocol calculation in the service provider network. Neither the customer network nor the service provider network can implement independent Layer 2 protocol calculations.

Figure 1 L2PT application scenario



L2PT is introduced to resolve the problem. L2PT provides the following functions:

- Multicasts Layer 2 protocol packets from a customer network in a VLAN. Dispersed customer networks can complete an independent Layer 2 protocol calculation, which is transparent to the service provider network.
- Isolates Layer 2 protocol packets from different customer networks through different VLANs.

Supported protocols

H3C devices support L2PT for the following protocols:

- CDP.
- CFD.
- DLDP.
- EOAM.
- GVRP.

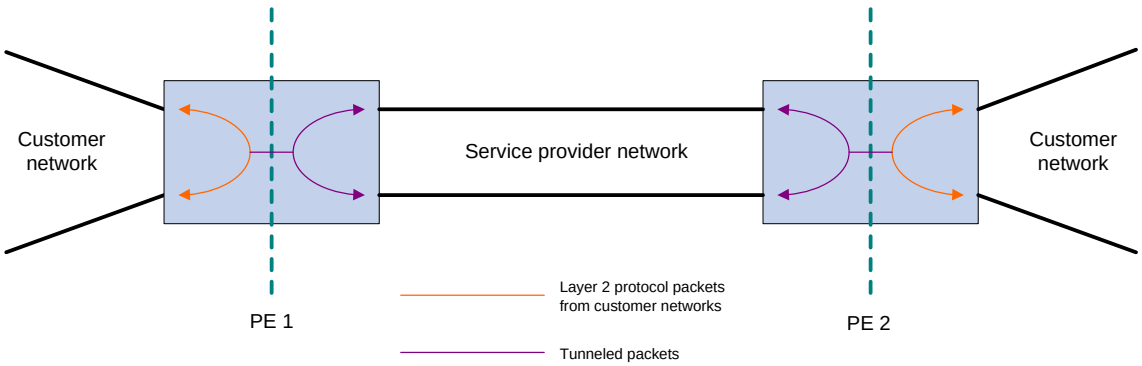
- LACP.
- LLDP.
- MVRP.
- PAgP.
- PVST.
- STP (including STP, RSTP, and MSTP).
- UDLD.
- VTP.

L2PT operating mechanism

As shown in Figure 2, L2PT operates as follows:

- When a port of PE 1 receives a Layer 2 protocol packet from the customer network in a VLAN, it performs the following operations:
  - Multicasts the packet out of all customer-facing ports in the VLAN except the receiving port.
  - Encapsulates the packet with a specified destination multicast address, and multicasts it out of all ISP-facing ports in the VLAN. The encapsulated packet is called the BPDU tunneled packet.
- When a port of PE 2 in the VLAN receives the tunneled packet from the service provider network, it performs the following operations:
  - Multicasts the packet out of all ISP-facing ports in the VLAN except the receiving port.
  - Decapsulates the packet and multicasts the decapsulated packet out of all customer-facing ports in the VLAN.

Figure 2 L2PT operating mechanism

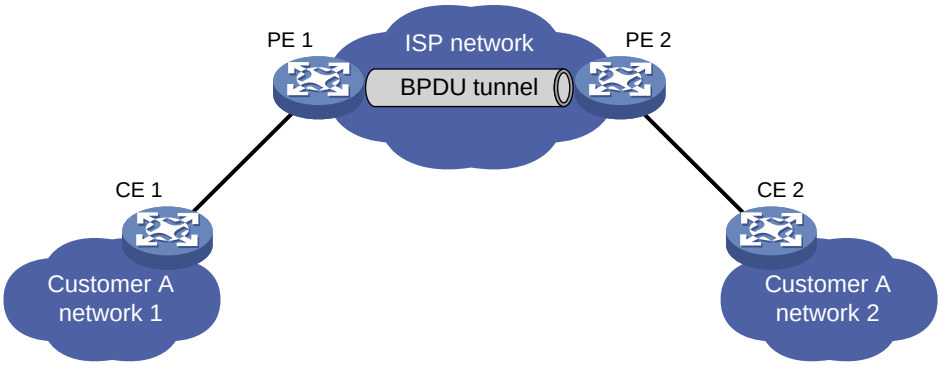


For example, as shown in Figure 3, PE 1 receives an STP packet (BPDU) from network 1 to network 2. CEs are the edge devices on the customer network, and PEs are the edge devices on the service provider network. L2PT processes the packet as follows:

1. PE 1 performs the following operations:
   a. Encapsulates the packet with a specified destination multicast MAC address (010f-e200-0003 by default).
   b. Sends the tunneled packet out of all ISP-facing ports in the packet's VLAN.
2. Upon receiving the tunneled packet, PE 2 decapsulates the packet and sends the BPDU to CE 2.

Through L2PT, both the ISP network and Customer A's network can perform independent spanning tree calculations.

Figure 3 L2PT network diagram



L2PT tasks at a glance

To configure L2PT, perform the following tasks:

1. Enabling L2PT

   This feature is applicable only to customer-facing ports.
2. (Optional.) Setting the destination multicast MAC address for tunneled packets

Enabling L2PT

Restrictions and guidelines for L2PT

- To enable L2PT for a Layer 2 protocol on a port, perform the following tasks:
  - Enable the protocol on the connected CE, and disable the protocol on the port.
  - When a PE establishes a connection to a network device within the service provider network through CDP, you must enable CDP compatibility for LLDP on the PE. CDP compatibility for LLDP can be enabled only globally, and cannot be disabled separately on customer-facing interfaces. As a result, the CDP packets from the CE cannot be transparently transmitted within the service provider network. In this case, as a best practice, do not enable L2PT for CDP on the PE. For L2PT to take effect on CDP on the PE, you must disable CDP compatibility for LLDP globally on the PE, which will cause the PE to fail to communicate with the network devices within the service provider network through CDP. Before you disable CDP compatibility for LLDP on the PE, make sure you know its influence on the network. For more information about CDP compatibility of LLDP, see "Configuring LLDP."
  - Disable the protocol (for example, STP) on the PE ports connecting to an aggregate interface on a CE when the following conditions exist:
    - The protocol is running on the aggregate interface on the CE.
    - The aggregate interface on the CE connects to an L2PT-enabled port on the PE.
  - Enable L2PT on PE ports connected to a customer network. If you enable L2PT on ports connected to the service provider network, L2PT determines that the ports are connected to a customer network.
  - Make sure the VLAN tags of Layer 2 protocol packets are not changed or deleted for the tunneled packets to be transmitted correctly across the service provider network.
- L2PT for LLDP supports LLDP packets from only nearest bridge agents.
- You can enable L2PT on a member port of a Layer 2 aggregation group, but the configuration does not take effect.

Enabling L2PT for a protocol in Layer 2 Ethernet interface view

Restrictions and guidelines

LACP and EOAM require point-to-point transmission. If you enable L2PT on a Layer 2 Ethernet interface for LACP or EOAM, L2PT multicasts LACP or EOAM packets out of customer-facing ports. As a result, the transmission between two CEs is not point-to-point. To ensure point-to-point transmission for the LACP or EOAM packets, you must configure other features (for example, VLAN).

Procedure

1. Enter system view.

   system-view
2. Enter Layer 2 Ethernet interface view.

   interface *interface-type interface-number*
3. Enable L2PT for a protocol.

   l2protocol { **cdp** | **cfd** | **dldp** | **dtp** | **eoam** | **gvrp** | **lacp** | **lldp** | **mvrp** | **pagp** | **pvst** | **stp** | **udld** | **vtp** } **tunnel dot1q**

   By default, L2PT is disabled for all protocols.

   The **dtp** and **cfd** keywords are supported only in Release 6331 and later.

Enabling L2PT for a protocol in Layer 2 aggregate interface view

1. Enter system view.

   system-view
2. Enter Layer 2 aggregate interface view.

   interface bridge-aggregation *interface-type interface-number*
3. Enable L2PT for a protocol.

   l2protocol { **cdp** | **cfd** | **gvrp** | **lacp** | **lldp** | **mvrp** | **pagp** | **pvst** | **stp** | **udld** | **vtp** } **tunnel dot1q**

   By default, L2PT is disabled for all protocols.

   The **cfd** keyword is supported only in Release 6331 and later.

Setting the destination multicast MAC address for tunneled packets

About the destination multicast MAC address for tunneled packets

The default destination multicast MAC address for tunneled packets is 010f-e200-0003. You can modify the destination multicast MAC address for tunneled packets of the specific protocol or all protocols.

Restrictions and guidelines

The **l2protocol tunnel-dmac** command sets the destination multicast MAC address for tunneled packets of all protocols. The **l2protocol type tunnel-dmac** command sets the

destination multicast MAC address for tunneled packets of the specified protocol. If both commands are executed, the **l2protocol type tunnel-dmac** command takes priority.

For tunneled packets to be recognized, set the same destination multicast MAC addresses for packets of the same protocol on PEs that are connected to the same customer network.

As a best practice, set different destination multicast MAC addresses on PEs connected to different customer networks. It prevents L2PT from sending packets of a customer network to another customer network.

Procedure

1. Enter system view.
   system-view
2. Perform at least one of the following tasks:
   - Set the destination multicast MAC address for tunneled packets of all protocols.
     l2protocol tunnel-dmac *mac-address*
   - Set the destination multicast MAC address for tunneled packets of the specified protocol.
     l2protocol type { **cdp** | **cfd** | **dldp** | **dtp** | **eoam** | **gvrp** | **lacp** | **lldp** | **mvrp** | **pagp** | **pvst** | **stp** | **udld** | **vtp** } **tunnel-dmac** *mac-address*
     This command is supported only in Release 6331 and later.

   By default, 010f-e200-0003 is used for tunneled packets.

Display and maintenance commands for L2PT

Execute **display** commands in any view and **reset** commands in user view.

Task	Command
Display L2PT statistics.	**display l2protocol statistics** [**interface** *interface-type interface-number*]
Clear L2PT statistics.	**reset l2protocol statistics** [**interface** *interface-type interface-number*]

L2PT configuration examples

Example: Configuring L2PT for STP

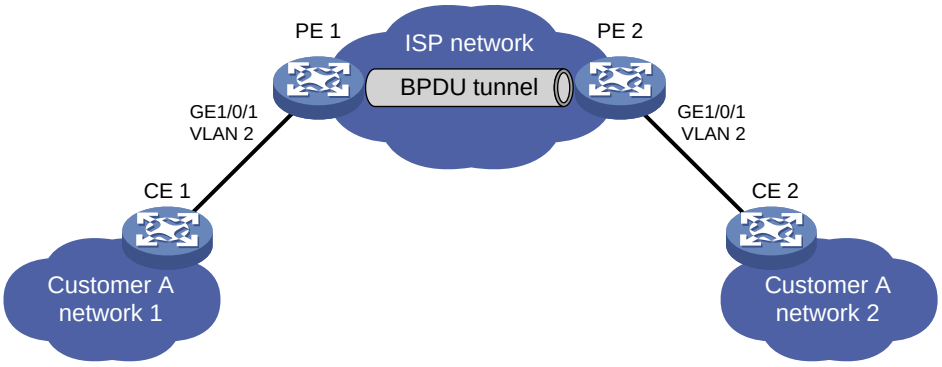
Network configuration

As shown in Figure 4, the MAC addresses of CE 1 and CE 2 are 00e0-fc02-5800 and 00e0-fc02-5802, respectively. MSTP is enabled in Customer A's network, and default MSTP settings are used.

Perform the following tasks on the PEs:

- Configure the ports that connect to CEs as access ports, and configure the ports in the service provider network as trunk ports. Configure ports in the service provider network to allow packets from any VLAN to pass.
- Enable L2PT for STP to enable Customer A's network to implement independent spanning tree calculation across the service provider network.
- Set the destination multicast MAC address to 0100-0ccd-cdd0 for tunneled packets.

Figure 4 Network diagram



Procedure

1. Configure PE 1:

   # Set the destination multicast address to 0100-0ccd-cdd0 for tunneled packets.

   ```
   <PE1> system-view
   [PE1] l2protocol tunnel-dmac 0100-0ccd-cdd0
   ```

   # Create VLAN 2.

   ```
   [PE1] vlan 2
   [PE1-vlan2] quit
   ```

   # Configure GigabitEthernet 1/0/1 as an access port and assign the port to VLAN 2.

   ```
   [PE1] interface gigabitethernet 1/0/1
   [PE1-GigabitEthernet1/0/1] port access vlan 2
   ```

   # Disable STP and enable L2PT for STP on GigabitEthernet 1/0/1.

   ```
   [PE1-GigabitEthernet1/0/1] undo stp enable
   [PE1-GigabitEthernet1/0/1] l2protocol stp tunnel dot1q
   [PE1-GigabitEthernet1/0/1] quit
   ```

   # Configure GigabitEthernet 1/0/2 connected to the service provider network as a trunk port, and assign the port to all VLANs.

   ```
   [PE1] interface gigabitethernet 1/0/2
   [PE1-GigabitEthernet1/0/2] port link-type trunk
   [PE1-GigabitEthernet1/0/2] port trunk permit vlan all
   [PE1-GigabitEthernet1/0/2] quit
   ```

2. Configure PE 2 in the same way PE 1 is configured. (Details not shown.)

Verifying the configuration

Verify that the root bridge of Customer A's network is CE 1.

```
<CE2> display stp root
 MST ID   Root Bridge ID       ExtPathCost IntPathCost Root Port
 0        32768.00e0-fc02-5800 0           0
```

Verify that the root bridge of the service provider network is not CE 1.

```
[PE1] display stp root
 MST ID   Root Bridge ID       ExtPathCost IntPathCost Root Port
 0        32768.0cda-41c5-ba50 0           0
```

Example: Configuring L2PT for LACP

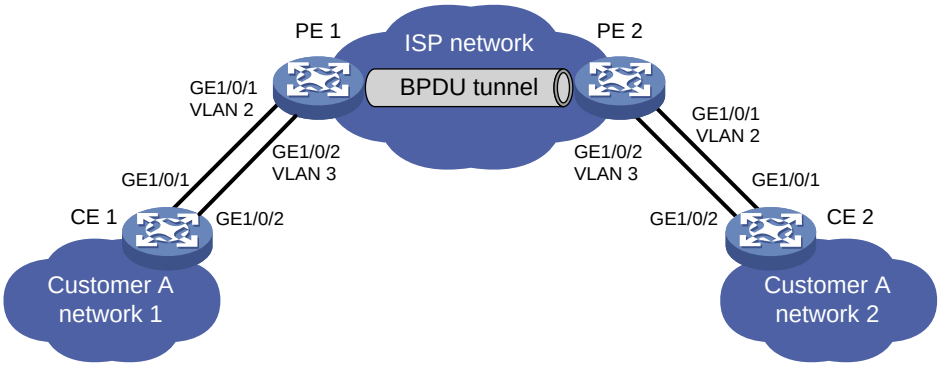
Network configuration

As shown in Figure 5, the MAC addresses of CE 1 and CE 2 are 0001-0000-0000 and 0004-0000-0000, respectively.

Perform the following tasks:

- Configure Ethernet link aggregation on CE 1 and CE 2.
- Configure GigabitEthernet 1/0/1 and GigabitEthernet 1/0/2 on CE 1 to form aggregate links with GigabitEthernet 1/0/1 and GigabitEthernet 1/0/2 on CE 2, respectively.
- Enable L2PT for LACP to enable CE 1 and CE 2 to implement Ethernet link aggregation across the service provider network.

Figure 5 Network diagram



Requirements analysis

To meet the network requirements, perform the following tasks:

- For Ethernet link aggregation to operate correctly, configure VLANs on the PEs to ensure point-to-point transmission between CE 1 and CE 2 in an aggregation group.
  - Set the PVIDs to VLAN 2 and VLAN 3 for GigabitEthernet 1/0/1 and GigabitEthernet 1/0/2 on PE 1, respectively.
  - Configure PE 2 in the same way PE 1 is configured.
  - Configure ports that connect to the CEs as trunk ports.
- To retain the VLAN tag of the customer network, enable QinQ on GigabitEthernet 1/0/1 and GigabitEthernet 1/0/2 on both PE 1 and PE 2.
- For packets from any VLAN to be transmitted, configure all ports in the service provider network as trunk ports.

Procedure

1. Configure CE 1:

Configure Layer 2 aggregation group Bridge-Aggregation 1 to operate in dynamic aggregation mode.

```
<CE1> system-view
[CE1] interface bridge-aggregation 1
[CE1-Bridge-Aggregation1] port link-type access
[CE1-Bridge-Aggregation1] link-aggregation mode dynamic
[CE1-Bridge-Aggregation1] quit
```

Assign GigabitEthernet 1/0/1 and GigabitEthernet 1/0/2 to Bridge-Aggregation 1.

```
[CE1] interface gigabitethernet 1/0/1
```

```
[CE1-GigabitEthernet1/0/1] port link-aggregation group 1
[CE1-GigabitEthernet1/0/1] quit
[CE1] interface gigabitethernet 1/0/2
[CE1-GigabitEthernet1/0/2] port link-aggregation group 1
[CE1-GigabitEthernet1/0/2] quit
```

2. Configure CE 2 in the same way CE 1 is configured. (Details not shown.)

3. Configure PE 1:

Create VLANs 2 and 3.

```
<PE1> system-view
[PE1] vlan 2
[PE1-vlan2] quit
[PE1] vlan 3
[PE1-vlan3] quit
```

Configure GigabitEthernet 1/0/1 as a trunk port, assign the port to VLAN 2, and set the PVID to VLAN 2.

```
[PE1] interface gigabitethernet 1/0/1
[PE1-GigabitEthernet1/0/1] port link-mode bridge
[PE1-GigabitEthernet1/0/1] port link-type trunk
[PE1-GigabitEthernet1/0/1] port trunk permit vlan 2
[PE1-GigabitEthernet1/0/1] port trunk pvid vlan 2
```

Enable QinQ on GigabitEthernet 1/0/1.

```
[PE1-GigabitEthernet1/0/1] qinq enable
```

Enable L2PT for LACP on GigabitEthernet 1/0/1.

```
[PE1-GigabitEthernet1/0/1] l2protocol lacp tunnel dot1q
[PE1-GigabitEthernet1/0/1] quit
```

Configure GigabitEthernet 1/0/2 as a trunk port, assign the port to VLAN 3, and set the PVID to VLAN 3.

```
[PE1] interface gigabitethernet 1/0/2
[PE1-GigabitEthernet1/0/2] port link-mode bridge
[PE1-GigabitEthernet1/0/2] port link-type trunk
[PE1-GigabitEthernet1/0/2] port trunk permit vlan 3
[PE1-GigabitEthernet1/0/2] port trunk pvid vlan 3
```

Enable QinQ on GigabitEthernet 1/0/2.

```
[PE1-GigabitEthernet1/0/2] qinq enable
```

Enable L2PT for LACP on GigabitEthernet 1/0/2.

```
[PE1-GigabitEthernet1/0/2] l2protocol lacp tunnel dot1q
[PE1-GigabitEthernet1/0/2] quit
```

4. Configure PE 2 in the same way PE 1 is configured. (Details not shown.)

Verifying the configuration

Verify that CE 1 and CE 2 have completed Ethernet link aggregation successfully.

```
[CE1] display link-aggregation member-port
Flags: A -- LACP_Activity, B -- LACP_Timeout, C -- Aggregation,
       D -- Synchronization, E -- Collecting, F -- Distributing,
       G -- Defaulted, H -- Expired

GigabitEthernet1/0/1:
Aggregate Interface: Bridge-Aggregation1
```

```
Local:
   Port Number: 3
   Port Priority: 32768
   Oper-Key: 1
   Flag: {ACDEF}
Remote:
   System ID: 0x8000, 0004-0000-0000
   Port Number: 3
   Port Priority: 32768
   Oper-Key: 1
   Flag: {ACDEF}
Received LACP Packets: 23 packet(s)
Illegal: 0 packet(s)
Sent LACP Packets: 26 packet(s)

GigabitEthernet1/0/2:
Aggregate Interface: Bridge-Aggregation1
Local:
   Port Number: 4
   Port Priority: 32768
   Oper-Key: 1
   Flag: {ACDEF}
Remote:
   System ID: 0x8000, 0004-0000-0000
   Port Number: 4
   Port Priority: 32768
   Oper-Key: 1
   Flag: {ACDEF}
Received LACP Packets: 10 packet(s)
Illegal: 0 packet(s)
Sent LACP Packets: 13 packet(s)
[CE2] display link-aggregation member-port
Flags: A -- LACP_Activity, B -- LACP_Timeout, C -- Aggregation,
      D -- Synchronization, E -- Collecting, F -- Distributing,
      G -- Defaulted, H -- Expired

GigabitEthernet1/0/1:
Aggregate Interface: Bridge-Aggregation1
Local:
   Port Number: 3
   Port Priority: 32768
   Oper-Key: 1
   Flag: {ACDEF}
Remote:
   System ID: 0x8000, 0001-0000-0000
   Port Number: 3
   Port Priority: 32768
   Oper-Key: 1
```

```
   Flag: {ACDEF}
Received LACP Packets: 23 packet(s)
Illegal: 0 packet(s)
Sent LACP Packets: 26 packet(s)

GigabitEthernet1/0/2:
Aggregate Interface: Bridge-Aggregation1
Local:
   Port Number: 4
   Port Priority: 32768
   Oper-Key: 1
   Flag: {ACDEF}
Remote:
   System ID: 0x8000, 0001-0000-0000
   Port Number: 4
   Port Priority: 32768
   Oper-Key: 1
   Flag: {ACDEF}
Received LACP Packets: 10 packet(s)
Illegal: 0 packet(s)
Sent LACP Packets: 13 packet(s)
```

Contents

Configuring PPPoE relay

About PPPoE

Point-to-Point Protocol over Ethernet (PPPoE) extends PPP by transporting PPP frames encapsulated in Ethernet over point-to-point links.

PPPoE specifies the methods for establishing PPPoE sessions and encapsulating PPP frames over Ethernet. PPPoE requires a point-to-point relationship between peers instead of a point-to-multipoint relationship as in multi-access environments such as Ethernet. PPPoE provides Internet access for the hosts in an Ethernet through a remote access device and implement access control, authentication, and accounting on a per-host basis. Integrating the low cost of Ethernet and scalability and management functions of PPP, PPPoE gained popularity in various application environments, such as residential access networks.

For more information about PPPoE, see RFC 2516.

PPPoE network structure

PPPoE uses the client/server model. The PPPoE client initiates a connection request to the PPPoE server. After session negotiation between them is complete, a session is established between them, and the PPPoE server provides access control, authentication, and accounting to the PPPoE client.

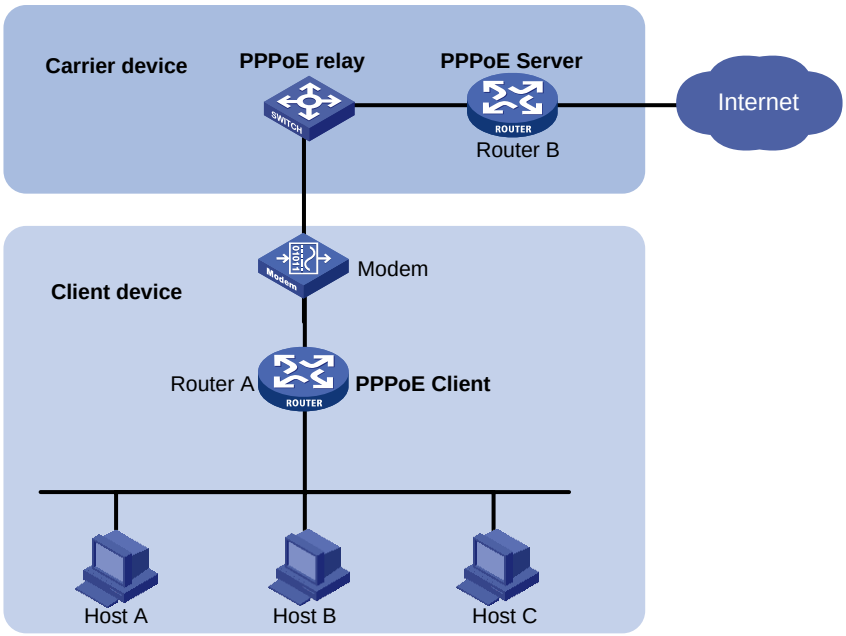
To granularly manage the PPPoE clients based on their location information, you can deploy a PPPoE relay between the PPPoE clients and PPPoE server.

PPPoE network structures are classified into router-initiated and host-initiated network structures depending on the starting point of the PPPoE session.

Router-initiated network structure

As shown in Figure 1, the PPPoE session is established between routers (Router A and Router B). All hosts share one PPPoE session for data transmission without being installed with PPPoE client software. This network structure is typically used by enterprises.

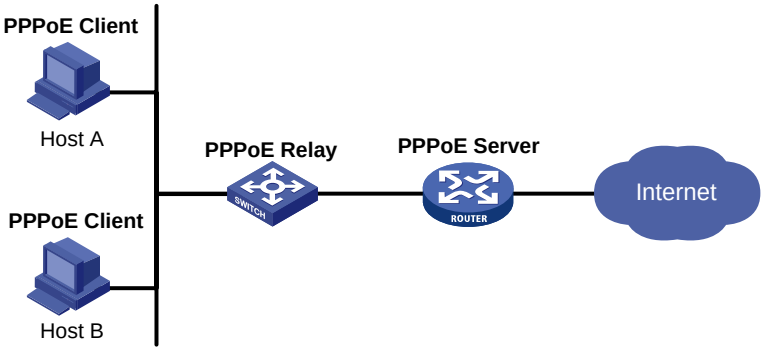
Figure 1 Router-initiated network structure



Host-initiated network structure

As shown in Figure 2, a PPPoE session is established between each host (PPPoE client) and the carrier router (PPPoE server). The service provider assigns an account to each host for billing and control. The host must be installed with PPPoE client software.

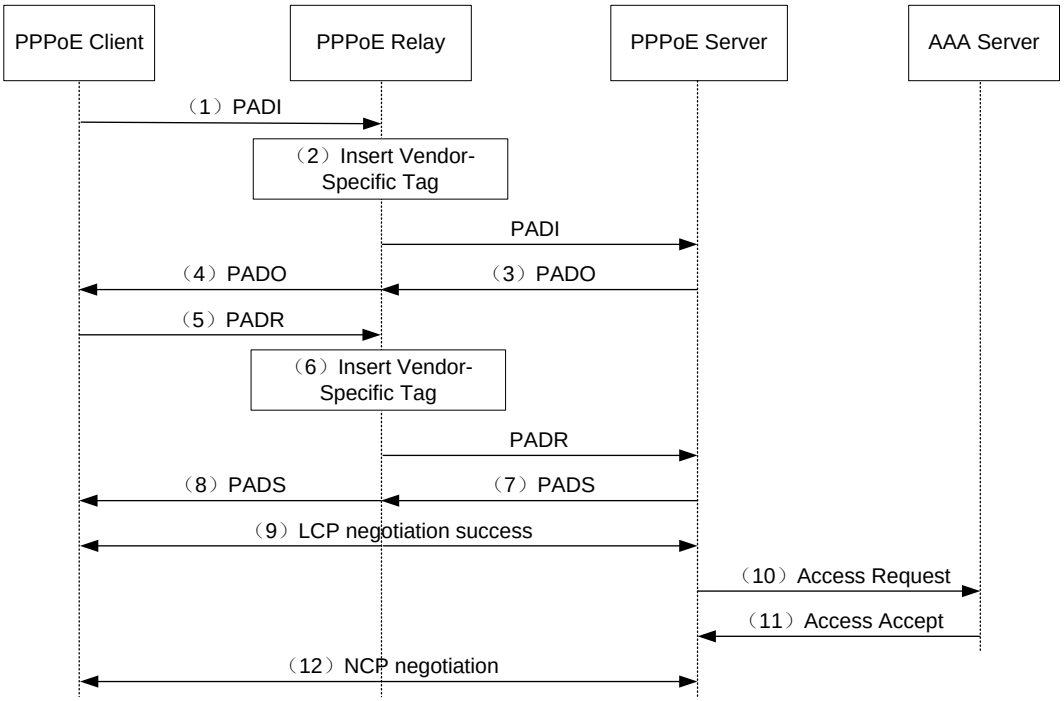
Figure 2 Host-initiated network structure



PPPoE relay fundamentals

The PPPoE relay controls protocol packet forwarding through monitoring the protocol packet exchange between the PPPoE client and the PPPoE server. Figure 3 shows the detailed process.

Figure 3 PPPoE client access procedure in a PPPoE relay network



1. The PPPoE client broadcasts a PADI packet.
2. When receiving the PADI packet, the PPPoE relay adds the vendor-specific tag field to the PADI packet and broadcasts the packet out of all trusted ports.

   The vendor-specific tag in a PPPoE packet identifies the location information (for example, the access port and VLANs) of a PPPoE client.
3. When receiving the PADI packets, the PPPoE server responds with a PADO packet to the PPPoE client.
4. When receiving the PADO packet, the PPPoE relay forwards the packet to the PPPoE client.
5. When receiving the PADO packet, the PPPoE client unicasts a PADR packet to the PPPoE server to apply for the PPPoE service.
6. When receiving the PADR packet, the PPPoE relay adds the vendor-specific tag to the packet and searches for an outgoing interface based on the destination MAC address of the PADR packet.
   - If the outgoing interface is a trusted port, the PPPoE relay forwards the packet out of the port.
   - If the outgoing interface is an untrusted port, the PPPoE relay drops the PADR packet.
7. When receiving the PADR packet, the PPPoE server assigns a session ID to the PPPoE client and binds the session ID to the vendor-specific tag. Then, the PPPoE server responds with a PADS packet to the PPPoE client.
8. When receiving the PADS packet, the PPPoE relay forwards the packet to the PPPoE client.
9. When receiving the PADS packet, the PPPoE client starts the LCP negotiation and authentication with the PPPoE server.
10. During the authentication phase, the PPPoE server will send the location information, username, and password of the PPPoE client to the RADIUS server for authentication.
11. The RADIUS server compares the location information, username, and password saved in the database with those of the PPPoE client. If they match, the PPPoE client passes the authentication.

12. After the PPPoE client passes authentication, the PPPoE client starts NCP negotiation with the PPPoE server. After the NCP negotiation succeeds, the PPPoE client successfully comes online.

Protocols and standards

RFC 2516: A Method for Transmitting PPP Over Ethernet (PPPoE)

Restrictions and guidelines for PPPoE

The switch series can act only as the PPPoE relay.

Configuring the PPPoE relay

PPPoE relay tasks at a glance

To configure the PPPoE relay, perform the following tasks:

1. Enabling the PPPoE relay function
2. Configuring PPPoE relay trusted ports
3. (Optional.) Enabling an interface to strip the vendor-specific tags of the PPPoE server-side packets
4. (Optional.) Configuring the circuit ID and remote ID padding formats for the client-side PPPoE packets on the PPPoE relay
5. (Optional.) Configuring the vendor-specific tag processing policy for the client-side PPPoE packets on the PPPoE relay

Enabling the PPPoE relay function

About the PPPoE relay function

For the PPPoE relay-related configurations to take effect, you must enable the PPPoE relay function.

Procedure

1. Enter system view.
   `system-view`
2. Enable the PPPoE relay function.
   `pppoe-relay enable`
   By default, the PPPoE relay function is disabled.

Configuring PPPoE relay trusted ports

About PPPoE relay trusted ports

A PPPoE relay-enabled device processes PPPoE protocol packets as follows:

- When receiving PADI, PADR, and PADT on untrusted ports, the device can forward the packets out of only the trusted ports.
- When receiving PADO and PADS packets on untrusted ports, the device directly drops the packets.

- When receiving PADO, PADS, and PADT packets on trusted ports, the device can forward the packets out of any port.
- When receiving PADI and PADR packets on trusted ports, the device can forward the packets out of only the trusted ports.

For a PPPoE relay to correctly forward and process PPPoE protocol packets, you must configure the PPPoE server-facing interfaces on the PPPoE relay as trusted ports, and configure the PPPoE client-facing interfaces on the PPPoE relay as untrusted ports.

Restrictions and guidelines

This command is not supported on Layer 2 aggregation group member ports. If a Layer 2 Ethernet interface is configured with this command before joining a Layer 2 aggregation group, the command is cleared on the member port after the member port joins the aggregation group.

Procedure

1. Enter system view.

   system-view
2. Enter Layer 2 Ethernet interface view.

   interface *interface-type interface-number*
3. Configure the interface as a PPPoE relay trusted port.

   pppoe-relay trust

   By default, an interface is not configured as a PPPoE relay trusted port.

Enabling an interface to strip the vendor-specific tags of the PPPoE server-side packets

About stripping the vendor-specific tags of the PPPoE server-side packets

When the PPPoE relay receives PADO and PADS packets from the PPPoE server on a PPPoE relay trusted port with this feature enabled, the PPPoE relay strips the vendor-specific tags of the packets before forwarding the packets.

Restrictions and guidelines

This feature takes effect only on packets received on PPPoE relay trusted ports.

This command is not supported on Layer 2 aggregation group member ports. If a Layer 2 Ethernet interface is configured with this command before joining a Layer 2 aggregation group, the command is cleared on the member port after the member ports joins the aggregation group.

Procedure

1. Enter system view.

   system-view
2. Enter Layer 2 Ethernet interface view.

   interface *interface-type interface-number*
3. Enable the interface to strip the vendor-specific tags of the PPPoE server-side packets.

   pppoe-relay server-information vendor-specific strip

   By default, the function of stripping vendor-specific tags of the PPPoE server-side packets is disabled.

Configuring the circuit ID and remote ID padding formats for the client-side PPPoE packets on the PPPoE relay

About the circuit ID and remote ID padding formats for the client-side PPPoE packets on the PPPoE relay

When the PPPoE relay receives PPPoE packets from the PPPoE client, the PPPoE relay pads the circuit ID and remote ID with the contents in the format configured by using this command.

Both the circuit ID and remote ID are of up to 63 characters. When the content to be padded exceeds 63 characters, the first 63 characters are padded.

Procedure

1. Enter system view.

   system-view

2. Configure the circuit ID and remote ID padding formats for the client-side PPPoE packets on the PPPoE relay.

   pppoe-relay client-information format { **circuit-id** | **remote-id** } { **ascii** | **hex** | **user-defined** *text* }

   By default, both the circuit ID padding format and the remote ID padding format for the client-side PPPoE packets are the ASCII string format on the PPPoE relay.

Configuring the vendor-specific tag processing policy for the client-side PPPoE packets on the PPPoE relay

About the vendor-specific tag processing policy for the client-side PPPoE packets on the PPPoE relay

When the PPPoE relay receives PADI or PADR packets, the PPPoE relay processes the packet according to whether the packets carry the vendor-specific tag and the configured vendor-specific tag processing policy. Then, the PPPoE relay sends the packets to the PPPoE server. Table 1 shows the detailed process.

Table 1 Vendor-specific tag processing policy on the PPPoE relay

Whether the received packets carry the vendor-specific tag	Vendor-specific tag processing policy	Processing for packets on the PPPoE relay
The received packets carry vendor-specific tag	Drop	Strips the vendor-specific tag and then forwards the packets.
	Keep	Keeps the vendor-specific tag unchanged and forwards the packets.
	Replace	Pads the vendor-specific tag in the configured format, replaces the original vendor-specific tag with the new vendor-specific tag, and forwards the packets.
The received packets do not carry vendor-specific tag	Drop	Directly forwards the packets.
	Keep	Directly forwards the packets.
	Replace	Pads the vendor-specific tag in the configured format, adds the new vendor-specific tag to the packets, and forwards the packets.

Restrictions and guidelines

This feature can be configured both in system view and in interface view. The configuration in system view takes effect on all interfaces. The configuration in interface view takes effect only on the current interface. The configuration in interface view takes precedence over the configuration in system view.

The processing policy takes effect only on incoming packets of interfaces.

This command is not supported on Layer 2 aggregation group member ports. If a Layer 2 Ethernet interface is configured with this command before joining a Layer 2 aggregation group, the command is cleared on the member port after the member ports joins the aggregation group.

Configuring the global vendor-specific tag processing policy for the client-side PADI and PADR packets on the PPPoE relay

1. Enter system view.

   system-view

2. Configure the global vendor-specific tag processing policy for the client-side PADI and PADR packets on the PPPoE relay.

   pppoe-relay client-information strategy { **drop** | **keep** | **replace** }

   By default, the global vendor-specific tag processing policy for the client-side PADI and PADR packets on the PPPoE relay is replace.

Configuring an interface-level vendor-specific tag processing policy for the client-side PADI and PADR packets on the PPPoE relay

1. Enter system view.

   system-view

2. Enter Layer 2 Ethernet interface view.

   interface *interface-type interface-number*

3. Configure the vendor-specific tag processing policy for the client-side PADI and PADR packets for the interface on the PPPoE relay.

   pppoe-relay client-information strategy { **drop** | **keep** | **replace** }

   By default, no vendor-specific tag processing policy for the client-side PADI and PADR packets is configured for an interface on the PPPoE relay.

Display and maintenance commands for PPPoE relay

Execute **display** commands in any view and **reset** commands in user view.

Task	Command
Display the vendor-specific tag processing configuration for client-side packets on the PPPoE relay.	**display pppoe-relay client-information** { **format** | **strategy** }
Display packet statistics for the PPPoE relay.	**display pppoe-relay statistics** [**interface** *interface-type interface-number*]
Clear packet statistics for the PPPoE relay.	**reset pppoe-relay statistics**

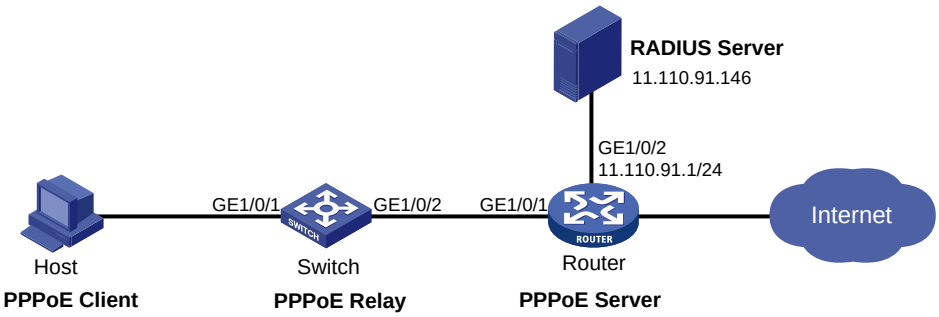
PPPoE configuration examples

Example: Configuring PPPoE relay

Network configuration

The host uses the PPPoE access method to connect to the router through the switch. The switch acts as the PPPoE relay. The router acts as the PPPoE server and assigns IPv4 addresses to the PPPoE client through a PPP address pool.

Figure 4 Network diagram



Procedure

1. Configure the switch as the PPPoE relay:

   # Enable the PPPoE relay function.

   ```
   <Switch> system-view
   [Switch] pppoe-relay enable
   ```

   # Configure the server-facing interface GigabitEthernet 1/0/2 as a PPPoE relay trusted port.

   ```
   [Switch] interface GigabitEthernet 1/0/2
   [Switch-GigabitEthernet1/0/2] pppoe-relay trust
   ```

2. Configure the router as a PPPoE server:

   # Create a PPPoE user.

   ```
   <Router> system-view
   [Router] local-user user1 class network
   [Router-luser-network-user1] password simple pass1
   [Router-luser-network-user1] service-type ppp
   [Router-luser-network-user1] quit
   ```

   # Configure Virtual-Template 1 to use CHAP for authentication and use a PPP address pool for IP address assignment. Set the DNS server IP address for the peer.

   ```
   [Router] interface virtual-template 1
   [Router-Virtual-Template1] ppp authentication-mode chap domain system
   [Router-Virtual-Template1] ppp chap user user1
   [Router-Virtual-Template1] remote address pool 1
   [Router-Virtual-Template1] ppp ipcp dns 8.8.8.8
   [Router-Virtual-Template1] quit
   ```

   # Configure a PPP address pool that contains nine assignable IP addresses, and configure a gateway address for the PPP address pool.

   ```
   [Router] ip pool 1 1.1.1.2 1.1.1.10
   [Router] ip pool 1 gateway 1.1.1.1
   ```

Enable the PPPoE server on GigabitEthernet 1/0/1, and bind the interface to Virtual-Template 1.

```
[Router] interface gigabitethernet 1/0/1
[Router-GigabitEthernet1/0/1] pppoe-server bind virtual-template 1
[Router-GigabitEthernet1/0/1] quit
```

Configure the default ISP domain (**system**) to use the RADIUS scheme for authentication, authorization, and accounting.

```
[Router] domain system
[Router-isp-system] authentication ppp radius-scheme rs1
[Router-isp-system] authorization ppp radius-scheme rs1
[Router-isp-system] accounting ppp radius-scheme rs1
[Router-isp-system] quit
```

Configure a RADIUS scheme, and specify the primary authentication server and the primary accounting server.

```
[Router] radius scheme rs1
[Router-radius-rs1] primary authentication 11.110.91.146
[Router-radius-rs1] primary accounting 11.110.91.146
```

Set the shared key for secure communication with the authentication and accounting servers to **expert** in plain text.

```
[Router-radius-rs1] key authentication simple expert
[Router-radius-rs1] key accounting simple expert
[Router-radius-rs1] quit
```

3. Configure the RADIUS server:
   a. Configure the authentication and accounting passwords as **expert**.
   b. Add a PPPoE user with username **user1** and password **123456**.

   For more information, see the user manual for the RADIUS server.

Verifying the configuration

Install the PPPoE client software and configure the username and password (**user1** and **pass1** in this example) on the hosts. Then, the hosts can use PPPoE to access the Internet through the router.

Layer 3—IP Services Configuration Guide

This command reference is applicable to the following switches and software versions:

H3C S5120V2-LI switch series (Release 6308P01 and later)
H3C S3100V3-SI switch series (Release 6309P01 and later)
H3C S5110V2 switch series (Release 6310 and later)
H3C S5110V2-SI switch series (Release 6310 and later)
H3C S5000V3-EI switch series (Release 6310 and later)
H3C S5000V5-EI switch series (Release 6319P01 and later)
H3C S5000E-X switch series (Release 6310 and later)
H3C S5130S-LI switch series (Release 6310 and later)
H3C MS4320V2 switch series (Release 6308P01 and later)
H3C MS4320 switch series (Release 6308P01 and later)
H3C MS4300V2 switch series (Release 6308P01 and later)
H3C MS4200 switch series (Release 6310 and later)
H3C WS5810-WiNet switch series (Release 6308P01 and later)
H3C WS5820-WiNet switch series (Release 6308P01 and later)
H3C WAS6000 switch series (Release 6308P01 and later)
H3C S5000X-EI switch series (Release 6329 and later)
H3C MS4320V3 switch series (Release 6329 and later)
H3C S5120V3-SI switch series (Release 6329 and later)
H3C S5120V3-LI switch series (Release 6329 and later)

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Preface

This configuration guide describes the IP services fundamentals and configuration procedures.

This preface includes the following topics about the documentation:

Audience

This documentation is intended for:

- Network planners.
- Field technical support and servicing engineers.
- Network administrators.

Conventions

The following information describes the conventions used in the documentation.

Command conventions

Convention	Description
Boldface	**Bold** text represents commands and keywords that you enter literally as shown.
Italic	*Italic* text represents arguments that you replace with actual values.
[ ]	Square brackets enclose syntax choices (keywords or arguments) that are optional.
{ x | y | ... }	Braces enclose a set of required syntax choices separated by vertical bars, from which you select one.
[x | y | ...]	Square brackets enclose a set of optional syntax choices separated by vertical bars, from which you select one or none.
{ x | y | ... } *	Asterisk marked braces enclose a set of required syntax choices separated by vertical bars, from which you select a minimum of one.
[x | y | ...] *	Asterisk marked square brackets enclose optional syntax choices separated by vertical bars, from which you select one choice, multiple choices, or none.
&<1-n>	The argument or keyword and argument combination before the ampersand (&) sign can be entered 1 to n times.
#	A line that starts with a pound (#) sign is comments.

GUI conventions

Convention	Description
Boldface	Window names, button names, field names, and menu items are in Boldface. For example, the **New User** window opens; click **OK**.
>	Multi-level menus are separated by angle brackets. For example, **File** > **Create** > **Folder**.

Symbols

Convention	Description
WARNING!	An alert that calls attention to important information that if not understood or followed can result in personal injury.
CAUTION:	An alert that calls attention to important information that if not understood or followed can result in data loss, data corruption, or damage to hardware or software.
IMPORTANT:	An alert that calls attention to essential information.
NOTE:	An alert that contains additional or supplementary information.
TIP:	An alert that provides helpful information.

Network topology icons

Convention	Description
	Represents a generic network device, such as a router, switch, or firewall.
	Represents a routing-capable device, such as a router or Layer 3 switch.
	Represents a generic switch, such as a Layer 2 or Layer 3 switch, or a router that supports Layer 2 forwarding and other Layer 2 features.
	Represents an access controller, a unified wired-WLAN module, or the access controller engine on a unified wired-WLAN switch.
	Represents an access point.
	Represents a wireless terminator unit.
	Represents a wireless terminator.
	Represents a mesh access point.
	Represents omnidirectional signals.
	Represents directional signals.
	Represents a security product, such as a firewall, UTM, multiservice security gateway, or load balancing device.
	Represents a security module, such as a firewall, load balancing, NetStream, SSL VPN, IPS, or ACG module.

Examples provided in this document

Examples in this document might use devices that differ from your device in hardware model, configuration, or software version. It is normal that the port numbers, sample output, screenshots, and other information in the examples differ from what you have on your device.

Documentation feedback

You can e-mail your comments about product documentation to info@h3c.com.

We appreciate your comments.

Contents

Configuring ARP

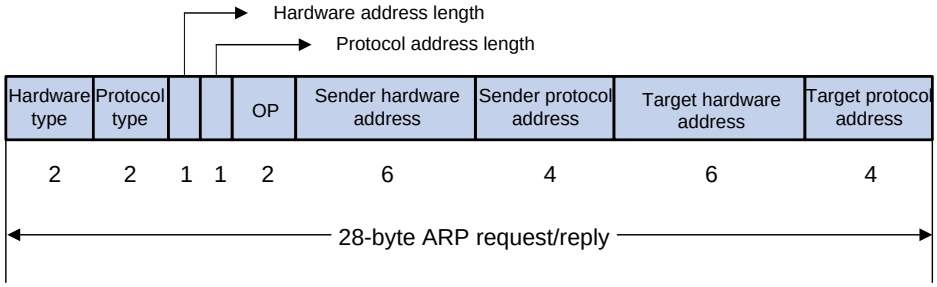
About ARP

ARP resolves IP addresses into MAC addresses on Ethernet networks.

ARP message format

ARP uses two types of messages: ARP request and ARP reply. Figure 1 shows the format of ARP request/reply messages. Numbers in the figure refer to field lengths.

Figure 1 ARP message format



- **Hardware type**—Hardware address type. The value 1 represents Ethernet.
- **Protocol type**—Type of the protocol address to be mapped. The hexadecimal value 0x0800 represents IP.
- **Hardware address length and protocol address length**—Length, in bytes, of a hardware address and a protocol address. For an Ethernet address, the value of the hardware address length field is 6. For an IPv4 address, the value of the protocol address length field is 4.
- **OP**—Operation code, which describes the type of ARP message. The value 1 represents an ARP request, and the value 2 represents an ARP reply.
- **Sender hardware address**—Hardware address of the device sending the message.
- **Sender protocol address**—Protocol address of the device sending the message.
- **Target hardware address**—Hardware address of the device to which the message is being sent.
- **Target protocol address**—Protocol address of the device to which the message is being sent.

ARP operating mechanism

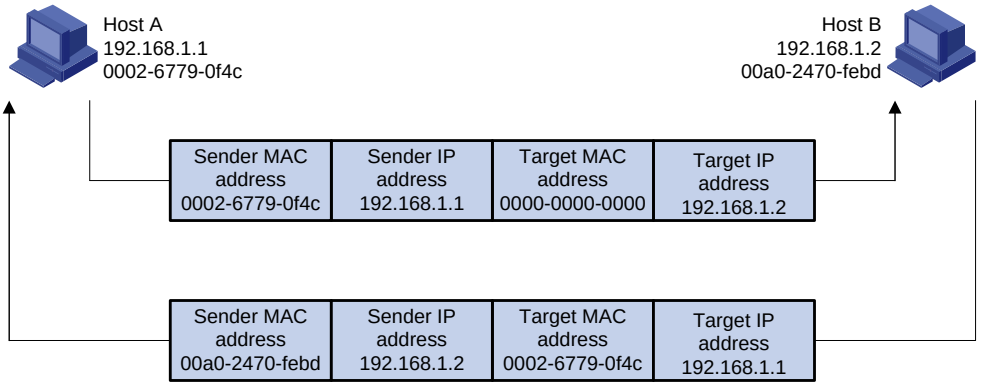
As shown in Figure 2, Host A and Host B are on the same subnet. Host A sends a packet to Host B as follows:

1. Host A looks through the ARP table for an ARP entry for Host B. If one entry is found, Host A uses the MAC address in the entry to encapsulate the IP packet into a data link layer frame. Then Host A sends the frame to Host B.
2. If Host A finds no entry for Host B, Host A buffers the packet and broadcasts an ARP request. The payload of the ARP request contains the following information:
   - **Sender IP address and sender MAC address**—Host A's IP address and MAC address.
   - **Target IP address**—Host B's IP address.
   - **Target MAC address**—An all-zero MAC address.

All hosts on this subnet can receive the broadcast request, but only the requested host (Host B) processes the request.

3. Host B compares its own IP address with the target IP address in the ARP request. If they are the same, Host B operates as follows:
   a. Adds the sender IP address and sender MAC address into its ARP table.
   b. Encapsulates its MAC address into an ARP reply.
   c. Unicasts the ARP reply to Host A.
4. After receiving the ARP reply, Host A operates as follows:
   a. Adds the MAC address of Host B into its ARP table.
   b. Encapsulates the MAC address into the packet and sends the packet to Host B.

Figure 2 ARP address resolution process



If Host A and Host B are on different subnets, Host A sends a packet to Host B as follows:

1. Host A broadcasts an ARP request where the target IP address is the IP address of the gateway.
2. The gateway responds with its MAC address in an ARP reply to Host A.
3. Host A uses the gateway's MAC address to encapsulate the packet, and then sends the packet to the gateway.
4. If the gateway has an ARP entry for Host B, it forwards the packet to Host B directly. If not, the gateway broadcasts an ARP request, in which the target IP address is the IP address of Host B.
5. After the gateway gets the MAC address of Host B, it sends the packet to Host B.

ARP entry types

An ARP table stores dynamic ARP entries, OpenFlow ARP entries, Rule ARP entries, and static ARP entries.

Dynamic ARP entry

ARP automatically creates and updates dynamic entries. A dynamic ARP entry is removed when its aging timer expires or the output interface goes down. In addition, a dynamic ARP entry can be overwritten by a static ARP entry.

Static ARP entry

A static ARP entry is manually configured and maintained. It does not age out and cannot be overwritten by any dynamic ARP entry.

Static ARP entries protect communication between devices because attack packets cannot modify the IP-to-MAC mapping in a static ARP entry.

The device supports the following types of static ARP entries:

- **Long static ARP entry**—It is directly used for forwarding packets. A long static ARP entry contains the IP address, MAC address, VLAN, and output interface.
- **Short static ARP entry**—It contains only the IP address and MAC address.

  If the output interface is a VLAN interface, the device sends an ARP request whose target IP address is the IP address in the short entry. If the sender IP and MAC addresses in the received ARP reply match the short static ARP entry, the device performs the following operations:
  - Adds the interface that received the ARP reply to the short static ARP entry.
  - Uses the resolved short static ARP entry to forward IP packets.
- **Multiport ARP entry**—It contains the IP address, MAC address, VLAN information.

  The device can use a multiport ARP entry that has the same MAC address, VLAN as a multicast or multiport unicast MAC address entry for packet forwarding. A multiport ARP entry is manually configured. It does not age out and cannot be overwritten by any dynamic ARP entry.

To communicate with a host by using a fixed IP-to-MAC mapping, configure a short static ARP entry on the device. To communicate with a host by using a fixed IP-to-MAC mapping through an interface in a VLAN, configure a long static ARP entry on the device.

OpenFlow ARP entry

ARP creates OpenFlow ARP entries by learning from the OpenFlow module. An OpenFlow ARP entry does not age out, and it cannot be updated. An OpenFlow ARP entry can be used directly to forward packets. For more information about OpenFlow, see *OpenFlow Configuration Guide*.

Rule ARP entry

Rule ARP entries can be directly used for packet forwarding. A Rule ARP entry does not age out, and it cannot be updated. It can be overwritten by a static ARP entry.

ARP creates Rule ARP entries by learning from the portal authentication module. For more information about portal authentication, see portal authentication configuration in *Security Configuration Guide.*

ARP tasks at a glance

All ARP tasks are optional.

- Configuring a static ARP entry
  - Configuring a short static ARP entry
  - Configuring a long static ARP entry
  - Configuring a multiport ARP entry
- Configuring features for dynamic ARP entries
  - Setting the dynamic ARP learning limit for a device
  - Setting the dynamic ARP learning limit for an interface
  - Setting the aging timer for dynamic ARP entries
  - Setting the maximum number of probes for dynamic ARP entries
  - Setting the interval for probing dynamic ARP entries
  - Enabling dynamic ARP entry check
- Synchronizing ARP entries across all member devices
- Enabling user information checking for ARP entries:
  - Enabling recording user IP address conflicts
  - Enabling interface consistency check between ARP and MAC address entries
  - Enabling recording user port migrations
- Enabling ARP logging

Configuring a static ARP entry

Static ARP entries are effective when the device functions correctly.

Configuring a short static ARP entry

Restrictions and guidelines

A resolved short static ARP entry becomes unresolved upon certain events, for example, when the resolved output interface goes down, or the corresponding VLAN or VLAN interface is deleted.

Procedure

1. Enter system view.
   system-view
2. Configure a short static ARP entry.
   arp static *ip-address mac-address*

Configuring a long static ARP entry

About long static ARP entries

Long static ARP entries can be effective or ineffective. Ineffective long static ARP entries cannot be used for packet forwarding. A long static ARP entry is ineffective when any of the following conditions exists:

- The IP address in the entry conflicts with a local IP address.
- No local interface has an IP address in the same subnet as the IP address in the ARP entry.

A long static ARP entry for a VLAN is deleted if the VLAN or VLAN interface is deleted.

Procedure

1. Enter system view.
   system-view
2. Configure a long static ARP entry.
   arp static *ip-address mac-address* [*vlan-id interface-type interface-number*]

Configuring a multiport ARP entry

About multiport ARP entries

A multiport ARP entry contains an IP address, MAC address, output interface, and VLAN ID information. The VLAN and output interfaces are specified by a multiport unicast MAC address entry or a multicast MAC address entry. For more information about multiport unicast MAC address entries, see *Layer—2 LAN Switching Configuration Guide*. For more information about multicast MAC address entries, see *IP Multicast Configuration Guide*.

A multiport ARP entry can overwrite a dynamic, short static or long static ARP entry. Conversely, a short static or long static ARP entry can overwrite a multiport ARP entry.

Restrictions and guidelines

For a multiport ARP entry to be effective for packet forwarding, make sure the following conditions are met:

- A multiport unicast MAC address entry or a multicast MAC address entry exists.

- The multiport ARP entry must have the same MAC address as the multiport unicast MAC address entry or the multicast MAC address entry.
- The IP address in the multiport ARP entry must reside on the same subnet as the VLAN interface of the specified VLAN.

If an aggregate interface is the output interface of an entry and its member ports reside on multiple IRF member devices, the device cannot use the entry to forward packets. To resolve this issue, set the global link-aggregation load sharing mode to a mode other than source or destination MAC address-based by using the **link-aggregation global load-sharing mode** command. For more information about this command, see Ethernet link aggregation in *Layer 2—LAN Switching Command Reference*.

Procedure

1. Enter system view.

   system-view
2. Configure a multiport unicast MAC address entry or a multicast MAC address entry.
   - In a common network, configure a multiport unicast MAC address entry.

     mac-address multiport *mac-address* **interface** *interface-list* **vlan** *vlan-id*
   - In a common network, configure a multicast MAC address entry.

     mac-address multicast *mac-address* **interface** *interface-list* **vlan** *vlan-id*
3. Configure a multiport ARP entry.

   arp multiport *ip-address mac-address vlan-id*

Configuring features for dynamic ARP entries

Setting the dynamic ARP learning limit for a device

About the dynamic ARP learning limit for a device

A device can dynamically learn ARP entries. To prevent a device from holding too many ARP entries, you can set the maximum number of dynamic ARP entries that the device can learn. When the limit is reached, the device stops ARP learning.

If you set a value lower than the number of existing dynamic ARP entries, the device does not delete the existing entries unless they age out. You can use the **reset arp dynamic** command to clear dynamic ARP entries.

Procedure

1. Enter system view.

   system-view
2. Set the dynamic ARP learning limit for the device.

   arp max-learning-number *max-number* **slot** *slot-number*

   The default setting varies by device model. For more information, see the command reference.

   To disable the device from dynamic ARP learning, set the value to 0.

Setting the dynamic ARP learning limit for an interface

About setting the dynamic ARP learning limit for an interface

An interface can dynamically learn ARP entries. To prevent an interface from holding too many ARP entries, you can set the maximum number of dynamic ARP entries that the interface can learn. When the limit is reached, the interface stops ARP learning.

You can set limits for both a Layer 2 interface and the VLAN interface for a permitted VLAN on the Layer 2 interface. The Layer 2 interface learns an ARP entry only when neither limit is reached.

The total dynamic ARP learning limit for all interfaces will not be higher than the dynamic ARP learning limit for the device.

Procedure

1. Enter system view.

   system-view
2. Enter interface view.

   interface *interface-type interface-number*
3. Set the dynamic ARP learning limit for the interface.

   arp max-learning-num *max-number* [**alarm** *alarm-threshold*]

   The default setting varies by device model. For more information, see the command reference.

   To disable the interface from dynamic ARP learning, set the value to 0.

Setting the aging timer for dynamic ARP entries

About the aging timer for dynamic ARP entries

Each dynamic ARP entry in the ARP table has a limited lifetime, called an aging timer. The aging timer of a dynamic ARP entry is reset each time the dynamic ARP entry is updated. A dynamic ARP entry that is not updated before its aging timer expires is deleted from the ARP table.

You can set the aging timer for dynamic ARP entries in system view or in interface view. The aging timer set in interface view takes precedence over the aging timer set in system view.

Procedure

1. Enter system view.

   system-view
2. Set the aging timer for dynamic ARP entries.
   - Set the aging timer for dynamic ARP entries in system view.

     arp timer aging { *aging-minutes* | **second** *aging-seconds* }

     By default, the aging timer for dynamic ARP entries in system view is 20 minutes.
   - Execute the following commands in sequence to set the aging timer for dynamic ARP entries in interface view:

     interface *interface-type interface-number*

     arp timer aging { *aging-minutes* | **second** *aging-seconds* }

     By default, the aging timer for dynamic ARP entries in interface view is the aging timer set in system view.

Setting the maximum number of probes for dynamic ARP entries

About the maximum number of probes for dynamic ARP entries

This probe mechanism keeps legal dynamic ARP entries valid and avoids unnecessary ARP resolution during later traffic forwarding. It sends ARP requests for the IP address in a dynamic ARP entry.

- If the device receives an ARP reply before the entry aging timer expires, the device resets the aging timer.
- If the device does not receive any ARP reply after the maximum number of probes is made, the device deletes the entry when the entry aging timer expires.

You can set the maximum number of probes in system view or in interface view. The probe count set in interface view takes precedence over the probe count set in system view.

Procedure

1. Enter system view.

   system-view
2. Set the maximum number of probes for dynamic ARP entries.
   - Set the maximum number of probes for dynamic ARP entries in system view.

     arp timer aging probe-count *count*

     By default, the maximum number of probes in system view for dynamic ARP entries is 3.
   - Execute the following commands in sequence to set the maximum number of probes for dynamic ARP entries:

     interface *interface-type interface-number*

     arp timer aging probe-count *count*

     By default, the maximum number of probes in interface view for dynamic ARP entries is the maximum number of probes set in system view.

Setting the interval for probing dynamic ARP entries

About the interval for probing dynamic ARP entries

The probing feature keeps legal dynamic ARP entries valid and avoids unnecessary ARP resolution during later traffic forwarding.

Before a dynamic ARP entry is aged out, the device sends ARP requests for the IP address in the ARP entry.

- If the device receives an ARP reply during the probe interval, the device resets the aging timer.
- If the device does not receive any ARP reply during the probe interval, the device starts a new probe.
- If the maximum number probes are made, and still no ARP reply is received, the device deletes the entry.

You can set the probe interval in system view and in interface view. The probe interval in interface view takes precedence over the probe interval in system view.

Restrictions and guidelines

- If massive traffic exists in the network, set a long interval.
- During the dynamic ARP entry probing process, a dynamic ARP entry will not be deleted if its aging time expires. If a reply is received during the probe, the aging timer of the ARP entry is reset.

- For the device to perform the specified number of probes, make sure the following requirement is met:

  Aging time of the dynamic ARP entries > the maximum number of probes × probe interval

Procedure

1. Enter system view.

   system-view
2. Set the interval for probing dynamic ARP entries.
   - Set the interval for probing dynamic ARP entries in system view.

     arp timer aging probe-interval *interval*

     By default, the probe interval is 5 seconds.
   - Execute the following commands in sequence to set the interval for probing dynamic ARP entries:

     interface *interface-type interface-number*

     arp timer aging probe-interval *interval*

     By default, the probe interval depends on the setting in system view.

Enabling dynamic ARP entry check

About dynamic ARP entry check

The dynamic ARP entry check feature disables the device from supporting dynamic ARP entries that contain multicast MAC addresses. The device cannot learn dynamic ARP entries containing multicast MAC addresses. You cannot manually add static ARP entries containing multicast MAC addresses.

When dynamic ARP entry check is disabled, ARP entries containing multicast MAC addresses are supported. The device can learn dynamic ARP entries containing multicast MAC addresses obtained from the ARP packets sourced from a unicast MAC address. You can also manually add static ARP entries containing multicast MAC addresses.

Procedure

1. Enter system view.

   system-view
2. Enable dynamic ARP entry check.

   arp check enable

   By default, dynamic ARP entry check is enabled.

Synchronizing ARP entries across all member devices

About ARP entry synchronization

This task ensures that all IRF member devices in an IRF fabric have the same ARP entries.

Restrictions and guidelines

To synchronize ARP entries across all member devices in a timely manner, you can schedule the device to automatically execute the **arp smooth** command. For information about scheduling a task, see the device management configuration in *Fundamentals Configuration Guide*.

Procedure

To synchronize ARP entries from the master device to all subordinate devices, execute the following command in user view:

arp smooth

Enabling recording user IP address conflicts

About recording user IP address conflicts

This feature enables the device to detect and record user IP address conflicts. The device determines that a conflict occurs if an incoming non-gratuitous ARP packet has the same sender IP address as an existing ARP entry but a different sender MAC address. The device generates a user IP address conflict record, logs the conflict, and sends the log to the information center. For information about the log destination and output rule configuration in the information center, see the information center in *Network Management and Monitoring Configuration Guide*.

Procedure

1. Enter system view.

   system-view

2. Enable recording user IP address conflicts.

   arp user-ip-conflict record enable

   The default differs depending on the software version, as shown below:

Versions	Default setting
Versions earlier than Release 6350	Recording user IP address conflicts is disabled.
Release 6350 and later	• If the device starts up with the initial configuration, recording user IP address conflicts is disabled. • If the device starts up with the factory defaults, recording user IP address conflicts is enabled.

Enabling interface consistency check between ARP and MAC address entries

About interface consistency check between ARP and MAC address entries

In an unstable network, the receiving interface for packets from a user might change. The interface in the MAC address entry can be updated immediately while the interface in the ARP entry cannot. In this case, the packets matching the ARP entry will be sent out of an incorrect interface. To solve this problem, you can use this feature to periodically check the interface consistency between the ARP and MAC address entry for a user. If the interfaces are not the same, ARP sends ARP requests in the VLAN of the ARP entry and updates the entry with the ARP reply receiving interface.

Use **display mac-address** to display MAC address entries. For more information about this command, see MAC address table in *Layer 2—LAN Switching Command Reference.*

Procedure

1. Enter system view.

   system-view

2. Enable interface consistency check between ARP and MAC address entries.

   arp mac-interface-consistency check enable

By default, interface consistency check between ARP and MAC address entries is disabled.

Enabling recording user port migrations

About recording user port migrations

This feature enables the device to detect and record user port migration events. A user port migrates if an incoming ARP packet has the same sender IP address and sender MAC address as an existing ARP entry but a different ingress port. The device generates a user port migration record, logs the migration event, sends the log to the information center, and updates the interface for the ARP entry. For information about the log destination and output rule configuration in the information center, see the information center in *Network Management and Monitoring Configuration Guide*.

Restrictions and guidelines

To avoid device performance degradation, disable recording user port migrations if too many user port migration logs are generated.

Procedure

1. Enter system view.
   `system-view`
2. Enable recording user port migrations.
   `arp user-move record enable`
   By default, recording user port migrations is disabled.

Enabling ARP logging

About ARP logging

This feature enables a device to log ARP events when ARP cannot resolve IP addresses correctly. The log information helps administrators locate and solve problems. The device can log the following ARP events:

- On a proxy ARP-disabled interface, the target IP address of a received ARP packet is not one of the following IP addresses:
  - The IP address of the receiving interface.
  - The virtual IP address of the VRRP group.
- The sender IP address of a received ARP reply conflicts with one of the following IP addresses:
  - The IP address of the receiving interface.
  - The virtual IP address of the VRRP group.

The device sends ARP log messages to the information center. You can use the **`info-center source`** command to specify the log output rules for the information center. For more information about information center, see *Network Management and Monitoring Configuration Guide*.

Procedure

1. Enter system view.
   `system-view`
2. Enable ARP logging.
   `arp check log enable`
   By default, ARP logging is disabled.

Display and maintenance commands for ARP

IMPORTANT:

Clearing ARP entries from the ARP table might cause communication failures. Make sure the entries to be cleared do not affect current communications.

Execute **display** commands in any view and **reset** commands in user view.

Task	Command
Display ARP entries.	**display arp** [[**all** | **dynamic** | **multiport** | **static**] [**slot** *slot-number*] | **vlan** *vlan-id* | **interface** *interface-type interface-number*] [**count** | **verbose**]
Display the maximum number of ARP entries that a device supports.	**display arp entry-limit**
Display the ARP entry for an IP address.	**display arp** *ip-address* [**slot** *slot-number*] [**verbose**]
Display the number of OpenFlow ARP entries.	**display arp openflow count** [**slot** *slot-number*]
Display the aging timer of dynamic ARP entries.	**display arp timer aging**
Display user IP address conflicts.	**display arp user-ip-conflict record** [**slot** *slot-number*]
Display user port migrations.	**display arp user-move record** [**slot** *slot-number*]
Clear ARP entries from the ARP table.	**reset arp** { **all** | **dynamic** | **interface** *interface-type interface-number* | **multiport** | **slot** *slot-number* | **static** }

ARP configuration examples

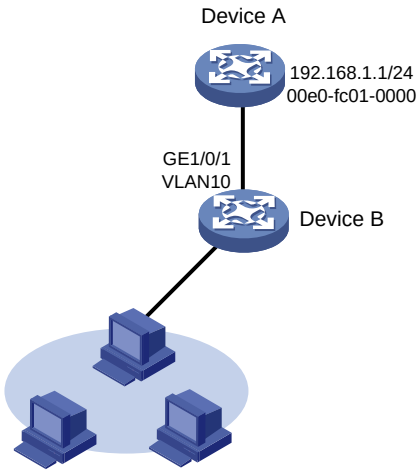
Example: Configuring a long static ARP entry

Network configuration

As shown in Figure 3, hosts are connected to Device B. Device B is connected to Device A through interface GigabitEthernet 1/0/1 in VLAN 10.

To ensure secure communications between Device A and Device B, configure a long static ARP entry for Device A on Device B.

Figure 3 Network diagram



Procedure

Create VLAN 10.

```
<DeviceB> system-view
[DeviceB] vlan 10
[DeviceB-vlan10] quit
```

Add interface GigabitEthernet 1/0/1 to VLAN 10.

```
[DeviceB] interface gigabitethernet 1/0/1
[DeviceB-GigabitEthernet1/0/1] port access vlan 10
[DeviceB-GigabitEthernet1/0/1] quit
```

Create VLAN-interface 10 and configure its IP address.

```
[DeviceB] interface vlan-interface 10
[DeviceB-vlan-interface10] ip address 192.168.1.2 8
[DeviceB-vlan-interface10] quit
```

Configure a long static ARP entry that has IP address 192.168.1.1, MAC address 00e0-fc01-0000, and output interface GigabitEthernet 1/0/1 in VLAN 10.

```
[DeviceB] arp static 192.168.1.1 00e0-fc01-0000 10 gigabitethernet 1/0/1
```

Verifying the configuration

Verify that Device B has a long static ARP entry for Device A.

```
[DeviceB] display arp static
  Type: S-Static   D-Dynamic   O-Openflow   R-Rule   M-Multiport  I-Invalid
IP address      MAC address    VLAN/VSI   Interface               Aging Type
192.168.1.1     00e0-fc01-0000 10         GE1/0/1                 --    S
```

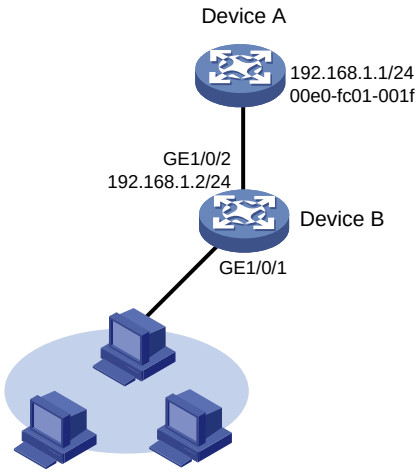
Example: Configuring a short static ARP entry

Network configuration

As shown in Figure 4, hosts are connected to Device B. Device B is connected to Device A through interface GigabitEthernet 1/0/2.

To ensure secure communications between Device A and Device B, configure a short static ARP entry for Device A on Device B.

Figure 4 Network diagram



Procedure

Configure an IP address for GigabitEthernet 1/0/2.

```
<DeviceB> system-view
[DeviceB] interface gigabitethernet 1/0/2
[DeviceB-GigabitEthernet1/0/2] ip address 192.168.1.2 24
[DeviceB-GigabitEthernet1/0/2] quit
```

Configure a short static ARP entry that has IP address 192.168.1.1 and MAC address 00e0-fc01-001f.

```
[DeviceB] arp static 192.168.1.1 00e0-fc01-001f
```

Verifying the configuration

Verify that Device B has a short static ARP entry for Device A

```
[DeviceB] display arp static
  Type: S-Static   D-Dynamic   O-Openflow   R-Rule   M-Multiport  I-Invalid
IP address      MAC address    VLAN/VSI   Interface               Aging Type
192.168.1.1     00e0-fc01-001f --         --                      --    S
```

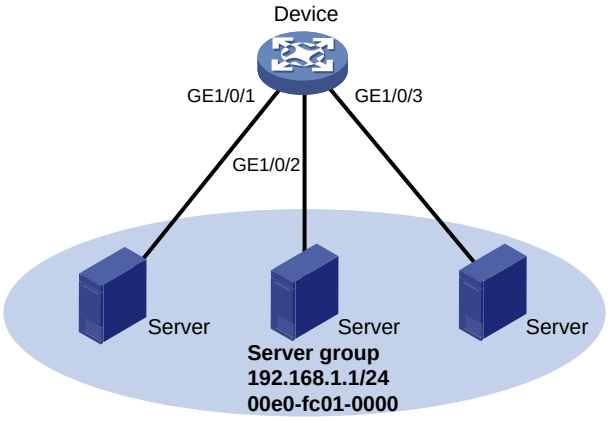
Example: Configuring a multiport ARP entry

Network configuration

As shown in Figure 5, a device connects to three servers through interfaces GigabitEthernet 1/0/1, GigabitEthernet 1/0/2, and GigabitEthernet 1/0/3 in VLAN 10. The servers share the IP address 192.168.1.1/24 and MAC address 00e0-fc01-0000.

Configure a multiport ARP entry so that the device sends IP packets with the destination IP address 192.168.1.1 to the three servers.

Figure 5 Network diagram



Procedure

Create VLAN 10.

```
<Device> system-view
[Device] vlan 10
[Device-vlan10] quit
```

Add GigabitEthernet 1/0/1, GigabitEthernet 1/0/2, and GigabitEthernet 1/0/3 to VLAN 10.

```
[Device] interface gigabitethernet 1/0/1
[Device-GigabitEthernet1/0/1] port access vlan 10
[Device-GigabitEthernet1/0/1] quit
[Device] interface gigabitethernet 1/0/2
[Device-GigabitEthernet1/0/2] port access vlan 10
[Device-GigabitEthernet1/0/2] quit
[Device] interface gigabitethernet 1/0/3
[Device-GigabitEthernet1/0/3] port access vlan 10
[Device-GigabitEthernet1/0/3] quit
```

Create VLAN-interface 10 and specify its IP address.

```
[Device] interface vlan-interface 10
[Device-vlan-interface10] ip address 192.168.1.2 24
[Device-vlan-interface10] quit
```

Configure a multiport unicast MAC address entry that has MAC address 00e0-fc01-0000, and output interfaces GigabitEthernet 1/0/1, GigabitEthernet 1/0/2, and GigabitEthernet 1/0/3 in VLAN 10.

```
[Device] mac-address multiport 00e0-fc01-0000 interface gigabitethernet 1/0/1 to
gigabitethernet 1/0/3 vlan 10
```

Configure a multiport ARP entry with IP address 192.168.1.1 and MAC address 00e0-fc01-0000.

```
[Device] arp multiport 192.168.1.1 00e0-fc01-0000 10
```

Verifying the configuration

Verify that the device has a multiport ARP entry with IP address 192.168.1.1 and MAC address 00e0-fc01-0000.

```
[Device] display arp
  Type: S-Static   D-Dynamic   O-Openflow   R-Rule   M-Multiport  I-Invalid
IP address      MAC address    VLAN/VSI   Interface               Aging Type
192.168.1.1     00e0-fc01-0000 10         --                      --    M
```

Configuring gratuitous ARP

About gratuitous ARP

In a gratuitous ARP packet, the sender IP address and the target IP address are the IP address of the sending device.

A device sends a gratuitous ARP packet for either of the following purposes:

- Determine whether its IP address is already used by another device. If the IP address is already used, the device is informed of the conflict by an ARP reply.
- Inform other devices of a MAC address change.

IP conflict detection

When an interface obtains an IP address, the device broadcasts gratuitous ARP packets in the LAN where the interface resides. If the device receives an ARP reply, its IP address conflicts with the IP address of another device in the LAN. The device displays a log message about the conflict and informs the administrator to change the IP address. The device will not use the conflicting IP address. If no ARP reply is received, the device uses the IP address.

Gratuitous ARP packet learning

This feature enables a device to create or update ARP entries by using the sender IP and MAC addresses in received gratuitous ARP packets.

When this feature is disabled, the device uses received gratuitous ARP packets to update existing ARP entries only. ARP entries are not created based on the received gratuitous ARP packets, which saves ARP table space.

Periodic sending of gratuitous ARP packets

Periodic sending of gratuitous ARP packets helps downstream devices update ARP entries or MAC entries in a timely manner.

This feature can implement the following functions:

- Prevent gateway spoofing.

  Gateway spoofing occurs when an attacker uses the gateway address to send gratuitous ARP packets to the hosts on a network. The traffic destined for the gateway from the hosts is sent to the attacker instead. As a result, the hosts cannot access the external network.

  To prevent such gateway spoofing attacks, you can enable the gateway to send gratuitous ARP packets at intervals. Gratuitous ARP packets contain the primary IP address and manually configured secondary IP addresses of the gateway, so hosts can learn correct gateway information.
- Prevent ARP entries from aging out.

  If network traffic is heavy or if the host CPU usage is high, received ARP packets can be discarded or are not promptly processed. Eventually, the dynamic ARP entries on the receiving host age out. The traffic between the host and the corresponding devices is interrupted until the host re-creates the ARP entries.

  To prevent this problem, you can enable the gateway to send gratuitous ARP packets periodically. Gratuitous ARP packets contain the primary IP address and manually configured

secondary IP addresses of the gateway, so the receiving hosts can update ARP entries in a timely manner.

- Prevent the virtual IP address of a VRRP group from being used by a host.

  The master router of a VRRP group can periodically send gratuitous ARP packets to the hosts on the local network. The hosts can then update local ARP entries and avoid using the virtual IP address of the VRRP group. The sender MAC address in the gratuitous ARP packet is the virtual MAC address of the virtual router. For more information about VRRP, see *High Availability Configuration Guide*.

Gratuitous ARP tasks at a glance

All gratuitous ARP tasks are optional. If all of the following features are disabled, gratuitous ARP still provides the IP conflict detection function.

- Enabling IP conflict notification
- Enabling gratuitous ARP packet learning
- Enabling periodic sending of gratuitous ARP packets
- Enabling sending gratuitous ARP packets for ARP requests with sender IP address on a different subnet
- Configuring gratuitous ARP packet retransmission for the device MAC address change

Enabling IP conflict notification

About IP conflict notification

Upon detecting an IP conflict, the device will sends a gratuitous ARP request. By default, the device displays an error message only after it receives an ARP reply. You can enable this feature to allow the device to display an error message immediately upon detecting an IP conflict.

Procedure

1. Enter system view.

   `system-view`
2. Enable IP conflict notification.

   `arp ip-conflict log prompt`

   The default differs depending on the software version, as shown below:

Versions	Default setting
Versions earlier than Release 6350	IP conflict notification is disabled.
Release 6350 and later	• If the device starts up with the initial configuration, IP conflict notification is disabled. • If the device starts up with the factory defaults, IP conflict notification is enabled.

Enabling gratuitous ARP packet learning

1. Enter system view.

   `system-view`
2. Enable gratuitous ARP packet learning.

   `gratuitous-arp-learning enable`

By default, gratuitous ARP packet learning is enabled.

Enabling periodic sending of gratuitous ARP packets

Restrictions and guidelines

- You can enable periodic sending of gratuitous ARP packets on a maximum of 1024 interfaces.
- Periodic sending of gratuitous ARP packets takes effect on an interface only when the following conditions are met:
  - The data link layer state of the interface is up.
  - The interface has an IP address.
- If you change the sending interval for gratuitous ARP packets, the configuration takes effect at the next sending interval.
- The sending interval for gratuitous ARP packets might be much longer than the specified sending interval in any of the following circumstances:
  - This feature is enabled on multiple interfaces.
  - Each interface is configured with multiple secondary IP addresses.
  - A small sending interval is configured when the previous two conditions exist.

Procedure

1. Enter system view.
   system-view
2. Enter interface view.
   interface *interface-type interface-number*
3. Enable periodic sending of gratuitous ARP packets.
   arp send-gratuitous-arp [**interval** *interval*]
   By default, periodic sending of gratuitous ARP packets is disabled.

Enabling sending gratuitous ARP packets for ARP requests with sender IP address on a different subnet

1. Enter system view.
   system-view
2. Enable the device to send gratuitous ARP packets upon receiving ARP requests whose sender IP address belongs to a different subnet.
   gratuitous-arp-sending enable
   By default, a device does not send gratuitous ARP packets upon receiving ARP requests whose sender IP address belongs to a different subnet.

Configuring gratuitous ARP packet retransmission for the device MAC address change

About gratuitous ARP packet retransmission for the device MAC address change

The device sends a gratuitous ARP packet to inform other devices of its MAC address change. However, the other devices might fail to receive the packet because the device sends the gratuitous ARP packet once only by default. Configure the gratuitous ARP packet retransmission feature to ensure that the other devices can receive the packet.

Procedure

1. Enter system view.

   system-view

2. Set the times and the interval for retransmitting a gratuitous ARP packet for the device MAC address change.

   gratuitous-arp mac-change retransmit *times* **interval** *seconds*

   By default, the device sends a gratuitous packet to inform its MAC address change once only.

Configuring proxy ARP

About proxy ARP

Proxy ARP enables a device on one network to answer ARP requests for an IP address on another network. With proxy ARP, hosts on different broadcast domains can communicate with each other as they would on the same broadcast domain.

Proxy ARP includes common proxy ARP and local proxy ARP.

- **Common proxy ARP**—Allows communication between hosts that connect to different Layer 3 interfaces and reside in different broadcast domains.
- **Local proxy ARP**—Allows communication between hosts that connect to the same Layer 3 interface and reside in different broadcast domains.

Enabling common proxy ARP

1. Enter system view.
   system-view
2. Enter interface view.
   interface *interface-type interface-number*
   Only VLAN interfaces are supported.
3. Enable common proxy ARP.
   proxy-arp enable
   By default, common proxy ARP is disabled.

Enabling local proxy ARP

1. Enter system view.
   system-view
2. Enter interface view.
   interface *interface-type interface-number*
   Only VLAN interfaces are supported.
3. Enable local proxy ARP.
   local-proxy-arp enable [**ip-range** *start-ip-address* **to** *end-ip-address*]
   By default, local proxy ARP is disabled.

Display and maintenance commands for proxy ARP

Execute **display** commands in any view.

Task	Command
Display common proxy ARP	**display proxy-arp** [**interface** *interface-type*

Task	Command
status.	*interface-number*]
Display local proxy ARP status.	**display local-proxy-arp** [**interface** *interface-type interface-number*]

Common proxy ARP configuration example

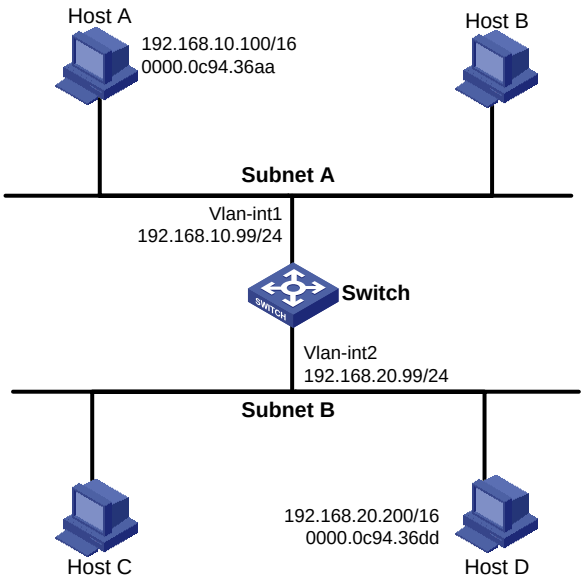
Example: Configuring common proxy ARP

Network configuration

As shown in Figure 6, Host A and Host D have the same IP prefix and mask, but they are located on different subnets separated by the switch. Host A belongs to VLAN 1, and Host D belongs to VLAN 2. No default gateway is configured on Host A and Host D.

Configure common proxy ARP on the switch to enable communication between the two hosts.

Figure 6 Network diagram



Procedure

Create VLAN 2.

```
<Switch> system-view
[Switch] vlan 2
[Switch-vlan2] quit
```

Configure the IP address of VLAN-interface 1.

```
[Switch] interface vlan-interface 1
[Switch-Vlan-interface1] ip address 192.168.10.99 255.255.255.0
```

Enable common proxy ARP on VLAN-interface 1.

```
[Switch-Vlan-interface1] proxy-arp enable
[Switch-Vlan-interface1] quit
```

Configure the IP address of VLAN-interface 2.

```
[Switch] interface vlan-interface 2
[Switch-Vlan-interface2] ip address 192.168.20.99 255.255.255.0
```

Enable common proxy ARP on VLAN-interface 2.

```
[Switch-Vlan-interface2] proxy-arp enable.
```

Verifying the configuration

Verify that Host A and Host D can ping each other.

Configuring ARP snooping

About ARP snooping

ARP snooping is used in Layer 2 switching networks. It creates ARP snooping entries by using information in ARP packets. MFF can use the ARP snooping entries. For more information about MFF, see *Security Configuration Guide*.

Creation of ARP snooping entries

If you enable ARP snooping for a VLAN, ARP packets received in the VLAN are redirected to the CPU. For the VLAN, the CPU uses the sender IP and MAC addresses of the ARP packets, and the receiving VLAN and port to create ARP snooping entries.

Aging of ARP snooping entries

The aging timer and valid period of an ARP snooping entry are 25 minutes and 15 minutes. If an ARP snooping entry is not updated in 12 minutes, the device sends an ARP request. The ARP request uses the IP address of the entry as the target IP address. If an ARP snooping entry is not updated in 15 minutes, it becomes invalid and cannot be used. After that, if an ARP packet matching the entry is received, the entry becomes valid, and its aging timer restarts.

If the aging timer of an ARP snooping entry expires, the entry is removed.

Protection for ARP snooping

An attack occurs if an ARP packet has the same sender IP address as a valid ARP snooping entry but a different sender MAC address. The ARP snooping entry becomes invalid, and it is removed in 1 minute.

Enabling ARP snooping for a VLAN

1. Enter system view.
   system-view
2. Enter VLAN view.
   vlan *vlan-id*
3. Enable ARP snooping for the VLAN.
   arp snooping enable
   By default, ARP snooping is disabled for a VLAN.

Display and maintenance commands for ARP snooping

Execute **display** commands in any view and **reset** commands in user view.

Task	Command
Display ARP snooping entries.	**display arp snooping vlan** [*vlan-id*] [**slot** *slot-number*] [**count**] **display arp snooping vlan ip** *ip-address* [**slot** *slot-number*]
Delete ARP snooping entries.	**reset arp snooping vlan** [*vlan-id*] **reset arp snooping vlan ip** *ip-address*

Configuring ARP direct route advertisement

About ARP direct route advertisement

This feature generates host routes based on ARP entries for packet forwarding and route advertisement.

Enabling ARP direct route advertisement

1. Enter system view.
   system-view
2. Enter interface view.
   interface *interface-type interface-number*
3. Enable the ARP direct route advertisement feature.
   arp route-direct advertise
   By default, the ARP direct route advertisement feature is disabled.

Contents

Configuring IP addressing

About IP addressing

The IP addresses in this chapter refer to IPv4 addresses unless otherwise specified.

IP address representation and classes

IP addressing uses a 32-bit address to identify each host on an IPv4 network. To make addresses easier to read, they are written in dotted decimal notation, each address being four octets in length. For example, address 00001010000000010000000100000001 in binary is written as 10.1.1.1.

Each IP address breaks down into the following sections:

- **Net ID**—Identifies a network. The first several bits of a net ID, known as the class field or class bits, identify the class of the IP address.
- **Host ID**—Identifies a host on a network.

IP addresses are divided into five classes, as shown in Figure 1. The shaded areas represent the address class. The first three classes are most commonly used.

Figure 1 IP address classes

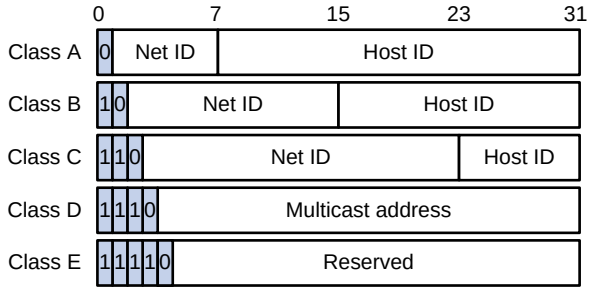


Table 1 IP address classes and ranges

Class	Address range	Remarks
A	0.0.0.0 to 127.255.255.255	The IP address 0.0.0.0 is used by a host at startup for temporary communication. This address is never a valid destination address. Addresses starting with 127 are reserved for loopback test. Packets destined to these addresses are processed locally as input packets rather than sent to the link.
B	128.0.0.0 to 191.255.255.255	N/A
C	192.0.0.0 to 223.255.255.255	N/A
D	224.0.0.0 to 239.255.255.255	Multicast addresses.
E	240.0.0.0 to 255.255.255.255	Reserved for future use, except for the broadcast address 255.255.255.255.

Special IP addresses

The following IP addresses are for special use and cannot be used as host IP addresses:

- **IP address with an all-zero net ID**—Identifies a host on the local network. For example, IP address 0.0.0.16 indicates the host with a host ID of 16 on the local network.
- **IP address with an all-zero host ID**—Identifies a network.
- **IP address with an all-one host ID**—Identifies a directed broadcast address. For example, a packet with the destination address of 192.168.1.255 will be broadcast to all the hosts on the network 192.168.1.0.

Subnetting and masking

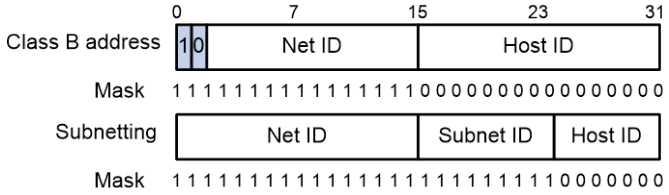
Subnetting divides a network into smaller networks called subnets by using some bits of the host ID to create a subnet ID.

Masking identifies the boundary between the host ID and the combination of net ID and subnet ID.

Each subnet mask comprises 32 bits that correspond to the bits in an IP address. In a subnet mask, consecutive ones represent the net ID and subnet ID, and consecutive zeros represent the host ID.

Before being subnetted, Class A, B, and C networks use these default masks (also called natural masks): 255.0.0.0, 255.255.0.0, and 255.255.255.0, respectively.

Figure 2 Subnetting a Class B network



Subnetting increases the number of addresses that cannot be assigned to hosts. Therefore, using subnets means accommodating fewer hosts.

For example, a Class B network without subnetting can accommodate 1022 more hosts than the same network subnetted into 512 subnets.

- **Without subnetting**—65534 (2^{16} – 2) hosts. (The two deducted addresses are the broadcast address, which has an all-one host ID, and the network address, which has an all-zero host ID.)
- **With subnetting**—Using the first nine bits of the host-id for subnetting provides 512 (2^{9}) subnets. However, only seven bits remain available for the host ID. This allows 126 (2^{7} – 2) hosts in each subnet, a total of 64512 (512 × 126) hosts.

IP address assignment

The following are methods available for assigning an IP address to an interface:

- Manual assignment. This chapter describes only manual IP address assignment for interfaces.
- BOOTP. For information about BOOTP, see "Configuring the BOOTP client."
- DHCP. For information about DHCP, see "Configuring the DHCP client."

These methods are mutually exclusive. If you change the IP address assignment method, the new IP address will overwrite the previous address.

Assigning an IP address to an interface

About manual IP address assignment

An interface can have one primary address and multiple secondary addresses.

Typically, you need to configure a primary IP address for an interface. If the interface connects to multiple subnets, configure primary and secondary IP addresses on the interface so the subnets can communicate with each other through the interface.

In an IRF fabric, you can assign an IP address to the management Ethernet port of each member in the management Ethernet port view of the master. Only the IP address assigned to the management Ethernet port of the master takes effect. After an IRF fabric split, the IP addresses assigned to the management Ethernet ports of the new masters (original subordinates) take effect. Then you can use these IP addresses to log in to the new masters for troubleshooting.

Restrictions and guidelines

- An interface can have only one primary IP address. If you execute the **ip address** command multiple times to specify different primary IP addresses on an interface, the most recent configuration takes effect.
- You cannot assign secondary IP addresses to an interface that obtains an IP address through IP unnumbered, BOOTP, or DHCP.
- The primary and secondary IP addresses assigned to the interface can be located on the same network segment. Different interfaces on your device must reside on different network segments.
- After an IRF split, the routing information on the original master might not be updated immediately. As a result, the management Ethernet port of the original master cannot be pinged from the master (original subordinate) in another IRF fabric. To resolve the problem, wait until route synchronization between the devices is completed or enable NSR for the routing protocol. For information about NSR, see *Layer 3—IP Routing Configuration Guide*.
- The following commands are mutually exclusive. You can configure only one of these commands to assign an IP address to the management Ethernet port of the IRF master.
  - The **ip address** command with the **irf-member** *member-id* option that specifies the master.
  - The **ip address** command that does not contain the **irf-member** *member-id* option.
  - The **ip address dhcp-alloc** command.
- You can assign interfaces IP addresses that have different masks but the same network address if ANDed with the shortest mask. For example, 1.1.1.1/16 and 1.1.2.1/24 have the same network address 1.1.0.0 if ANDed with 255.255.0.0. You can assign the IP addresses to two interfaces on the device. By default, users connected to the two interfaces cannot communicate with each other. For the users to communicate, you must configure common proxy ARP on the device. For more information, see "Configuring proxy ARP."

Procedure

1. Enter system view.

   system-view
2. Enter interface view.

   interface *interface-type interface-number*
3. Assign an IP address to the interface.

   ip address *ip-address* { *mask-length* | *mask* } [**irf-member** *member-id* | **sub**]

   By default, no IP address is assigned to the interface.

To assign an IP address to the management Ethernet port of an IRF member device, enter the master's management Ethernet port view and specify the **irf-member** *member-id* option.

Configuring IP unnumbered

About IP unnumbered

You can configure an interface to borrow an IP address from other interfaces. This is called IP unnumbered, and the interface borrowing the IP address is called IP unnumbered interface.

You can use IP unnumbered to save IP addresses when available IP addresses are inadequate or when an interface is used only occasionally.

Restrictions and guidelines

- Loopback interfaces cannot borrow IP addresses of other interfaces, but other interfaces can borrow IP addresses of loopback interfaces.
- An interface cannot borrow an IP address from an unnumbered interface.
- Multiple interfaces can use the same unnumbered IP address.
- If an interface has multiple manually configured IP addresses, only the manually configured primary IP address can be borrowed.
- A dynamic routing protocol cannot be enabled on the interface where IP unnumbered is configured. To enable the interface to communicate with other devices, configure a static route to the peer device on the interface.

Prerequisites

Assign an IP address to the interface from which you want to borrow the IP address. Alternatively, you can configure the interface to obtain one through BOOTP, or DHCP.

Procedure

1. Enter system view.
   system-view
2. Enter interface view.
   interface *interface-type interface-number*
3. Specify the interface to borrow the IP address of the specified interface.
   ip address unnumbered interface *interface-type interface-number*
   By default, the interface does not borrow IP addresses from other interfaces.

Display and maintenance commands for IP addressing

Execute **display** commands in any view.

Task	Command
Display IP configuration and statistics for the specified or all Layer 3 interfaces.	**display ip interface** [*interface-type interface-number*]
Display brief IP configuration for Layer 3 interfaces.	**display ip interface** [*interface-type* [*interface-number*]] **brief** [**description**]

IP addressing configuration examples

Example: Manually specifying an IP address

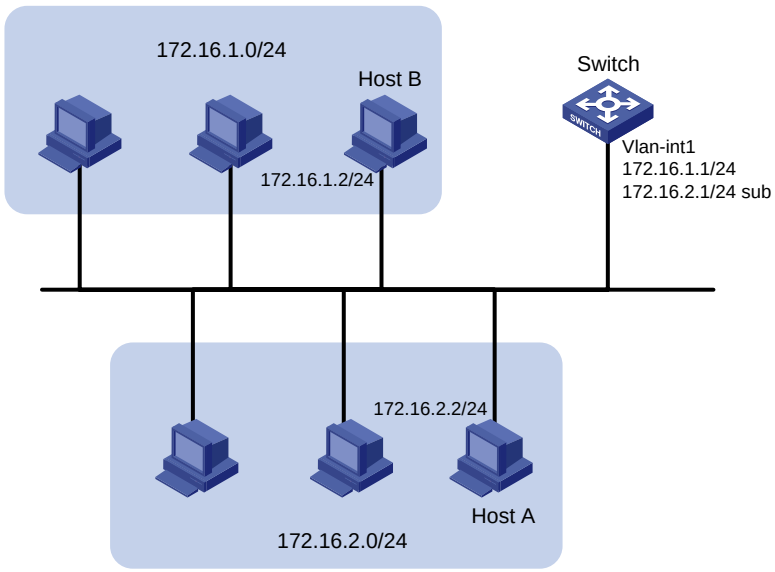
Network configuration

As shown in Figure 3, a port in VLAN 1 on a switch is connected to a LAN comprising two segments: 172.16.1.0/24 and 172.16.2.0/24.

To enable the hosts on the two network segments to communicate with the external network through the switch, and to enable the hosts on the LAN to communicate with each other:

- Assign a primary IP address and a secondary IP address to VLAN-interface 1 on the switch.
- Set the primary IP address of the switch as the gateway address of the PCs on subnet 172.16.1.0/24, and set the secondary IP address of the switch as the gateway address of the PCs on subnet 172.16.2.0/24.

Figure 3 Network diagram



Procedure

Assign a primary IP address and a secondary IP address to VLAN-interface 1.

```
<Switch> system-view
[Switch] interface vlan-interface 1
[Switch-Vlan-interface1] ip address 172.16.1.1 255.255.255.0
[Switch-Vlan-interface1] ip address 172.16.2.1 255.255.255.0 sub
```

Set the gateway address to 172.16.1.1 on the PCs attached to subnet 172.16.1.0/24, and to 172.16.2.1 on the PCs attached to subnet 172.16.2.0/24.

Verifying the configuration

Verify the connectivity between a host on subnet 172.16.1.0/24 and the switch.

```
<Switch> ping 172.16.1.2
Ping 172.16.1.2 (172.16.1.2): 56 data bytes, press CTRL_C to break
56 bytes from 172.16.1.2: icmp_seq=0 ttl=128 time=7.000 ms
56 bytes from 172.16.1.2: icmp_seq=1 ttl=128 time=2.000 ms
56 bytes from 172.16.1.2: icmp_seq=2 ttl=128 time=1.000 ms
```

```
56 bytes from 172.16.1.2: icmp_seq=3 ttl=128 time=1.000 ms
56 bytes from 172.16.1.2: icmp_seq=4 ttl=128 time=2.000 ms
--- Ping statistics for 172.16.1.2 ---
5 packet(s) transmitted, 5 packet(s) received, 0.0% packet loss
round-trip min/avg/max/std-dev = 1.000/2.600/7.000/2.245 ms
```

Verify the connectivity between a host on subnet 172.16.2.0/24 and the switch.

```
<Switch> ping 172.16.2.2
Ping 172.16.2.2 (172.16.2.2): 56 data bytes, press CTRL_C to break
56 bytes from 172.16.2.2: icmp_seq=0 ttl=128 time=2.000 ms
56 bytes from 172.16.2.2: icmp_seq=1 ttl=128 time=7.000 ms
56 bytes from 172.16.2.2: icmp_seq=2 ttl=128 time=1.000 ms
56 bytes from 172.16.2.2: icmp_seq=3 ttl=128 time=2.000 ms
56 bytes from 172.16.2.2: icmp_seq=4 ttl=128 time=1.000 ms
--- Ping statistics for 172.16.2.2 ---
5 packet(s) transmitted, 5 packet(s) received, 0.0% packet loss
round-trip min/avg/max/std-dev = 1.000/2.600/7.000/2.245 ms
```

Verify the connectivity between a host on subnet 172.16.1.0/24 and a host on subnet 172.16.2.0/24. The ping operation succeeds.

Contents

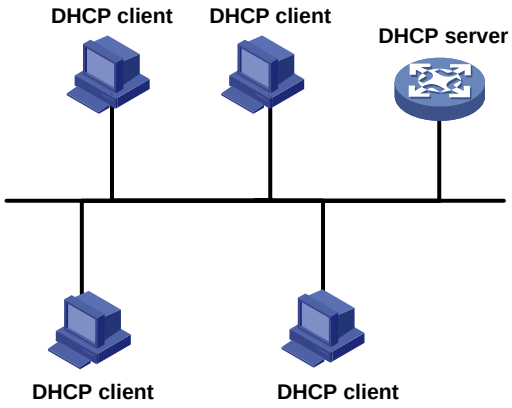
DHCP overview

DHCP network model

The Dynamic Host Configuration Protocol (DHCP) provides a framework to assign configuration information to network devices.

Figure 1 shows a typical DHCP application scenario where the DHCP clients and the DHCP server reside on the same subnet. The DHCP clients can also obtain configuration parameters from a DHCP server on another subnet through a DHCP relay agent. For more information about the DHCP relay agent, see "Configuring the DHCP relay agent."

Figure 1 A typical DHCP application



DHCP address allocation

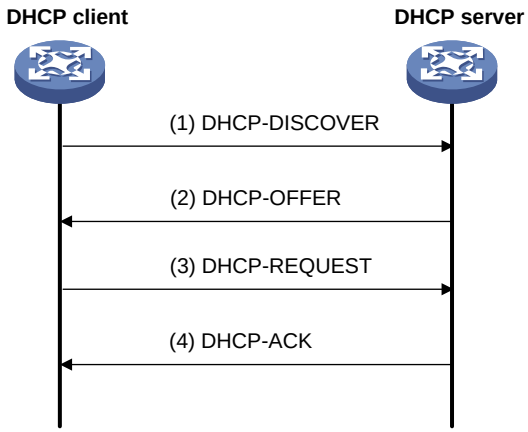
Allocation mechanisms

DHCP supports the following allocation mechanisms:

- **Static allocation**—The network administrator assigns an IP address to a client, such as a WWW server, and DHCP conveys the assigned address to the client.
- **Automatic allocation**—DHCP assigns a permanent IP address to a client.
- **Dynamic allocation**—DHCP assigns an IP address to a client for a limited period of time, which is called a lease. Most DHCP clients obtain their addresses in this way.

IP address allocation process

Figure 2 IP address allocation process



As shown in Figure 2, a DHCP server assigns an IP address to a DHCP client in the following process:

1. The client broadcasts a DHCP-DISCOVER message to locate a DHCP server.
2. Each DHCP server offers configuration parameters such as an IP address to the client in a DHCP-OFFER message. The sending mode of the DHCP-OFFER is determined by the flag field in the DHCP-DISCOVER message. For more information, see "DHCP message format."
3. If the client receives multiple offers, it accepts the first received offer, and broadcasts it in a DHCP-REQUEST message to formally request the IP address. (IP addresses offered by other DHCP servers can be assigned to other clients.)
4. All DHCP servers receive the DHCP-REQUEST message. However, only the server selected by the client does one of the following operations:
   - Returns a DHCP-ACK message to confirm that the IP address has been allocated to the client.
   - Returns a DHCP-NAK message to deny the IP address allocation.

After receiving the DHCP-ACK message, the client verifies the following details before using the assigned IP address:

- The assigned IP address is not in use. To verify this, the client broadcasts a gratuitous ARP packet. The assigned IP address is not in use if no response is received within the specified time.
- The assigned IP address is not on the same subnet as any IP address in use on the client.

Otherwise, the client sends a DHCP-DECLINE message to the server to request an IP address again.

IP address lease extension

A dynamically assigned IP address has a lease. When the lease expires, the IP address is reclaimed by the DHCP server. To continue using the IP address, the client must extend the lease duration.

When about half of the lease duration elapses, the DHCP client unicasts a DHCP-REQUEST to the DHCP server to extend the lease. Depending on the availability of the IP address, the DHCP server returns one of the following messages:

- A DHCP-ACK unicast confirming that the client's lease duration has been extended.
- A DHCP-NAK unicast denying the request.

If the client receives no reply, it broadcasts another DHCP-REQUEST message for lease extension when about seven-eighths of the lease duration elapses. Again, depending on the availability of the IP address, the DHCP server returns either a DHCP-ACK unicast or a DHCP-NAK unicast.

DHCP message format

Figure 3 shows the DHCP message format. DHCP uses some of the fields in significantly different ways. The numbers in parentheses indicate the size of each field in bytes.

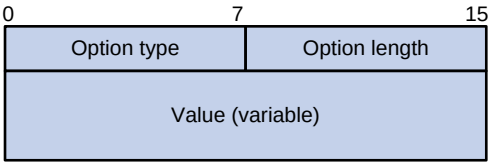
Figure 3 DHCP message format

- **op**—Message type defined in options field. 1 = REQUEST, 2 = REPLY
- **htype**, **hlen**—Hardware address type and length of the DHCP client.
- **hops**—Number of relay agents a request message traveled.
- **xid**—Transaction ID, a random number chosen by the client to identify an IP address allocation.
- **secs**—Filled in by the client, the number of seconds elapsed since the client began address acquisition or renewal process. This field is reserved and set to 0.
- **flags**—The leftmost bit is defined as the BROADCAST (B) flag. If this flag is set to 0, the DHCP server sent a reply back by unicast. If this flag is set to 1, the DHCP server sent a reply back by broadcast. The remaining bits of the flags field are reserved for future use.
- **ciaddr**—Client IP address if the client has an IP address that is valid and usable. Otherwise, set to zero. (The client does not use this field to request an IP address to lease.)
- **yiaddr**—Your IP address. It is an IP address assigned by the DHCP server to the DHCP client.
- **siaddr**—Server IP address, from which the client obtained configuration parameters.
- **giaddr**—Gateway IP address. It is the IP address of the first relay agent to which a request message travels.
- **chaddr**—Client hardware address.
- **sname**—Server host name, from which the client obtained configuration parameters.
- **file**—Boot file (also called system software image) name and path information, defined by the server to the client.
- **options**—Optional parameters field that is variable in length. Optional parameters include the message type, lease duration, subnet mask, domain name server IP address, and WINS IP address.

DHCP options

DHCP extends the message format as an extension to BOOTP for compatibility. DHCP uses the options field to carry information for dynamic address allocation and provide additional configuration information for clients.

Figure 4 DHCP option format



Common DHCP options

The following are common DHCP options:

- **Option 3**—Router option. It specifies the gateway address to be assigned to the clients.
- **Option 6**—DNS server option. It specifies the DNS server IP address to be assigned to the clients.
- **Option 33**—Static route option. It specifies a list of classful static routes (the destination addresses in these static routes are classful) that a client should add into its routing table. If both Option 33 and Option 121 exist, Option 33 is ignored.
- **Option 51**—IP address lease option.
- **Option 53**—DHCP message type option. It identifies the type of the DHCP message.
- **Option 55**—Parameter request list option. It is used by a DHCP client to request specified configuration parameters. The option includes values that correspond to the parameters requested by the client.
- **Option 60**—Vendor class identifier option. A DHCP client uses this option to identify its vendor. A DHCP server uses this option to distinguish DHCP clients, and assigns IP addresses to them.
- **Option 66**—TFTP server name option. It specifies the TFTP server domain name to be assigned to the clients.
- **Option 67**—Boot file name option. It specifies the boot file name to be assigned to the client.
- **Option 121**—Classless route option. It specifies a list of classless static routes (the destination addresses in these static routes are classless) that a client should add into its routing table. If both Option 33 and Option 121 exist, Option 33 is ignored.
- **Option 150**—TFTP server IP address option. It specifies the TFTP server IP address to be assigned to the clients.

For more information about DHCP options, see RFC 2132 and RFC 3442.

Custom DHCP options

Some options, such as Option 43, Option 82, and Option 184, have no standard definitions in RFC 2132.

Vendor-specific option (Option 43)

Option 43 function

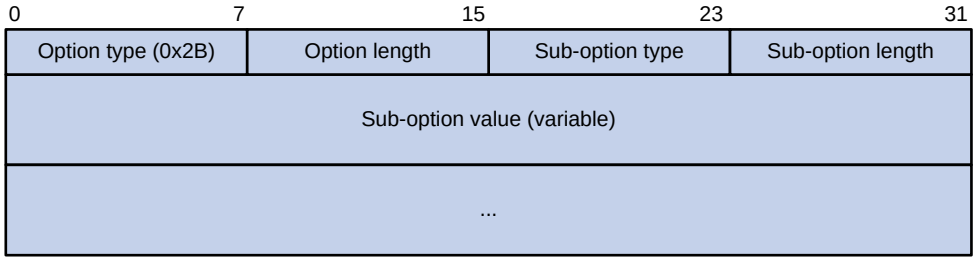
DHCP servers and clients use Option 43 to exchange vendor-specific configuration information.

The DHCP client can obtain the following information through Option 43:

- ACS parameters, including the ACS URL, username, and password.
- Service provider identifier, which is acquired by the CPE from the DHCP server and sent to the ACS for selecting vender-specific configurations and parameters. For more information about CPE and ACS, see *Network Management and Monitoring Configuration Guide*.
- PXE server address, which is used to obtain the boot file or other control information from the PXE server.

Option 43 format

Figure 5 Option 43 format



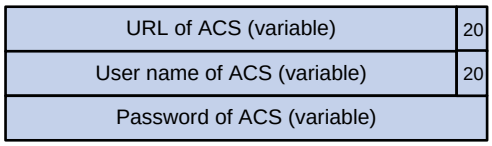
Network configuration parameters are carried in different sub-options of Option 43 as shown in Figure 5.

- **Sub-option type**—The field value can be 0x01 (ACS parameter sub-option), 0x02 (service provider identifier sub-option), or 0x80 (PXE server address sub-option).
- **Sub-option length**—Excludes the sub-option type and sub-option length fields.
- **Sub-option value**—The value format varies by sub-option.

Sub-option value field format

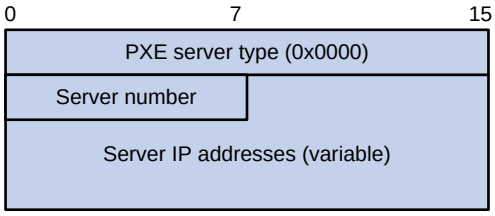
- **ACS parameter sub-option value field**—Includes the ACS URL, username, and password separated by spaces (hexadecimal number 20) as shown in Figure 6.

  Figure 6 ACS parameter sub-option value field

- **Service provider identifier sub-option value field**—Includes the service provider identifier.
- **PXE server address sub-option value field**—Includes the PXE server type that can only be 0, the server number that indicates the number of PXE servers contained in the sub-option, and server IP addresses, as shown in Figure 7.

Figure 7 PXE server address sub-option value field



Relay agent option (Option 82)

Option 82 is the relay agent option. It records the location information about the DHCP client. When a DHCP relay agent or DHCP snooping device receives a client's request, it adds Option 82 to the request and sends it to the server.

The administrator can use Option 82 to locate the DHCP client and further implement security control and accounting. The DHCP server can use Option 82 to provide individual configuration policies for the clients.

Option 82 can include a maximum of 255 sub-options and must include a minimum of one sub-option. Option 82 supports the following sub-options: sub-option 1 (Circuit ID), sub-option 2 (Remote ID), sub-option 5 (Link Selection), and sub-option 9 (Vendor-Specific). Option 82 has no standard definition. Its padding formats vary by vendor.

- Circuit ID has the following padding modes:
  - **String padding mode**—Includes a character string specified by the user.
  - **Normal padding mode**—Includes the VLAN ID and interface number of the interface that receives the client's request.
  - **Verbose padding mode**—Includes the access node identifier specified by the user, and the VLAN ID, interface number and interface type of the interface that receives the client's request.
- Remote ID has the following padding modes:
  - **String padding mode**—Includes a character string specified by the user.
  - **Normal padding mode**—Includes the MAC address of the DHCP relay agent interface or the MAC address of the DHCP snooping device that receives the client's request.
  - **Sysname padding mode**—Includes the name of the device. To set the device name, use the **sysname** command in system view.
- The Link Selection sub-option carries the IP address in the **giaddr** field or the IP address of a relay interface. If you use the **dhcp relay source-address** { *ip-address* | **interface** *interface-type interface-number* } command, you must enable the DHCP relay agent to support Option 82. This sub-option will then be included in Option 82.
- The Vendor-Specific sub-option supports only the bas padding mode. The padding content includes the user-configured access node identifier and the VLAN ID, interface number, and interface type of the interface that receives the client's request. This sub-option is supported only on DHCP snooping devices.

Option 184

Option 184 is a reserved option. You can define the parameters in the option as needed. The device supports Option 184 carrying voice related parameters, so a DHCP client with voice functions can get voice parameters from the DHCP server.

Option 184 has the following sub-options:

- **Sub-option 1**—Specifies the IP address of the primary network calling processor. The primary processor acts as the network calling control source and provides program download services. For Option 184, you must define sub-option 1 to make other sub-options take effect.
- **Sub-option 2**—Specifies the IP address of the backup network calling processor. DHCP clients contact the backup processor when the primary one is unreachable.
- **Sub-option 3**—Specifies the voice VLAN ID and the result whether the DHCP client takes this VLAN as the voice VLAN.
- **Sub-option 4**—Specifies the failover route that includes the IP address and the number of the target user. A SIP VoIP user uses this IP address and number to directly establish a connection to the target SIP user when both the primary and backup calling processors are unreachable.

Protocols and standards

- RFC 2131, *Dynamic Host Configuration Protocol*
- RFC 2132, *DHCP Options and BOOTP Vendor Extensions*
- RFC 1542, *Clarifications and Extensions for the Bootstrap Protocol*
- RFC 3046, *DHCP Relay Agent Information Option*
- RFC 3442, *The Classless Static Route Option for Dynamic Host Configuration Protocol (DHCP) version 4*

Configuring the DHCP server

About DHCP server

A DHCP server manages a pool of IP addresses and client configuration parameters. It selects an IP address and configuration parameters from the address pool and allocates them to a requesting DHCP client.

DHCP address assignment mechanisms

Configure the following address assignment mechanisms as needed:

- **Static address allocation**—Manually bind the MAC address or ID of a client to an IP address in a DHCP address pool. When the client requests an IP address, the DHCP server assigns the IP address in the static binding to the client.
- **Dynamic address allocation**—Specify IP address ranges in a DHCP address pool. Upon receiving a DHCP request, the DHCP server dynamically selects an IP address from the matching IP address range in the address pool.

You can specify IP address ranges in an address pool by using either of the following methods:

- **Method 1**—A primary subnet being divided into multiple address ranges in an address pool
- **Method 2**—A primary subnet and multiple secondary subnets in an address pool

A primary subnet being divided into multiple address ranges in an address pool

An address range includes a common IP address range and IP address ranges for DHCP user classes.

Upon receiving a DHCP request, the DHCP server finds a user class matching the client and selects an IP address in the address range of the user class for the client. A user class can include multiple matching rules, and a client matches the user class as long as it matches any of the rules. In address pool view, you can specify different address ranges for different user classes.

The DHCP server selects an IP address for a client by performing the following steps:

1. DHCP server compares the client against DHCP user classes in the order they are configured.
2. If the client matches a user class, the DHCP server selects an IP address from the address range of the user class.
3. If the matching user class has no assignable addresses, the DHCP server compares the client against the next user class. If all the matching user classes have no assignable addresses, the DHCP server selects an IP address from the common address range.
4. If the DHCP client does not match any DHCP user class, the DHCP server selects an address in the IP address range specified by the **`address range`** command. If the address range has no assignable IP addresses or it is not configured, the address allocation fails.

NOTE:

All address ranges must belong to the primary subnet. If an address range does not reside on the primary subnet, DHCP cannot assign the addresses in the address range.

A primary subnet and multiple secondary subnets in an address pool

The DHCP server selects an IP address from the primary subnet first. If there is no assignable IP address on the primary subnet, the DHCP server selects an IP address from secondary subnets in the order they are configured.

Principles for selecting an address pool

The DHCP server observes the following principles to select an address pool for a client:

1. If there is an address pool where an IP address is statically bound to the MAC address or ID of the client, the DHCP server selects this address pool and assigns the statically bound IP address and other configuration parameters to the client.
2. If the receiving interface has a DHCP policy and the DHCP client matches a user class, the DHCP server selects the address pool that is bound to the matching user class. If no matching user class is found, the server assigns an IP address and other parameters from the default DHCP address pool. If no default address pool is specified or the default address pool does not have assignable IP addresses, the address assignment fails.
3. If the receiving interface has an address pool applied, the DHCP server selects an IP address and other configuration parameters from this address pool.
4. If the above conditions are not met, the DHCP server selects an address pool depending on the client location.
    - **Client on the same subnet as the server**—The DHCP server compares the IP address of the receiving interface with the primary subnets of all address pools.
        - If a match is found, the server selects the address pool with the longest-matching primary subnet.
        - If no match is found, the DHCP server compares the IP address with the secondary subnets of all address pools. The server selects the address pool with the longest-matching secondary subnet.
    - **Client on a different subnet than the server**—The DHCP server compares the IP address in the **giaddr** field of the DHCP request with the primary subnets of all address pools.
        - If a match is found, the server selects the address pool with the longest-matching primary subnet.
        - If no match is found, the DHCP server compares the IP address with the secondary subnets of all address pools. The server selects the address pool with the longest-matching secondary subnet.

For example, two address pools 1.1.1.0/24 and 1.1.1.0/25 are configured but not applied to any DHCP server's interfaces.

- If the IP address of the receiving interface is 1.1.1.1/25, the DHCP server selects the address pool 1.1.1.0/25. If the address pool has no available IP addresses, the DHCP server will not select the other pool and the address allocation will fail.
- If the IP address of the receiving interface is 1.1.1.130/25, the DHCP server selects the address pool 1.1.1.0/24.

To ensure correct address allocation, keep the IP addresses used for dynamic allocation on one of the subnets:

- **Clients on the same subnet as the server**—Subnet where the DHCP server receiving interface resides.
- **Clients on a different subnet than the server**—Subnet where the first DHCP relay interface that faces the clients resides.

NOTE:

As a best practice, configure a minimum of one matching primary subnet in your network. Otherwise, the DHCP server selects only the first matching secondary subnet for address allocation. If the network has more DHCP clients than the assignable IP addresses in the secondary subnet, not all DHCP clients can obtain IP addresses.

IP address allocation sequence

The DHCP server selects an IP address for a client in the following sequence:

1. IP address statically bound to the client's MAC address or ID.
2. IP address that was ever assigned to the client.
3. IP address designated by the Option 50 field in the DHCP-DISCOVER message sent by the client.

   Option 50 is the Requested IP Address option. The client uses this option to specify the wanted IP address in a DHCP-DISCOVER message. The content of Option 50 is user defined.
4. First assignable IP address found in the way discussed in "DHCP address assignment mechanisms" and "Principles for selecting an address pool."
5. IP address that was a conflict or passed its lease duration. If no IP address is assignable, the server does not respond.

NOTE:

- If a client moves to another subnet, the DHCP server selects an IP address in the address pool matching the new subnet. It does not assign the IP address that was once assigned to the client.
- Conflicted IP addresses can be assigned to other DHCP clients only after the addresses are in conflict for an hour.

Restrictions: Hardware compatibility with DHCP server

S5110V2-SI, S5000V3-EI, S5000E-X, S5000X-EI, and WAS6000 do not support the DHCP server functionality.

S5000V5-EI supports the DHCP server functionality as from Release 6328P02 and Release 6337.

DHCP server tasks at a glance

To configure the DHCP server, perform the following tasks:

1. (Optional.) Creating a DHCP user class
2. Configuring an address pool on the DHCP server
3. (Optional.) Modifying the address pool selection method on the DHCP server
   - Applying an address pool to an interface
   - Configuring a DHCP policy for dynamic assignment
4. Enabling DHCP
5. Enabling the DHCP server on an interface
6. (Optional.) Configuring advanced DHCP features
   - Configuring IP address conflict detection
   - Enabling handling of Option 82
   - Configuring the DHCP server security features
   - Configuring DHCP server compatibility
   - Setting the DSCP value for DHCP packets sent by the DHCP server
   - Configuring DHCP binding auto backup
   - Enabling client offline detection on the DHCP server

7. (Optional.) Configuring SNMP notification and logging
   - Configuring address pool usage alarming
   - Enabling DHCP logging on the DHCP server

Creating a DHCP user class

About DHCP user class

The DHCP server classifies DHCP users into different user classes according to the hardware address, option information, or the **giaddr** field in the received DHCP requests. The server allocates IP addresses and configuration parameters to DHCP clients in different user classes.

Procedure

1. Enter system view.

   system-view
2. Create a DHCP user class and enter DHCP user class view.

   dhcp class *class-name*
3. Configure a match rule for the DHCP user class.

   if-match rule *rule-number* { **hardware-address** *hardware-address* **mask** *hardware-address-mask* | **option** *option-code* [**ascii** *ascii-string* [**offset** *offset* | **partial**] | **hex** *hex-string* [**mask** *mask* | **offset** *offset* **length** *length* | **partial**]] | **relay-agent** *gateway-address* }

   By default, no match rule is configured for a DHCP user class.

Configuring an address pool on the DHCP server

DHCP address pool tasks at a glance

To configure a DHCP address pool, perform the following tasks:

1. Creating a DHCP address pool
2. Specifying IP address ranges in a DHCP address pool

   In one DHCP address pool, the two dynamic allocation methods cannot be both configured, but static and dynamic address allocations can be both implemented.
   - Specifying a primary subnet and multiple address ranges in a DHCP address pool
   - Specifying a primary subnet and multiple secondary subnets in a DHCP address pool
   - Configuring a static binding in a DHCP address pool
3. Specifying other configuration parameters to be assigned to DHCP clients
   - Specifying gateways for DHCP clients
   - Specifying a domain name suffix for DHCP clients
   - Specifying DNS servers for DHCP clients
   - Specifying WINS servers and NetBIOS node type for DHCP clients
   - Specifying BIMS server for DHCP clients
   - Specifying the configuration file for DHCP client automatic configuration
   - Specifying a server for DHCP clients
   - Configuring Option 184 parameters for DHCP clients
   - Customizing DHCP options
4. (Optional.) Configuring the DHCP user class whitelist

Creating a DHCP address pool

1. Enter system view.
   system-view
2. Create a DHCP address pool and enter its view.
   dhcp server ip-pool *pool-name*

Specifying a primary subnet and multiple address ranges in a DHCP address pool

About a primary subnet and multiple address ranges in a DHCP address pool

Some scenarios need to classify DHCP clients on the same subnet into different address groups. To meet this need, you can configure DHCP user classes and specify different address ranges for the classes. The clients matching a user class can then get the IP addresses of an address range. In addition, you can specify a common address range for the clients that do not match any user class. If no common address range is specified, such clients fail to obtain IP addresses.

If there is no need to classify clients, you do not need to configure DHCP user classes or their address ranges.

Restrictions and guidelines

- If you execute the **network** or **address range** command multiple times for the same address pool, the most recent configuration takes effect.
- If you execute the **forbidden-ip** command multiple times, you exclude multiple address ranges from dynamic allocation.
- IP addresses specified by the **forbidden-ip** command are not assignable in the current address pool, but are assignable in other address pools. IP addresses specified by the **dhcp server forbidden-ip** command are not assignable in any address pool.
- You can use **class range** to modify an existing address range, and the new address range can include IP addresses that are being used by clients. Upon receiving a lease extension request for such an IP address, the DHCP server allocates a new IP address to the requesting client. But the original lease continues aging in the address pool, and will be released when the lease duration is reached. To release such lease without waiting for its timeout, execute the **reset dhcp server ip-in-use** command.

Procedure

1. Enter system view.
   system-view
2. Enter DHCP address pool view.
   dhcp server ip-pool *pool-name*
3. Specify the primary subnet in the address pool.
   network *network-address* [*mask-length* | **mask** *mask*]
   By default, no primary subnet is specified.
4. (Optional.) Specify the common address range.
   address range *start-ip-address end-ip-address*
   By default, no IP address range is specified.
5. (Optional.) Specify an IP address range for a DHCP user class.
   class *class-name* **range** *start-ip-address end-ip-address*
   By default, no IP address range is specified for a user class.

The DHCP user class must already be created by using the **dhcp class** command.

6. (Optional.) Set the address lease duration.

   expired { **day** *day* [**hour** *hour* [**minute** *minute* [**second** *second*]]] | **unlimited** }

   The default setting is 1 day.

7. (Optional.) Exclude the specified IP addresses in the address pool from dynamic allocation.

   forbidden-ip *ip-address*&<1-8>

   By default, all IP addresses in the DHCP address pool are assignable.

8. (Optional.) Exclude the specified IP addresses from automatic allocation in system view.

   a. Return to system view.

      quit

   b. Exclude the specified IP addresses from automatic allocation globally.

      dhcp server forbidden-ip *start-ip-address* [*end-ip-address*]

      By default, except for the IP address of the DHCP server interface, IP addresses in all address pools are assignable.

Specifying a primary subnet and multiple secondary subnets in a DHCP address pool

About a primary subnet and multiple secondary subnets in a DHCP address pool

If an address pool has a primary subnet and multiple secondary subnets, the server assigns IP addresses on a secondary subnet when the primary subnet has no assignable IP addresses.

Restrictions and guidelines

IP addresses specified by the **forbidden-ip** command are not assignable in the current address pool, but are assignable in other address pools. IP addresses specified by the **dhcp server forbidden-ip** command are not assignable in any address pool.

Specifying a primary subnet and multiple secondary subnets

1. Enter system view.

   system-view

2. Enter DHCP address pool view.

   dhcp server ip-pool *pool-name*

3. Specify the primary subnet.

   network *network-address* [*mask-length* | **mask** *mask*]

   By default, no primary subnet is specified.

   You can specify only one primary subnet in each address pool. If you execute the **network** command multiple times, the most recent configuration takes effect.

4. (Optional.) Specify a secondary subnet.

   network *network-address* [*mask-length* | **mask** *mask*] **secondary**

   By default, no secondary subnet is specified.

   You can specify a maximum of 32 secondary subnets in one address pool.

5. (Optional.) Return to address pool view.

   quit

Setting the lease duration for dynamically allocation IP addresses

1. Enter system view.

system-view

2. Enter DHCP address pool view.

   dhcp server ip-pool *pool-name*

3. Set the address lease duration.

   expired { **day** *day* [**hour** *hour* [**minute** *minute* [**second** *second*]]] | **unlimited** }

   The default setting is 1 day.

Excluding IP addresses from dynamic allocation

1. Enter system view.

   system-view

2. Enter DHCP address pool view.

   dhcp server ip-pool *pool-name*

3. Exclude the specified IP addresses from dynamic allocation.

   forbidden-ip *ip-address*&<1-8>

   By default, all IP addresses in the DHCP address pool are assignable.

   To exclude multiple address ranges from the address pool, repeat this step.

4. (Optional.) Exclude the specified IP addresses from dynamic allocation in system view.

   a. Return to system view.

      quit

   b. Exclude the specified IP addresses from dynamic allocation globally.

      dhcp server forbidden-ip *start-ip-address* [*end-ip-address*]

      By default, except for the IP address of the DHCP server interface, IP addresses in all address pools are assignable.

      To exclude multiple address ranges globally, repeat this step.

Configuring a static binding in a DHCP address pool

About static binding in a DHCP address pool

Some DHCP clients, such as a WWW server, need fixed IP addresses. To provide a fixed IP address for a client, you can statically bind the MAC address or ID of the client to an IP address in a DHCP address pool. When the client requests an IP address, the DHCP server assigns the IP address in the static binding to the client.

Restrictions and guidelines

- The IP address of a static binding cannot be the address of the DHCP server interface. Otherwise, an IP address conflict occurs and the bound client cannot obtain an IP address correctly.
- Multiple interfaces on the same device might all use DHCP to request a static IP address. In this case, use client IDs rather than the device's MAC address to identify the interfaces. Otherwise, IP address allocation will fail.

Procedure

1. Enter system view.

   system-view

2. Enter DHCP address pool view.

   dhcp server ip-pool *pool-name*

3. Configure a static binding.

static-bind ip-address *ip-address* [*mask-length* | **mask** *mask*] { **client-identifier** *client-identifier* | **hardware-address** *hardware-address* [**ethernet** | **token-ring**] }

By default, no static binding is configured.

One IP address can be bound to only one client MAC or client ID. You cannot modify bindings that have been created. To change the binding for a DHCP client, you must delete the existing binding first.

4. (Optional.) Set the lease duration for the IP address.

   expired { **day** *day* [**hour** *hour* [**minute** *minute* [**second** *second*]]] | **unlimited** }

   By default, the lease duration is 1 day.

Specifying gateways for DHCP clients

About gateways for DHCP clients

DHCP clients send packets destined for other networks to a gateway. The DHCP server can assign the gateway address to the DHCP clients.

Restrictions and guidelines

You can specify gateway addresses in each address pool on the DHCP server. A maximum of 64 gateways can be specified in DHCP address pool view or secondary subnet view.

The DHCP server assigns gateway addresses to clients on a secondary subnet in the following ways:

- If gateways are specified in both address pool view and secondary subnet view, DHCP assigns those specified in the secondary subnet view.
- If gateways are specified in address pool view but not in secondary subnet view, DHCP assigns those specified in address pool view.

Procedure

1. Enter system view.

   system-view

2. Enter DHCP address pool view.

   dhcp server ip-pool *pool-name*

3. Specify gateways.

   gateway-list *ip-address*&<1-64>

   By default, no gateway is specified.

4. (Optional.) Specify gateways in secondary subnet view.

   a. Enter secondary subnet view.

      network *network-address* [*mask-length* | **mask** *mask*] **secondary**

   b. Specify gateways.

      gateway-list *ip-address*&<1-64>

      By default, no gateway is specified.

Specifying a domain name suffix for DHCP clients

About domain name suffix for DHCP clients

You can specify a domain name suffix in a DHCP address pool on the DHCP server. With this suffix assigned, the client only needs to input part of a domain name, and the system adds the domain name suffix for name resolution. For more information about DNS, see "Configuring DNS."

Procedure

1. Enter system view.
   system-view
2. Enter DHCP address pool view.
   dhcp server ip-pool *pool-name*
3. Specify a domain name suffix.
   domain-name *domain-name*
   By default, no domain name is specified.

Specifying DNS servers for DHCP clients

About DNS servers for DHCP clients

To access hosts on the Internet through domain names, a DHCP client must contact a DNS server to resolve names. You can specify up to eight DNS servers in a DHCP address pool.

Procedure

1. Enter system view.
   system-view
2. Enter DHCP address pool view.
   dhcp server ip-pool *pool-name*
3. Specify DNS servers.
   dns-list *ip-address*&<1-8>
   By default, no DNS server is specified.

Specifying WINS servers and NetBIOS node type for DHCP clients

About WINS servers and NetBIOS node type for DHCP clients

A Microsoft DHCP client using NetBIOS protocol must contact a WINS server for name resolution.

In addition, you must specify one of the following NetBIOS node types to approach name resolution:

- **b (broadcast)-node**—A b-node client sends the destination name in a broadcast message. The destination returns its IP address to the client after receiving the message.
- **p (peer-to-peer)-node**—A p-node client sends the destination name in a unicast message to the WINS server. The WINS server returns the destination IP address.
- **m (mixed)-node**—An m-node client broadcasts the destination name. If it receives no response, it unicasts the destination name to the WINS server to get the destination IP address.
- **h (hybrid)-node**—An h-node client unicasts the destination name to the WINS server. If it receives no response, it broadcasts the destination name to get the destination IP address.

Procedure

1. Enter system view.
   system-view
2. Enter DHCP address pool view.
   dhcp server ip-pool *pool-name*
   By default, no DHCP address pool exists.
3. Specify WINS servers.
   nbns-list *ip-address*&<1-8>
   By default, no WINS server is specified.
   This step is optional for b-node. You can specify a maximum of eight WINS servers for such clients in one DHCP address pool.
4. Specify the NetBIOS node type.
   netbios-type { **b-node** | **h-node** | **m-node** | **p-node** }
   By default, no NetBIOS node type is specified.

Specifying BIMS server for DHCP clients

About BIMS server for DHCP clients

Perform this task to provide the BIMS server IP address, port number, and shared key for the clients. The DHCP clients contact the BIMS server to get configuration files and perform software upgrade and backup.

Procedure

1. Enter system view.
   system-view
2. Enter DHCP address pool view.
   dhcp server ip-pool *pool-name*
3. Specify the BIMS server IP address, port number, and shared key.
   bims-server ip *ip-address* [**port** *port-number*] **sharekey** { **cipher** | **simple** } *string*
   By default, no BIMS server information is specified.

Specifying the configuration file for DHCP client automatic configuration

About configuration file for DHCP client automatic configuration

Automatic configuration enables a device to automatically obtain a set of configuration settings at startup. The server-based automatic configuration requires the cooperation of the DHCP server and file server (TFTP or HTTP server). The device uses the obtained parameters to contact the file server to get the configuration file. For more information about automatic configuration, see *Fundamentals Configuration Guide*.

Specifying the configuration file on a TFTP file server

1. Enter system view.
   system-view
2. Enter DHCP address pool view.
   dhcp server ip-pool *pool-name*

By default, no DHCP address pool exists.

3. Specify the IP address or the name of a TFTP server.
   - Specify the IP address of the TFTP server.
     tftp-server ip-address *ip-address*
     By default, no TFTP server IP address is specified.
   - Specify the name of the TFTP server.
     tftp-server domain-name *domain-name*
     By default, no TFTP server name is specified.
4. Specify the configuration file name.
   bootfile-name *bootfile-name*
   By default, no configuration file name is specified.

Specifying the URL of the configuration file on an HTTP file server

1. Enter system view.
   system-view
2. Enter DHCP address pool view.
   dhcp server ip-pool *pool-name*
3. Specify the URL of the configuration file.
   bootfile-name *url*
   By default, no configuration file URL is specified.

Specifying a server for DHCP clients

About a server for DHCP clients

Some DHCP clients need to obtain configuration information from a server, such as a TFTP server. You can specify the IP address of that server. The DHCP server sends the server's IP address to DHCP clients along with other configuration information.

Procedure

1. Enter system view.
   system-view
2. Enter DHCP address pool view.
   dhcp server ip-pool *pool-name*
3. Specify the IP address of a server.
   next-server *ip-address*
   By default, no server is specified.

Configuring Option 184 parameters for DHCP clients

About Option 184 parameters for DHCP clients

To assign calling parameters to DHCP clients with voice service, you must configure Option 184 on the DHCP server. For more information about Option 184, see "Option 184."

Procedure

1. Enter system view.
   system-view
2. Enter DHCP address pool view.

dhcp server ip-pool *pool-name*

3. Specify the IP address of the primary network calling processor.
   voice-config ncp-ip *ip-address*
   By default, no primary network calling processor is specified.
   After you configure this command, the other Option 184 parameters take effect.
4. (Optional.) Specify the IP address of the backup server.
   voice-config as-ip *ip-address*
   By default, no backup network calling processor is specified.
5. (Optional.) Configure the voice VLAN.
   voice-config voice-vlan *vlan-id* { **disable** | **enable** }
   By default, no voice VLAN is configured.
6. (Optional.) Specify the failover IP address and dialer string.
   voice-config fail-over *ip-address dialer-string*
   By default, no failover IP address or dialer string is specified.

Customizing DHCP options

DHCP option customization applications

You can customize DHCP options for the following purposes:

- Add newly released options.
- Add options for which the vendor defines the contents, for example, Option 43.
- Add options for which the CLI does not provide a dedicated configuration command. For example, you can use the **option 4 ip-address 1.1.1.1** command to define the time server address 1.1.1.1 for DHCP clients.
- Add all option values if the actual requirement exceeds the limit for a dedicated option configuration command. For example, the **dns-list** command can specify up to eight DNS servers. To specify more than eight DNS servers, you must use the **option 6** command to define all DNS servers.

Common DHCP options

Table 1 lists common DHCP options and their parameters.

Table 1 Common DHCP options

Option	Option name	Corresponding command	Recommended parameter in the option command
3	Router Option	**gateway-list**	**ip-address**
6	Domain Name Server Option	**dns-list**	**ip-address**
15	Domain Name	**domain-name**	**ascii**
44	NetBIOS over TCP/IP Name Server Option	**nbns-list**	**ip-address**
46	NetBIOS over TCP/IP Node Type Option	**netbios-type**	**hex**
66	TFTP server name	**tftp-server**	**ascii**
67	Boot file name	**bootfile-name**	**ascii**

Option	Option name	Corresponding command	Recommended parameter in the option command
43	Vendor Specific Information	N/A	**hex**

Restrictions and guidelines

Use caution when customizing DHCP options because the configuration might affect DHCP operation.

You can customize a DHCP option in a DHCP address pool

You can customize a DHCP option in a DHCP option group, and specify the option group for a user class in an address pool. A DHCP client in the user class will obtain the option configuration.

Customizing a DHCP option in a DHCP address pool

1. Enter system view.

   system-view

2. Enter DHCP address pool view.

   dhcp server ip-pool *pool-name*

3. Customize a DHCP option.

   option *code* { **ascii** *ascii-string* | **hex** *hex-string* | **ip-address** *ip-address*&<1-8> }

   By default, no DHCP option is customized in a DHCP address pool.

   DHCP options specified in DHCP option groups take precedence over those specified in DHCP address pools.

Customizing a DHCP option in a DHCP option group

1. Enter system view.

   system-view

2. Create a DHCP option group and enter DHCP option group view.

   dhcp option-group *option-group-number*

3. Customize a DHCP option.

   option *code* { **ascii** *ascii-string* | **hex** *hex-string* | **ip-address** *ip-address*&<1-8> }

   By default, no DHCP option is customized in a DHCP option group.

   If multiple DHCP option groups have the same option, the server selects the option in the DHCP option group first matching the user class.

4. Return to system view.

   quit

5. Enter DHCP address pool view.

   dhcp server ip-pool *pool-name*

6. Specify the DHCP option group for the DHCP user class.

   class *class-name* **option-group** *option-group-number*

   By default, no DHCP option group is specified for a DHCP user class.

Configuring the DHCP user class whitelist

About DHCP user class whitelist

The DHCP user class whitelist allows the DHCP server to process requests only from clients on the DHCP user class whitelist.

Restrictions and guidelines

The whitelist does not take effect on clients who request static IP addresses, and the server always processes their requests.

Procedure

1. Enter system view.

   system-view

2. Enter DHCP address pool view.

   dhcp server ip-pool *pool-name*

3. Enable the DHCP user class whitelist.

   verify class

   By default, the DHCP user class whitelist is disabled.

4. Add DHCP user classes to the DHCP user class whitelist.

   valid class *class-name*&<1-8>

   By default, no DHCP user class is on the DHCP user class whitelist.

Applying an address pool to an interface

About applying an address pool to an interface

Perform this task to apply a DHCP address pool to an interface.

Upon receiving a DHCP request from the interface, the DHCP server performs address allocation in the following ways:

- If a static binding is found for the client, the server assigns the static IP address and configuration parameters from the address pool that contains the static binding.
- If no static binding is found for the client, the server uses the address pool applied to the interface for address and configuration parameter allocation.

Procedure

1. Enter system view.

   system-view

2. Enter interface view.

   interface *interface-type interface-number*

3. Apply an address pool to the interface.

   dhcp server apply ip-pool *pool-name*

   By default, no address pool is applied to an interface.

   If the applied address pool does not exist, the DHCP server fails to perform dynamic address allocation.

Configuring a DHCP policy for dynamic assignment

About a DHCP policy for dynamic assignment

In a DHCP policy, each DHCP user class has a bound DHCP address pool. Clients matching different user classes obtain IP addresses and other parameters from different address pools. The DHCP policy must be applied to the interface that acts as the DHCP server. When receiving a DHCP request, the DHCP server compares the packet against the user classes in the order that they are configured.

- If a matching user class is found and the bound address pool has assignable IP addresses, the server assigns an IP address and other parameters from the address pool. If the address pool does not have assignable IP addresses, the address assignment fails.
- If no match is found, the server assigns an IP address and other parameters from the default DHCP address pool. If no default address pool is specified or the default address pool does not have assignable IP addresses, the address assignment fails.

For successful address assignment, make sure the applied DHCP policy and the bound address pools exist.

Restrictions and guidelines

A DHCP policy take effect only after it is applied to an interface.

Procedure

1. Enter system view.
   system-view
2. Create a DHCP policy and enter DHCP policy view.
   dhcp policy *policy-name*
3. Specify a DHCP address pool for a DHCP user class.
   class *class-name* **ip-pool** *pool-name*
   By default, no address pool is specified for a user class.
4. Specify the default DHCP address pool.
   default ip-pool *pool-name*
   By default, no default address pool is specified.
5. Return to system view.
   quit
6. Enter interface view.
   interface *interface-type interface-number*
7. Apply the DHCP policy to the interface.
   dhcp apply-policy *policy-name*
   By default, no DHCP policy is applied to an interface.

Enabling DHCP

Restrictions and guideline

You must enable DHCP to make other DHCP configurations take effect.

Procedure

1. Enter system view.
   system-view
2. Enable DHCP.
   dhcp enable
   By default, DHCP is disabled.

Enabling the DHCP server on an interface

About enabling the DHCP server on an interface

Perform this task to enable the DHCP server on an interface. Upon receiving a DHCP request on the interface, the DHCP server assigns the client an IP address and other configuration parameters from a DHCP address pool.

Procedure

1. Enter system view.
   system-view
2. Enter interface view.
   interface *interface-type interface-number*
3. Enable the DHCP server on the interface.
   dhcp select server
   By default, the DHCP server is enabled on the interface.

Configuring IP address conflict detection

About IP address conflict detection

Before assigning an IP address, the DHCP server pings that IP address.

- If the server receives a response within the specified period, it selects and pings another IP address.
- If it receives no response, the server continues to ping the IP address until the maximum number of ping packets are sent. If still no response is received, the server assigns the IP address to the requesting client. The DHCP client uses gratuitous ARP to perform IP address conflict detection.

Procedure

1. Enter system view.
   system-view
2. (Optional.) Set the maximum number of ping packets to be sent for conflict detection.
   dhcp server ping packets *number*
   The default setting is one.
   To disable IP address conflict detection, set the value to **0**.
3. (Optional.) Set the ping timeout time.
   dhcp server ping timeout *milliseconds*
   The default setting is 500 ms.
   To disable IP address conflict detection, set the value to **0**.

Enabling handling of Option 82

About handling of Option 82

Perform this task to enable the DHCP server to handle Option 82. Upon receiving a DHCP request that contains Option 82, the DHCP server adds Option 82 into the DHCP response.

If you disable the DHCP to handle Option 82, it does not add Option 82 into the response message.

You must enable handling of Option 82 on both the DHCP server and the DHCP relay agent to ensure correct processing for Option 82. For information about enabling handling of Option 82 on the DHCP relay agent, see "Configuring DHCP relay agent support for Option 82."

Procedure

1. Enter system view.

   `system-view`
2. Enable the server to handle Option 82.

   `dhcp server relay information enable`

   By default, handling of Option 82 is enabled.

Configuring the DHCP server security features

Restrictions and guidelines

The DHCP server security features are not applicable if a DHCP relay agent exists in the network. This is because the MAC address of the DHCP relay agent is encapsulated as the source MAC address in the DHCP request received by the DHCP server. In this case, you must configure the DHCP relay agent security features. For more information, see "Configuring the DHCP relay agent security features."

Configuring DHCP starvation attack protection

About DHCP starvation attack protection

A DHCP starvation attack occurs when an attacker constantly sends forged DHCP requests using different MAC addresses in the **chaddr** field to a DHCP server. This exhausts the IP address resources of the DHCP server so legitimate DHCP clients cannot obtain IP addresses. The DHCP server might also fail to work because of exhaustion of system resources. For information about the fields in the DHCP messages, see "DHCP message format."

The following methods are available to relieve or prevent such attacks.

- To relieve a DHCP starvation attack that uses DHCP packets encapsulated with different source MAC addresses, perform the following configuration on an interface:
  - Execute the **`mac-address max-mac-count`** command to set the MAC learning limit. For more information about this command, see *Layer 2—LAN Switching Command Reference*.
  - Disable unknown frame forwarding when the MAC learning limit is reached.
- To prevent a DHCP starvation attack that uses DHCP requests encapsulated with the same source MAC address, you can enable MAC address check on the DHCP server. The DHCP server compares the **chaddr** field of a received DHCP request with the source MAC address in the frame header. If they are the same, the DHCP server verifies this request as legal and processes it. If they are not the same, the server discards the DHCP request.

Procedure

1. Enter system view.
   system-view
2. Enter interface view.
   interface *interface-type interface-number*
3. Enable MAC address check.
   dhcp server check mac-address
   By default, MAC address check is disabled.

Configuring DHCP server compatibility

Perform this task to enable the DHCP server to support DHCP clients that are incompliant with RFC.

Configuring the DHCP server to always broadcast responses

About configuring the DHCP server to always broadcast responses

By default, the DHCP server broadcasts a response only when the broadcast flag in the DHCP request is set to 1. You can configure the DHCP server to ignore the broadcast flag and always broadcast a response. This feature is useful when some clients set the broadcast flag to 0 but do not accept unicast responses.

The DHCP server always unicasts a response in the following situations, regardless of whether this feature is configured or not:

- The DHCP request is from a DHCP client that has an IP address (the **ciaddr** field is not 0).
- The DHCP request is forwarded by a DHCP relay agent from a DHCP client (the **giaddr** field is not 0).

Procedure

1. Enter system view.
   system-view
2. Enable the DHCP server to always broadcast all responses.
   dhcp server always-broadcast
   By default, the DHCP server reads the broadcast flag to decide whether to broadcast or unicast a response.

Returning a DHCP-NAK message upon client notions of incorrect IP addresses

About returning a DHCP-NAK message upon client notions of incorrect IP addresses

A DHCP client can send a DHCP-REQUEST message directly or upon receiving a DHCP-OFFER message. Upon receiving the request, the DHCP server will check if the client notion of its IP address is correct. If the requested IP address is different from the allocated one or has no matching lease record, the DHCP server remains silent by default. After the allocated IP address lease for the client expires, the DHCP server will make response to request from the client.

This feature enables the DHCP server to return DHCP-NAK messages if the client notions of their IP addresses are incorrect. After receiving the DHCP-NAK message, the DHCP client will request an IP address again.

Procedure

1. Enter system view.

   ```
   system-view
   ```

2. Enable the DHCP server to return a DHCP-NAK message if the client notions of their IP addresses are incorrect.

   ```
   dhcp server request-ip-address check
   ```

   By default, the DHCP server does not return a DHCP-NAK message if the client notions of their IP addresses are incorrect.

Configuring the DHCP server to ignore BOOTP requests

About configuring the DHCP server to ignore BOOTP requests

The lease duration of the IP addresses obtained by the BOOTP clients is unlimited. For some scenarios that do not allow unlimited leases, you can configure the DHCP server to ignore BOOTP requests.

Procedure

1. Enter system view.

   ```
   system-view
   ```

2. Configure the DHCP server to ignore BOOTP requests.

   ```
   dhcp server bootp ignore
   ```

   By default, the DHCP server processes BOOTP requests.

Configuring the DHCP server to send BOOTP responses in RFC 1048 format

About configuring the DHCP server to send BOOTP responses in RFC 1048 format

Not all BOOTP clients can send requests that are compatible with RFC 1048. By default, the DHCP server does not process the Vend field of RFC 1048-incompliant requests but copies the Vend field into responses.

This feature enables the DHCP server to fill the Vend field in RFC 1048-compliant format in DHCP responses to RFC 1048-incompliant requests sent by BOOTP clients.

Procedure

1. Enter system view.

   ```
   system-view
   ```

2. Enable the DHCP server to send BOOTP responses in RFC 1048 format to the RFC 1048-incompliant BOOTP requests.

   ```
   dhcp server bootp reply-rfc-1048
   ```

   By default, the DHCP server directly copies the Vend field of such requests into the responses.

Setting the DSCP value for DHCP packets sent by the DHCP server

About DSCP value for DHCP packets

The DSCP value of a packet specifies the priority level of the packet and affects the transmission priority of the packet.

Procedure

1. Enter system view.

   system-view

2. Set the DSCP value for DHCP packets sent by the DHCP server.

   dhcp dscp *dscp-value*

   By default, the DSCP value in DHCP packets sent by the DHCP server is 56.

Configuring DHCP binding auto backup

About DHCP binding auto backup

The auto backup feature saves bindings to a backup file and allows the DHCP server to download the bindings from the backup file at the server reboot. The bindings include the lease bindings and conflicted IP addresses. They cannot survive a reboot on the DHCP server.

The DHCP server does not provide services during the download process. If a connection error occurs during the process and cannot be repaired in a short amount of time, you can terminate the download operation. Manual interruption allows the DHCP server to provide services without waiting for the connection to be repaired.

Procedure

1. Enter system view.

   system-view

2. Configure the DHCP server to back up the bindings to a file.

   dhcp server database filename { *filename* | **url** *url* [**username** *username* [**password** { **cipher** | **simple** } *string*]] }

   By default, the DHCP server does not back up the DHCP bindings.

   With this command executed, the DHCP server backs up its bindings immediately and runs auto backup.

3. (Optional.) Manually save the DHCP bindings to the backup file.

   dhcp server database update now

4. (Optional.) Set the waiting time after a DHCP binding change for the DHCP server to update the backup file.

   dhcp server database update interval *interval*

   By default, the DHCP server waits 300 seconds to update the backup file after a DHCP binding change. If no DHCP binding changes, the backup file is not updated.

5. (Optional.) Terminate the download of DHCP bindings from the backup file.

   dhcp server database update stop

   This command only triggers one termination.

Enabling client offline detection on the DHCP server

About client offline detection on the DHCP server

The client offline detection feature reclaims an assigned IP address and deletes the binding entry when the ARP entry for the IP address ages out.

Restrictions and guidelines

The feature does not function if an ARP entry is manually deleted.

Procedure

1. Enter system view.
   system-view
2. Enter interface view.
   interface *interface-type interface-number*
3. Enable client offline detection.
   dhcp client-detect
   By default, client offline detection is disabled on the DHCP server.

Configuring address pool usage alarming

About address pool usage alarming

Perform this task to set the threshold for address pool usage alarming. When the threshold is exceeded, the system sends log messages to the information center. According to the log information, you can optimize the address pool configuration. For more information about the information center, see *Network Management and Monitoring Configuration Guide*.

Procedure

1. Enter system view.
   system-view
2. Enter DHCP address pool view.
   dhcp server ip-pool *pool-name*
3. (Optional.) Set the threshold for address pool usage alarming.
   ip-in-use threshold *threshold-value*
   The default threshold is 100%.

Enabling DHCP logging on the DHCP server

About DHCP logging on the DHCP server

The DHCP logging feature enables the DHCP server to generate DHCP logs and send them to the information center. The information helps administrators locate and solve problems. For information about the log destination and output rule configuration in the information center, see *Network Management and Monitoring Configuration Guide*.

Restrictions and guidelines

As a best practice, disable this feature if the log generation affects the device performance or reduces the address allocation efficiency. For example, this situation might occur when a large number of clients frequently come online or go offline.

Procedure

1. Enter system view.
   system-view
2. Enable DHCP logging.
   dhcp log enable
   By default, DHCP logging is disabled.

Display and maintenance commands for DHCP server

IMPORTANT:

A restart of the DHCP server or execution of the **reset dhcp server ip-in-use** command deletes all lease information. The DHCP server denies any DHCP request for lease extension, and the client must request an IP address again.

Execute **display** commands in any view and **reset** commands in user view.

Task	Command
Display information about IP address conflicts.	**display dhcp server conflict** [**ip** *ip-address*]
Display information about DHCP binding auto backup.	**display dhcp server database**
Display information about lease-expired IP addresses.	**display dhcp server expired** [**ip** *ip-address* | **pool** *pool-name*]
Display information about assignable IP addresses.	**display dhcp server free-ip** [**pool** *pool-name*]
Display information about assigned IP addresses.	**display dhcp server ip-in-use** [**ip** *ip-address* | **pool** *pool-name*]
Display information about DHCP address pools.	**display dhcp server pool** [*pool-name*]
Display DHCP server statistics.	**display dhcp server statistics** [**pool** *pool-name*]
Clear information about IP address conflicts.	**reset dhcp server conflict** [**ip** *ip-address*]
Clear information about lease-expired IP addresses.	**reset dhcp server expired** [**ip** *ip-address* | **pool** *pool-name*]
Clear information about assigned IP addresses.	**reset dhcp server ip-in-use** [**ip** *ip-address* | **pool** *pool-name*]
Clear DHCP server statistics.	**reset dhcp server statistics**

DHCP server configuration examples

Example: Configuring static IP address assignment

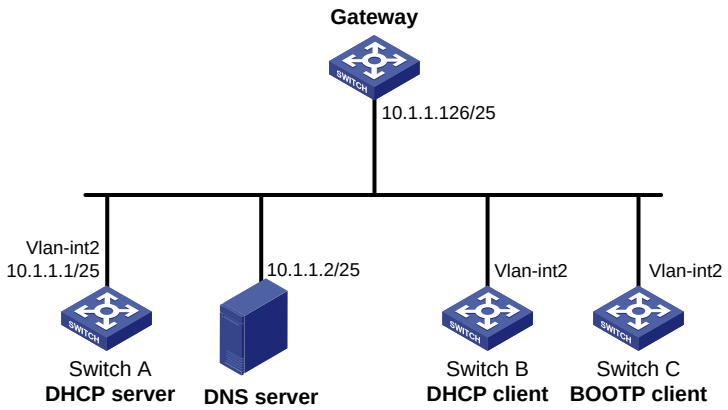
Network configuration

As shown in Figure 8, Switch B (DHCP client) and Switch C (BOOTP client) obtain the IP address, DNS server address, and gateway address from Switch A (DHCP server).

The client ID of VLAN-interface 2 on Switch B is 0030-3030-662e-6532-3030-2e30-3030-322d-4574-6865-726e-6574.

The MAC address of VLAN-interface 2 on Switch C is 000f-e200-01c0.

Figure 8 Network diagram



Procedure

1. Specify an IP address for VLAN-interface 2 on Switch A.

```
<SwitchA> system-view
[SwitchA] interface vlan-interface 2
[SwitchA-Vlan-interface2] ip address 10.1.1.1 25
[SwitchA-Vlan-interface2] quit
```

2. Configure the DHCP server:

Create DHCP address pool 0.

```
[SwitchA] dhcp server ip-pool 0
```

Configure a static binding for Switch B.

```
[SwitchA-dhcp-pool-0] static-bind ip-address 10.1.1.5 25 client-identifier
0030-3030-662e-6532-3030-2e30-3030-322d-4574-6865-726e-6574
```

Configure a static binding for Switch C.

```
[SwitchA-dhcp-pool-0] static-bind ip-address 10.1.1.6 25 hardware-address
000f-e200-01c0
```

Specify the DNS server address and the gateway address.

```
[SwitchA-dhcp-pool-0] dns-list 10.1.1.2
[SwitchA-dhcp-pool-0] gateway-list 10.1.1.126
[SwitchA-dhcp-pool-0] quit
[SwitchA]
```

Enable DHCP.

```
[SwitchA] dhcp enable
```

Enable the DHCP server on VLAN-interface 2.

```
[SwitchA] interface vlan-interface 2
[SwitchA-Vlan-interface2] dhcp select server
[SwitchA-Vlan-interface2] quit
```

Verifying the configuration

Verify that Switch B can obtain IP address 10.1.1.5 and all other network parameters from Switch A. (Details not shown.)

Verify that Switch C can obtain IP address 10.1.1.6 and all other network parameters from Switch A. (Details not shown.)

On the DHCP server, display the IP addresses assigned to the clients.

```
[SwitchA] display dhcp server ip-in-use
IP address       Client-identifier/    Lease expiration      Type
                 Hardware address
10.1.1.5         0030-3030-662e-6532-  Jan 21 14:27:27 2014  Static(C)
                 3030-2e30-3030-322d-
                 4574-6865-726e-6574
10.1.1.6         000f-e200-01c0        Unlimited             Static(C)
```

Example: Configuring dynamic IP address assignment

Network configuration

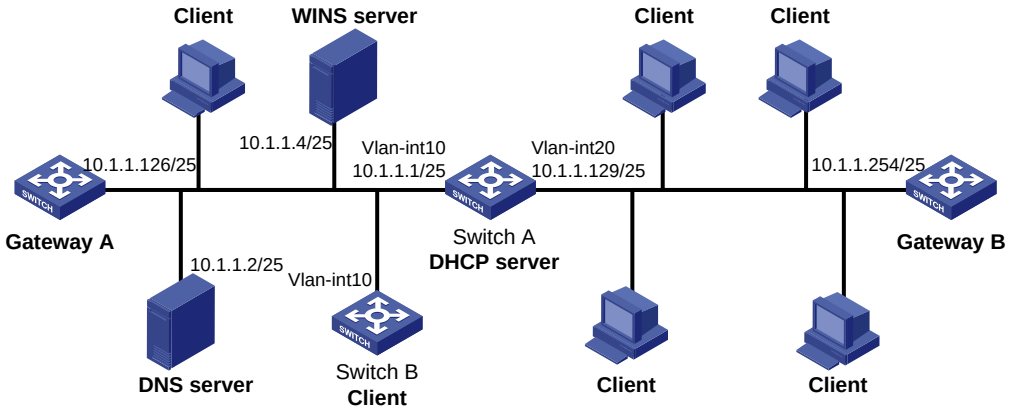
As shown in Figure 9, the DHCP server (Switch A) assigns IP addresses to clients on subnet 10.1.1.0/24, which is subnetted into 10.1.1.0/25 and 10.1.1.128/25.

Configure DHCP server on Switch A to implement the following assignment scheme.

Table 2 Assignment scheme

DHCP clients	IP address	Lease	Other configuration parameters
Clients connected to VLAN-interface 10	IP addresses on subnet 10.1.1.0/25	10 days and 12 hours	• Gateway: 10.1.1.126/25 • DNS server: 10.1.1.2/25 • Domain name: aabbcc.com • WINS server: 10.1.1.4/25
Clients connected to VLAN-interface 20	IP addresses on subnet 10.1.1.128/25	Five days	• Gateway: 10.1.1.254/25 • DNS server: 10.1.1.2/25 • Domain name: aabbcc.com

Figure 9 Network diagram



Procedure

1. Specify IP addresses for the VLAN interfaces. (Details not shown.)
2. Configure the DHCP server:

   # Exclude the DNS server address, WINS server address, and gateway addresses from dynamic allocation.

   ```
   <SwitchA> system-view
   [SwitchA] dhcp server forbidden-ip 10.1.1.2
   [SwitchA] dhcp server forbidden-ip 10.1.1.4
   [SwitchA] dhcp server forbidden-ip 10.1.1.126
   [SwitchA] dhcp server forbidden-ip 10.1.1.254
   ```

   # Configure DHCP address pool 1 to assign IP addresses and other configuration parameters to clients on subnet 10.1.1.0/25.

   ```
   [SwitchA] dhcp server ip-pool 1
   [SwitchA-dhcp-pool-1] network 10.1.1.0 mask 255.255.255.128
   [SwitchA-dhcp-pool-1] expired day 10 hour 12
   [SwitchA-dhcp-pool-1] domain-name aabbcc.com
   [SwitchA-dhcp-pool-1] dns-list 10.1.1.2
   [SwitchA-dhcp-pool-1] gateway-list 10.1.1.126
   [SwitchA-dhcp-pool-1] nbns-list 10.1.1.4
   [SwitchA-dhcp-pool-1] quit
   ```

   # Configure DHCP address pool 2 to assign IP addresses and other configuration parameters to clients on subnet 10.1.1.128/25.

   ```
   [SwitchA] dhcp server ip-pool 2
   [SwitchA-dhcp-pool-2] network 10.1.1.128 mask 255.255.255.128
   [SwitchA-dhcp-pool-2] expired day 5
   [SwitchA-dhcp-pool-2] domain-name aabbcc.com
   [SwitchA-dhcp-pool-2] dns-list 10.1.1.2
   [SwitchA-dhcp-pool-2] gateway-list 10.1.1.254
   [SwitchA-dhcp-pool-2] quit
   ```

   # Enable DHCP.

   ```
   [SwitchA] dhcp enable
   ```

   # Enable the DHCP server on VLAN-interface 10 and VLAN-interface 20.

   ```
   [SwitchA] interface vlan-interface 10
   [SwitchA-Vlan-interface10] dhcp select server
   ```

```
[SwitchA-Vlan-interface10] quit
[SwitchA] interface vlan-interface 20
[SwitchA-Vlan-interface20] dhcp select server
[SwitchA-Vlan-interface20] quit
```

Verifying the configuration

Verify that clients on subnets 10.1.1.0/25 and 10.1.1.128/25 can obtain correct IP addresses and all other network parameters from Switch A. (Details not shown.)

On the DHCP server, display the IP addresses assigned to the clients.

```
[SwitchA] display dhcp server ip-in-use
IP address       Client-identifier/    Lease expiration      Type
                 Hardware address
10.1.1.3         0031-3865-392e-6262-  Jan 14 22:25:03 2015  Auto(C)
                 3363-2e30-3230-352d-
                 4745-302f-30
10.1.1.5         0031-fe65-4203-7e02-  Jan 14 22:25:03 2015  Auto(C)
                 3063-5b30-3230-4702-
                 620e-712f-5e
10.1.1.130       3030-3030-2e30-3030-  Jan 9 10:45:11 2015   Auto(C)
                 662e-3030-3033-2d45-
                 7568-6572-1e
10.1.1.131       3030-0020-fe02-3020-  Jan 9 10:45:11 2015   Auto(C)
                 7052-0201-2013-1e02
                 0201-9068-23
10.1.1.132       2020-1220-1102-3021-  Jan 9 10:45:11 2015   Auto(C)
                 7e52-0211-2025-3402
                 0201-9068-9a
10.1.1.133       2021-d012-0202-4221-  Jan 9 10:45:11 2015   Auto(C)
                 8852-0203-2022-55e0
                 3921-0104-31
```

Example: Configuring DHCP user class

Network requirement

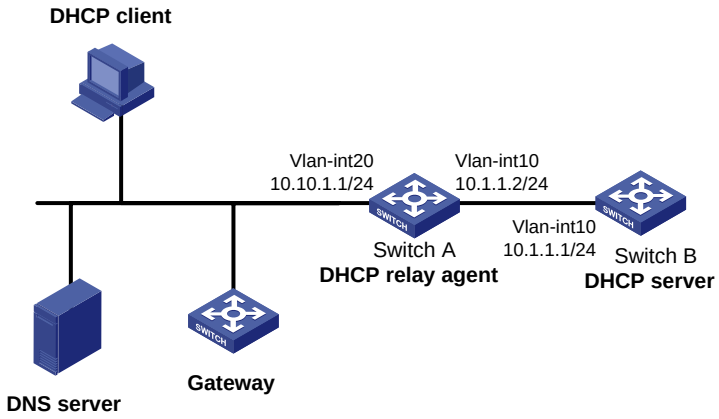
As shown in Figure 10, the DHCP relay agent (Switch A) forwards DHCP packets between DHCP clients and the DHCP server (Switch B). Enable switch A to support Option 82 so that switch A can add Option 82 in the DHCP requests sent by the DHCP clients.

Configure the address allocation scheme as follows:

Assign IP addresses	To clients
10.10.1.2 to 10.10.1.10	The DHCP request contains Option 82.
10.10.1.11 to 10.10.1.26	The hardware address in the request is six bytes long and begins with **aabb-aabb-aab**.

For clients on subnet 10.10.1.0/24, the DNS server address is 10.10.1.20/24 and the gateway address is 10.10.1.254/24.

Figure 10 Network diagram



Procedure

1. Specify IP addresses for interfaces on the DHCP server and the DHCP relay agent. (Details not shown.)
2. Configure DHCP services:

   # Create DHCP user class **tt** and configure a match rule to match client requests with Option 82.

   ```
   <SwitchB> system-view
   [SwitchB] dhcp class tt
   [SwitchB-dhcp-class-tt] if-match rule 1 option 82
   [SwitchB-dhcp-class-tt] quit
   ```

   # Create DHCP user class **ss** and configure a match rule to match DHCP requests in which the hardware address is six bytes long and begins with **aabb-aabb-aab**.

   ```
   [SwitchB] dhcp class ss
   [SwitchB-dhcp-class-ss] if-match rule 1 hardware-address aabb-aabb-aab0 mask
   ffff-ffff-fff0
   [SwitchB-dhcp-class-ss] quit
   ```

   # Create DHCP address pool **aa**.

   ```
   [SwitchB] dhcp server ip-pool aa
   ```

   # Specify the subnet for dynamic allocation.

   ```
   [SwitchB-dhcp-pool-aa] network 10.10.1.0 mask 255.255.255.0
   ```

   # Specify the address range for dynamic allocation.

   ```
   [SwitchB-dhcp-pool-aa] address range 10.10.1.2 10.10.1.100
   ```

   # Specify the address range for user class **tt**.

   ```
   [SwitchB-dhcp-pool-aa] class tt range 10.10.1.2 10.10.1.10
   ```

   # Specify the address range for user class **ss**.

   ```
   [SwitchB-dhcp-pool-aa] class ss range 10.10.1.11 10.10.1.26
   ```

   # Specify the gateway address and the DNS server address.

   ```
   [SwitchB-dhcp-pool-aa] gateway-list 10.10.1.254
   [SwitchB-dhcp-pool-aa] dns-list 10.10.1.20
   [SwitchB-dhcp-pool-aa] quit
   ```

   # Enable DHCP and configure the DHCP server to handle Option 82.

   ```
   [SwitchB] dhcp enable
   [SwitchB] dhcp server relay information enable
   ```

   # Enable DHCP server on VLAN-interface 10.

```
[SwitchB] interface vlan-interface 10
[SwitchB-Vlan-interface10] dhcp select server
[SwitchB-Vlan-interface10] quit
```

Verifying the configuration

Verify that clients matching the user classes can obtain IP addresses in the specified ranges and all other configuration parameters from the DHCP server. (Details not shown.)

Display the IP address assigned by the DHCP server.

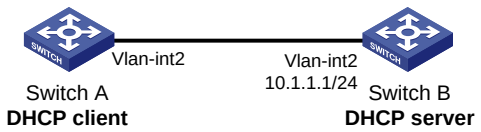
```
[SwitchB] display dhcp server ip-in-use
IP address       Client-identifier/    Lease expiration      Type
                 Hardware address
10.10.1.2        0031-3865-392e-6262-  Jan 14 22:25:03 2015  Auto(C)
                 3363-2e30-3230-352d-
                 4745-302f-30
10.10.1.11       aabb-aabb-aab1        Jan 14 22:25:03 2015  Auto(C)
```

Example: Configuring DHCP user class whitelist

Network configuration

As shown in Figure 11, configure the DHCP user class whitelist to allow the DHCP server to assign IP addresses to clients whose hardware addresses are six bytes long and begin with **aabb-aabb**.

Figure 11 Network diagram



Procedure

1. Specify IP addresses for the interfaces on the DHCP server. (Details not shown.)
2. Configure DHCP:

   # Create DHCP user class **ss** and configure a match rule to match DHCP requests in which the hardware address is six bytes long and begins with **aabb-aabb**.

   ```
   <SwitchB> system-view
   [SwitchB] dhcp class ss
   [SwitchB-dhcp-class-ss] if-match rule 1 hardware-address aabb-aabb-0000 mask
   ffff-ffff-0000
   [SwitchB-dhcp-class-ss] quit
   ```

   # Create DHCP address pool **aa**.

   ```
   [SwitchB] dhcp server ip-pool aa
   ```

   # Specify the subnet for dynamic allocation.

   ```
   [SwitchB-dhcp-pool-aa] network 10.1.1.0 mask 255.255.255.0
   ```

   # Enable the DHCP user class whitelist.

   ```
   [SwitchB-dhcp-pool-aa] verify class
   ```

   # Add DHCP user class **ss** to the DHCP user class whitelist.

   ```
   [SwitchB-dhcp-pool-aa] valid class ss
   [SwitchB-dhcp-pool-aa] quit
   ```

   # Enable DHCP.

   ```
   [SwitchB] dhcp enable
   ```

Enable DHCP server on VLAN-interface 2.

```
[SwitchB] interface vlan-interface 2
[SwitchB-Vlan-interface2] dhcp select server
[SwitchB-Vlan-interface2] quit
```

Verifying the configuration

Verify that clients matching the DHCP user class can obtain IP addresses on subnet 10.1.1.0/24 from the DHCP server. (Details not shown.)

On the DHCP server, display the IP addresses assigned to the clients.

```
[SwitchB] display dhcp server ip-in-use
IP address       Client-identifier/    Lease expiration      Type
                 Hardware address
10.1.1.2         aabb-aabb-ab01        Jan 14 22:25:03 2015  Auto(C)
```

Example: Configuring primary and secondary subnets

Network configuration

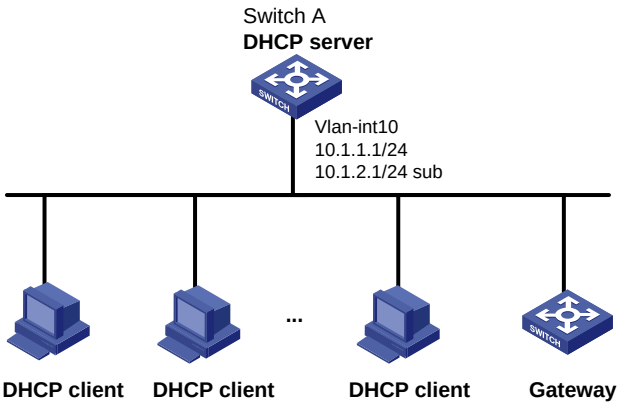
As shown in Figure 12, the DHCP server (Switch A) dynamically assigns IP addresses to clients in the LAN.

Configure two subnets in the address pool on the DHCP server: 10.1.1.0/24 as the primary subnet and 10.1.2.0/24 as the secondary subnet. The DHCP server selects IP addresses from the secondary subnet when the primary subnet has no assignable addresses.

Switch A assigns the following parameters:

- The default gateway 10.1.1.254/24 to clients on subnet 10.1.1.0/24.
- The default gateway 10.1.2.254/24 to clients on subnet 10.1.2.0/24.

Figure 12 Network diagram



Procedure

Create DHCP address pool **aa**.

```
<SwitchA> system-view
[SwitchA] dhcp server ip-pool aa
```

Specify the primary subnet and the gateway address for dynamic allocation.

```
[SwitchA-dhcp-pool-aa] network 10.1.1.0 mask 255.255.255.0
[SwitchA-dhcp-pool-aa] gateway-list 10.1.1.254
```

Specify the secondary subnet and the gateway address for dynamic allocation.

```
[SwitchA-dhcp-pool-aa] network 10.1.2.0 mask 255.255.255.0 secondary
```

```
[SwitchA-dhcp-pool-aa-secondary] gateway-list 10.1.2.254
[SwitchA-dhcp-pool-aa-secondary] quit
[SwitchA-dhcp-pool-aa] quit
```

Enable DHCP.

```
[SwitchA] dhcp enable
```

Configure the primary and secondary IP addresses of VLAN-interface 10.

```
[SwitchA] interface vlan-interface 10
[SwitchA-Vlan-interface10] ip address 10.1.1.1 24
[SwitchA-Vlan-interface10] ip address 10.1.2.1 24 sub
```

Enable the DHCP server on VLAN-interface 10.

```
[SwitchA-Vlan-interface10] dhcp select server
[SwitchA-Vlan-interface10] quit
```

Verifying the configuration

Verify that the DHCP server assigns clients IP addresses and gateway address from the secondary subnet when no address is available from the primary subnet. (Details not shown.)

Display the primary and secondary subnet IP addresses the DHCP server has assigned. The following is part of the command output.

```
[SwitchA] display dhcp server ip-in-use
IP address       Client-identifier/    Lease expiration      Type
                 Hardware address
10.1.1.2         0031-3865-392e-6262-  Jan 14 22:25:03 2015  Auto(C)
                 3363-2e30-3230-352d-
                 4745-302f-30
10.1.2.2         3030-3030-2e30-3030-  Jan 14 22:25:03 2015  Auto(C)
                 662e-3030-3033-2d45-
                 7568-6572-1e
```

Example: Customizing DHCP option

Network configuration

As shown in Figure 13, DHCP clients obtain IP addresses and PXE server addresses from the DHCP server (Switch A). The subnet for address allocation is 10.1.1.0/24.

Configure the address allocation scheme as follows:

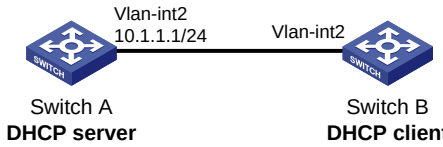
Assign PXE addresses	To clients
2.3.4.5 and 3.3.3.3	The hardware address in the request is six bytes long and begins with **aabb-aabb**.
1.2.3.4 and 2.2.2.2.	Other clients.

The DHCP server assigns PXE server addresses to DHCP clients through Option 43, a customized option. The format of Option 43 and that of the PXE server address sub-option are shown in Figure 5 and Figure 7. For example, the value of Option 43 configured in the DHCP address pool is 80 0B 00 00 02 01 02 03 04 02 02 02 02.

- The number 80 is the value of the sub-option type.
- The number 0B is the value of the sub-option length.
- The numbers 00 00 are the value of the PXE server type.
- The number 02 indicates the number of servers.

- The numbers 01 02 03 04 02 02 02 02 indicate that the PXE server addresses are 1.2.3.4 and 2.2.2.2.

Figure 13 Network diagram



Procedure

1. Specify IP addresses for the interfaces. (Details not shown.)
2. Configure the DHCP server:

   # Create DHCP user class **ss** and configure a match rule to match DHCP requests in which the hardware address is six bytes long and begins with **aabb-aabb**.

```
<SwitchA> system-view
[SwitchA] dhcp class ss
[SwitchA-dhcp-class-ss] if-match rule 1 hardware-address aabb-aabb-0000 mask
ffff-ffff-0000
[SwitchA-dhcp-class-ss] quit
```

   # Create DHCP option group 1 and customize Option 43.

```
[SwitchA] dhcp option-group 1
[SwitchA-dhcp-option-group-1] option 43 hex 800B000002020304050303030303
```

   # Enable the DHCP server on VLAN-interface 2.

```
[SwitchA] interface vlan-interface 2
[SwitchA-Vlan-interface2] dhcp select server
[SwitchA-Vlan-interface2] quit
```

   # Create DHCP address pool 0.

```
[SwitchA] dhcp server ip-pool 0
```

   # Specify the subnet for dynamic address allocation.

```
[SwitchA-dhcp-pool-0] network 10.1.1.0 mask 255.255.255.0
```

   # Customize Option 43.

```
[SwitchA-dhcp-pool-0] option 43 hex 800B000002010203040202020202
```

   # Associate DHCP user class **ss** with option group 1.

```
[SwitchA-dhcp-pool-0] class ss option-group 1
[SwitchA-dhcp-pool-0] quit
```

   # Enable DHCP.

```
[SwitchA] dhcp enable
```

Verifying the configuration

Verify that Switch B can obtain an IP address on subnet 10.1.1.0/24 and the corresponding PXE server addresses from Switch A. (Details not shown.)

On the DHCP server, display the IP addresses assigned to the clients.

```
[SwitchA] display dhcp server ip-in-use
IP address       Client-identifier/    Lease expiration      Type
                 Hardware address
10.1.1.2         aabb-aabb-ab01        Jan 14 22:25:03 2015  Auto(C)
```

Troubleshooting DHCP server configuration

Failure to obtain a non-conflicting IP address

Symptom

A client's IP address obtained from the DHCP server conflicts with an IP address of another host.

Solution

Another host on the subnet might have the same IP address.

To resolve the problem:

1. Disable the client's network adapter or disconnect the client's network cable. Ping the IP address of the client from another host to check whether there is a host using the same IP address.
2. If a ping response is received, the IP address has been manually configured on a host. Execute the **`dhcp server forbidden-ip`** command on the DHCP server to exclude the IP address from dynamic allocation.
3. Enable the network adapter or connect the network cable, release the IP address, and obtain another one on the client. For example, to release the IP address and obtain another one on a Windows XP DHCP client:
   a. In Windows environment, execute the **`cmd`** command to enter the DOS environment.
   b. Enter **`ipconfig /release`** to relinquish the IP address.
   c. Enter **`ipconfig /renew`** to obtain another IP address.

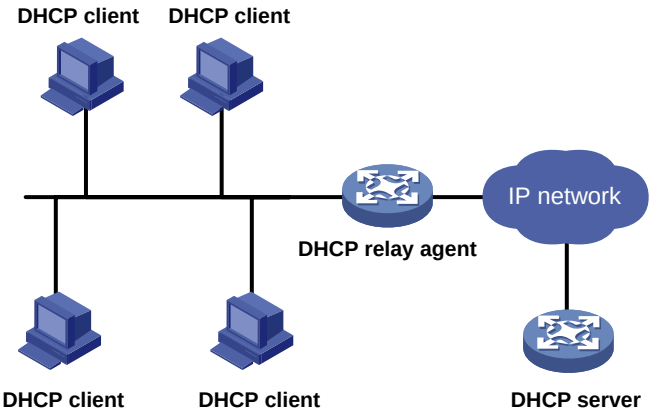
Configuring the DHCP relay agent

About DHCP relay agent

The DHCP relay agent enables clients to get IP addresses and configuration parameters from a DHCP server on another subnet.

Figure 14 shows a typical application of the DHCP relay agent.

Figure 14 DHCP relay agent application

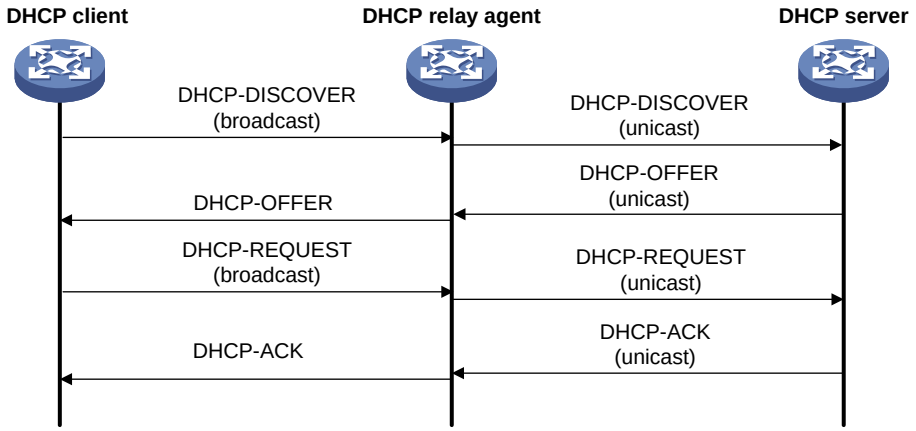


DHCP relay agent operation

The DHCP server and client interact with each other in the same way regardless of whether the relay agent exists. For the interaction details, see "IP address allocation process." The following only describes steps related to the DHCP relay agent:

1. After receiving a DHCP-DISCOVER or DHCP-REQUEST broadcast message from a DHCP client, the DHCP relay agent processes the message as follows:
   a. Fills the **giaddr** field of the message with its IP address.
   b. Unicasts the message to the designated DHCP server.
2. Based on the **giaddr** field, the DHCP server returns an IP address and other configuration parameters in a response.
3. The relay agent conveys the response to the client.

Figure 15 DHCP relay agent operation



DHCP relay agent support for Option 82

Option 82 records the location information about the DHCP client. It enables the administrator to perform the following tasks:

- Locate the DHCP client for security and accounting purposes.
- Assign IP addresses in a specific range to clients.

For more information about Option 82, see "Relay agent option (Option 82)."

If the DHCP relay agent supports Option 82, it handles DHCP requests by following the strategies described in Table 3.

If a response returned by the DHCP server contains Option 82, the DHCP relay agent removes the Option 82 before forwarding the response to the client.

Table 3 Handling strategies of the DHCP relay agent

If a DHCP request has…	Handling strategy	The DHCP relay agent…
Option 82	Drop	Drops the message.
	Keep	Forwards the message without changing Option 82.
	Replace	Forwards the message after replacing the original Option 82 with the Option 82 padded according to the configured padding format, padding content, and code type.
No Option 82	N/A	Forwards the message after adding Option 82 padded according to the configured padding format, padding content, and code type.

DHCP relay agent tasks at a glance

To configure a DHCP relay agent, perform the following tasks:

1. Enabling DHCP
2. Enabling the DHCP relay agent on an interface
3. Specifying DHCP servers
4. (Optional.) Configuring advanced features:
   - Specifying a DHCP relay address pool for DHCP clients

Enabling DHCP

Restrictions and guidelines

You must enable DHCP to make other DHCP relay agent settings take effect.

Procedure

1. Enter system view.
   `system-view`
2. Enable DHCP.
   `dhcp enable`
   By default, DHCP is disabled.

Enabling the DHCP relay agent on an interface

About enabling the DHCP relay agent on an interface

With the DHCP relay agent enabled, an interface forwards incoming DHCP requests to a DHCP server.

An IP address pool that contains the IP address of the DHCP relay interface must be configured on the DHCP server. Otherwise, the DHCP clients connected to the relay agent cannot obtain correct IP addresses.

Procedure

1. Enter system view.
   `system-view`
2. Enter interface view.
   `interface` *`interface-type interface-number`*
3. Enable the DHCP relay agent.
   `dhcp select relay`
   By default, when DHCP is enabled, an interface operates in the DHCP server mode.

Specifying DHCP servers

Specifying DHCP servers on a relay agent

About specifying DHCP servers on a relay agent

To improve availability, you can specify several DHCP servers on the DHCP relay agent. When the interface receives request messages from clients, the relay agent forwards them to all DHCP servers.

Restrictions and guidelines

The IP address of any specified DHCP server must not reside on the same subnet as the IP address of the relay interface. Otherwise, the clients might fail to obtain IP addresses.

Procedure

1. Enter system view.
   system-view
2. Enter interface view.
   interface *interface-type interface-number*
3. Specify a DHCP server address on the relay agent.
   dhcp relay server-address *ip-address* [**class** *class-name*]
   By default, no DHCP server address is specified on the relay agent.
   To specify multiple DHCP server addresses, repeat this step. You can specify a maximum of eight DHCP servers.

Specifying DHCP servers in a DHCP relay address pool

About specifying DHCP servers in a DHCP relay address pool

DHCP address pools created on a DHCP relay agent are called DHCP relay address pools. You can create a relay address pool and specify DHCP servers in this address pool. This feature allows DHCP clients of the same type to obtain IP addresses and other configuration parameters from the DHCP servers specified in the matching DHCP relay address pool.

It applies to scenarios where the DHCP relay agent connects to clients of the same access type but classified into different types by their locations. In this case, the relay interface typically has no IP address configured. You can use the **gateway-list** command to specify gateway addresses for clients matching the same DHCP relay address pool and bind the gateway addresses to the device's MAC address.

Upon receiving a DHCP DISCOVER or REQUEST from a client that matches a DHCP relay address pool, the relay agent processes the packet as follows:

- Fills the **giaddr** field of the packet with a specified gateway address.
- Forwards the packet to all DHCP servers in the matching DHCP relay address pool.

The DHCP servers select a DHCP relay address pool according to the gateway address.

Procedure

1. Enter system view.
   system-view
2. Create a DHCP relay address pool and enter its view.
   dhcp server ip-pool *pool-name*
3. Specify gateways in the DHCP relay address pool.
   gateway-list *ip-address*&<1-64>
   By default, no gateway address is specified.
4. Specify DHCP servers in the DHCP relay address pool.
   remote-server *ip-address*&<1-8>
   By default, no DHCP server is specified in the DHCP relay address pool.
   You can specify a maximum of eight DHCP servers in one DHCP relay address pool for high availability.

Specifying the DHCP server selecting algorithm

About DHCP server selecting algorithm

The DHCP relay agent supports the **polling** and **master-backup** DHCP server selecting algorithms.

By default, the DHCP relay agent uses the **polling** algorithm. It forwards DHCP requests to all DHCP servers. The DHCP clients select the DHCP server from which the first received DHCP reply comes.

If the DHCP relay agent uses the **master-backup** algorithm, it forwards DHCP requests to the master DHCP server first. If the master DHCP server is not available, the relay agent forwards the subsequent DHCP requests to a backup DHCP server. If the backup DHCP server is not available, the relay agent selects the next backup DHCP server, and so on. If no backup DHCP server is available, it repeats the process starting from the master DHCP server.

The master DHCP server is determined in one of the following ways:

- In a common network where multiple DHCP server addresses are specified on the DHCP relay interface, the first specified DHCP server is the master. The other DHCP servers are backup.
- In a network where DHCP relay address pools are configured on the DHCP relay agent, the first specified DHCP server in a DHCP relay address pool is the master. The other DHCP servers in the DHCP relay address pool are backup.

DHCP server selection supports the following functions:

- **DHCP server response timeout time**—The DHCP relay agent determines that a DHCP server is not available if it does not receive any response from the server within the DHCP server response timeout time. The DHCP server response timeout time is configurable and the default is 30 seconds.
- **DHCP server switchback**—If the DHCP relay agent selects a backup DHCP server, it does not switch back to the master DHCP server by default. You can configure the DHCP relay agent to switch back to the master DHCP server after a delay. If the master DHCP server is available, the DHCP relay agent forwards DHCP requests to the master DHCP server. If the master DHCP server is not available, the DHCP relay agent still uses the backup DHCP server.

Specifying the DHCP server selecting algorithm in interface view

1. Enter system view.
   system-view
2. Enter interface view.
   interface *interface-type interface-number*
3. Specify the DHCP server selecting algorithm.
   dhcp relay server-address algorithm { **master-backup** | **polling** }
   By default, the **polling** algorithm is used. The DHCP relay agent forwards DHCP requests to all DHCP servers.
4. (Optional.) Set the DHCP server response timeout time for DHCP server switchover.
   dhcp relay dhcp-server timeout *time*
   By default, the DHCP server response timeout time is 30 seconds.
5. (Optional.) Enable the switchback to the master DHCP server and set the delay time.
   dhcp relay master-server switch-delay *delay-time*
   By default, the DHCP relay agent does not switch back to the master DHCP server.

Specifying the DHCP server selecting algorithm in DHCP relay address pool view

1. Enter system view.
   system-view
2. Enter DHCP relay address pool view.

dhcp server ip-pool *pool-name*

3. Specify the DHCP server selecting algorithm.

   dhcp relay server-address algorithm { **master-backup** | **polling** }

   By default, the **polling** algorithm is used. The DHCP relay agent forwards DHCP requests to all DHCP servers.

4. (Optional.) Set the DHCP server response timeout time for DHCP server switchover.

   dhcp-server timeout *time*

   By default, the DHCP server response timeout time is 30 seconds.

5. (Optional.) Enable the switchback to the master DHCP server and set the delay time.

   master-server switch-delay *delay-time*

   By default, the DHCP relay agent does not switch back to the master DHCP server.

Specifying a DHCP relay address pool for DHCP clients

About specifying a DHCP relay address pool for DHCP clients

After you configure multiple DHCP relay address pools on a DHCP relay agent, you can specify these pools on an interface. To match DHCP clients based on options, you can define option settings when you specify the relay address pools.

If you specify multiple DHCP relay address pools on an interface, the relay agent selects a DHCP relay address pool for a DHCP client as follows:

1. Compares option values in the DHCP request in descending order against option values in DHCP relay address pools.
   - If a match (other than 60) is found, the matching process stops and the relay agent selects that matching relay address pool.
   - If the matching option value is 60, the relay agent continues to compare the Option 60 content in the request and the Option 60 string in the relay address pool:
     - If the Option 60 content matches the string, the relay address pool is selected.
     - If the Option 60 content does not match the string, the relay address pool is not selected. If another relay address pool is specified to match Option 60 but has no Option 60 string defined, the relay agent selects that relay address pool.
2. If still no DHCP relay address pool is matched, the relay agent selects the DHCP relay address pool with no options specified.

Restrictions and guidelines

If you specify DHCP servers by configuring both of the following methods on an interface, the DHCP relay address pool setting takes effect.

- Specify DHCP relay address pools by using the **dhcp relay pool** command.
- Specify DHCP servers directly on an interface by using the **dhcp relay server-address** command.

When you specify a DHCP relay address pool on an interface to define the DHCP servers, make sure the **remote-server** command is configured in the DHCP relay address pool. Otherwise, the relay agent drops DHCP requests. The DHCP requests are not forwarded to any DHCP server even if the **dhcp relay server-address** command is configured.

Procedure

1. Enter system view.

system-view

2. Create a DHCP relay address pool and enter its view.
   dhcp server ip-pool *pool-name*
   By default, no DHCP relay address pools exist.
3. Specify DHCP servers in the DHCP relay address pool.
   remote-server *ip-address*&<1-8>
   By default, no DHCP server is specified in the DHCP relay address pool.
4. Specify gateway addresses for the clients matching the DHCP relay address pool.
   gateway-list *ip-address*&<1-64>
   By default, no gateway address is specified.
5. Specify the DHCP server selecting algorithm.
   remote-server algorithm { **master-backup** | **polling** }
   By default, the **polling** algorithm is used. The DHCP relay agent forwards DHCP requests to all DHCP servers at the same time.
6. Return to system view.
   quit
7. Enter interface view.
   interface *interface-type interface-number*
8. Specify a DHCP relay address pool for DHCP clients.
   dhcp relay pool *pool-name* [**option** { 60 [*option-text*] | *code* }]
   By default, no DHCP relay address pool is specified for DHCP clients.

Configuring the DHCP relay agent security features

Enabling the DHCP relay agent to record relay entries

About enabling the DHCP relay agent to record relay entries

Perform this task to enable the DHCP relay agent to automatically record clients' IP-to-MAC bindings (relay entries) after they obtain IP addresses through DHCP.

Some security features use the relay entries to check incoming packets and block packets that do not match any entry. In this way, illegal hosts are not able to access external networks through the relay agent. Examples of the security features are ARP address check, authorized ARP, and IP source guard.

Restrictions and guidelines

The DHCP relay agent does not record IP-to-MAC bindings for DHCP clients running on synchronous/asynchronous serial interfaces.

Procedure

1. Enter system view.
   system-view
2. Enable the relay agent to record relay entries.
   dhcp relay client-information record
   By default, the relay agent does not record relay entries.

Enabling periodic refresh of dynamic relay entries

About enabling periodic refresh of dynamic relay entries

A DHCP client unicasts a DHCP-RELEASE message to the DHCP server to release its IP address. The DHCP relay agent conveys the message to the DHCP server and does not remove the IP-to-MAC entry of the client.

With this feature, the DHCP relay agent uses the IP address of a relay entry to periodically send a DHCP-REQUEST message to the DHCP server.

The relay agent maintains the relay entries depending on what it receives from the DHCP server:

- If the server returns a DHCP-ACK message or does not return any message within an interval, the DHCP relay agent removes the relay entry. In addition, upon receiving the DHCP-ACK message, the relay agent sends a DHCP-RELEASE message to release the IP address.
- If the server returns a DHCP-NAK message, the relay agent keeps the relay entry.

Procedure

1. Enter system view.

   system-view
2. Enable periodic refresh of dynamic relay entries.

   dhcp relay client-information refresh enable

   By default, periodic refresh of dynamic relay entries is enabled.
3. (Optional.) Set the refresh interval.

   dhcp relay client-information refresh [**auto** | **interval** *interval*]

   By default, the refresh interval is **auto**, which is calculated based on the number of total relay entries.

Enabling DHCP starvation attack protection

About DHCP starvation attack protection

A DHCP starvation attack occurs when an attacker constantly sends forged DHCP requests using different MAC addresses in the **chaddr** field to a DHCP server. This exhausts the IP address resources of the DHCP server so legitimate DHCP clients cannot obtain IP addresses. The DHCP server might also fail to work because of exhaustion of system resources. The following methods are available to relieve or prevent such attacks.

- To relieve a DHCP starvation attack that uses DHCP packets encapsulated with different source MAC addresses, you can use one of the following methods:
  - Limit the number of ARP entries that a Layer 3 interface can learn.
  - Set the MAC learning limit for a Layer 2 port, and disable unknown frame forwarding when the MAC learning limit is reached.
- To prevent a DHCP starvation attack that uses DHCP requests encapsulated with the same source MAC address, you can enable MAC address check on the DHCP relay agent. The DHCP relay agent compares the **chaddr** field of a received DHCP request with the source MAC address in the frame header. If they are the same, the DHCP relay agent forwards the request to the DHCP server. If not, the relay agent discards the request.

Enable MAC address check only on the DHCP relay agent directly connected to the DHCP clients. A DHCP relay agent changes the source MAC address of DHCP packets before sending them.

A MAC address check entry has an aging time. When the aging time expires, both of the following occur:

- The entry ages out.

- The DHCP relay agent rechecks the validity of DHCP requests sent from the MAC address in the entry.

Procedure

1. Enter system view.
   system-view
2. Set the aging time for MAC address check entries.
   dhcp relay check mac-address aging-time *time*
   The default aging time is 30 seconds.
   This command takes effect only after you execute the **dhcp relay check mac-address** command.
3. Enter the interface view.
   interface *interface-type interface-number*
4. Enable MAC address check.
   dhcp relay check mac-address
   By default, MAC address check is disabled.

Enabling DHCP server proxy on the DHCP relay agent

About enabling DHCP server proxy on the DHCP relay agent

The DHCP server proxy feature isolates DHCP servers from DHCP clients and protects DHCP servers against attacks.

Upon receiving a response from the server, the DHCP server proxy modifies the server's IP address as the relay interface's IP address before sending out the response. The DHCP client takes the DHCP relay agent as the DHCP server.

Procedure

1. Enter system view.
   system-view
2. Enter interface view.
   interface *interface-type interface-number*
3. Enable DHCP relay agent and DHCP server proxy on the interface.
   dhcp select relay proxy
   By default, the interface operates in DHCP server mode after DHCP is enabled.

Enabling client offline detection on the DHCP relay agent

About client offline detection on the DHCP relay agent

The client offline detection on the DHCP relay agent detects the user online status based on the ARP entry aging. When an ARP entry ages out, the DHCP client offline detection feature deletes the relay entry for the IP address and sends a RELEASE message to the DHCP server.

If DHCP relay agent and DHCP snooping are configured on the same device, the DHCP snooping module deletes its DHCP snooping entries after it obtains the RELEASE messages from the relay agent module.

Restrictions and guidelines

The feature does not function if an ARP entry is manually deleted.

Procedure

1. Enter system view.
   system-view
2. Enable the relay agent to record relay entries.
   dhcp relay client-information record
   By default, the relay agent does not record relay entries.
   Without relay entries, client offline detection cannot function correctly.
3. Enter interface view.
   interface *interface-type interface-number*
4. Enable the DHCP relay agent.
   dhcp select relay
   By default, when DHCP is enabled, an interface operates in the DHCP server mode.
5. Enable client offline detection.
   dhcp client-detect
   By default, client offline detection is disabled on the DHCP relay agent.

Configuring the DHCP relay agent to release an IP address

About configuring the DHCP relay agent to release an IP address

Configure the relay agent to release the IP address for a relay entry. The relay agent sends a DHCP-RELEASE message to the server and meanwhile deletes the relay entry. Upon receiving the DHCP-RELEASE message, the DHCP server releases the IP address.

This command can release only the IP addresses in the recorded relay entries.

Procedure

1. Enter system view.
   system-view
2. Configure the DHCP relay agent to release an IP address.
   dhcp relay release ip *ip-address*

Configuring DHCP relay agent support for Option 82

To support Option 82, you must perform related configuration on both the DHCP server and relay agent. For DHCP server Option 82 configuration, see "Enabling handling of Option 82."

Procedure

1. Enter system view.
   system-view
2. Enter interface view.
   interface *interface-type interface-number*
3. Enable the relay agent to handle Option 82.
   dhcp relay information enable

By default, handling of Option 82 is disabled.

4. (Optional.) Configure the strategy for handling DHCP requests that contain Option 82.

   dhcp relay information strategy { **drop** | **keep** | **replace** }

   By default, the handling strategy is **replace**.

   If the handling strategy is **replace**, configure a padding mode and a padding format for Option 82. If the handling strategy is **keep** or **drop**, you do not need to configure a padding mode or padding format for Option 82.

5. (Optional.) Configure the padding mode and padding format for the Circuit ID sub-option.

   dhcp relay information circuit-id { **bas** | **string** *circuit-id* | { **normal** | **verbose** [**node-identifier** { **mac** | **sysname** | **user-defined** *node-identifier* }] [**interface**] } [**format** { **ascii** | **hex** }] }

   By default, the padding mode for Circuit ID sub-option is **normal**, and the padding format is **hex**.

   The device name (**sysname**) must not include spaces if it is configured as the padding content for sub-option 1. Otherwise, the DHCP relay agent will fail to add or replace Option 82.

6. (Optional.) Configure the padding mode and padding format for the Remote ID sub-option.

   dhcp relay information remote-id { **normal** [**format** { **ascii** | **hex** }] | **string** *remote-id* | **sysname** }

   By default, the padding mode for the Remote ID sub-option is **normal**, and the padding format is **hex**.

Setting the DSCP value for DHCP packets sent by the DHCP relay agent

About the DSCP value for DHCP packets sent by the DHCP relay agent

The DSCP value of a packet specifies the priority level of the packet and affects the transmission priority of the packet.

Procedure

1. Enter system view.

   system-view

2. Set the DSCP value for DHCP packets sent by the DHCP relay agent.

   dhcp dscp *dscp-value*

   By default, the DSCP value in DHCP packets sent by the DHCP relay agent is 56.

Specifying the DHCP relay agent address for the **giaddr** field

Manually specifying the DHCP relay agent address for the **giaddr** field

About manually specifying the DHCP relay agent address for the giaddr field

This task allows you to specify the IP addresses to be encapsulated to the **giaddr** field of the DHCP requests. If you do not specify any DHCP relay agent address, the primary IP address of the DHCP relay interface is encapsulated to the **giaddr** field of DHCP requests.

Procedure

1. Enter system view.
   ```
   system-view
   ```
2. Enter interface view.
   ```
   interface interface-type interface-number
   ```
3. Specify the DHCP relay agent address to be encapsulated in relayed DHCP requests.
   ```
   dhcp relay gateway ip-address
   ```
   By default, the primary IP address of the DHCP relay interface is encapsulated in the relayed DHCP requests.

Configuring smart relay to specify the DHCP relay agent address for the **giaddr** field

About smart relay

By default, the relay agent only encapsulates the primary IP address to the **giaddr** field of all requests before relaying them to the DHCP server. The DHCP server then selects an IP address on the same subnet as the address in the **giaddr** filed. If no assignable addresses on the subnet are available, the DHCP server does not assign any IP address. The DHCP smart relay feature is introduced to allow the DHCP relay agent to encapsulate secondary IP addresses when the DHCP server does not send back a DHCP-OFFER message.

The relay agent initially encapsulates its primary IP address to the **giaddr** field before forwarding a request to the DHCP server. If no DHCP-OFFER is received, the relay agent allows the client to send a maximum of two requests to the DHCP server by using the primary IP address. If no DHCP-OFFER is returned after two retries, the relay agent switches to a secondary IP address. If the DHCP server still does not respond, the next secondary IP address is used. After the secondary IP addresses are all tried and the DHCP server does not respond, the relay agent repeats the process by starting from the primary IP address.

Procedure

1. Enter system view.
   ```
   system-view
   ```
2. Enable the DHCP smart relay feature.
   ```
   dhcp smart-relay enable
   ```
   By default, the DHCP smart relay feature is disabled.

Specifying the source IP address for relayed DHCP requests

About specifying the source IP address for relayed DHCP requests

This task is required if multiple relay interfaces share the same IP address or if a relay interface does not have routes to DHCP servers. You can specify an IP address or the IP address of another interface, typically the loopback interface, on the DHCP relay agent as the source IP address for DHCP requests. The relay interface inserts the source IP address in the source IP address field as well as the **giaddr** field in DHCP requests.

If multiple relay interfaces share the same IP address, you must also configure the relay interface to support Option 82. Upon receiving a DHCP request, the relay interface inserts the subnet information in sub-option 5 in Option 82. The DHCP server assigns an IP address according to

sub-option 5. The DHCP relay agent looks up the output interface in the MAC address table to forward the DHCP reply.

Procedure

1. Enter system view.

   system-view

2. Enter interface view.

   interface *interface-type interface-number*

3. Specify the source IP address for DHCP requests.

   dhcp relay source-address { *ip-address* | **interface** *interface-type interface-number* }

   By default, the DHCP relay agent uses the primary IP address of the interface that connects to the DHCP server as the source IP address for relayed DHCP requests. If this interface does not have an IP address, the DHCP relay agent uses an IP address that shares the same subnet with the DHCP server.

   You can specify only one source IP address for DHCP requests on an interface.

Display and maintenance commands for DHCP relay agent

Execute **display** commands in any view and **reset** commands in user view.

Task	Command
Display MAC address check entries on the DHCP relay agent.	**display dhcp relay check mac-address**
Display relay entries on the DHCP relay agent.	**display dhcp relay client-information** [**interface** *interface-type interface-number* | **ip** *ip-address*]
Display Option 82 configuration information on the DHCP relay agent.	**display dhcp relay information** [**interface** *interface-type interface-number*]
Display information about DHCP servers on an interface.	**display dhcp relay server-address** [**interface** *interface-type interface-number*]
Display packet statistics on the DHCP relay agent.	**display dhcp relay statistics** [**interface** *interface-type interface-number*]
Clear relay entries on the DHCP relay agent.	**reset dhcp relay client-information** [**interface** *interface-type interface-number* | **ip** *ip-address*]
Clear packet statistics on the DHCP relay agent.	**reset dhcp relay statistics** [**interface** *interface-type interface-number*]

DHCP relay agent configuration examples

Example: Configuring basic DHCP relay agent

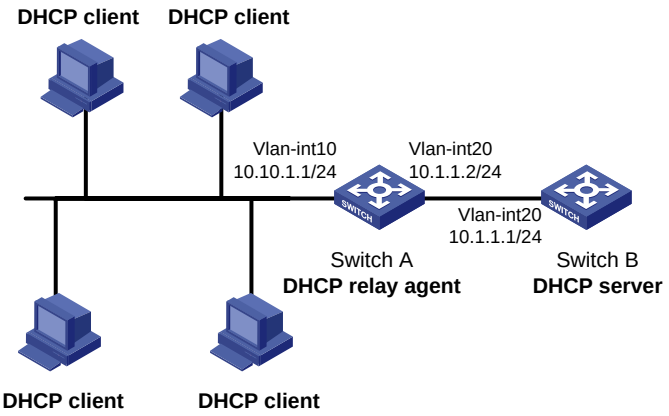
Network configuration

As shown in Figure 16, configure the DHCP relay agent on Switch A. The DHCP relay agent enables DHCP clients to obtain IP addresses and other configuration parameters from the DHCP server on another subnet.

The DHCP relay agent and server are on different subnets. Configure static or dynamic routing to make them reachable to each other.

Perform the configuration on the DHCP server to guarantee the client-server communication. For DHCP server configuration information, see "DHCP server configuration examples."

Figure 16 Network diagram



Procedure

Specify IP addresses for the interfaces. (Details not shown.)

Enable DHCP.

```
<SwitchA> system-view
[SwitchA] dhcp enable
```

Enable the DHCP relay agent on VLAN-interface 10.

```
[SwitchA] interface vlan-interface 10
[SwitchA-Vlan-interface10] dhcp select relay
```

Specify the IP address of the DHCP server on the relay agent.

```
[SwitchA-Vlan-interface10] dhcp relay server-address 10.1.1.1
```

Verifying the configuration

Verify that DHCP clients can obtain IP addresses and all other network parameters from the DHCP server through the DHCP relay agent. (Details not shown.)

Display the statistics of DHCP packets forwarded by the DHCP relay agent.

```
[SwitchA] display dhcp relay statistics
```

Display relay entries if you have enabled relay entry recording on the DHCP relay agent.

```
[SwitchA] display dhcp relay client-information
```

Example: Configuring Option 82

Network configuration

As shown in Figure 16, the DHCP relay agent (Switch A) replaces Option 82 in DHCP requests before forwarding them to the DHCP server (Switch B).

- The Circuit ID sub-option is **company001.**
- The Remote ID sub-option is **device001**.

To use Option 82, you must also enable the DHCP server to handle Option 82.

Procedure

Specify IP addresses for the interfaces. (Details not shown.)

Enable DHCP.

```
<SwitchA> system-view
[SwitchA] dhcp enable
```

Enable the DHCP relay agent on VLAN-interface 10.

```
[SwitchA] interface vlan-interface 10
[SwitchA-Vlan-interface10] dhcp select relay
```

Specify the IP address of the DHCP server.

```
[SwitchA-Vlan-interface10] dhcp relay server-address 10.1.1.1
```

Configure the handling strategies and padding content of Option 82.

```
[SwitchA-Vlan-interface10] dhcp relay information enable
[SwitchA-Vlan-interface10] dhcp relay information strategy replace
[SwitchA-Vlan-interface10] dhcp relay information circuit-id string company001
[SwitchA-Vlan-interface10] dhcp relay information remote-id string device001
```

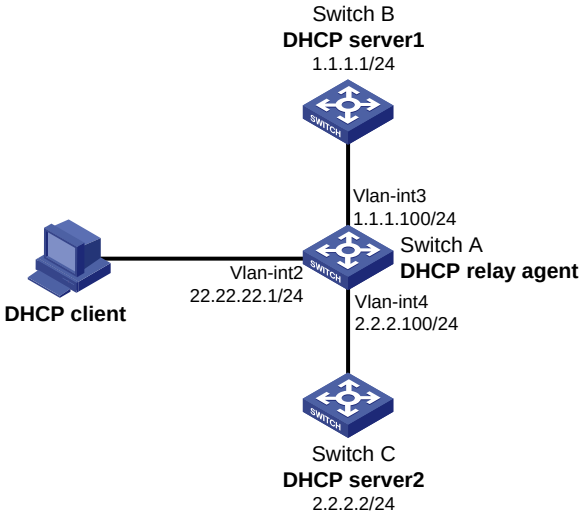
Example: Configuring DHCP server selection

Network configuration

As shown in Figure 17, the DHCP client and the DHCP servers are in different subnets. DHCP server 1 and DHCP server 2 both have a DHCP address pool that contains IP addresses in subnet 22.22.22.0/24, but neither has DHCP enabled.

Configure the DHCP relay agent for the DHCP client to obtain an IP address in subnet 22.22.22.0/24 and other configuration parameters from a DHCP server. The DHCP relay agent is connected to the DHCP client through VLAN-interface 2, to DHCP server 1 through VLAN-interface 3, and to DHCP server 2 through VLAN-interface 4.

Figure 17 Network diagram



Procedure

1. Assign IP addresses to interfaces on the switches. (Details not shown.)
2. Configure Switch B and Switch C as DHCP servers. (Details not shown.)
3. Configure the DHCP relay agent on Switch A:

   # Enable DHCP.

   ```
   <SwitchA> system-view
   [SwitchA] dhcp enable
   ```

   # Enable the DHCP relay agent on VLAN-interface 2.

   ```
   [SwitchA] interface vlan-interface 2
   [SwitchA-Vlan-interface2] dhcp select relay
   ```

   # Specify the IP addresses of the DHCP servers.

   ```
   [SwitchA-Vlan-interface2] dhcp relay server-address 1.1.1.1
   [SwitchA-Vlan-interface2] dhcp relay server-address 2.2.2.2
   ```

   # Specify the DHCP server selecting algorithm as **master-backup**.

   ```
   [SwitchA-Vlan-interface2] dhcp relay server-address algorithm master-backup
   ```

   # Configure the DHCP relay agent to switch back to the master DHCP server 3 minutes after it switches to the backup DHCP server.

   ```
   [SwitchA-Vlan-interface2] dhcp relay master-server switch-delay 3
   ```

Verifying the configuration

Verify that the DHCP client cannot obtain an IP address and that the following log is output in about 30 seconds.

```
DHCPR/3/DHCPR_SERVERCHANGE:
 Switched to the server at 2.2.2.2 because the current server did not respond.
```

Enable DHCP on the DHCP server at 1.1.1.1. (Details not shown.)

Verify that the DHCP client cannot obtain an IP address and that the following log is output in about 3 minutes.

```
DHCPR/3/DHCPR_SWITCHMASTER:
 Switched to the master DHCP server at 1.1.1.1.
```

Verify that the DHCP client obtains an IP address. (Details not shown.)

Troubleshooting DHCP relay agent configuration

Failure of DHCP clients to obtain configuration parameters through the DHCP relay agent

Symptom

DHCP clients cannot obtain configuration parameters through the DHCP relay agent.

Solution

Some problems might occur with the DHCP relay agent or server configuration.

To locate the problem, enable debugging and execute the **`display`** command on the DHCP relay agent to view the debugging information and interface state information.

Check that:

- DHCP is enabled on the DHCP server and relay agent.
- The DHCP server has an address pool on the same subnet as the DHCP clients.
- The DHCP server and DHCP relay agent can reach each other.
- The DHCP server address specified on the DHCP relay interface connected to the DHCP clients is correct.

Configuring the DHCP client

About DHCP client

With DHCP client enabled, an interface uses DHCP to obtain configuration parameters from the DHCP server, for example, an IP address.

Restrictions and guidelines: DHCP client configuration

The DHCP client configuration is supported only on VLAN interfaces.

DHCP client tasks at a glance

To configure a DHCP client, perform the following tasks:

1. Enabling the DHCP client on an interface
2. Configuring a DHCP client ID for an interface

   Perform this task if the DHCP client uses the client ID to obtain IP addresses.
3. (Optional.) Enabling duplicated address detection
4. (Optional.) Setting the DSCP value for DHCP packets sent by the DHCP client
5. (Optional.) Configuring Option 60 for DHCP requests

Enabling the DHCP client on an interface

Restrictions and guidelines

- If the number of IP address request failures reaches the system-defined amount, the DHCP client-enabled interface uses a default IP address.
- An interface can be configured to acquire an IP address in multiple ways. The new configuration overwrites the old.
- Secondary IP addresses cannot be configured on an interface that is enabled with the DHCP client.
- If the interface obtains an IP address on the same segment as another interface on the device, the interface does not use the assigned address. Instead, it requests a new IP address from the DHCP server.

Procedure

1. Enter system view.

   system-view
2. Enter interface view.

   interface *interface-type interface-number*
3. Configure an interface to use DHCP for IP address acquisition.

   ip address dhcp-alloc

   The default setting varies as follows:

- For the S3100V3-SI switch series, MS4320V2 switch series, MS4320 switch series, MS4200 switch series, and MS4300V2 switch series, an interface does not use DHCP for IP address acquisition.
- For the S5110V2 switch series, S5110V2-SI switch series, S5130S-LI switch series, S5130S-SI switch series, S5000V3-EI switch series, S5000E-X switch series, WS5810-WiNet switch series, WS5820-WiNet switch series, and WAS6100 switch series:
  - If the switch starts with initial configuration, an interface does not use DHCP for IP address acquisition.
  - If the switch starts with factory defaults, VLAN-interface 1 obtains an IP address through DHCP.

For more information about initial configuration and factory defaults, see configuration file management configuration in *Fundamentals Configuration Guide*.

Configuring a DHCP client ID for an interface

About DHCP client ID

A DHCP client ID is added to the DHCP option 61 to uniquely identify a DHCP client. A DHCP server can assign IP addresses to clients based on their DHCP client IDs.

DHCP client ID includes an ID type and a type value. Each ID type has a fixed type value. You can specify a DHCP client ID by using one of the following methods:

- Use an ASCII string as the client ID. If an ASCII string is used, the type value is 00.
- Use a hexadecimal number as the client ID. If a hexadecimal number is used, the type value is the first two characters in the number.
- Use the MAC address of an interface to generate a client ID. If this method is used, the type value is 01.

The type value of a DHCP client ID can be displayed by the **display dhcp server ip-in-use** or **display dhcp client** command.

Restrictions and guidelines

Make sure the ID for each DHCP client is unique.

Procedure

1. Enter system view.

   system-view
2. Enter interface view.

   interface *interface-type interface-number*
3. Configure a DHCP client ID for the interface.

   dhcp client identifier { **ascii** *ascii-string* | **hex** *hex-string* | **mac** *interface-type interface-number* }

   By default, an interface generates the DHCP client ID based on its MAC address. If the interface has no MAC address, it uses the MAC address of the first Ethernet interface to generate its client ID.

Enabling duplicated address detection

About duplicated address detection

DHCP client detects IP address conflict through ARP packets. An attacker can act as the IP address owner to send an ARP reply. The spoofing attack makes the client unable to use the IP address

assigned by the server. As a best practice, disable duplicate address detection when ARP attacks exist on the network.

Procedure

1. Enter system view.
   system-view
2. Enable duplicate address detection.
   dhcp client dad enable
   By default, the duplicate address detection feature is enabled on an interface.

Setting the DSCP value for DHCP packets sent by the DHCP client

About setting the DSCP value for DHCP packets sent by the DHCP client

The DSCP value of a packet specifies the priority level of the packet and affects the transmission priority of the packet.

Procedure

1. Enter system view.
   system-view
2. Set the DSCP value for DHCP packets sent by the DHCP client.
   dhcp client dscp *dscp-value*
   By default, the DSCP value in DHCP packets sent by the DHCP client is 56.

Configuring Option 60 for DHCP requests

About this task

Option 60 acts as a vendor class identifier (VCI). You can configure a DHCP client to send a request with Option 60 for the DHCP server to make class-based IP address assignment. When the DHCP server receives a request with Option 60 from a client, the server identifies the user class of the client. Then, the server assigns the client an IP address from the IP range specified for the user class.

By default, Option 60 contains the vendor name and the product name. To define this option for DHCP requests, perform this task.

Software version and feature compatibility

This feature is supported only in Release 6340 and later.

Procedure

1. Enter system view.
   system-view
2. Enter interface view.
   interface *interface-type interface-number*
3. Configure Option 60 for DHCP requests.
   dhcp client class-id { **ascii** *ascii-string* | **hex** *hex-string* }
   By default, Option 60 contains the vendor name and the product name.

Display and maintenance commands for DHCP client

Execute **display** command in any view.

Task	Command
Display DHCP client information.	**display dhcp client** [**verbose**] [**interface** *interface-type interface-number*]

DHCP client configuration examples

Example: Configuring DHCP client

Network configuration

As shown in Figure 19, on a LAN, Switch B contacts the DHCP server through VLAN-interface 2 to obtain an IP address, a DNS server address, and static route information. The DHCP client's IP address resides on subnet 10.1.1.0/24. The DNS server address is 20.1.1.1. The next hop of the static route to subnet 20.1.1.0/24 is 10.1.1.2.

The DHCP server uses Option 121 to assign static route information to DHCP clients. Figure 18 shows the Option 121 format. The destination descriptor field contains the following parts: subnet mask length and destination network address, both in hexadecimal notation. In this example, the destination descriptor is 18 14 01 01 (the subnet mask length is 24 and the network address is 20.1.1.0 in dotted decimal notation). The next hop address is 0A 01 01 02 (10.1.1.2 in dotted decimal notation).

Figure 18 Option 121 format

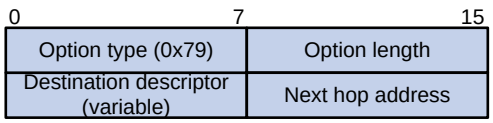
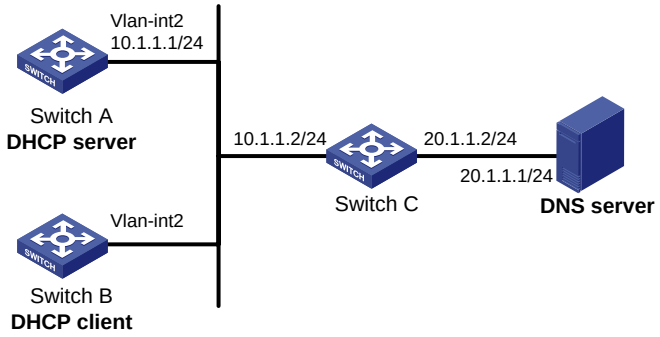


Figure 19 Network diagram



Procedure

1. Configure Switch A:

   # Specify an IP address for VLAN-interface 2.

   ```
   <SwitchA> system-view
   ```

```
[SwitchA] interface vlan-interface 2
[SwitchA-Vlan-interface2] ip address 10.1.1.1 24
[SwitchA-Vlan-interface2] quit
```

Exclude an IP address from dynamic allocation.

```
[SwitchA] dhcp server forbidden-ip 10.1.1.2
```

Configure DHCP address pool 0. Specify the subnet, lease duration, DNS server address, and a static route to subnet 20.1.1.0/24.

```
[SwitchA] dhcp server ip-pool 0
[SwitchA-dhcp-pool-0] network 10.1.1.0 mask 255.255.255.0
[SwitchA-dhcp-pool-0] expired day 10
[SwitchA-dhcp-pool-0] dns-list 20.1.1.1
[SwitchA-dhcp-pool-0] option 121 hex 18 14 01 01 0A 01 01 02
[SwitchA-dhcp-pool-0] quit
```

Enable DHCP.

```
[SwitchA] dhcp enable
```

2. Configure Switch B:

Configure VLAN-interface 2 to use DHCP for IP address acquisition.

```
<SwitchB> system-view
[SwitchB] interface vlan-interface 2
[SwitchB-Vlan-interface2] ip address dhcp-alloc
[SwitchB-Vlan-interface2] quit
```

Verifying the configuration

Display the IP address and other network parameters assigned to Switch B.

```
[SwitchB-Vlan-interface2] display dhcp client verbose
Vlan-interface2 DHCP client information:
 Current state: BOUND
 Allocated IP: 10.1.1.3 255.255.255.0
 Allocated lease: 864000 seconds, T1: 331858 seconds, T2: 756000 seconds
 Lease from May 21 19:00:29 2012   to   May 31 19:00:29 2012
 DHCP server: 10.1.1.1
 Transaction ID: 0xcde72232
 Classless static routes:
   Destination: 20.1.1.0, Mask: 255.255.255.0, NextHop: 10.1.1.2
 DNS servers: 20.1.1.1
 Client ID type: acsii(type value=00)
 Client ID value: 000c.29d3.8659-Vlan2
 Client ID (with type) hex: 0030-3030-632e-3239-
                            6433-2e38-3635-392d-
                            4574-6830-2f30-2f32
 T1 will timeout in 3 days 19 hours 48 minutes 43 seconds
```

Display the route information on Switch B. The output shows that a static route to subnet 20.1.1.0/24 is added to the routing table.

```
[SwitchB] display ip routing-table
Destinations : 11        Routes : 11
Destination/Mask    Proto  Pre  Cost         NextHop         Interface
10.1.1.0/24         Direct 0    0            10.1.1.3        Vlan2
10.1.1.3/32         Direct 0    0            127.0.0.1       InLoop0
```

```
20.1.1.0/24         Static 70   0           10.1.1.2        Vlan2
10.1.1.255/32       Direct 0    0           10.1.1.3        Vlan2
127.0.0.0/8         Direct 0    0           127.0.0.1       InLoop0
127.0.0.0/32        Direct 0    0           127.0.0.1       InLoop0
127.0.0.1/32        Direct 0    0           127.0.0.1       InLoop0
127.255.255.255/32  Direct 0    0           127.0.0.1       InLoop0
224.0.0.0/4         Direct 0    0           0.0.0.0         NULL0
224.0.0.0/24        Direct 0    0           0.0.0.0         NULL0
255.255.255.255/32  Direct 0    0           127.0.0.1       InLoop0
```

Configuring DHCP snooping

About DHCP snooping

DHCP snooping is a security feature for DHCP.

DHCP snooping works between the DHCP client and server, or between the DHCP client and DHCP relay agent. It guarantees that DHCP clients obtain IP addresses from authorized DHCP servers. Also, it records IP-to-MAC bindings of DHCP clients (called DHCP snooping entries) for security purposes.

DHCP snooping defines trusted and untrusted ports to make sure clients obtain IP addresses only from authorized DHCP servers.

- **Trusted**—A trusted port can forward DHCP messages correctly to make sure the clients get IP addresses from authorized DHCP servers.
- **Untrusted**—An untrusted port cannot forward DHCP requests to the DHCP server. It discards received DHCP-ACK and DHCP-OFFER messages to prevent unauthorized servers from assigning IP addresses.

DHCP snooping reads DHCP-ACK messages received from trusted ports and DHCP-REQUEST messages to create DHCP snooping entries. A DHCP snooping entry includes the MAC and IP addresses of a client, the port that connects to the DHCP client, and the VLAN.

The following features need to use DHCP snooping entries:

- **ARP attack detection**—Uses DHCP snooping entries to filter ARP packets from unauthorized clients. For more information, see *Security Configuration Guide*.
- **MAC-forced forwarding (MFF)**—Auto-mode MFF performs the following tasks:
  - Intercepts ARP requests from clients.
  - Uses DHCP snooping entries to find the gateway address.
  - Returns the gateway MAC address to the clients.

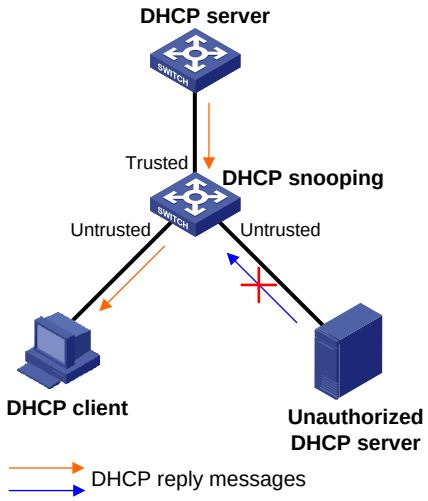
  This feature forces the client to send all traffic to the gateway so that the gateway can monitor client traffic to prevent malicious attacks among clients. For more information, see *Security Configuration Guide*.
- **IP source guard**—Uses DHCP snooping entries to filter illegal packets on a per-port basis. For more information, see *Security Configuration Guide*.
- **VLAN mapping**—Uses DHCP snooping entries to replace service provider VLAN in packets with customer VLAN before sending the packets to clients. For more information, see *Layer 2—LAN Switching Configuration Guide*.

Application of trusted and untrusted ports

Configure ports facing the DHCP server as trusted ports, and configure other ports as untrusted ports.

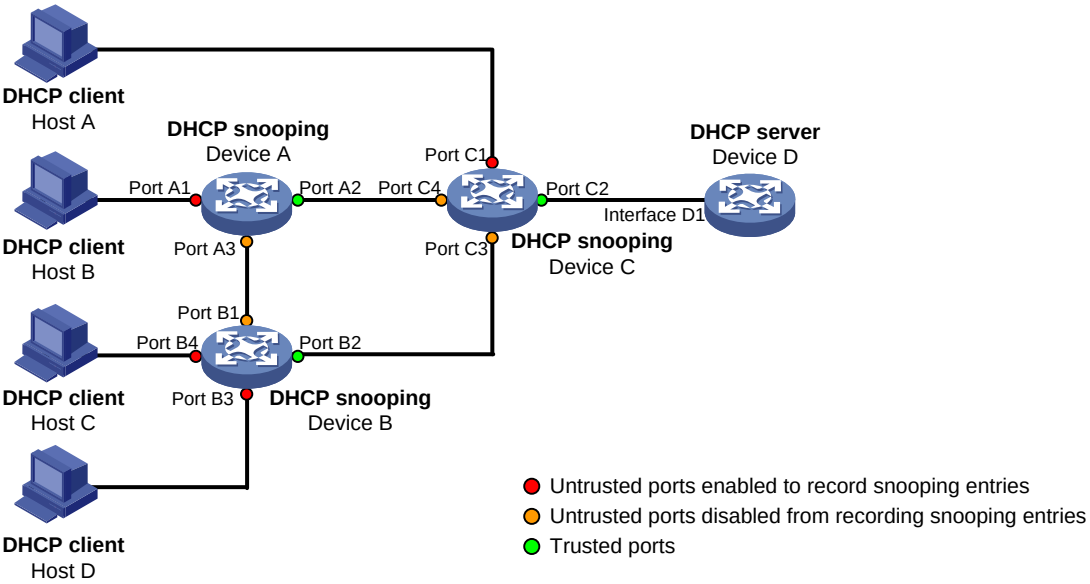
As shown in Figure 20, configure the DHCP snooping device's port that is connected to the DHCP server as a trusted port. The trusted port forwards response messages from the DHCP server to the client. The untrusted port connected to the unauthorized DHCP server discards incoming DHCP response messages.

Figure 20 Trusted and untrusted ports



In a cascaded network as shown in Figure 21, configure the DHCP snooping devices' ports facing the DHCP server as trusted ports. To save system resources, you can enable only the untrusted ports directly connected to the DHCP clients to record DHCP snooping entries.

Figure 21 Trusted and untrusted ports in a cascaded network



DHCP snooping support for Option 82

Option 82 records the location information about the DHCP client so the administrator can locate the DHCP client for security and accounting purposes. For more information about Option 82, see "Relay agent option (Option 82)."

Sub-option 9 (Vendor-Specific) in Option 82 is supported only on DHCP snooping devices. Each DHCP snooping device with the **append** Option 82 handling strategy adds the following information to the sub-option in the received DHCP request:

- Node identifier of the current DHCP snooping device.
- Information about the client-side interface.

- VLAN of the DHCP client.

After the management device receives the DHCP request, it can determine the network topology that the request has travelled and locate the DHCP client.

DHCP snooping uses the same strategies as the DHCP relay agent to handle Option 82 for DHCP request messages, as shown in Table 4. If a response returned by the DHCP server contains Option 82, DHCP snooping removes Option 82 before forwarding the response to the client. If the response contains no Option 82, DHCP snooping forwards it directly.

Table 4 Handling strategies

If a DHCP request has…	Handling strategy	DHCP snooping…
Option 82	Append	• Forwards the message after padding the Vendor-Specific sub-option with the content specified in the **dhcp snooping information vendor-specific** command. • Forwards the message without changing Option 82 if the **dhcp snooping information vendor-specific** command is not configured.
	Drop	Drops the message.
	Keep	Forwards the message without changing Option 82.
	Replace	Forwards the message after replacing the original Option 82 with the Option 82 padded according to the configured padding format, padding content, and code type.
No Option 82	N/A	Forwards the message after adding the Option 82 padded according to the configured padding format, padding content, and code type.

Restrictions and guidelines: DHCP snooping configuration

- The DHCP snooping configuration does not take effect on a Layer 2 Ethernet interface that is an aggregation member port. The configuration takes effect when the interface leaves the aggregation group.
- Specify the ports connected to authorized DHCP servers as trusted ports to make sure that DHCP clients can obtain valid IP addresses. The trusted ports and the ports connected to DHCP clients must be in the same VLAN.
- You can specify the following interfaces as trusted ports: Layer 2 Ethernet interfaces and Layer 2 aggregate interfaces. For more information about aggregate interfaces, see Ethernet link aggregation in *Layer 2—LAN Switching Configuration Guide*.

DHCP snooping tasks at a glance

To configure DHCP snooping, perform the following tasks:

1. Configuring basic DHCP snooping features
2. (Optional.) Configuring DHCP snooping support for Option 82
3. (Optional.) Configuring DHCP snooping entry auto backup
4. (Optional.) Setting the maximum number of DHCP snooping entries
5. (Optional.) Configuring DHCP packet rate limit

6. (Optional.) Configuring DHCP snooping security features
7. (Optional.) Enabling DHCP snooping logging
8. (Optional.) Disabling DHCP snooping on an interface

Configuring basic DHCP snooping features

Configuring basic DHCP snooping features in a common network

About basic DHCP snooping features in a common network

Basic DHCP snooping features refer to the following:

- Enabling DHCP snooping.
- Configuring DHCP snooping trusted ports.
- Enabling recording client information in DHCP snooping entries.

If you enable DHCP snooping globally, DHCP snooping is enabled on all interfaces on the device.

You can also enable DHCP snooping for specific VLANs. After enabling DHCP snooping for a VLAN, you can configure the other basic DHCP snooping features in the VLAN.

Restrictions and guidelines

If the basic DHCP snooping features are configured globally, you can only use the undo form of the global configuration commands to disable the settings globally. The VLAN-specific configuration commands cannot disable the settings.

If the basic DHCP snooping features are configured in a VLAN, you can only use the undo form of the VLAN-specific configuration commands to disable the settings in the VLAN. The global configuration command cannot disable the settings.

Configuring basic DHCP snooping features globally

1. Enter system view.
   `system-view`
2. Enable DHCP snooping globally.
   `dhcp snooping enable`
   By default, DHCP snooping is disabled globally.
3. Enter interface view.
   `interface` *`interface-type interface-number`*
   This interface must connect to the DHCP server.
4. Specify the port as a trusted port.
   `dhcp snooping trust`
   By default, all ports are untrusted ports after DHCP snooping is enabled.
5. (Optional.) Enable the recording of DHCP snooping entries.
   a. Return to system view.
      `quit`
   b. Enter interface view.
      `interface` *`interface-type interface-number`*
      This interface must connect to the DHCP client.
   c. Enable the recording of DHCP snooping entries.

dhcp snooping binding record

By default, the recording of DHCP snooping entries is disabled.

Configuring basic DHCP snooping features for VLANs

1. Enter system view.
   system-view
2. Enable DHCP snooping for VLANs.
   dhcp snooping enable vlan *vlan-id-list*
   By default, DHCP snooping is disabled for all VLANs.
3. Enter VLAN view
   vlan *vlan-id*
   Make sure DHCP snooping is enabled for the VLAN.
4. Configure an interface in the VLAN as a trusted port.
   dhcp snooping trust interface *interface-type interface-number*
   By default, all interfaces in the VLAN are untrusted ports.
5. (Optional.) Enable recording of client information in DHCP snooping entries.
   dhcp snooping binding record
   By default, recording of client information in DHCP snooping entries is disabled.

Configuring DHCP snooping support for Option 82

Restrictions and guidelines

- The Option 82 configuration on a Layer 2 Ethernet interface that has been added to an aggregation group does not take effect unless the interface leaves the aggregation group.
- To support Option 82, you must configure Option 82 on both the DHCP server and the DHCP snooping device. For information about configuring Option 82 on the DHCP server, see "Enabling handling of Option 82."
- If Option 82 contains the device name, the device name must contain no spaces. Otherwise, DHCP snooping drops the message. You can use the **sysname** command to specify the device name. For more information about this command, see *Fundamentals Command Reference*.
- DHCP snooping uses "outer VLAN tag.inner VLAN tag" to fill the VLAN ID field of sub-option 1 in verbose padding format if either of the following conditions exists:
  - DHCP snooping and QinQ work together.
  - DHCP snooping receives a DHCP packet with two VLAN tags.

  For example, if the outer VLAN tag is 10 and the inner VLAN tag is 20, the VLAN ID field is 000a.0014. The hexadecimal digit **a** represents the outer VLAN tag 10, and the hexadecimal digit **14** represents the inner VLAN tag 20.

Procedure

1. Enter system view.
   system-view
2. Enter interface view or VLAN view.
   - Enter interface view.
     interface *interface-type interface-number*
   - Enter VLAN view.
     vlan *vlan-id*

NOTE:

VLAN view is supported only in Release 6348P01 and later.

3. Enable DHCP snooping to support Option 82.

   dhcp snooping information enable

   By default, DHCP snooping does not support Option 82.

4. (Optional.) Configure a handling strategy for DHCP requests that contain Option 82.

   dhcp snooping information strategy { **append** | **drop** | **keep** | **replace** }

   By default, the handling strategy is **replace**.

   If the handling strategy is **append** or **replace**, configure a padding mode and padding format for Option 82. If the handling strategy is **keep** or **drop**, you do not need to configure any padding mode or padding format for Option 82.

5. (Optional.) Configure the padding mode and padding format for the Circuit ID sub-option.

   dhcp snooping information circuit-id { **normal-extended** | [**vlan** *vlan-id*] **string** *circuit-id* | { **normal** | **verbose** [**node-identifier** { **mac** | **sysname** | **user-defined** *node-identifier* }] } [**format** { **ascii** | **hex** }] }

   By default, the padding mode is **normal** and the padding format is **hex** for the Circuit ID sub-option.

   If the device name (**sysname**) is configured as the padding content for sub-option 1, make sure the device name does not include spaces. Otherwise, the DHCP snooping device will fail to add or replace Option 82.

   When you use this command in VLAN view, the **vlan** *vlan-id* option is not supported.

   The **normal-extended** keyword is supported only in Release 6328 and later.

6. (Optional.) Configure the padding mode and padding format for the Remote ID sub-option.

   dhcp snooping information remote-id { **normal** [**format** { **ascii** | **hex** }] | [**vlan** *vlan-id*] **string** *remote-id* | **sysname** }

   By default, the padding mode is **normal** and the padding format is **hex** for the Remote ID sub-option.

   When you use this command in VLAN view, the **vlan** *vlan-id* option is not supported.

   This command is supported only in Release 6348P01 and later.

7. (Optional.) Configure the padding mode for the Vendor-Specific sub-option.

   dhcp snooping information vendor-specific [**vlan** *vlan-id*] **bas** [**node-identifier** { **mac** | **sysname** | **user-defined** *string* }]

   By default, the device does not pad the Vendor-Specific sub-option.

   When you use this command in VLAN view, the **vlan** *vlan-id* option is not supported.

Configuring DHCP snooping entry auto backup

About DHCP snooping entry auto backup

The auto backup feature saves DHCP snooping entries to a backup file, and allows the DHCP snooping device to download the entries from the backup file at device reboot. The entries on the DHCP snooping device cannot survive a reboot. The auto backup helps the security features provide services if these features (such as IP source guard) must use DHCP snooping entries for user authentication.

Restrictions and guidelines

If you disable DHCP snooping with the **undo dhcp snooping enable** command, the device deletes all DHCP snooping entries, but entries stored in the backup file still exist. They are deleted next time the device updates the backup file.

Procedure

1. Enter system view.

   system-view

2. Configure the DHCP snooping device to back up DHCP snooping entries to a file.

   dhcp snooping binding database filename { *filename* | **url** *url* [**username** *username* [**password** { **cipher** | **simple** } *string*]] }

   By default, the DHCP snooping device does not back up DHCP snooping entries.

   With this command executed, the DHCP snooping device backs up DHCP snooping entries immediately and runs auto backup.

   This command automatically creates the file if you specify a non-existent file.

3. (Optional.) Manually save DHCP snooping entries to the backup file.

   dhcp snooping binding database update now

4. (Optional.) Set the waiting time after a DHCP snooping entry change for the DHCP snooping device to update the backup file.

   dhcp snooping binding database update interval *interval*

   By default, the DHCP snooping device waits 300 seconds to update the backup file after a DHCP snooping entry change. If no DHCP snooping entry changes, the backup file is not updated.

Setting the maximum number of DHCP snooping entries

About setting the maximum number of DHCP snooping entries

Perform this task to prevent the system resources from being overused.

Procedure

1. Enter system view.

   system-view

2. Enter interface view.

   interface *interface-type interface-number*

3. Set the maximum number of DHCP snooping entries for the interface to learn.

   dhcp snooping max-learning-num *max-number*

   By default, the number of DHCP snooping entries for an interface to learn is unlimited.

Configuring DHCP packet rate limit

About DHCP packet rate limit

Perform this task to set the maximum rate at which an interface can receive DHCP packets. This feature discards exceeding DHCP packets to prevent attacks that send large number of DHCP packets.

Restrictions and guidelines

The rate set on the Layer 2 aggregate interface applies to all members of the aggregate interface. If a member interface leaves the aggregation group, it uses the rate set in its Ethernet interface view.

Procedure

1. Enter system view.
   system-view
2. Enter interface view.
   interface *interface-type interface-number*
3. Enable DHCP snooping packet rate limit on an interface and set the limit value.
   dhcp snooping rate-limit *rate*
   By default, the DHCP snooping packet rate limit is disabled on an interface.

Configuring DHCP snooping security features

Enabling DHCP starvation attack protection

About DHCP starvation attack protection

A DHCP starvation attack occurs when an attacker constantly sends forged DHCP requests that contain identical or different sender MAC addresses in the **chaddr** field to a DHCP server. This attack exhausts the IP address resources of the DHCP server so legitimate DHCP clients cannot obtain IP addresses. The DHCP server might also fail to work because of exhaustion of system resources. For information about the fields of DHCP packet, see "DHCP message format."

You can prevent DHCP starvation attacks in the following ways:

- If the forged DHCP requests contain different sender MAC addresses, use the **mac-address max-mac-count** command to set the MAC learning limit on a Layer 2 port. For more information about the command, see *Layer 2—LAN Switching Command Reference*.
- If the forged DHCP requests contain the same sender MAC address, perform this task to enable MAC address check for DHCP snooping. This feature compares the **chaddr** field of a received DHCP request with the source MAC address field in the frame header. If they are the same, the request is considered valid and forwarded to the DHCP server. If not, the request is discarded.

Procedure

1. Enter system view.
   system-view
2. Enter interface view.
   interface *interface-type interface-number*
3. Enable MAC address check.
   dhcp snooping check mac-address
   By default, MAC address check is disabled.

Enabling DHCP-REQUEST attack protection

About DHCP-REQUEST attack protection

DHCP-REQUEST messages include DHCP lease renewal packets, DHCP-DECLINE packets, and DHCP-RELEASE packets. This feature prevents the unauthorized clients that forge the DHCP-REQUEST messages from attacking the DHCP server.

Attackers can forge DHCP lease renewal packets to renew leases for legitimate DHCP clients that no longer need the IP addresses. These forged messages disable the victim DHCP server from releasing the IP addresses.

Attackers can also forge DHCP-DECLINE or DHCP-RELEASE packets to terminate leases for legitimate DHCP clients that still need the IP addresses.

To prevent such attacks, you can enable DHCP-REQUEST check. This feature uses DHCP snooping entries to check incoming DHCP-REQUEST messages.

- If a matching entry is found for a message, this feature compares the entry with the message information.
  - If they are consistent, the message is considered as valid and forwarded to the DHCP server.
  - If they are different, the message is considered as a forged message and is discarded.
- If no matching entry is found, the message is considered valid and forwarded to the DHCP server.

Procedure

1. Enter system view.

   `system-view`
2. Enter interface view.

   `interface` *`interface-type interface-number`*
3. Enable DHCP-REQUEST check.

   `dhcp snooping check request-message`

   By default, DHCP-REQUEST check is disabled.

Configuring a DHCP packet blocking port

About DHCP packet blocking port

Perform this task to configure a port as a DHCP packet blocking port. This blocking port drops all incoming DHCP requests.

Procedure

1. Enter system view.

   `system-view`
2. Enter interface view.

   `interface` *`interface-type interface-number`*
3. Configure the port to block DHCP requests.

   `dhcp snooping deny`

   By default, the port does not block DHCP requests.

CAUTION:

To avoid IP address acquisition failure, configure a port to block DHCP packets only if no DHCP clients are attached to it.

Enabling DHCP snooping logging

About DHCP snooping logging

The DHCP snooping logging feature enables the DHCP snooping device to generate DHCP snooping logs and send them to the information center. The information helps administrators locate and solve problems. For information about the log destination and output rule configuration in the information center, see *Network Management and Monitoring Configuration Guide*.

Restrictions and guidelines

As a best practice, disable this feature if the log generation affects the device performance.

Procedure

1. Enter system view.
   `system-view`
2. Enable DHCP snooping logging.
   `dhcp snooping log enable`
   By default, DHCP snooping logging is disabled.

Disabling DHCP snooping on an interface

About disabling DHCP snooping on an interface

This feature allows you to narrow down the interface range where DHCP snooping takes effect. For example, to enable DHCP snooping globally except for a specific interface, you can enable DHCP snooping globally and disable DHCP snooping on the target interface.

Procedure

1. Enter system view.
   `system-view`
2. Enter interface view.
   `interface` *`interface-type interface-number`*
3. Disable DHCP snooping on the interface.
   `dhcp snooping disable`
   By default:
   - If you enable DHCP snooping globally or for a VLAN, DHCP snooping is enabled on all interfaces on the device or on all interfaces in the VLAN.
   - If you do not enable DHCP snooping globally or for a VLAN, DHCP snooping is disabled on all interfaces on the device or on all interfaces in the VLAN.

Display and maintenance commands for DHCP snooping

Execute **`display`** commands in any view, and **`reset`** commands in user view.

Task	Command
Display DHCP snooping entries.	**`display dhcp snooping binding`** [**`ip`** *`ip-address`* [**`vlan`** *`vlan-id`*]] [**`verbose`**]

Task	Command
Display information about the file that stores DHCP snooping entries.	**display dhcp snooping binding database**
Display Option 82 configuration information on the DHCP snooping device.	**display dhcp snooping information** { **all** | **interface** *interface-type interface-number* }
Display DHCP packet statistics on the DHCP snooping device.	**display dhcp snooping packet statistics** [**slot** *slot-number*]
Display information about trusted ports.	**display dhcp snooping trust**
Clear DHCP snooping entries.	**reset dhcp snooping binding** { **all** | **ip** *ip-address* [**vlan** *vlan-id*] }
Clear DHCP packet statistics on the DHCP snooping device.	**reset dhcp snooping packet statistics** [**slot** *slot-number*]

DHCP snooping configuration examples

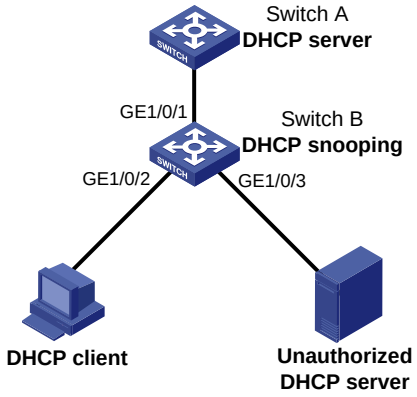
Example: Configuring basic DHCP snooping features globally

Network configuration

As shown in Figure 22, Switch B is connected to the authorized DHCP server through GigabitEthernet 1/0/1, to the unauthorized DHCP server through GigabitEthernet 1/0/3, and to the DHCP client through GigabitEthernet 1/0/2.

Configure only the port connected to the authorized DHCP server to forward the responses from the DHCP server. Enable the DHCP snooping device to record clients' IP-to-MAC bindings by reading DHCP-ACK messages received from the trusted port and the DHCP-REQUEST messages.

Figure 22 Network diagram



Procedure

Enable DHCP snooping globally.

```
<SwitchB> system-view
[SwitchB] dhcp snooping enable
```

Configure GigabitEthernet 1/0/1 as a trusted port.

```
[SwitchB] interface gigabitethernet 1/0/1
[SwitchB-GigabitEthernet1/0/1] dhcp snooping trust
[SwitchB-GigabitEthernet1/0/1] quit
```

Enable recording clients' IP-to-MAC bindings on GigabitEthernet 1/0/2.

```
[SwitchB] interface gigabitethernet 1/0/2
[SwitchB-GigabitEthernet1/0/2] dhcp snooping binding record
[SwitchB-GigabitEthernet1/0/2] quit
```

Verifying the configuration

Verify that the DHCP client can obtain an IP address and other configuration parameters only from the authorized DHCP server. (Details not shown.)

Display the DHCP snooping entry recorded for the client.

```
[SwitchB] display dhcp snooping binding
```

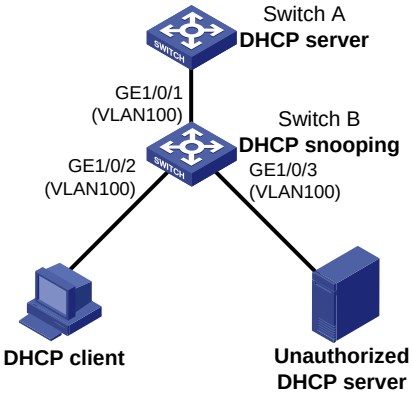
Example: Configuring basic DHCP snooping features for a VLAN

Network configuration

As shown in Figure 23, Switch B is connected to the authorized DHCP server through GigabitEthernet 1/0/1, to the unauthorized DHCP server through GigabitEthernet 1/0/3, and to the DHCP client through GigabitEthernet 1/0/2.

Configure only the port in VLAN 100 connected to the authorized DHCP server to forward the responses from the DHCP server. Enable the port in VLAN 100 to record clients' IP-to-MAC bindings by reading DHCP-ACK messages received from the trusted port and the DHCP-REQUEST messages.

Figure 23 Network diagram



Procedure

Assign GigabitEthernet 1/0/1, GigabitEthernet 1/0/2, and GigabitEthernet 1/0/3 to VLAN 100.

```
<SwitchB> system-view
[SwitchB] vlan 100
[SwitchB-vlan100] port gigabitethernet 1/0/1 to gigabitethernet 1/0/3
[SwitchB-vlan100] quit
```

Enable DHCP snooping for VLAN 100.

```
[SwitchB] dhcp snooping enable vlan 100
```

Configure GigabitEthernet 1/0/1 as DHCP snooping trusted port.

```
[SwitchB] vlan 100
[SwitchB-vlan100] dhcp snooping trust interface gigabitethernet 1/0/1
```

Enable recording clients' IP-to-MAC bindings in VLAN 100.

```
[SwitchB-vlan100] dhcp snooping binding record
[SwitchB-vlan100] quit
```

Verifying the configuration

Verify that the DHCP client can obtain an IP address and other configuration parameters only from the authorized DHCP server. (Details not shown.)

Display the DHCP snooping entry recorded for the client.

```
[SwitchB] display dhcp snooping binding
```

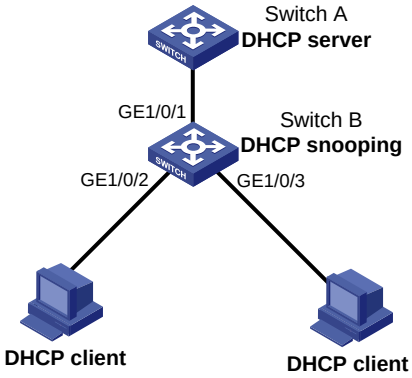
Example: Configuring DHCP snooping support for Option 82

Network configuration

As shown in Figure 24, enable DHCP snooping and configure Option 82 on Switch B as follows:

- Configure the handling strategy for DHCP requests that contain Option 82 as **`replace`**.
- On GigabitEthernet 1/0/2, configure the padding content for the Circuit ID sub-option as **`company001`** and for the Remote ID sub-option as **`device001`**.
- On GigabitEthernet 1/0/3, configure the padding mode for the Circuit ID sub-option as **`verbose`**, access node identifier as **`sysname`**, and padding format as **`ascii`**. Configure the padding content for the Remote ID sub-option as **`device001`**.

Figure 24 Network diagram



Procedure

Enable DHCP snooping.

```
<SwitchB> system-view
[SwitchB] dhcp snooping enable
```

Configure GigabitEthernet 1/0/1 as a trusted port.

```
[SwitchB] interface gigabitethernet 1/0/1
[SwitchB-GigabitEthernet1/0/1] dhcp snooping trust
[SwitchB-GigabitEthernet1/0/1] quit
```

Configure Option 82 on GigabitEthernet 1/0/2.

```
[SwitchB] interface gigabitethernet 1/0/2
[SwitchB-GigabitEthernet1/0/2] dhcp snooping information enable
[SwitchB-GigabitEthernet1/0/2] dhcp snooping information strategy replace
[SwitchB-GigabitEthernet1/0/2] dhcp snooping information circuit-id string company001
[SwitchB-GigabitEthernet1/0/2] dhcp snooping information remote-id string device001
[SwitchB-GigabitEthernet1/0/2] quit
```

Configure Option 82 on GigabitEthernet 1/0/3.

```
[SwitchB] interface gigabitethernet 1/0/3
[SwitchB-GigabitEthernet1/0/3] dhcp snooping information enable
[SwitchB-GigabitEthernet1/0/3] dhcp snooping information strategy replace
[SwitchB-GigabitEthernet1/0/3] dhcp snooping information circuit-id verbose
node-identifier sysname format ascii
[SwitchB-GigabitEthernet1/0/3] dhcp snooping information remote-id string device001
```

Verifying the configuration

Display Option 82 configuration information on GigabitEthernet 1/0/2 and GigabitEthernet 1/0/3 on the DHCP snooping device.

```
[SwitchB] display dhcp snooping information
```

Configuring the BOOTP client

About BOOTP client

BOOTP client application

An interface that acts as a BOOTP client can use BOOTP to obtain information (such as IP address) from the BOOTP server.

To use BOOTP, an administrator must configure a BOOTP parameter file for each BOOTP client on the BOOTP server. The parameter file contains information such as MAC address and IP address of a BOOTP client. When a BOOTP client sends a request to the BOOTP server, the BOOTP server searches for the BOOTP parameter file and returns the corresponding configuration information.

BOOTP is usually used in relatively stable environments. In network environments that change frequently, DHCP is more suitable.

Because a DHCP server can interact with a BOOTP client, you can use the DHCP server to assign an IP address to the BOOTP client. You do not need to configure a BOOTP server. The DHCP server will assign an IP address to the BOOTP client based on the IP address allocation sequence.

Obtaining an IP address dynamically

A BOOTP client dynamically obtains an IP address from a BOOTP server as follows:

1. The BOOTP client broadcasts a BOOTP request, which contains its own MAC address.
2. Upon receiving the request, the BOOTP server searches the configuration file for the IP address and other information according to the BOOTP client's MAC address.
3. The BOOTP server returns a BOOTP response to the BOOTP client.
4. The BOOTP client obtains the IP address from the received response.

A DHCP server can take the place of the BOOTP server in the following dynamic IP address acquisition.

Protocols and standards

- RFC 951, *Bootstrap Protocol (BOOTP)*
- RFC 2132, *DHCP Options and BOOTP Vendor Extensions*
- RFC 1542, *Clarifications and Extensions for the Bootstrap Protocol*

Configuring an interface to use BOOTP for IP address acquisition

1. Enter system view.
   system-view
2. Enter interface view.
   interface *interface-type interface-number*
   BOOTP client configuration applies only to VLAN interfaces.
3. Configure an interface to use BOOTP for IP address acquisition.

ip address bootp-alloc

By default, an interface does not use BOOTP for IP address acquisition.

Display and maintenance commands for BOOTP client

Execute **display** command in any view.

Task	Command
Display BOOTP client information.	**display bootp client** [**interface** *interface-type interface-number*]

BOOTP client configuration examples

Example: Configuring BOOTP client

Network configuration

As shown in Figure 9, Switch B's port belonging to VLAN 10 is connected to the LAN. VLAN-interface 10 obtains an IP address from the DHCP server by using BOOTP.

To make the BOOTP client obtain an IP address from the DHCP server, you must perform configuration on the DHCP server. For more information, see "DHCP server configuration examples."

Procedure

The following describes the configuration on Switch B, which acts as a client.

Configure VLAN-interface 10 to dynamically obtain an IP address from the DHCP server.

```
<SwitchB> system-view
[SwitchB] interface vlan-interface 10
[SwitchB-Vlan-interface10] ip address bootp-alloc
```

Verifying the configuration

Display the IP address assigned to the BOOTP client.

```
[SwitchB] display bootp client
```

Contents

Configuring DNS

About DNS

Domain Name System (DNS) is a distributed database used by TCP/IP applications to translate domain names into IP addresses. The domain name-to-IP address mapping is called a DNS entry.

Types of DNS services

DNS services can be static or dynamic. After a user specifies a name, the device checks the static name resolution table for an IP address. If no IP address is available, it contacts the DNS server for dynamic name resolution, which takes more time than static name resolution. To improve efficiency, you can put frequently queried name-to-IP address mappings in the local static name resolution table.

Static domain name resolution

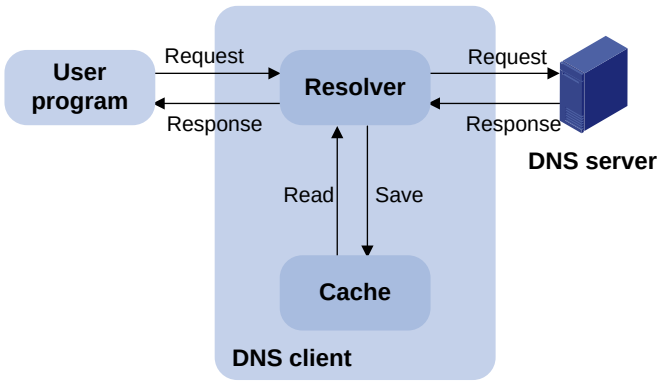
Static domain name resolution means manually creating mappings between domain names and IP addresses. For example, you can create a static DNS mapping for a device so that you can Telnet to the device by using the domain name.

Dynamic domain name resolution

Architecture

Figure 1 shows the relationship between the user program, DNS client, and DNS server. The DNS client includes the resolver and cache. The user program and DNS client can run on the same device or different devices. The DNS server and the DNS client usually run on different devices.

Figure 1 Dynamic domain name resolution



The device can function as a DNS client, but not a DNS server.

If an alias is configured for a domain name on the DNS server, the device can resolve the alias into the IP address of the host.

Resolution process

The dynamic domain name resolution process is as follows:

1. A user program sends a name query to the resolver of the DNS client.

2. The DNS resolver looks up the local domain name cache for a match. If the resolver finds a match, it sends the corresponding IP address back. If not, it sends a query to the DNS server.
3. The DNS server looks up the corresponding IP address of the domain name in its DNS database. If no match is found, the server sends a query to other DNS servers. This process continues until a result, whether successful or not, is returned.
4. After receiving a response from the DNS server, the DNS client returns the resolution result to the user program.

Caching

Dynamic domain name resolution allows the DNS client to store latest DNS entries in the DNS cache. The DNS client does not need to send a request to the DNS server for a repeated query within the aging time. To make sure the entries from the DNS server are up to date, a DNS entry is removed when its aging timer expires. The DNS server determines how long a mapping is valid, and the DNS client obtains the aging information from DNS responses.

DNS suffixes

You can configure a domain name suffix list so that the resolver can use the list to supply the missing part of an incomplete name.

For example, you can configure **com** as the suffix for aabbcc.com. The user only needs to enter **aabbcc** to obtain the IP address of aabbcc.com. The resolver adds the suffix and delimiter before passing the name to the DNS server.

The name resolver handles the queries based on the domain names that the user enters:

- If the user enters a domain name without a dot (.) (for example, aabbcc), the resolver considers the domain name to be a host name. It adds a DNS suffix to the host name before performing the query operation. If no match is found for any host name and suffix combination, the resolver uses the user-entered domain name (for example, aabbcc) for the IP address query.
- If the user enters a domain name with a dot (.) among the letters (for example, www.aabbcc), the resolver directly uses this domain name for the query operation. If the query fails, the resolver adds a DNS suffix for another query operation.
- If the user enters a domain name with a dot (.) at the end (for example, aabbcc.com.), the resolver considers the domain name an FQDN and returns the successful or failed query result. The dot at the end of the domain name is considered a terminating symbol.

DNS proxy

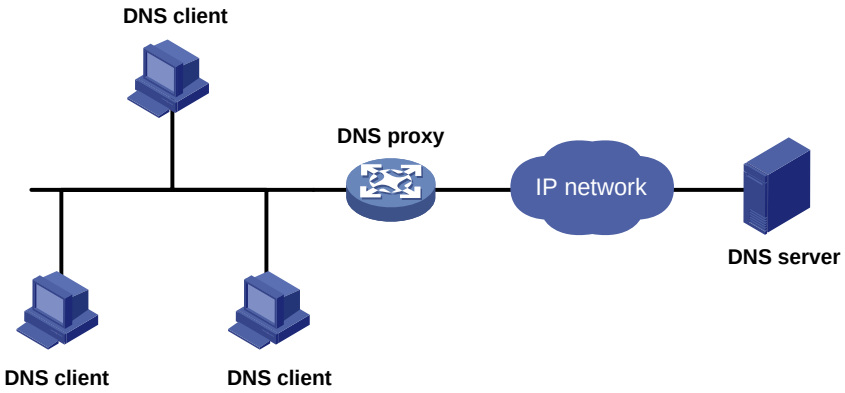
The DNS proxy performs the following functions:

- Forwards the request from the DNS client to the designated DNS server.
- Conveys the reply from the DNS server to the client.

The DNS proxy simplifies network management. When the DNS server address is changed, you can change the configuration only on the DNS proxy instead of on each DNS client.

Figure 2 shows the typical DNS proxy application.

Figure 2 DNS proxy application



A DNS proxy operates as follows:

1. A DNS client considers the DNS proxy as the DNS server, and sends a DNS request to the DNS proxy. The destination address of the request is the IP address of the DNS proxy.
2. The DNS proxy searches the local static domain name resolution table and dynamic domain name resolution cache after receiving the request. If the requested information is found, the DNS proxy returns a DNS reply to the client.
3. If the requested information is not found, the DNS proxy sends the request to the designated DNS server for domain name resolution.
4. After receiving a reply from the DNS server, the DNS proxy records the IP address-to-domain name mapping and forwards the reply to the DNS client.

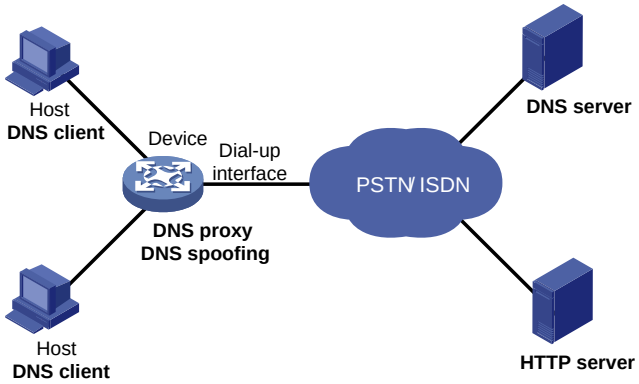
If no DNS server is designated or no route is available to the designated DNS server, the DNS proxy does not forward DNS requests.

DNS spoofing

As shown in Figure 3, DNS spoofing is applied to the dial-up network.

- The device connects to a PSTN/ISDN network through a dial-up interface. The device triggers the establishment of a dial-up connection only when packets are to be forwarded through the dial-up interface.
- The device acts as a DNS proxy and is specified as a DNS server on the hosts. After the dial-up connection is established, the device dynamically obtains the DNS server address through DHCP or another autoconfiguration mechanism.

Figure 3 DNS spoofing application



The DNS proxy does not have the DNS server address or cannot reach the DNS server after startup. A host accesses the HTTP server in the following steps:

1. The host sends a DNS request to the device to resolve the domain name of the HTTP server into an IP address.
2. Upon receiving the request, the device searches the local static and dynamic DNS entries for a match. Because no match is found, the device spoofs the host by replying a configured IP address. The device must have a route to the IP address with the dial-up interface as the output interface.

   The IP address configured for DNS spoofing is not the actual IP address of the requested domain name. Therefore, the TTL field is set to 0 in the DNS reply. When the DNS client receives the reply, it creates a DNS entry and ages it out immediately.
3. Upon receiving the reply, the host sends an HTTP request to the replied IP address.
4. When forwarding the HTTP request through the dial-up interface, the device performs the following operations:
   - Establishes a dial-up connection with the network.
   - Dynamically obtains the DNS server address through DHCP or another autoconfiguration mechanism.
5. Because the DNS entry ages out immediately upon creation, the host sends another DNS request to the device to resolve the HTTP server domain name.
6. The device operates the same as a DNS proxy. For more information, see "DNS proxy."
7. After obtaining the IP address of the HTTP server, the host can access the HTTP server.

Without DNS spoofing, the device forwards the DNS requests from the host to the DNS server if it cannot find a matching local DNS entry. However, the device cannot obtain the DNS server address, because no dial-up connection is established. Therefore, the device cannot forward or answer the requests from the client. DNS resolution fails, and the client cannot access the HTTP server.

DNS tasks at a glance

To configure DNS, perform the following tasks:

1. Configuring the DNS client

   Choose the following tasks as needed:
   - Configuring static domain name resolution
   - Configuring dynamic domain name resolution
2. (Optional.) Configuring the DNS proxy
3. (Optional.) Configuring DNS spoofing

   This feature is applied to the dial-up network.
4. (Optional.) Specifying the source interface for DNS packets
5. (Optional.) Configuring the DNS trusted interface
6. (Optional.) Setting the DSCP value for outgoing DNS packets

Configuring the DNS client

Configuring static domain name resolution

Restrictions and guidelines

Each host name maps to only one IPv4 address and one IPv6 address.

A maximum of 2048 DNS entries can be configured.

Procedure

1. Enter system view.

   system-view

2. Configure a host name-to-address mapping. Choose the options to configure as needed:

   IPv4:

   ip host *host-name ip-address*

   IPv6:

   ipv6 host *host-name ipv6-address*

Configuring dynamic domain name resolution

Restrictions and guidelines

- The limit on the number of DNS servers on the device is as follows:
  - In system view, you can specify a maximum of six DNS server IPv4 addresses.
  - In system view, you can specify a maximum of six DNS server IPv6 addresses.
  - In interface view, you can specify a maximum of six DNS server IPv4 addresses.
- A DNS server address is required so that DNS queries can be sent to a correct server for resolution. If you specify both an IPv4 address and an IPv6 address, the device performs the following operations:
  - Sends an IPv4 DNS query first to the DNS server IPv4 addresses. If the query fails, the device turns to the DNS server IPv6 addresses.
  - Sends an IPv6 DNS query first to the DNS server IPv6 addresses. If the query fails, the devices turns to the DNS server IPv4 addresses.
- A DNS server address specified in system view takes priority over a DNS server address specified in interface view. A DNS server address specified earlier has a higher priority. A DNS server address manually specified takes priority over a DNS server address dynamically obtained, for example, through DHCP. The device first sends a DNS query to the DNS server address of the highest priority. If the first query fails, it sends the DNS query to the DNS server address of the second highest priority, and so on.
- You can configure a DNS suffix that the system automatically adds to the incomplete domain name that a user enters.
  - You can configure a maximum of 16 DNS suffixes.
  - A DNS suffix manually configured takes priority over a DNS suffix dynamically obtained, for example, through DHCP. A DNS suffix configured earlier has a higher priority. The device first uses the suffix that has the highest priority. If the query fails, the device uses the suffix that has the second highest priority, and so on.

Procedure

1. Enter system view.

   system-view

2. (Optional.) Configure a DNS suffix.

   dns domain *domain-name*

   By default, no DNS suffix is configured and only the domain name that a user enters is resolved.

3. Specify a DNS server address.

   IPv4:

   dns server *ip-address*

   IPv6:

ipv6 dns server *ipv6-address* [*interface-type interface-number*]

In versions earlier than Release 6348P01, in the factory-default settings, no DNS server address is specified.

In Release 6348P01 and later:

- In the initial configuration, no DNS server address is specified.
- In the factory-default settings, a DNS server with IP address 114.114.114.114 is specified.

For more information about the initial configuration and factory-default settings, see configuration file management in *Fundamentals Configuration Guide*.

Configuring the DNS proxy

Restrictions and guidelines

You can specify multiple DNS servers. The DNS proxy forwards a request to the DNS server that has the highest priority. If having not received a reply, it forwards the request to a DNS server that has the second highest priority, and so on.

You can specify both an IPv4 address and an IPv6 address.

- A DNS proxy forwards an IPv4 name query first to IPv4 DNS servers. If no reply is received, it forwards the request to IPv6 DNS servers.
- A DNS proxy forwards an IPv6 name query first to IPv6 DNS servers. If no reply is received, it forwards the request to IPv4 DNS servers.

Procedure

1. Enter system view.

   system-view
2. Enable DNS proxy.

   dns proxy enable

   By default, DNS proxy is disabled.
3. Specify a DNS server address.

   IPv4:

   dns server *ip-address*

   IPv6:

   ipv6 dns server *ipv6-address* [*interface-type interface-number*]

   By default, no DNS server address is specified.

Configuring DNS spoofing

Restrictions and guidelines

- You can configure only one replied IPv4 address and one replied IPv6 address. If you execute the command multiple times, the most recent configuration takes effect.
- After DNS spoofing takes effect, the device spoofs a DNS request even though a matching static DNS entry exists.

Prerequisites

The DNS proxy is enabled on the device.

No DNS server or route to any DNS server is specified on the device.

Procedure

1. Enter system view.

   system-view

2. Enable DNS proxy.

   dns proxy enable

   By default, DNS proxy is disabled.

3. Enable DNS spoofing and specify the IP address used to spoof DNS requests. Choose one option as needed:

   IPv4:

   dns spoofing *ip-address*

   IPv6:

   ipv6 dns spoofing *ipv6-address*

   By default, DNS spoofing is disabled.

Specifying the source interface for DNS packets

About the source interface for DNS packets

This task enables the device to always use the primary IP address of the specified source interface as the source IP address of outgoing DNS packets. This feature applies to scenarios in which the DNS server responds only to DNS requests sourced from a specific IP address. If no IP address is configured on the source interface, no DNS packets can be sent out.

Restrictions and guidelines

When sending an IPv6 DNS request, the device follows the method defined in RFC 3484 to select an IPv6 address of the source interface.

You can configure only one source interface.

Procedure

1. Enter system view.

   system-view

2. Specify the source interface for DNS packets.

   dns source-interface *interface-type interface-number*

   By default, no source interface for DNS packets is specified.

Configuring the DNS trusted interface

About DNS trusted interface

This task enables the device to use only the DNS suffix and domain name server information obtained through the trusted interface. The device can then obtain the correct resolved IP address. This feature protects the device against attackers that act as the DHCP server to assign incorrect DNS suffix and domain name server address.

Restrictions and guidelines

You can configure a maximum of 128 DNS trusted interfaces.

Procedure

1. Enter system view.

   system-view

2. Specify the DNS trusted interface.

   dns trust-interface *interface-type interface-number*

   By default, no DNS trusted interface is specified.

Setting the DSCP value for outgoing DNS packets

About the DSCP value for outgoing DNS packets

The DSCP value of a packet specifies the priority level of the packet and affects the transmission priority of the packet. A bigger DSCP value represents a higher priority.

Procedure

1. Enter system view.

   system-view

2. Set the DSCP value for DNS packets sent by a DNS client or a DNS proxy.

   IPv4:

   dns dscp *dscp-value*

   By default, the DSCP value is 0 in IPv4 DNS packets sent by a DNS client or a DNS proxy.

   IPv6:

   ipv6 dns dscp *dscp-value*

   By default, the DSCP value is 0 in IPv6 DNS packets sent by a DNS client or a DNS proxy.

Display and maintenance commands for DNS

Execute **display** commands in any view and **reset** commands in user view.

Task	Command
Display DNS suffixes.	**display dns domain** [**dynamic**]
Display the domain name resolution table.	**display dns host** [**ip** | **ipv6**]
Display IPv4 DNS server information.	**display dns server** [**dynamic**]
Display IPv6 DNS server information.	**display ipv6 dns server** [**dynamic**]
Clear dynamic DNS entries.	**reset dns host** [**ip** | **ipv6**]

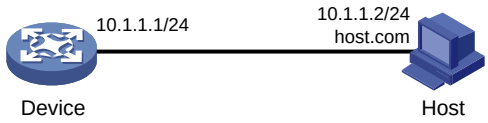
IPv4 DNS configuration examples

Example: Configuring static domain name resolution

Network configuration

As shown in Figure 4, the host at 10.1.1.2 is named **host.com**. Configure static IPv4 DNS on the device so that the device can use the easy-to-remember domain name rather than the IP address to access the host.

Figure 4 Network diagram



Procedure

Configure a mapping between host name **host.com** and IP address 10.1.1.2.

```
<Sysname> system-view
[Sysname] ip host host.com 10.1.1.2
```

Verify that the device can use static domain name resolution to resolve domain name **host.com** into IP address 10.1.1.2.

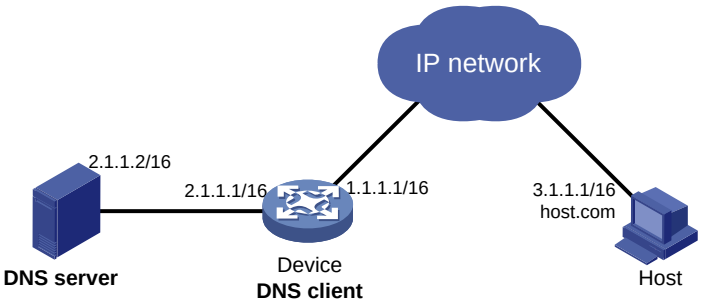
```
[Sysname] ping host.com
Ping host.com (10.1.1.2): 56 data bytes, press CTRL_C to break
56 bytes from 10.1.1.2: icmp_seq=0 ttl=255 time=1.000 ms
56 bytes from 10.1.1.2: icmp_seq=1 ttl=255 time=1.000 ms
56 bytes from 10.1.1.2: icmp_seq=2 ttl=255 time=1.000 ms
56 bytes from 10.1.1.2: icmp_seq=3 ttl=255 time=1.000 ms
56 bytes from 10.1.1.2: icmp_seq=4 ttl=255 time=2.000 ms

--- Ping statistics for host.com ---
5 packet(s) transmitted, 5 packet(s) received, 0.0% packet loss
round-trip min/avg/max/std-dev = 1.000/1.200/2.000/0.400 ms
```

Example: Configuring dynamic domain name resolution

Network configuration

As shown in Figure 5, configure the DNS server to store the mapping between the host's domain name **host** and IPv4 address 3.1.1.1/16 in the **com** domain. Configure dynamic IPv4 DNS and DNS suffix **com** on the device so that the device can use domain name **host** to access the host.

Figure 5 Network diagram



Procedure

Before performing the following configuration, make sure that:

- The device and the host can reach each other.
- The IP addresses of the interfaces are configured as shown in Figure 5.

1. Configure the DNS server:

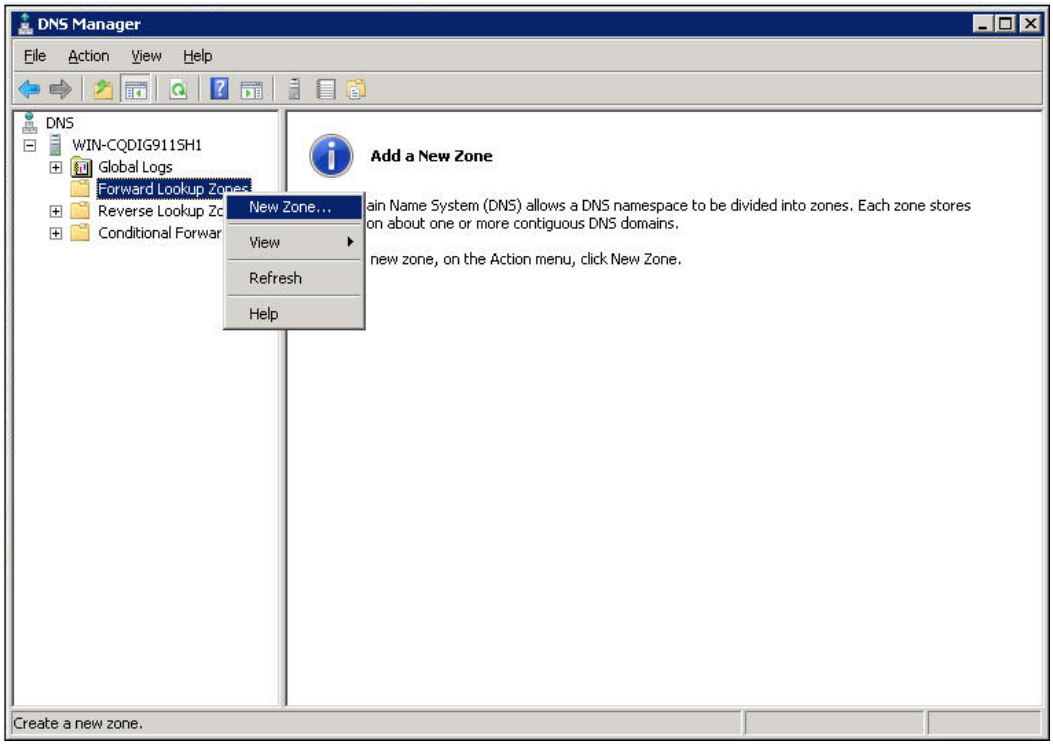
The configuration might vary by DNS server. The following configuration is performed on a PC running Windows Server 2008 R2.

a. Select **Start** > **Programs** > **Administrative Tools** > **DNS**.

The DNS server configuration page appears, as shown in Figure 6.

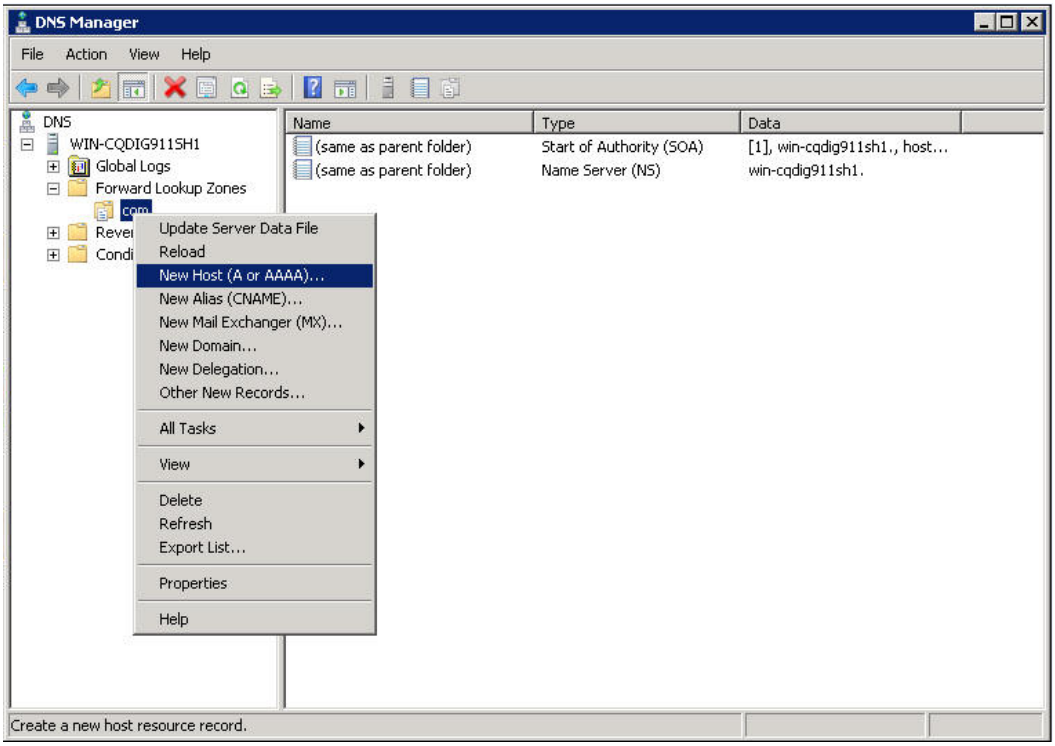
b. Right-click **Forward Lookup Zones**, select **New Zone**, and then follow the wizard to create a new zone named **com**.

Figure 6 Creating a zone



c. On the DNS server configuration page, right-click zone **com** and select **New Host**.

Figure 7 Adding a host

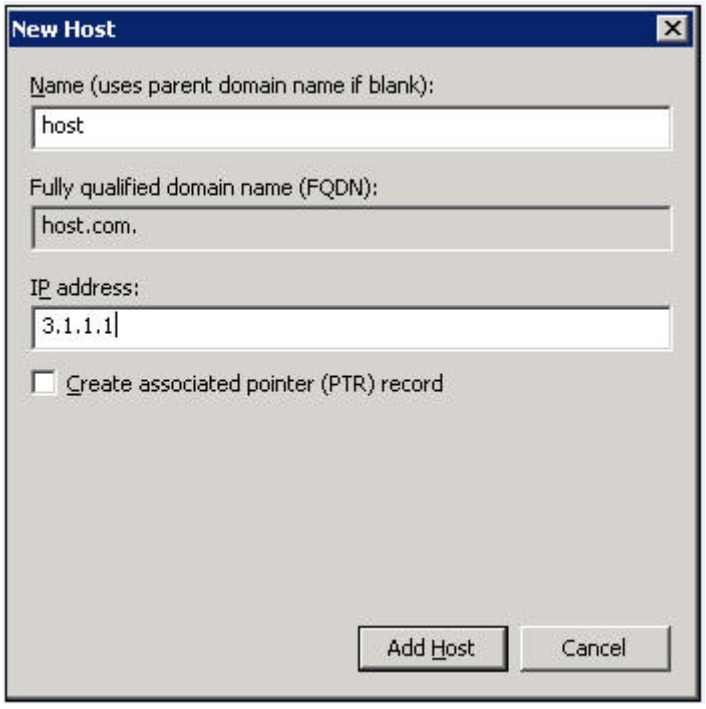


d. On the page that appears, enter host name **host** and IP address **3.1.1.1**.

e. Click **Add Host**.

The mapping between the IP address and host name is created.

Figure 8 Adding a mapping between domain name and IP address



2. Configure the DNS client:

Specify the DNS server 2.1.1.2.

```
<Sysname> system-view
[Sysname] dns server 2.1.1.2
```

Specify **com** as the name suffix.

```
[Sysname] dns domain com
```

Verifying the configuration

Verify that the device can use the dynamic domain name resolution to resolve domain name **host.com** into IP address 3.1.1.1.

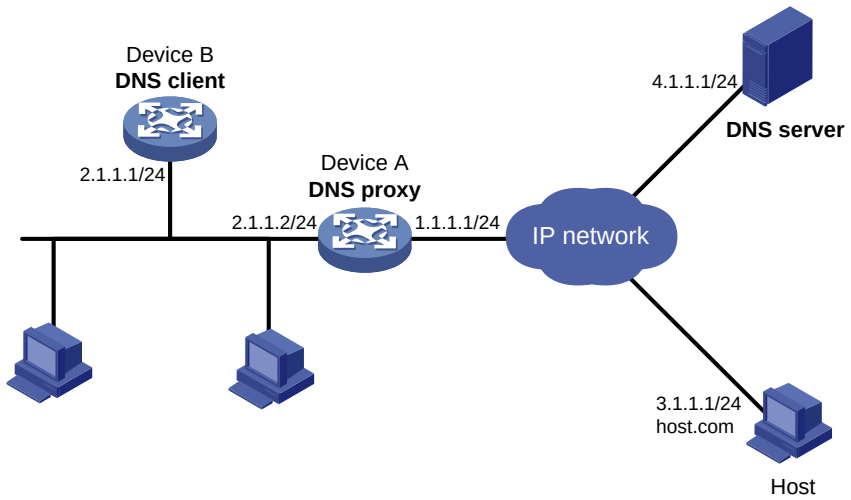
```
[Sysname] ping host
Ping host.com (3.1.1.1): 56 data bytes, press CTRL_C to break
56 bytes from 3.1.1.1: icmp_seq=0 ttl=255 time=1.000 ms
56 bytes from 3.1.1.1: icmp_seq=1 ttl=255 time=1.000 ms
56 bytes from 3.1.1.1: icmp_seq=2 ttl=255 time=1.000 ms
56 bytes from 3.1.1.1: icmp_seq=3 ttl=255 time=1.000 ms
56 bytes from 3.1.1.1: icmp_seq=4 ttl=255 time=2.000 ms

--- Ping statistics for host ---
5 packet(s) transmitted, 5 packet(s) received, 0.0% packet loss
round-trip min/avg/max/std-dev = 1.000/1.200/2.000/0.400 ms
```

Example: Configuring DNS proxy

Network configuration

As shown in Figure 9, configure Device A as the DNS proxy to forward DNS packets between the DNS client (Device B) and the DNS server at 4.1.1.1.

Figure 9 Network diagram



Procedure

Before performing the following configuration, make sure that:

- Device A, the DNS server, and the host can reach each other.
- The IP addresses of the interfaces are configured as shown in Figure 9.

1. Configure the DNS server:

The configuration might vary by DNS server. When a PC running Windows Server 2008 R2 acts as the DNS server, see "Example: Configuring dynamic domain name resolution" for configuration information.

2. Configure the DNS proxy:

   # Specify the DNS server 4.1.1.1.

   ```
   <DeviceA> system-view
   [DeviceA] dns server 4.1.1.1
   ```

   # Enable DNS proxy.

   ```
   [DeviceA] dns proxy enable
   ```

3. Configure the DNS client:

   ```
   <DeviceB> system-view
   ```

   # Specify the DNS server 2.1.1.2.

   ```
   [DeviceB] dns server 2.1.1.2
   ```

Verifying the configuration

Verify that DNS proxy on Device A functions.

```
[DeviceB] ping host.com
Ping host.com (3.1.1.1): 56 data bytes, press CTRL_C to break
56 bytes from 3.1.1.1: icmp_seq=0 ttl=255 time=1.000 ms
56 bytes from 3.1.1.1: icmp_seq=1 ttl=255 time=1.000 ms
56 bytes from 3.1.1.1: icmp_seq=2 ttl=255 time=1.000 ms
56 bytes from 3.1.1.1: icmp_seq=3 ttl=255 time=1.000 ms
56 bytes from 3.1.1.1: icmp_seq=4 ttl=255 time=2.000 ms

--- Ping statistics for host.com ---
5 packet(s) transmitted, 5 packet(s) received, 0.0% packet loss
round-trip min/avg/max/std-dev = 1.000/1.200/2.000/0.400 ms
```

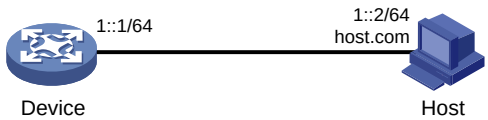
IPv6 DNS configuration examples

Example: Configuring static domain name resolution

Network configuration

As shown in Figure 10, the host at 1::2 is named **host.com**. Configure static IPv6 DNS on the device so that the device can use the easy-to-remember domain name rather than the IPv6 address to access the host.

Figure 10 Network diagram



Procedure

Configure a mapping between host name **host.com** and IPv6 address 1::2.

```
<Device> system-view
[Device] ipv6 host host.com 1::2
```

Verify that the device can use static domain name resolution to resolve domain name **host.com** into IPv6 address 1::2.

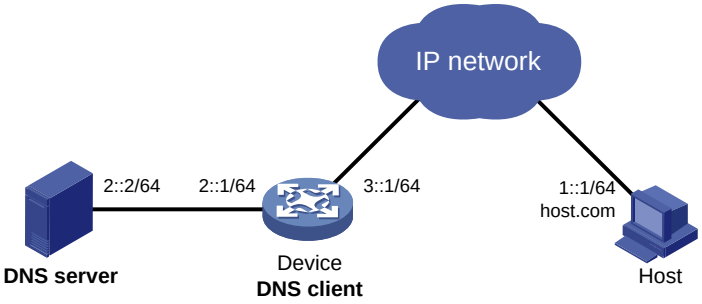
```
[Sysname] ping ipv6 host.com
Ping6(56 data bytes) 1::1 --> 1::2, press CTRL_C to break
56 bytes from 1::2, icmp_seq=0 hlim=128 time=1.000 ms
56 bytes from 1::2, icmp_seq=1 hlim=128 time=0.000 ms
56 bytes from 1::2, icmp_seq=2 hlim=128 time=1.000 ms
56 bytes from 1::2, icmp_seq=3 hlim=128 time=1.000 ms
56 bytes from 1::2, icmp_seq=4 hlim=128 time=0.000 ms

--- Ping6 statistics for host.com ---
5 packet(s) transmitted, 5 packet(s) received, 0.0% packet loss
round-trip min/avg/max/std-dev = 0.000/0.600/1.000/0.490 ms
```

Example: Configuring dynamic domain name resolution

Network configuration

As shown in Figure 11, configure the DNS server to store the mapping between the host's domain name **host** and IPv6 address 1::1/64 in the **com** domain. Configure dynamic IPv6 DNS and DNS suffix **com** on the device so that the device can use domain name **host** to access the host.

Figure 11 Network diagram



Procedure

Before performing the following configuration, make sure that:

- The device and the host can reach each other.
- The IPv6 addresses of the interfaces are configured as shown in Figure 11.

1. Configure the DNS server:

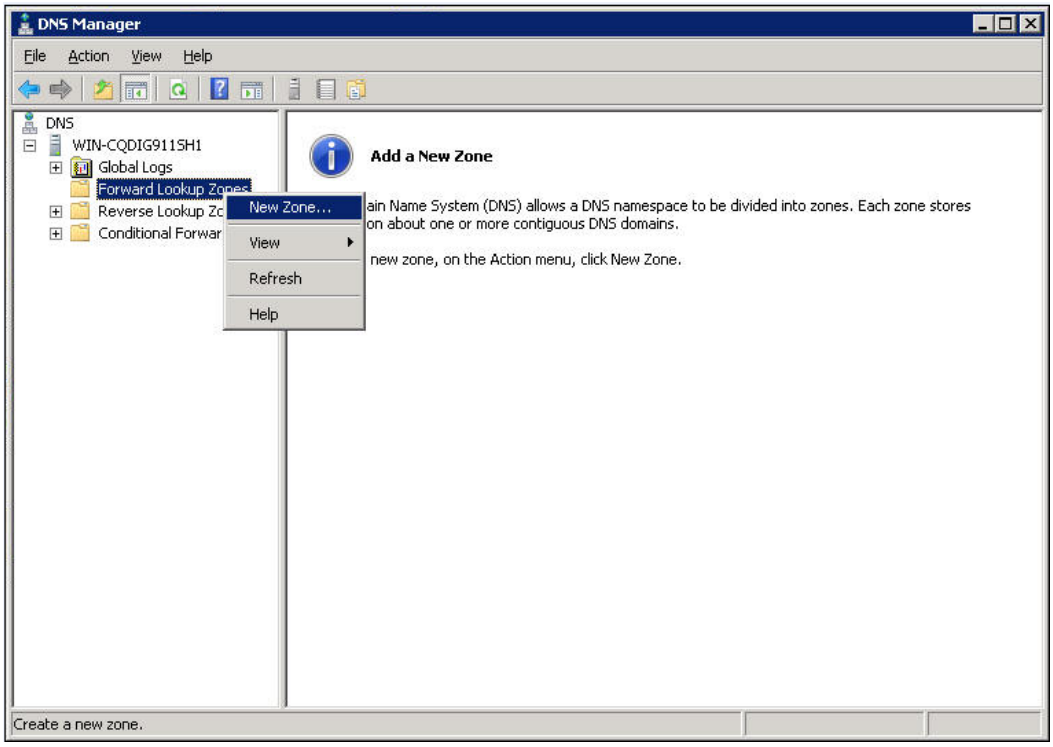
   The configuration might vary by DNS server. The following configuration is performed on a PC running Windows Server 2008 R2. Make sure that the DNS server supports IPv6 DNS so that the server can process IPv6 DNS packets and its interfaces can forward IPv6 packets.

   a. Select **Start** > **Programs** > **Administrative Tools** > **DNS**.

      The DNS server configuration page appears, as shown in Figure 12.

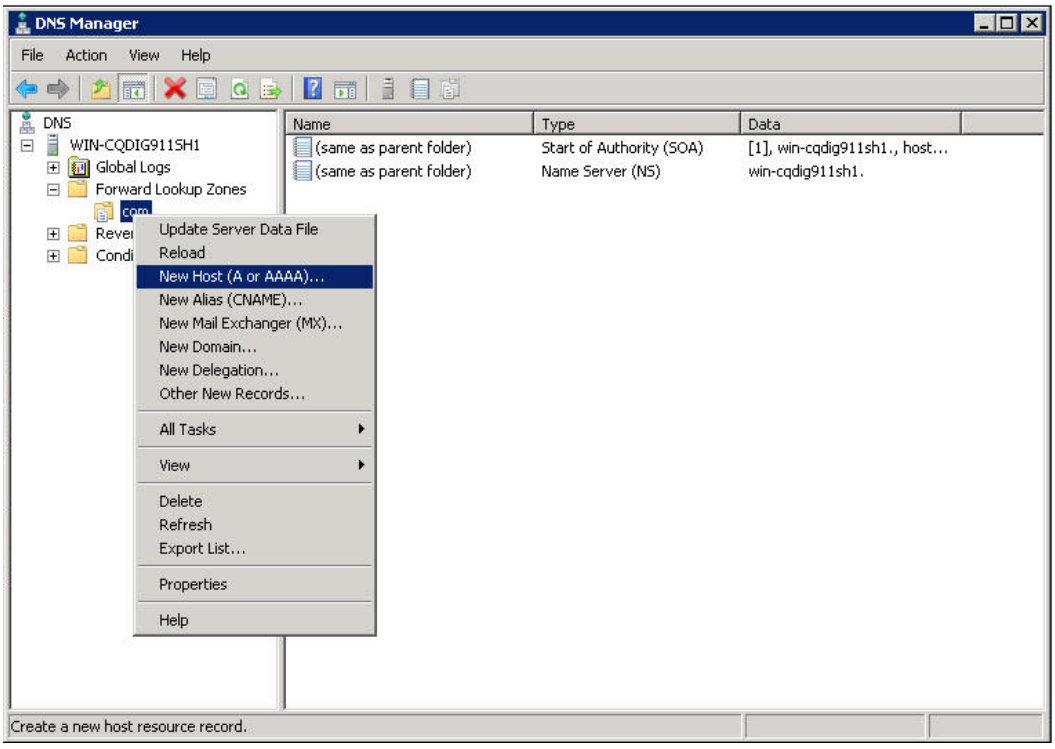
   b. Right-click **Forward Lookup Zones**, select **New Zone**, and then follow the wizard to create a new zone named **com**.

Figure 12 Creating a zone



c. On the DNS server configuration page, right-click zone **com** and select **New Host**.

Figure 13 Adding a host

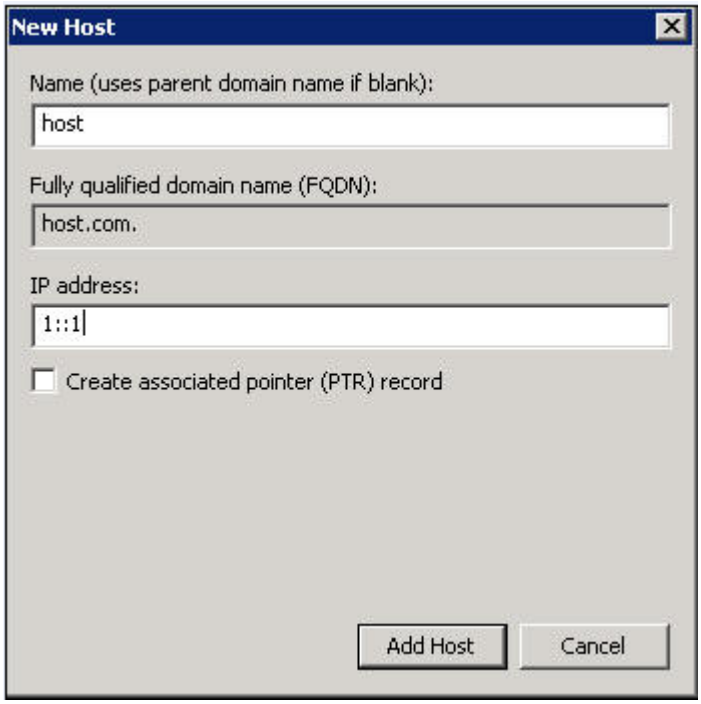


d. On the page that appears, enter host name **host** and IPv6 address **1::1**.

e. Click **Add Host**.

The mapping between the IPv6 address and host name is created.

Figure 14 Adding a mapping between domain name and IPv6 address



2. Configure the DNS client:

   # Specify the DNS server 2::2.

   ```
   <Device> system-view
   [Device] ipv6 dns server 2::2
   ```

   # Configure **com** as the DNS suffix.

   ```
   [Device] dns domain com
   ```

Verifying the configuration

Verify that the device can use the dynamic domain name resolution to resolve the domain name **host.com** into the IP address 1::1.

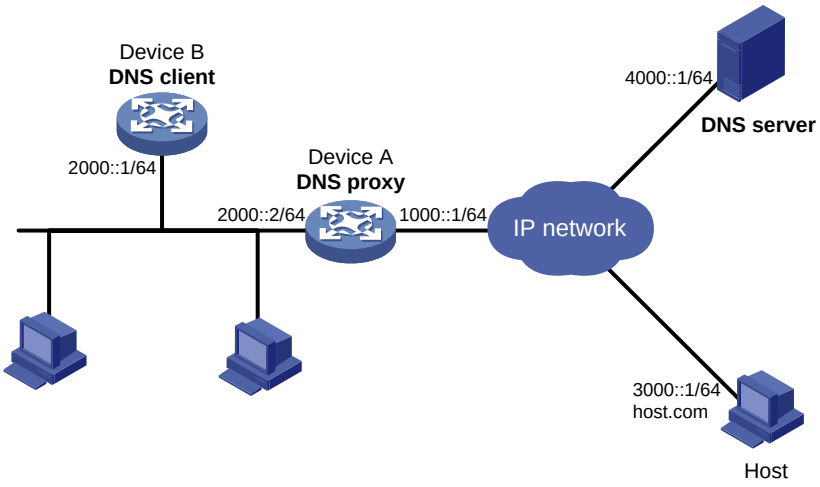
```
[Device] ping ipv6 host
Ping6(56 data bytes) 3::1 --> 1::1, press CTRL_C to break
56 bytes from 1::1, icmp_seq=0 hlim=128 time=1.000 ms
56 bytes from 1::1, icmp_seq=1 hlim=128 time=0.000 ms
56 bytes from 1::1, icmp_seq=2 hlim=128 time=1.000 ms
56 bytes from 1::1, icmp_seq=3 hlim=128 time=1.000 ms
56 bytes from 1::1, icmp_seq=4 hlim=128 time=0.000 ms

--- Ping6 statistics for host ---
5 packet(s) transmitted, 5 packet(s) received, 0.0% packet loss
round-trip min/avg/max/std-dev = 0.000/0.600/1.000/0.490 ms
```

Example: Configuring DNS proxy

Network configuration

As shown in Figure 15, configure Device A as the DNS proxy to forward DNS packets between the DNS client (Device B) and the DNS server at 4000::1.

Figure 15 Network diagram



Procedure

Before performing the following configuration, make sure that:

- Device A, the DNS server, and the host are reachable to each other.
- The IPv6 addresses of the interfaces are configured as shown in Figure 15.

1. Configure the DNS server:

   This configuration might vary by DNS server. When a PC running Windows Server 2008 R2 acts as the DNS server, see "Example: Configuring dynamic domain name resolution" for configuration information.

2. Configure the DNS proxy:

   # Specify the DNS server 4000::1.

   ```
   <DeviceA> system-view
   [DeviceA] ipv6 dns server 4000::1
   ```

   # Enable DNS proxy.

   ```
   [DeviceA] dns proxy enable
   ```

3. Configure the DNS client:

   # Specify the DNS server 2000::2.

   ```
   <DeviceB> system-view
   [DeviceB] ipv6 dns server 2000::2
   ```

Verifying the configuration

Verify that DNS proxy on Device A functions.

```
[DeviceB] ping host.com
Ping6(56 data bytes) 2000::1 --> 3000::1, press CTRL_C to break
56 bytes from 3000::1, icmp_seq=0 hlim=128 time=1.000 ms
56 bytes from 3000::1, icmp_seq=1 hlim=128 time=0.000 ms
56 bytes from 3000::1, icmp_seq=2 hlim=128 time=1.000 ms
56 bytes from 3000::1, icmp_seq=3 hlim=128 time=1.000 ms
56 bytes from 3000::1, icmp_seq=4 hlim=128 time=0.000 ms

--- Ping6 statistics for host.com ---
5 packet(s) transmitted, 5 packet(s) received, 0.0% packet loss
round-trip min/avg/max/std-dev = 0.000/0.600/1.000/0.490 ms
```

Troubleshooting DNS configuration

Failure to resolve IPv4 addresses

Symptom

After enabling dynamic domain name resolution, the user cannot get the correct IP address.

Solution

To resolve the problem:

1. Use the **`display dns host ip`** command to verify that the specified domain name is in the cache.
2. If the specified domain name does not exist, check that the DNS client can communicate with the DNS server.
3. If the specified domain name is in the cache, but the IP address is incorrect, check that the DNS client has the correct IP address of the DNS server.
4. Verify that the mapping between the domain name and IP address is correct on the DNS server.

Failure to resolve IPv6 addresses

Symptom

After enabling dynamic domain name resolution, the user cannot get the correct IPv6 address.

Solution

To resolve the problem:

1. Use the **`display dns host ipv6`** command to verify that the specified domain name is in the cache.
2. If the specified domain name does not exist, check that dynamic domain name resolution is enabled, and that the DNS client can communicate with the DNS server.
3. If the specified domain name is in the cache, but the IPv6 address is incorrect, check that the DNS client has the correct IPv6 address of the DNS server.
4. Verify that the mapping between the domain name and IPv6 address is correct on the DNS server.

Contents

Configuring IP forwarding basic settings

About FIB table

A device uses the FIB table to make packet forwarding decisions.

A device selects optimal routes from the routing table, and puts them into the FIB table. Each FIB entry specifies the next hop IP address and output interface for packets destined for a specific subnet or host.

For more information about the routing table, see *Layer 3—IP Routing Configuration Guide*.

Use the **display fib** command to display the FIB table. The following example displays the entire FIB table.

```
<Sysname> display fib

Destination count: 8 FIB entry count: 8

Flag:
  U:Usable   G:Gateway   H:Host   B:Blackhole   D:Dynamic   S:Static
  R:Relay     F:FRR

Destination/Mask   Nexthop         Flag     OutInterface/Token       Label
0.0.0.0/32         127.0.0.1       UH       InLoop0                  Null
127.0.0.0/8        127.0.0.1       U        InLoop0                  Null
127.0.0.0/32       127.0.0.1       UH       InLoop0                  Null
127.0.0.1/32       127.0.0.1       UH       InLoop0                  Null
127.255.255.255/32 127.0.0.1       UH       InLoop0                  Null
224.0.0.0/4        0.0.0.0         UB       NULL0                    Null
224.0.0.0/24       0.0.0.0         UB       NULL0                    Null
255.255.255.255/32 127.0.0.1       UH       InLoop0                  Null
```

A FIB entry includes the following items:

- **Destination**—Destination IP address.
- **Mask**—Network mask. The mask and the destination address identify the destination network. A logical AND operation between the destination address and the network mask yields the address of the destination network. For example, if the destination address is 192.168.1.40 and the mask 255.255.255.0, the address of the destination network is 192.168.1.0. A network mask includes a certain number of consecutive 1s. It can be expressed in dotted decimal format or by the number of the 1s.
- **Nexthop**—IP address of the next hop.
- **Flag**—Route flag.
- **OutInterface**—Output interface.
- **Token**—MPLS Label Switched Path index number.
- **Label**—Inner label.

Saving the IP forwarding entries to a file

Restrictions and guidelines

The feature automatically creates the file if you specify a nonexistent file. If the file already exists, this feature overwrites the file content.

This feature triggers one-time saving of the IP forwarding entries.

To automatically save the IP forwarding entries periodically, configure a schedule for the device to automatically run the **ip forwarding-table save** command. For information about scheduling a task, see *Fundamentals Configuration Guide*.

Procedure

To save the IP forwarding entries to a file, execute the following command in any view:

ip forwarding-table save filename *filename*

Display and maintenance commands for FIB table

Execute **display** commands in any view.

Task	Command
Display FIB entries.	**display fib** [*ip-address* [*mask* | *mask-length*]]

Contents

Configuring fast forwarding

About fast forwarding

Fast forwarding reduces route lookup time and improves packet forwarding efficiency by using a high-speed cache and data-flow-based technology. It identifies a data flow by using the following fields: source IP address, source port number, destination IP address, destination port number, and protocol number. After a flow's first packet is forwarded through the routing table, fast forwarding creates an entry and uses the entry to forward subsequent packets of the flow.

Restrictions and guidelines: Fast forwarding configuration

Fast forwarding can process fragmented IP packets, but it does not fragment IP packets.

Configuring the aging time for fast forwarding entries

About aging time for fast forwarding entries

The fast forwarding table uses an aging timer for each forwarding entry. If an entry is not updated before the timer expires, the device deletes the entry. If an entry has a hit within the aging time, the aging timer restarts.

Procedure

1. Enter system view.
   `system-view`
2. Configure the aging time for fast forwarding entries.
   `ip fast-forwarding aging-time` *`aging-time`*
   By default, the aging time is 30 seconds.

Configuring fast forwarding load sharing

About fast forwarding load sharing

Fast forwarding load sharing enables the device to identify a data flow by using the packet information.

If fast forwarding load sharing is disabled, the device identifies a data flow by the packet information and the input interface.

Procedure

1. Enter system view.
   `system-view`
2. Configure fast forwarding load sharing. Choose one option as needed:
   - Enable fast forwarding load sharing.
     `ip fast-forwarding load-sharing`

- Disable fast forwarding load sharing.
  undo ip fast-forwarding load-sharing

By default, fast forwarding load sharing is enabled.

Display and maintenance commands for fast forwarding

Execute **display** commands in any view and **reset** commands in user view.

Task	Command
Display the aging time of fast forwarding entries.	**display ip fast-forwarding aging-time**
Display fast forwarding entries.	**display ip fast-forwarding cache** [*ip-address*] [**slot** *slot-number*]
Display fast forwarding entries about fragmented packets.	**display ip fast-forwarding fragcache** [*ip-address*] [**slot** *slot-number*]
Clear the fast forwarding table.	**reset ip fast-forwarding cache** [**slot** *slot-number*]

Contents

Optimizing IP performance

IP performance optimization tasks at a glance

All IP performance optimization tasks are optional.

1. Configuring features for IP packets
   - Enabling an interface to forward directed broadcasts destined for the directly connected network
   - Setting the interface MTU for IPv4 packets
   - Enabling IPv4 local fragment reassembly

     This feature is applicable in IRF networks.
2. Configuring features for ICMP messages
   - Enabling sending ICMP error messages
   - Configuring rate limit for ICMP error messages
   - Disabling forwarding ICMP fragments
   - Specifying the source address for ICMP packets
   - Disabling sending a specific type of ICMP messages
   - Disabling receiving a specific type of ICMP messages
3. Configuring features for TCP packets
   - Setting TCP MSS for an interface
   - Configuring TCP path MTU discovery
   - Enabling SYN Cookie
   - Setting the TCP buffer size
   - Setting TCP timers
   - Enabling the Timestamps option encapsulation in outgoing TCP packets

Enabling an interface to forward directed broadcasts destined for the directly connected network

About forwarding broadcasts destined for the directly connected network

A directed broadcast packet is destined for all hosts on a specific network. In the destination IP address of the directed broadcast, the network ID identifies the target network, and the host ID is made up of all ones.

If an interface is allowed to forward directed broadcasts destined for the directly connected network, hackers can exploit this vulnerability to attack the target network. In some scenarios, however, an interface must send such directed broadcast packets to support the following features:

- **UDP helper**—Converts the directed broadcasts to unicasts and forwards them to a specific server.
- **Wake on LAN**—Sends the directed broadcasts to wake up the hosts on the target network.

You can configure this function to enable the interface to forward directed broadcast packets that are destined for directly connected network.

Procedure

1. Enter system view.

   system-view

2. Enter interface view.

   interface *interface-type interface-number*

3. Enable the interface to forward directed broadcasts destined for the directly connected network.

   ip forward-broadcast [**acl** *acl-number*]

   By default, an interface cannot forward directed broadcasts destined for the directly connected network.

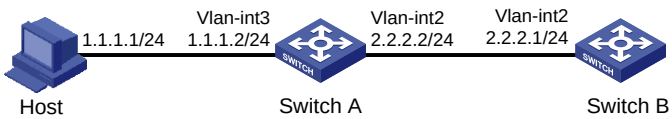
Example: Enabling an interface to forward directed broadcasts destined for the directly connected network

Network configuration

As shown in Figure 1, the default gateway of the host is the IP address 1.1.1.2/24 of VLAN-interface 3 of Switch A.

Switch B can receive directed broadcasts from the host to IP address 2.2.2.255.

Figure 1 Network diagram



Procedure

1. Configure Switch A:

   # Specify IP addresses for VLAN-interface 3 and VLAN-interface 2.

   ```
   <SwitchA> system-view
   [SwitchA] interface vlan-interface 3
   [SwitchA-Vlan-interface3] ip address 1.1.1.2 24
   [SwitchA-Vlan-interface3] quit
   [SwitchA] interface vlan-interface 2
   [SwitchA-Vlan-interface2] ip address 2.2.2.2 24
   ```

   # Enable VLAN-interface 2 to forward directed broadcasts directed for the directly connected network.

   ```
   [SwitchA-Vlan-interface2] ip forward-broadcast
   ```

2. Configure Switch B:

   # Configure a static route to the host.

   ```
   <SwitchB> system-view
   [SwitchB] ip route-static 1.1.1.1 24 2.2.2.2
   ```

   # Specify an IP address for VLAN-interface 2.

   ```
   [SwitchB] interface vlan-interface 2
   [SwitchB-Vlan-interface2] ip address 2.2.2.1 24
   ```

Verifying the configuration

After the configurations are completed, if you ping the subnet-directed broadcast address 2.2.2.255 on the host, VLAN-interface 2 of Switch B can receive the ping packets. If you delete the **ip forward-broadcast** configuration on any switch, the interface cannot receive the ping packets.

Setting the interface MTU for IPv4 packets

About setting the interface MTU for IPv4 packets

The interface MTU for IPv4 packets defines the largest size of an IPv4 packet that an interface can transmit without fragmentation. When a packet exceeds the MTU of the sending interface, the device processes the packet in one of the following ways:

- If the packet disallows fragmentation, the device discards it.
- If the packet allows fragmentation, the device fragments it and forwards the fragments.

Fragmentation and reassembling consume system resources, so set the MTU based on the network environment to avoid fragmentation.

Procedure

1. Enter system view.
   system-view
2. Enter interface view.
   interface *interface-type interface-number*
3. Set the interface MTU for IPv4 packets.
   ip mtu *mtu-size*
   By default, the interface MTU is not set.

Enabling IPv4 local fragment reassembly

About IPv4 local fragment reassembly

Use this feature on a multichassis IRF fabric to improve fragment reassembly efficiency. This feature enables a subordinate to reassemble the IPv4 fragments of a packet if all the fragments arrive at it. If this feature is disabled, all IPv4 fragments are delivered to the master device for reassembly. The feature applies only to fragments destined for the same subordinate.

Procedure

1. Enter system view.
   system-view
2. Enable IPv4 local fragment reassembly.
   ip reassemble local enable
   By default, IPv4 local fragment reassembly is disabled.

Enabling sending ICMP error messages

About sending ICMP error messages

ICMP messages are used by network layer and transport layer protocols to communicate updates and errors with other devices, facilitating network management.

Sending excessive ICMP messages increases network traffic. The device performance degrades if it receives a lot of malicious ICMP messages that cause it to respond with ICMP error messages. To prevent such problems, the sending of ICMP error messages is disabled by default. You can enable sending ICMP error messages of different types as needed.

ICMP error messages include redirect messages, time exceeded messages, and destination unreachable messages.

Enabling sending ICMP redirect messages

About ICMP redirect messages

A host that has only one default route sends all packets to the default gateway. The default gateway sends an ICMP redirect message to inform the host of a correct next hop by following these rules:

- The receiving and sending interfaces are the same.
- The packet source IP address and the IP address of the packet receiving interface are on the same segment.
- There is no source route option in the received packet.

ICMP redirect messages simplify host management and enable hosts to gradually optimize their routing table.

Procedure

1. Enter system view.

   ```
   system-view
   ```

2. Enable sending ICMP redirect messages.

   ```
   ip redirects enable
   ```

   By default, the sending of ICMP redirect messages is disabled.

Enabling sending ICMP time exceeded messages

About ICMP time exceeded messages

A device sends ICMP time exceeded messages by following these rules:

- The device sends the source an ICMP TTL exceeded in transit message when the following conditions are met:
  - The received packet is not destined for the device.
  - The TTL field of the packet is 1.
- When the device receives the first fragment of an IP datagram destined for it, it starts a timer. If the timer expires before all the fragments of the datagram are received, the device sends an ICMP fragment reassembly time exceeded message to the source.

Restrictions and guidelines

If the ICMP time exceeded message sending is disabled, the device does not send ICMP TTL exceeded in transit messages. However, it can still send ICMP fragment reassembly time exceeded messages.

Procedure

1. Enter system view.

   ```
   system-view
   ```

2. Enable sending ICMP time exceeded messages.

   ```
   ip ttl-expires enable
   ```

   By default, the sending of ICMP time exceeded messages is disabled.

Enable sending ICMP destination unreachable messages

About ICMP destination unreachable messages

A device sends ICMP destination unreachable messages by following these rules:

- The device sends the source an ICMP network unreachable message when the following conditions are met:
  - The packet does not match any route.
  - No default route exists in the routing table.
- The device sends the source an ICMP protocol unreachable message when the following conditions are met:
  - The packet is destined for the device.
  - The transport layer protocol of the packet is not supported by the device.
- The device sends the source an ICMP port unreachable message when the following conditions are met:
  - The UDP packet is destined for the device.
  - The packet's port number does not match the corresponding process.
- The device sends the source an ICMP source route failed message when the following conditions are met:
  - The source uses Strict Source Routing to send packets.
  - The intermediate device finds that the next hop specified by the source is not directly connected.
- The device sends the source an ICMP fragmentation needed and DF set message when the following conditions are met:
  - The MTU of the sending interface is smaller than the packet.
  - The packet has DF set.

Restrictions and guidelines

If a DHCP-enabled device receives an ICMP echo reply without sending any ICMP echo requests, the device does not send any ICMP protocol unreachable messages to the source. For more information about DHCP, see *Layer 3—IP Services Configuration Guide*.

Procedure

1. Enter system view.

   `system-view`
2. Enable sending ICMP destination unreachable messages.

   `ip unreachables enable`

   By default, the sending of ICMP destination unreachable messages is disabled.

Configuring rate limit for ICMP error messages

About the token bucket algorithm

To avoid sending excessive ICMP error messages within a short period that might cause network congestion, you can limit the rate at which ICMP error messages are sent. A token bucket algorithm is used with one token representing one ICMP error message.

A token is placed in the bucket at intervals until the maximum number of tokens that the bucket can hold is reached.

A token is removed from the bucket when an ICMP error message is sent. When the bucket is empty, ICMP error messages are not sent until a new token is placed in the bucket.

Procedure

1. Enter system view.

   system-view

2. Set the interval for tokens to arrive in the bucket and the bucket size for ICMP error messages.

   ip icmp error-interval *interval* [*bucketsize*]

   By default, a token is placed in the bucket at intervals of 100 milliseconds and the bucket allows a maximum of 10 tokens.

   To disable the ICMP rate limit, set the interval to 0 milliseconds.

Disabling forwarding ICMP fragments

Restrictions and guidelines

Disabling forwarding ICMP fragments can protect your device from ICMP fragment attacks.

Procedure

1. Enter system view.

   system-view

2. Disable forwarding ICMP fragments.

   ip icmp fragment discarding

   By default, forwarding ICMP fragments is enabled.

Specifying the source address for ICMP packets

About specifying source address for ICMP packets

Specifying the source IP address for outgoing ping echo requests and ICMP error messages helps users to locate the sending device easily. As a best practice, specify the IP address of the loopback interface as the source IP address.

Restrictions and guidelines

If you specify an IP address in the **ping** command, ping echo requests use the specified address as the source IP address rather than the IP address specified by the **ip icmp source** command.

Procedure

1. Enter system view.

   system-view

2. Specify the source address for outgoing ICMP packets.

   ip icmp source *ip-address*

   By default, no source address is specified for outgoing ICMP packets. No source address is specified for outgoing ICMP packets. The default source IP addresses for different types of ICMP packets vary as follows:

   - For an ICMP error message, the source IP address is the IP address of the receiving interface of the packet that triggers the ICMP error message. ICMP error messages include Time Exceeded, Port Unreachable, and Parameter Problem messages.
   - For an ICMP echo request, the source IP address is the IP address of the sending interface.
   - For an ICMP echo reply, the source IP address is the destination IP address of the ICMP echo request specific to this reply.

Disabling sending a specific type of ICMP messages

About this task

By default, the device sends all types of ICMP messages except Destination Unreachable, Time Exceeded, and Redirect messages. Attackers might obtain information from specific types of ICMP messages, causing security issues.

For security purposes, you can perform this task disable sending ICMP messages of specific types.

Software version and feature compatibility

This feature is supported only in R6348P01 and later.

Restrictions and guidelines

Disabling sending ICMP messages of a specific type might affect network operation. Please use this feature with caution.

To enable sending Destination Unreachable, Time Exceeded, or Redirect messages, you can perform one of the following tasks:

- Execute the **ip icmp send enable** command.
- Execute one of the following commands as needed:
  - **ip unreachables enable**
  - **ip ttl-expires enable**
  - **ip redirects enable**

Procedure

1. Enter system view.

   system-view

2. Disable the device from sending a specific type of ICMP messages.

   undo ip icmp { **name** *icmp-name* | **type** *icmp-type* **code** *icmp-code* } **send enable**

   By default, the device sends all types of ICMP messages except Destination Unreachable, Time Exceeded, and Redirect messages.

Disabling receiving a specific type of ICMP messages

About this task

By default, the device receives all types of ICMP messages. Such a setting might affect device performance if a large number of ICMP responses are received within a short time. To resolve this issue, you can perform this task to disable the device from receiving a specific type of ICMP messages.

Software version and feature compatibility

This feature is supported only in R6348P01 and later.

Restrictions and guidelines

Disabling receiving ICMP messages of a specific type might affect network operation. Please use this feature with caution.

Procedure

1. Enter system view.

   system-view

2. Disable the device from receiving a specific type of ICMP messages.

   undo ip icmp { **name** *icmp-name* | **type** *icmp-type* **code** *icmp-code* } **receive enable**

   By default, the device receives all types of ICMP messages.

Setting TCP MSS for an interface

About TCP MSS

The maximum segment size (MSS) option informs the receiver of the largest segment that the sender can accept. Each end announces its MSS during TCP connection establishment. If the size of a TCP segment is smaller than the MSS of the receiver, TCP sends the TCP segment without fragmentation. If not, it fragments the segment according to the receiver's MSS.

Restrictions and guidelines

- If you set the TCP MSS on an interface, the size of each TCP segment received or sent on the interface cannot exceed the MSS value.
- This configuration takes effect only for TCP connections established after the configuration rather than the TCP connections that already exist.
- This configuration is effective only for IP packets.

Procedure

1. Enter system view.

   system-view

2. Enter interface view.

   interface *interface-type interface-number*

3. Set the TCP MSS for the interface.

   tcp mss *value*

   By default, the TCP MSS is not set.

Configuring TCP path MTU discovery

About TCP path MTU discovery

TCP path MTU discovery (in RFC 1191) discovers the path MTU between the source and destination ends of a TCP connection. The device uses the path MTU to calculate the MSS to avoid IP fragmentation. The path MTU uses an aging mechanism to ensure that the source device can increase the path MTU when the minimum link MTU on the path increases.

TCP path MTU discovery works as follows:

1. A TCP source device sends a packet with the Don't Fragment (DF) bit set.
2. A router discards the packet that exceeds the MTU of the outgoing interface and returns an ICMP error message. The error message contains the MTU of the outgoing interface.
3. Upon receiving the ICMP message, the TCP source device calculates the current path MTU of the TCP connection.
4. The TCP source device sends subsequent TCP segments that each are smaller than the MSS (MSS = path MTU – IP header length – TCP header length).

If the TCP source device still receives ICMP error messages when the MSS is smaller than 32 bytes, the TCP source device will fragment packets.

An ICMP error message received from a router that does not support RFC 1191 has the MTU of the outgoing interface set to 0. Upon receiving the ICMP message, the TCP source device selects the path MTU smaller than the current path MTU from the MTU table as described in RFC 1191. Based on the selected path MTU, the TCP source device calculates the TCP MSS. The MTU table contains MTUs of 68, 296, 508, 1006, 1280, 1492, 2002, 4352, 8166, 17914, 32000, and 65535 bytes. Because the minimum TCP MSS specified by the system is 32 bytes, the actual minimum MTU is 72 bytes.

The aging mechanism of the path MTU is as follows:

- When the TCP source device receives an ICMP error message, it reduces the path MTU and starts an aging timer for the path MTU.
- After the aging timer expires, the source device uses a larger MSS in the MTU table, as described in RFC 1191.
- If no ICMP error message is received within two minutes, the source device increases the MSS again until the MSS negotiated during TCP three-way handshake is reached.

Prerequisites

Make sure all devices on a TCP connection are enabled to send ICMP error messages by using the **ip unreachables enable** command.

Procedure

1. Enter system view.

   system-view

2. Enable TCP path MTU discovery.

   tcp path-mtu-discovery [**aging** *age-time* | **no-aging**]

   By default, TCP path MTU discovery is disabled.

Enabling SYN Cookie

About SYN Cookie

A TCP connection is established through a three-way handshake. An attacker can exploit this mechanism to mount SYN Flood attacks. The attacker sends a large number of SYN packets, but does not respond to the SYN ACK packets from the server. As a result, the server establishes a large number of TCP semi-connections and can no longer handle normal services.

SYN Cookie can protect the server from SYN Flood attacks. When the server receives a SYN packet, it responds with a SYN ACK packet without establishing a TCP semi-connection. The server establishes a TCP connection and enters ESTABLISHED state only when it receives an ACK packet from the client.

Procedure

1. Enter system view.

   system-view

2. Enable SYN Cookie.

   tcp syn-cookie enable

   By default, SYN Cookie is disabled.

Setting the TCP buffer size

1. Enter system view.

   system-view
2. Set the size of TCP receive/send buffer.

   tcp window *window-size*

   The default buffer size is 63 KB.

Setting TCP timers

About TCP timers

You can set the following TCP timers:

- **SYN wait timer**—TCP starts the SYN wait timer after sending a SYN packet. Within the SYN wait timer if no response is received or the upper limit on TCP connection tries is reached, TCP fails to establish the connection.
- **FIN wait timer**—TCP starts the FIN wait timer when TCP changes the connection state to FIN_WAIT_2. If no FIN packet is received within the timer interval, TCP terminates the connection. If a FIN packet is received, TCP changes the connection state to TIME_WAIT. If a non-FIN packet is received, TCP restarts the timer, and tears down the connection when the timer expires.

Procedure

1. Enter system view.

   system-view
2. Set the TCP SYN wait timer.

   tcp timer syn-timeout *time-value*

   By default, the TCP SYN wait timer is 75 seconds.
3. Set the TCP FIN wait timer.

   tcp timer fin-timeout *time-value*

   By default, the TCP FIN wait timer is 675 seconds.

Enabling the Timestamps option encapsulation in outgoing TCP packets

About the Timestamps option encapsulation in outgoing TCP packets

Devices at each end of the TCP connection can calculate the RTT value by using the TCP Timestamps option carried in TCP packets. For security purpose in some networks, you can disable this feature at one end of the TCP connection to prevent intermediate devices from obtaining the Timestamps option information.

Procedure

1. Enter system view.

   system-view
2. Enable the device to encapsulate the TCP Timestamps option in outgoing TCP packets.

   tcp timestamps enable

   By default, the TCP timestamps option is encapsulated in outgoing TCP packets.

Display and maintenance commands for IP performance optimization

Execute **display** commands in any view and **reset** commands in user view.

Task	Command
Display ICMP statistics.	**display icmp statistics** [**slot** *slot-number*]
Display IP packet statistics.	**display ip statistics** [**slot** *slot-number*]
Display brief information about RawIP connections.	**display rawip** [**slot** *slot-number*]
Display detailed information about RawIP connections.	**display rawip verbose** [**slot** *slot-number* [**pcb** *pcb-index*]]
Display brief information about TCP connections.	**display tcp** [**slot** *slot-number*]
Display TCP traffic statistics.	**display tcp statistics** [**slot** *slot-number*]
Display detailed information about TCP connections.	**display tcp verbose** [**slot** *slot-number* [**pcb** *pcb-index*]]
Display brief information about UDP connections.	**display udp** [**slot** *slot-number*]
Display UDP traffic statistics.	**display udp statistics** [**slot** *slot-number*]
Display detailed information about UDP connections.	**display udp verbose** [**slot** *slot-number* [**pcb** *pcb-index*]]
Clear IP packet statistics.	**reset ip statistics** [**slot** *slot-number*]
Clear TCP traffic statistics.	**reset tcp statistics**
Clear UDP traffic statistics.	**reset udp statistics**

Contents

Configuring UDP helper

About UDP helper

UDP helper can provide the following packet conversion services for packets with specific UDP destination port numbers:

- Convert broadcast to unicast, and forward the unicast packets to specific destinations.
- Convert broadcast to multicast, and forward the multicast packets.

Restrictions: Hardware compatibility with UDP helper

The following switch series do not support UDP helper:

- S5110V2-SI.
- S5000V3-EI.
- S5000V5-EI.
- S5000E-X.
- S5000X-EI.
- WAS6000.

Configuring UDP helper to convert broadcast to unicast

About broadcast to unicast conversion

You can configure UDP helper to convert broadcast packets with specific UDP port numbers to unicast packets.

Upon receiving a UDP broadcast packet, UDP helper uses the configured UDP ports to match the UDP destination port number of the packet.

- If a match is found, UDP helper duplicates the packet and modifies the destination IP address of the copy to the configured unicast address. Then UDP helper forwards the unicast packet to the unicast address.
- If no match is found, UDP helper does not process the packet.

Procedure

1. Enter system view.

   `system-view`
2. Enable UDP helper.

   `udp-helper enable`

   By default, UDP helper is disabled.
3. Specify a UDP port number for UDP helper.

   `udp-helper port` { *`port-number`* | **`dns`** | **`netbios-ds`** | **`netbios-ns`** | **`tacacs`** | **`tftp`** | **`time`** }

By default, no UDP port numbers are specified for UDP helper.

Do not set UDP ports 67 and 68 for UDP helper, because UDP helper cannot forward DHCP broadcast packets.

You can specify a maximum of 256 UDP ports for UDP helper.

4. Enter interface view.

   interface *interface-type interface-number*

5. Specify a destination server for UDP helper to convert broadcast to unicast.

   udp-helper server *ip-address*

   By default, no destination servers are specified.

   Use this command on the interface that receives broadcast packets.

   You can specify a maximum of 20 unicast and multicast addresses for UDP helper to convert broadcast packets on an interface.

Configuring UDP helper to convert broadcast to multicast

About broadcast to multicast conversion

You can configure UDP helper to convert broadcast packets with specific UDP port numbers to multicast packets.

Upon receiving a UDP broadcast packet, UDP helper uses the configured UDP ports to match the UDP destination port number of the packet.

- If a match is found, UDP helper duplicates the packet and modifies the destination IP address of the copy to the configured multicast address. Then UDP helper forwards the packet to the multicast group.
- If no match is found, UDP helper does not process the packet.

Procedure

1. Enter system view.

   system-view

2. Enable UDP helper.

   udp-helper enable

   By default, UDP helper is disabled.

3. Specify a UDP port number for UDP helper.

   udp-helper port { *port-number* | **dns** | **netbios-ds** | **netbios-ns** | **tacacs** | **tftp** | **time** }

   By default, no UDP port numbers are specified for UDP helper.

   Do not set UDP ports 67 and 68 for UDP helper, because UDP helper cannot forward DHCP broadcast packets.

   You can specify a maximum of 256 UDP ports for UDP helper.

4. Enter interface view.

   interface *interface-type interface-number*

5. Specify a destination multicast address for UDP helper to convert broadcast to multicast.

   udp-helper broadcast-map *multicast-address* [**acl** *acl-number*]

   By default, no destination multicast addresses are specified for UDP helper.

   Use this command on the interface that receives broadcast packets.

You can specify a maximum of 20 unicast and multicast addresses for UDP helper to convert broadcast packets on an interface.

Display and maintenance commands for UDP helper

Execute **display** command in any view and **reset** commands in user view.

Task	Command
Display information about broadcast to unicast conversion by UDP helper on an interface.	**display udp-helper interface** *interface-type interface-number*
Clear packet statistics for UDP helper.	**reset udp-helper statistics**

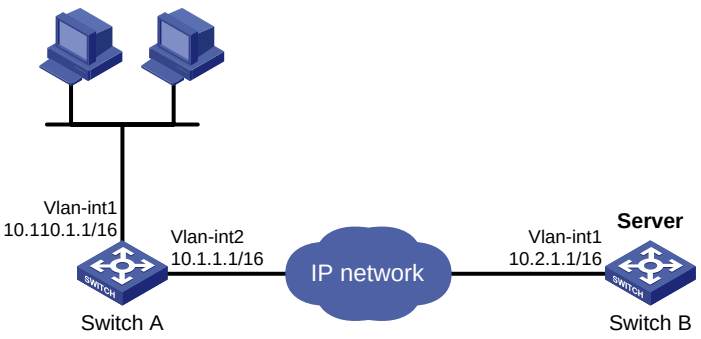
UDP helper configuration examples

Example: Configuring UDP helper to convert broadcast to unicast

Network configuration

As shown in Figure 1, configure UDP helper to convert broadcast to unicast on VLAN-interface 1 of Switch A. This feature enables Switch A to forward broadcast packets with UDP destination port number 55 to the destination server 10.2.1.1/16.

Figure 1 Network diagram



Procedure

Make sure Switch A can reach the subnet 10.2.0.0/16.

Enable UDP helper.

```
[SwitchA] System-view
[SwitchA] udp-helper enable
```

Enable the UDP port 55 for UDP helper.

```
[SwitchA] udp-helper port 55
```

Specify the destination server 10.2.1.1 for UDP helper to convert broadcast to unicast on VLAN-interface 1.

```
[SwitchA] interface vlan-interface 1
```

```
[SwitchA-Vlan-interface1] ip address 10.110.1.1 16
[SwitchA-Vlan-interface1] udp-helper server 10.2.1.1
```

Verifying the configuration

Display information about broadcast to unicast conversion by UDP helper on VLAN-interface 1.

```
[SwitchA-Vlan-interface1] display udp-helper interface vlan-interface 1
Interface               Server VPN instance          Server address Packets sent
Vlan-interface1         N/A                          10.2.1.1       5
```

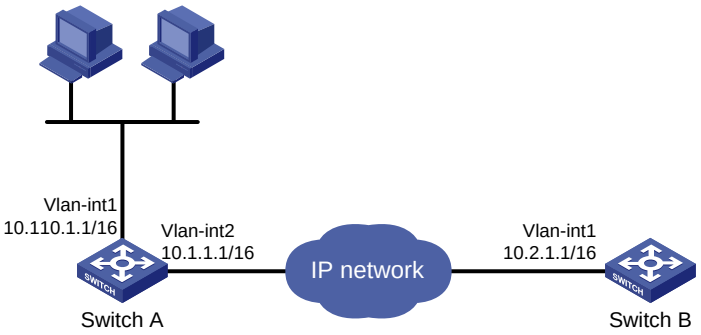
Example: Configuring UDP helper to convert broadcast to multicast

Network configuration

As shown in Figure 2, VLAN-interface 1 of Switch B can receive multicast packets destined to 225.1.1.1.

Configure UDP helper to convert broadcast to multicast on VLAN-interface 1 of Switch A. This feature enables Switch A to forward broadcast packets with UDP destination port number 55 to the multicast group 225.1.1.1.

Figure 2 Network diagram



Procedure

Make sure Switch A can reach the subnet 10.2.0.0/16.

1. Configure Switch A:

Enable UDP helper.

```
<SwitchA> system-view
[SwitchA] udp-helper enable
```

Enable the UDP port 55 for UDP helper.

```
[SwitchA] udp-helper port 55
```

Configure UDP helper to convert broadcast packets to multicast packets destined for 225.1.1.1.

```
[SwitchA] interface vlan-interface 1
[SwitchA-Vlan-interface1] ip address 10.110.1.1 16
[SwitchA-Vlan-interface1] udp-helper broadcast-map 225.1.1.1
[SwitchA-Vlan-interface1] quit
```

Enable IP multicast routing globally.

```
[SwitchA] multicast routing
[SwitchA-mrib] quit
```

Enable PIM-DM on VLAN-interface 1.

```
[SwitchA] interface vlan-interface 1
[SwitchA-Vlan-interface1] pim dm
[SwitchA-Vlan-interface1] quit
```

Enable PIM-DM and IGMP on VLAN-interface 2.

```
[SwitchA] interface vlan-interface 2
[SwitchA-Vlan-interface2] pim dm
[SwitchA-Vlan-interface2] igmp enable
```

Configure VLAN-interface 2 as a static member of multicast group 225.1.1.1.

```
[SwitchA-Vlan-interface2] igmp static-group 225.1.1.1
```

2. Configure Switch B:

Enable IP multicast routing globally.

```
<SwitchB> system-view
[SwitchB] multicast routing
[SwitchB-mrib] quit
```

Enable PIM-DM and IGMP on VLAN-interface 1.

```
[SwitchB] interface vlan-interface 1
[SwitchB-Vlan-interface1] pim dm
[SwitchB-Vlan-interface1] igmp enable
```

Configure VLAN-interface 1 as a static member of multicast group 225.1.1.1.

```
[SwitchB-Vlan-interface1] igmp static-group 225.1.1.1
```

Verifying the configuration

Verify that you can capture multicast packets from Switch A on Switch B.

Contents

Configuring basic IPv6 settings

About IPv6

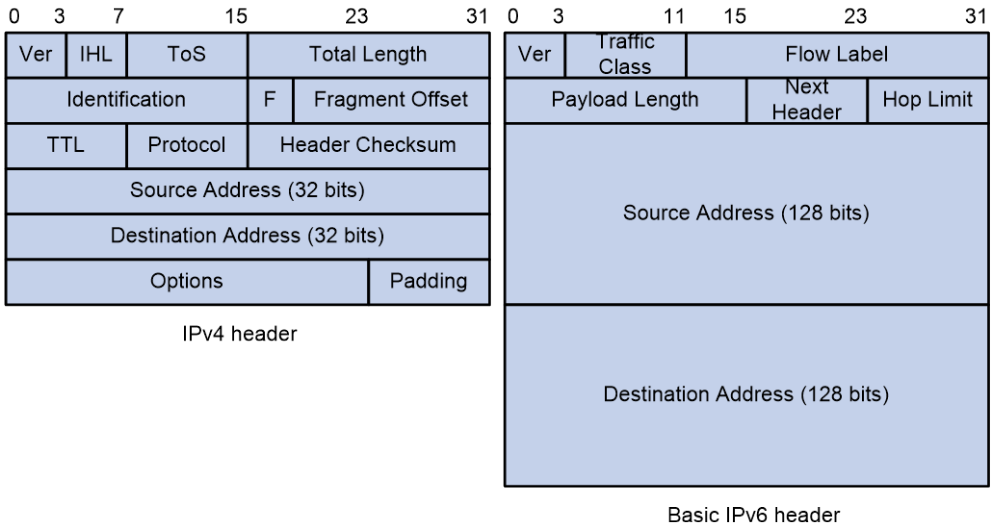
IPv6, also called IP next generation (IPng), was designed by the IETF as the successor to IPv4. One significant difference between IPv6 and IPv4 is that IPv6 increases the IP address size from 32 bits to 128 bits.

IPv6 features

Simplified header format

IPv6 removes several IPv4 header fields or moves them to the IPv6 extension headers to reduce the length of the basic IPv6 packet header. The basic IPv6 packet header has a fixed length of 40 bytes to simplify IPv6 packet handling and improve forwarding efficiency. Although the IPv6 address size is four times the IPv4 address size, the basic IPv6 packet header size is only twice the size of the option-less IPv4 packet header.

Figure 1 IPv4 packet header format and basic IPv6 packet header format



Larger address space

IPv6 can provide 3.4 x 10^{38} addresses to meet the requirements of hierarchical address assignment for both public and private networks.

Hierarchical address structure

IPv6 uses a hierarchical address structure to speed up route lookup and reduce the IPv6 routing table size through route aggregation.

Address autoconfiguration

To simplify host configuration, IPv6 supports stateful and stateless address autoconfiguration.

- Stateful address autoconfiguration enables a host to acquire an IPv6 address and other configuration information from a server (for example, a DHCPv6 server). For more information about DHCPv6 server, see "Configuring the DHCPv6 server."

- Stateless address autoconfiguration enables a host to automatically generate an IPv6 address and other configuration information by using its link-layer address and the prefix information advertised by a router.

To communicate with other hosts on the same link, a host automatically generates a link-local address based on its link-layer address and the link-local address prefix (FE80::/10).

Built-in security

IPv6 defines extension headers to support IPsec. IPsec provides end-to-end security and enhances interoperability among different IPv6 applications.

QoS support

The Flow Label field in the IPv6 header allows the device to label the packets of a specific flow for special handling.

Enhanced neighbor discovery mechanism

The IPv6 neighbor discovery protocol uses a group of ICMPv6 messages to manage information exchange among neighboring nodes on the same link. The group of ICMPv6 messages replaces ARP messages, ICMPv4 router discovery messages, and ICMPv4 redirect messages and provides a series of other functions.

Flexible extension headers

IPv6 eliminates the Options field in the header and introduces optional extension headers to provide scalability and improve efficiency. The Options field in the IPv4 packet header contains a maximum of 40 bytes, whereas the IPv6 extension headers are restricted to the maximum size of IPv6 packets.

IPv6 addresses

IPv6 address format

An IPv6 address is represented as a set of 16-bit hexadecimals separated by colons (:). An IPv6 address is divided into eight groups, and each 16-bit group is represented by four hexadecimal numbers, for example, 2001:0000:130F:0000:0000:09C0:876A:130B.

To simplify the representation of IPv6 addresses, you can handle zeros in IPv6 addresses by using the following methods:

- The leading zeros in each group can be removed. For example, the above address can be represented in a shorter format as 2001:0:130F:0:0:9C0:876A:130B.
- If an IPv6 address contains one or more consecutive groups of zeros, they can be replaced by a double colon (::). For example, the above address can be represented in the shortest format as 2001:0:130F::9C0:876A:130B.

IMPORTANT:

A double colon can appear once or not at all in an IPv6 address. This limit allows the device to determine how many zeros the double colon represents and correctly convert it to zeros to restore a 128-bit IPv6 address.

An IPv6 address consists of an address prefix and an interface ID, which are equivalent to the network ID and the host ID of an IPv4 address.

An IPv6 address prefix is written in IPv6-address/prefix-length notation. The prefix-length is a decimal number indicating how many leftmost bits of the IPv6 address are in the address prefix.

IPv6 address types

IPv6 addresses include the following types:

- **Unicast address**—An identifier for a single interface, similar to an IPv4 unicast address. A packet sent to a unicast address is delivered to the interface identified by that address.

- **Multicast address**—An identifier for a set of interfaces (typically belonging to different nodes), similar to an IPv4 multicast address. A packet sent to a multicast address is delivered to all interfaces identified by that address.

  Broadcast addresses are replaced by multicast addresses in IPv6.
- **Anycast address**—An identifier for a set of interfaces (typically belonging to different nodes). A packet sent to an anycast address is delivered to the nearest interface among the interfaces identified by that address. The nearest interface is chosen according to the routing protocol's measure of distance.

The type of an IPv6 address is designated by the first several bits, called the format prefix.

Table 1 Mappings between address types and format prefixes

Type		Format prefix (binary)	IPv6 prefix ID
Unicast address	Unspecified address	00...0 (128 bits)	::/128
	Loopback address	00...1 (128 bits)	::1/128
	Link-local address	1111111010	FE80::/10
	Global unicast address	Other forms	N/A
Multicast address		11111111	FF00::/8
Anycast address		Anycast addresses use the unicast address space and have the identical structure of unicast addresses.	

Unicast addresses

Unicast addresses include global unicast addresses, link-local unicast addresses, the loopback address, and the unspecified address.

- **Global unicast addresses**—Equivalent to public IPv4 addresses, global unicast addresses are provided for Internet service providers. This type of address allows for prefix aggregation to restrict the number of global routing entries.
- **Link-local addresses**—Used for communication among link-local nodes for neighbor discovery and stateless autoconfiguration. Packets with link-local source or destination addresses are not forwarded to other links.
- **A loopback address**—0:0:0:0:0:0:0:1 (or ::1). It has the same function as the loopback address in IPv4. It cannot be assigned to any physical interface. A node uses this address to send an IPv6 packet to itself.
- **An unspecified address**—0:0:0:0:0:0:0:0 (or ::). It cannot be assigned to any node. Before acquiring a valid IPv6 address, a node fills this address in the source address field of IPv6 packets. The unspecified address cannot be used as a destination IPv6 address.

Multicast addresses

IPv6 multicast addresses listed in Table 2 are reserved for special purposes.

Table 2 Reserved IPv6 multicast addresses

Address	Application
FF01::1	Node-local scope all-nodes multicast address.
FF02::1	Link-local scope all-nodes multicast address.
FF01::2	Node-local scope all-routers multicast address.
FF02::2	Link-local scope all-routers multicast address.

Multicast addresses also include solicited-node addresses. A node uses a solicited-node multicast address to acquire the link-layer address of a neighboring node on the same link and to detect

duplicate addresses. Each IPv6 unicast or anycast address has a corresponding solicited-node address. The format of a solicited-node multicast address is FF02:0:0:0:0:1:FFXX:XXXX. FF02:0:0:0:0:1:FF is fixed and consists of 104 bits, and XX:XXXX is the last 24 bits of an IPv6 unicast address or anycast address.

EUI-64 address-based interface identifiers

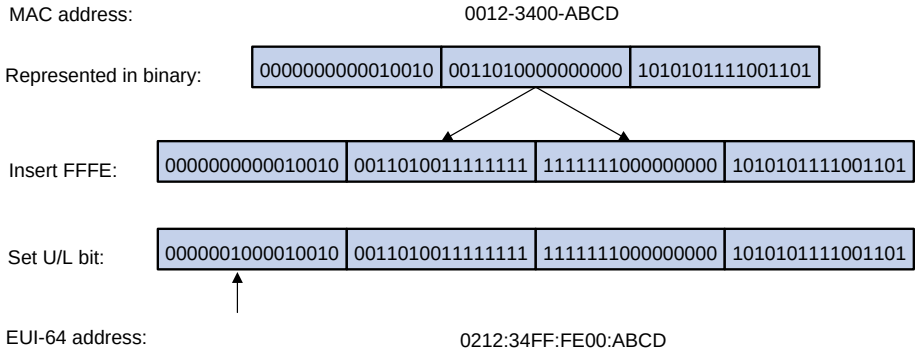
An interface identifier is 64 bits long and uniquely identifies an interface on a link.

On an IEEE 802 interface (such as a VLAN interface), the interface identifier is derived from the link-layer address (typically a MAC address) of the interface. The MAC address is 48 bits long.

To obtain an EUI-64 address-based interface identifier, follow these steps:

1. Insert the 16-bit binary number 1111111111111110 (hexadecimal value of FFFE) behind the 24th high-order bit of the MAC address.
2. Invert the universal/local (U/L) bit (the seventh high-order bit). This operation makes the interface identifier have the same local or global significance as the MAC address.

Figure 2 Converting a MAC address into an EUI-64 address-based interface identifier



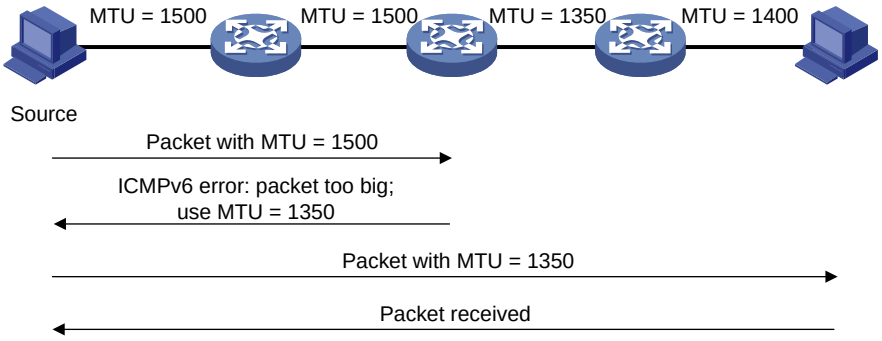
IPv6 path MTU discovery

The links that a packet passes from a source to a destination can have different MTUs, among which the minimum MTU is the path MTU. If a packet exceeds the path MTU, the source end fragments the packet to reduce the processing pressure on intermediate devices and to use network resources effectively.

A source end uses path MTU discovery to find the path MTU to a destination, as shown in Figure 3.

1. The source host sends a packet no larger than its MTU to the destination host.
2. If the MTU of an intermediate device's output interface is smaller than the packet, the device performs the following operations:
   - Discards the packet.
   - Returns an ICMPv6 error message containing the interface MTU to the source host.
3. Upon receiving the ICMPv6 error message, the source host performs the following operations:
   - Uses the returned MTU to limit the packet size.
   - Performs fragmentation.
   - Sends the fragments to the destination host.
4. Step 2 and step 3 are repeated until the destination host receives the packet. In this way, the source host finds the minimum MTU of all links in the path to the destination host.

Figure 3 Path MTU discovery process



IPv6 transition technologies

IPv6 transition technologies enable communication between IPv4 and IPv6 networks.

Dual stack

Dual stack is the most direct transition approach. A network node that supports both IPv4 and IPv6 is a dual-stack node. A dual-stack node configured with an IPv4 address and an IPv6 address can forward both IPv4 and IPv6 packets. An application that supports both IPv4 and IPv6 prefers IPv6 at the network layer.

Dual stack is suitable for communication between IPv4 nodes or between IPv6 nodes. It is the basis of all transition technologies. However, it does not solve the IPv4 address depletion issue because each dual-stack node must have a globally unique IPv4 address.

NAT-PT

Network Address Translation – Protocol Translation (NAT-PT) enables communication between IPv4 and IPv6 nodes by translating between IPv4 and IPv6 packets. It performs IP address translation, and according to different protocols, performs semantic translation for packets. This technology is only suitable for communication between a pure IPv4 node and a pure IPv6 node.

Protocols and standards

- RFC 1881, *IPv6 Address Allocation Management*
- RFC 1887, *An Architecture for IPv6 Unicast Address Allocation*
- RFC 1981, *Path MTU Discovery for IP version 6*
- RFC 2375, *IPv6 Multicast Address Assignments*
- RFC 2460, *Internet Protocol, Version 6 (IPv6) Specification*
- RFC 2464, *Transmission of IPv6 Packets over Ethernet Networks*
- RFC 2526, *Reserved IPv6 Subnet Anycast Addresses*
- RFC 3307, *Allocation Guidelines for IPv6 Multicast Addresses*
- RFC 4191, *Default Router Preferences and More-Specific Routes*
- RFC 4291, *IP Version 6 Addressing Architecture*
- RFC 4443, *Internet Control Message Protocol (ICMPv6) for the Internet Protocol Version 6 (IPv6) Specification*

IPv6 basics tasks at a glance

To configure basic IPv6 settings, perform the following tasks:

1. Configuring an IPv6 address

   Choose the following tasks as needed:

   - Configuring an IPv6 global unicast address
   - Configuring an IPv6 link-local address
   - Configuring an IPv6 anycast address
2. (Optional.) Configuring path MTU discovery
   - Setting the interface MTU for IPv6 packets
   - Setting a static path MTU for an IPv6 address
   - Setting the aging time for dynamic path MTUs
3. (Optional.) Controlling sending ICMPv6 messages
   - Configuring the rate limit for ICMPv6 error messages
   - Enabling replying to multicast echo requests
   - Enabling sending ICMPv6 destination unreachable messages
   - Enabling sending ICMPv6 time exceeded messages
   - Enabling sending ICMPv6 redirect messages
4. (Optional.) Enabling IPv6 local fragment reassembly

Configuring an IPv6 global unicast address

About IPv6 global unicast address

Use one of the following methods to configure an IPv6 global unicast address for an interface:

- **EUI-64 IPv6 address**—The IPv6 address prefix of the interface is manually configured, and the interface ID is generated automatically by the interface.
- **Manual configuration**—The IPv6 global unicast address is manually configured.
- **Stateless address autoconfiguration**—The IPv6 global unicast address is generated automatically based on the address prefix information contained in the RA message.
- **Prefix-specific address autoconfiguration**—The IPv6 global unicast address is generated automatically based on the prefix specified by its ID. The prefix can be manually configured or obtained through DHCPv6.

You can configure multiple IPv6 global unicast addresses on an interface.

Manually configured global unicast addresses (including EUI-64 IPv6 addresses) take precedence over automatically generated ones. If you manually configure a global unicast address with the same address prefix as an existing global unicast address on an interface, the manually configured one takes effect. However, it does not overwrite the automatically generated address. If you delete the manually configured global unicast address, the device uses the automatically generated one.

Generating an EUI-64 IPv6 address

1. Enter system view.

   `system-view`
2. Enter interface view.

interface *interface-type interface-number*

3. Configure an EUI-64 IPv6 address on the interface.

   ipv6 address { *ipv6-address prefix-length* | *ipv6-address*/*prefix-length* } **eui-64**

   By default, no EUI-64 IPv6 address is configured on an interface.

Manually assigning an IPv6 global unicast address

1. Enter system view.

   system-view

2. Enter interface view.

   interface *interface-type interface-number*

3. Assign an IPv6 global unicast address to the interface.

   ipv6 address { *ipv6-address prefix-length* | *ipv6-address*/*prefix-length* }

   By default, no IPv6 global unicast address is configured on an interface.

Stateless address autoconfiguration

About stateless address autoconfiguration and temporary address

Stateless address autoconfiguration enables an interface to automatically generate an IPv6 global unicast address by using the address prefix in the received RA message and the interface ID. On an IEEE 802 interface (such as an Ethernet interface or a VLAN interface), the interface ID is generated based on the interface's MAC address and is globally unique. An attacker can exploit this rule to identify the sending device easily.

To fix the vulnerability, you can configure the temporary address feature. With this feature, an IEEE 802 interface generates the following addresses:

- **Public IPv6 address**—Includes the address prefix in the RA message and a fixed interface ID generated based on the MAC address of the interface.
- **Temporary IPv6 address**—Includes the address prefix in the RA message and a random interface ID generated through MD5.

You can also configure the interface to preferentially use the temporary IPv6 address as the source address of sent packets. When the valid lifetime of the temporary IPv6 address expires, the interface deletes the address and generates a new one. This feature enables the system to send packets with different source addresses through the same interface. If the temporary IPv6 address cannot be used because of a DAD conflict, the public IPv6 address is used.

The preferred lifetime and valid lifetime for a temporary IPv6 address are determined as follows:

- The preferred lifetime of a temporary IPv6 address takes the smaller of the following values:
  - The preferred lifetime of the address prefix in the RA message.
  - The preferred lifetime configured for temporary IPv6 addresses minus DESYNC_FACTOR (a random number in the range of 0 to 600 seconds).
- The valid lifetime of a temporary IPv6 address takes the smaller of the following values:
  - The valid lifetime of the address prefix.
  - The valid lifetime configured for temporary IPv6 addresses.

Restrictions and guidelines

If the IPv6 prefix in the RA message is not 64 bits long, stateless address autoconfiguration fails to generate an IPv6 global unicast address.

To generate a temporary address, an interface must be enabled with stateless address autoconfiguration. Temporary IPv6 addresses do not overwrite public IPv6 addresses, so an interface can have multiple IPv6 addresses with the same address prefix but different interface IDs.

If an interface fails to generate a public IPv6 address because of a prefix conflict or other reasons, it does not generate any temporary IPv6 address.

Executing the **undo ipv6 address auto** command on an interface deletes all IPv6 global unicast addresses and link-local addresses that are automatically generated on the interface.

Enabling stateless address autoconfiguration

1. Enter system view.

   system-view
2. Enter interface view.

   interface *interface-type interface-number*
3. Enable stateless address autoconfiguration on an interface, so that the interface can automatically generate a global unicast address.

   ipv6 address auto

   By default, the stateless address autoconfiguration feature is disabled on an interface.

Configuring the temporary address feature and preferentially using the temporary IPv6 address as the source address of outgoing packets

1. Enter system view.

   system-view
2. Enable the temporary IPv6 address feature.

   ipv6 temporary-address [*valid-lifetime preferred-lifetime*]

   By default, the temporary IPv6 address feature is disabled.
3. Enable the system to preferentially use the temporary IPv6 address as the source address of the outgoing packets.

   ipv6 prefer temporary-address

   By default, the system does not preferentially use the temporary IPv6 address as the source address of the outgoing packets.

Configuring prefix-specific address autoconfiguration

1. Enter system view.

   system-view
2. Configure an IPv6 prefix.

   Choose one option as needed:

   - Configure a static IPv6 prefix.

     ipv6 prefix *prefix-number ipv6-prefix*/*prefix-length*

     By default, no static IPv6 prefixes exist.
   - Use DHCPv6 to obtain a dynamic IPv6 prefix.

     For more information about IPv6 prefix acquisition, see "Configuring the DHCPv6 client."
3. Enter interface view.

   interface *interface-type interface-number*
4. Specify an IPv6 prefix for an interface to automatically generate an IPv6 global unicast address and advertise the prefix.

   ipv6 address *prefix-number sub-prefix/prefix-length*

By default, no IPv6 prefix is specified for the interface to automatically generate an IPv6 global unicast address.

Configuring an IPv6 link-local address

About IPv6 link-local address

Configure IPv6 link-local addresses using one of the following methods:

- **Automatic generation**—The device automatically generates a link-local address for an interface according to the link-local address prefix (FE80::/10) and the link-layer address of the interface.
- **Manual assignment**—Manually configure an IPv6 link-local address for an interface.

Restrictions and guidelines

After you configure an IPv6 global unicast address for an interface, the interface automatically generates a link-local address. This link-local address is the same as the one generated by using the **ipv6 address auto link-local** command. If a link-local address is manually assigned to an interface, this manual assigned link-local address takes effect. If the manually assigned link-local address is deleted, the automatically generated link-local address takes effect.

Using the **undo ipv6 address auto link-local** command on an interface deletes only the link-local address generated by the **ipv6 address auto link-local** command. If the interface has an IPv6 global unicast address, it still has a link-local address. If the interface has no IPv6 global unicast address, it has no link-local address.

An interface can have only one link-local address. As a best practice, use the automatic generation method to avoid link-local address conflicts. If both the automatic generation and manual assignment methods are used, the manual assignment takes precedence.

- If you first use automatic generation and then manual assignment, the manually assigned link-local address overwrites the automatically generated one.
- If you first use manual assignment and then automatic generation, both of the following occur:
  - The link-local address is still the manually assigned one.
  - The automatically generated link-local address does not take effect. If you delete the manually assigned address, the automatically generated link-local address takes effect.

Configuring automatic generation of an IPv6 link-local address for an interface

1. Enter system view.

   system-view
2. Enter interface view.

   interface *interface-type interface-number*
3. Configure the interface to automatically generate an IPv6 link-local address.

   ipv6 address auto link-local

   By default, no link-local address is configured on an interface.

   After an IPv6 global unicast address is configured on the interface, a link-local address is generated automatically.

Manually assigning an IPv6 link-local address to an interface

1. Enter system view.
   system-view
2. Enter interface view.
   interface *interface-type interface-number*
3. Manually assign an IPv6 link-local address to the interface.
   ipv6 address { *ipv6-address* [*prefix-length*] | *ipv6-address/prefix-length* } **link-local**
   By default, no link-local address is configured on an interface.

Configuring an IPv6 anycast address

4. Enter system view.
   system-view
5. Enter interface view.
   interface *interface-type interface-number*
6. Configure an IPv6 anycast address.
   ipv6 address { *ipv6-address prefix-length* | *ipv6-address*/*prefix-length* } **anycast**
   By default, no IPv6 anycast address is configured on an interface.

Configuring path MTU discovery

Setting the interface MTU for IPv6 packets

About interface MTU for IPv6 packets

If the size of a packet exceeds the MTU of the sending interface, the device discards the packet. If the device is an intermediate device, it also sends the source host an ICMPv6 Packet Too Big message with the MTU of the sending interface. The source host fragments the packets according to the MTU. To avoid this situation, set a proper interface MTU.

Procedure

1. Enter system view.
   system-view
2. Enter interface view.
   interface *interface-type interface-number*
3. Set the interface MTU for IPv6 packets.
   ipv6 mtu *size*
   By default, no interface MTU is set.

Setting a static path MTU for an IPv6 address

About static path MTU for an IPv6 address

You can set a static path MTU for an IPv6 address. Before sending a packet to the IPv6 address, the device compares the output interface MTU with the static path MTU. If the packet size exceeds the

smaller one of the two values, the device fragments the packet according to the smaller value. After sending the fragmented packets, the device dynamically finds the path MTU to a destination host (see "IPv6 path MTU discovery").

Procedure

1. Enter system view.
   ```
   system-view
   ```
2. Set a static path MTU for an IPv6 address.
   ```
   ipv6 pathmtu ipv6-address value
   ```
   By default, no path MTU is set for any IPv6 address.

Setting the aging time for dynamic path MTUs

About the aging time for dynamic path MTUs

After the device dynamically discovers the path MTU to a destination host (see "IPv6 path MTU discovery"), it performs the following operations:

- Sends packets to the destination host based on this path MTU.
- Starts the aging timer for this path MTU.

When the aging timer expires, the device removes the dynamic path MTU and discovers the path MTU again.

Restrictions and guidelines

The aging time is invalid for a static path MTU.

Procedure

1. Enter system view.
   ```
   system-view
   ```
2. Set the aging time for dynamic path MTUs.
   ```
   ipv6 pathmtu age age-time
   ```
   The default setting is 10 minutes.

Controlling sending ICMPv6 messages

Configuring the rate limit for ICMPv6 error messages

About the rate limit for ICMPv6 error messages

To avoid sending excessive ICMPv6 error messages within a short period that might cause network congestion, you can limit the rate at which ICMPv6 error messages are sent. A token bucket algorithm is used with one token representing one ICMPv6 error message.

A token is placed in the bucket at intervals until the maximum number of tokens that the bucket can hold is reached.

A token is removed from the bucket when an ICMPv6 error message is sent. When the bucket is empty, ICMPv6 error messages are not sent until a new token is placed in the bucket.

Procedure

1. Enter system view.
   ```
   system-view
   ```

2. Set the bucket size and the interval for tokens to arrive in the bucket for ICMPv6 error messages.

   ipv6 icmpv6 error-interval *interval* [*bucketsize*]

   By default, the bucket allows a maximum of 10 tokens. A token is placed in the bucket at an interval of 100 milliseconds.

   To disable the ICMPv6 rate limit, set the interval to 0 milliseconds.

Enabling replying to multicast echo requests

1. Enter system view.

   system-view

2. Enable replying to multicast echo requests.

   ipv6 icmpv6 multicast-echo-reply enable

   By default, this feature is disabled.

Enabling sending ICMPv6 destination unreachable messages

About sending ICMPv6 destination unreachable messages

The device sends the source the following ICMPv6 destination unreachable messages:

- **ICMPv6 No Route to Destination message**—A packet to be forwarded does not match any route.
- **ICMPv6 Communication with Destination Administratively Prohibited message**—An administrative prohibition is preventing successful communication with the destination. This is typically caused by a firewall or an ACL on the device.
- **ICMPv6 Beyond Scope of Source Address message**—The destination is beyond the scope of the source IPv6 address. For example, a packet's source IPv6 address is a link-local address, and its destination IPv6 address is a global unicast address.
- **ICMPv6 Address Unreachable message**—The device fails to resolve the link layer address for the destination IPv6 address of a packet.
- **ICMPv6 Port Unreachable message**—No port process on the destination device exists for a received UDP packet.

Restrictions and guidelines

An ICMPv6 destination unreachable message indicates that the destination is not reachable from the source device. Attackers can launch malicious attacks to make the device generate incorrect ICMPv6 destination unreachable messages, which will affect the function of the network. To protect the network from malicious attacks and decrease unnecessary network traffic, you can disable the sending of ICMPv6 destination unreachable messages.

Procedure

1. Enter system view.

   system-view

2. Enable sending ICMPv6 destination unreachable messages.

   ipv6 unreachables enable

   By default, this feature is disabled.

Enabling sending ICMPv6 time exceeded messages

About sending ICMPv6 time exceeded messages

The device sends the source ICMPv6 time exceeded messages as follows:

- If a received packet is not destined for the device and its hop limit is 1, the device sends an ICMPv6 hop limit exceeded in transit message to the source.
- Upon receiving the first fragment of an IPv6 datagram destined for the device, the device starts a timer. If the timer expires before all fragments arrive, the device sends an ICMPv6 fragment reassembly time exceeded message to the source.

Restrictions and guidelines

If the device receives large numbers of malicious packets, its performance degrades greatly because it must send back ICMP time exceeded messages. To prevent such attacks, disable sending ICMPv6 time exceeded messages.

Procedure

1. Enter system view.

   `system-view`
2. Enable sending ICMPv6 time exceeded messages.

   `ipv6 hoplimit-expires enable`

   By default, sending ICMPv6 time exceeded messages is enabled.

Enabling sending ICMPv6 redirect messages

About sending ICMPv6 redirect messages

Upon receiving a packet from a host, the device sends an ICMPv6 redirect message to inform the host of a better next hop when the following conditions are met:

- The interface receiving the packet is the interface forwarding the packet.
- The selected route is not created or modified by any ICMPv6 redirect messages.
- The selected route is not a default route.
- The forwarded packet does not contain the routing extension header.

The ICMPv6 redirect feature simplifies host management by enabling hosts that hold few routes to optimize their routing table gradually. However, to avoid adding too many routes on hosts, this feature is disabled by default.

Procedure

1. Enter system view.

   `system-view`
2. Enable sending ICMPv6 redirect messages.

   `ipv6 redirects enable`

   By default, sending ICMPv6 redirect messages is disabled.

Specifying the source IPv6 address for unsolicited ICMPv6 packets

About specifying the source IPv6 address for unsolicited ICMPv6 packets

Perform this task to specify the source IPv6 address for outgoing ping echo requests and ICMPv6 error messages. It is a good practice to specify the IPv6 address of a loopback interface as the source IPv6 address. This feature helps users easily locate the sending device.

Restrictions and guidelines

For ICMPv6 echo requests, the source IPv6 address specified in the **ping ipv6** command has higher priority than the source IPv6 address specified in the **ipv6 icmpv6 source** command.

Procedure

1. Enter system view.
   system-view
2. Specify a source IPv6 address for unsolicited ICMPv6 packets.
   ipv6 icmpv6 source *ipv6-address*
   By default, no source address is specified for unsolicited ICMPv6 packets.

Enabling IPv6 local fragment reassembly

About IPv6 local fragment reassembly

Use this feature on a multichassis IRF fabric to improve fragment reassembly efficiency. This feature enables a subordinate to reassemble the IPv6 fragments of a packet if all the fragments arrive at it. If this feature is disabled, all IPv6 fragments are delivered to the master device for reassembly.

Restrictions and guidelines

The IPv6 local fragment reassembly feature applies only to fragments destined for the same subordinate.

Procedure

1. Enter system view.
   system-view
2. Enable IPv6 local fragment reassembly.
   ipv6 reassemble local enable
   By default, IPv6 local fragment reassembly is disabled.

Display and maintenance commands for IPv6 basics

Execute **display** commands in any view and **reset** commands in user view.

For information about the **display tcp statistics**, **display udp statistics**, **reset tcp statistics**, and **reset udp statistics** command, see the IP performance commands in *Layer 3—IP Services Command Reference*.

Task	Command
Display IPv6 FIB entries.	**display ipv6 fib** [*ipv6-address*

Task	Command
	[*prefix-length*]]
Display ICMPv6 traffic statistics.	**display ipv6 icmp statistics** [**slot** *slot-number*]
Display IPv6 information about the interface.	**display ipv6 interface** [*interface-type* [*interface-number*]] [**brief**]
Display IPv6 prefix information about the interface.	**display ipv6 interface** *interface-type interface-number* **prefix**
Display the IPv6 path MTU information.	**display ipv6 pathmtu** { *ipv6-address* | { **all** | **dynamic** | **static** } [**count**] }
Display the IPv6 prefix information.	**display ipv6 prefix** [*prefix-number*]
Display brief information about IPv6 RawIP connections.	**display ipv6 rawip** [**slot** *slot-number*]
Display detailed information about IPv6 RawIP connections.	**display ipv6 rawip verbose** [**slot** *slot-number* [**pcb** *pcb-index*]]
Display IPv6 and ICMPv6 packet statistics.	**display ipv6 statistics** [**slot** *slot-number*]
Display brief information about IPv6 TCP connections.	**display ipv6 tcp** [**slot** *slot-number*]
Display detailed information about IPv6 TCP connections.	**display ipv6 tcp verbose** [**slot** *slot-number* [**pcb** *pcb-index*]]
Display brief information about IPv6 UDP connections.	**display ipv6 udp** [**slot** *slot-number*]
Display detailed information about IPv6 UDP connections.	**display ipv6 udp verbose** [**slot** *slot-number* [**pcb** *pcb-index*]]
Display IPv6 TCP traffic statistics.	**display tcp statistics** [**slot** *slot-number*]
Display IPv6 UDP traffic statistics.	**display udp statistics** [**slot** *slot-number*]
Clear path MTUs.	**reset ipv6 pathmtu** { **all** | **dynamic** | **static** }
Clear IPv6 and ICMPv6 packet statistics.	**reset ipv6 statistics** [**slot** *slot-number*]
Clear IPv6 TCP traffic statistics.	**reset tcp statistics**
Clear IPv6 UDP traffic statistics.	**reset udp statistics**

Basic IPv6 settings configuration examples

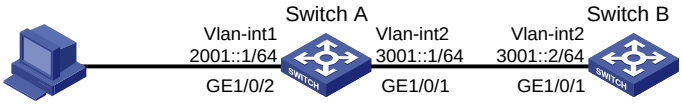
Example: Configuring basic IPv6 settings

Network configuration

As shown in Figure 4, a host, Switch A, and Switch B are connected through Ethernet ports. Add the Ethernet ports to corresponding VLANs. Configure IPv6 addresses for the VLAN interfaces and verify that they are connected. Switch B can reach the host.

Enable IPv6 on the host to automatically obtain an IPv6 address through IPv6 ND.

Figure 4 Network diagram



Procedure

This example assumes that the VLAN interfaces have been created on the switches.

1. Configure Switch A:

   # Specify a global unicast address for VLAN-interface 2.

   ```
   <SwitchA> system-view
   [SwitchA] interface vlan-interface 2
   [SwitchA-Vlan-interface2] ipv6 address 3001::1/64
   [SwitchA-Vlan-interface2] quit
   ```

   # Specify a global unicast address for VLAN-interface 1, and allow it to advertise RA messages (no interface advertises RA messages by default).

   ```
   [SwitchA] interface vlan-interface 1
   [SwitchA-Vlan-interface1] ipv6 address 2001::1/64
   [SwitchA-Vlan-interface1] undo ipv6 nd ra halt
   [SwitchA-Vlan-interface1] quit
   ```

2. Configure Switch B:

   # Configure a global unicast address for VLAN-interface 2.

   ```
   <SwitchB> system-view
   [SwitchB] interface vlan-interface 2
   [SwitchB-Vlan-interface2] ipv6 address 3001::2/64
   [SwitchB-Vlan-interface2] quit
   ```

   # Configure an IPv6 static route with destination IPv6 address 2001::/64 and next hop address 3001::1.

   ```
   [SwitchB] ipv6 route-static 2001:: 64 3001::1
   ```

3. Configure the host:

   Enable IPv6 for the host to automatically obtain an IPv6 address through IPv6 ND.

   # Display neighbor information for GigabitEthernet 1/0/2 on Switch A.

   ```
   [SwitchA] display ipv6 neighbors interface gigabitethernet 1/0/2
   Type: S-Static    D-Dynamic    O-Openflow     R-Rule    IS-Invalid static
   IPv6 address              MAC address    VID  Interface           State T  Aging
   FE80::215:E9FF:FEA6:7D14  0015-e9a6-7d14 1    GE1/0/2             STALE D  1238
   2001::15B:E0EA:3524:E791  0015-e9a6-7d14 1    GE1/0/2             STALE D  1248
   ```

   The output shows that the IPv6 global unicast address that Host obtained is 2001::15B:E0EA:3524:E791.

Verifying the configuration

Display the IPv6 interface settings on Switch A. All IPv6 global unicast addresses configured on the interface are displayed.

```
[SwitchA] display ipv6 interface vlan-interface 2
Vlan-interface2 current state: UP
Line protocol current state: UP
IPv6 is enabled, link-local address is FE80::20F:E2FF:FE00:2
  Global unicast address(es):
    3001::1, subnet is 3001::/64
```

```
  Joined group address(es):
    FF02::1
    FF02::2
    FF02::1:FF00:1
    FF02::1:FF00:2
  MTU is 1500 bytes
  ND DAD is enabled, number of DAD attempts: 1
  ND reachable time is 30000 milliseconds
  ND retransmit interval is 1000 milliseconds
  Hosts use stateless autoconfig for addresses
IPv6 Packet statistics:
  InReceives:                   25829
  InTooShorts:                  0
  InTruncatedPkts:              0
  InHopLimitExceeds:            0
  InBadHeaders:                 0
  InBadOptions:                 0
  ReasmReqds:                   0
  ReasmOKs:                     0
  InFragDrops:                  0
  InFragTimeouts:               0
  OutFragFails:                 0
  InUnknownProtos:              0
  InDelivers:                   47
  OutRequests:                  89
  OutForwDatagrams:             48
  InNoRoutes:                   0
  InTooBigErrors:               0
  OutFragOKs:                   0
  OutFragCreates:               0
  InMcastPkts:                  6
  InMcastNotMembers:            25747
  OutMcastPkts:                 48
  InAddrErrors:                 0
  InDiscards:                   0
  OutDiscards:                  0
[SwitchA] display ipv6 interface vlan-interface 1
Vlan-interface1 current state: UP
Line protocol current state: UP
IPv6 is enabled, link-local address is FE80::20F:E2FF:FE00:1C0
  Global unicast address(es):
    2001::1, subnet is 2001::/64
  Joined group address(es):
    FF02::1
    FF02::2
    FF02::1:FF00:1
    FF02::1:FF00:1C0
  MTU is 1500 bytes
```

```
  ND DAD is enabled, number of DAD attempts: 1
  ND reachable time is 30000 milliseconds
  ND retransmit interval is 1000 milliseconds
  ND advertised reachable time is 0 milliseconds
  ND advertised retransmit interval is 0 milliseconds
  ND router advertisements are sent every 600 seconds
  ND router advertisements live for 1800 seconds
  Hosts use stateless autoconfig for addresses
IPv6 Packet statistics:
  InReceives:                   272
  InTooShorts:                  0
  InTruncatedPkts:              0
  InHopLimitExceeds:            0
  InBadHeaders:                 0
  InBadOptions:                 0
  ReasmReqds:                   0
  ReasmOKs:                     0
  InFragDrops:                  0
  InFragTimeouts:               0
  OutFragFails:                 0
  InUnknownProtos:              0
  InDelivers:                   159
  OutRequests:                  1012
  OutForwDatagrams:             35
  InNoRoutes:                   0
  InTooBigErrors:               0
  OutFragOKs:                   0
  OutFragCreates:               0
  InMcastPkts:                  79
  InMcastNotMembers:            65
  OutMcastPkts:                 938
  InAddrErrors:                 0
  InDiscards:                   0
  OutDiscards:                  0
```

Display the IPv6 interface settings on Switch B. All IPv6 global unicast addresses configured on the interface are displayed.

```
[SwitchB] display ipv6 interface vlan-interface 2
Vlan-interface2 current state :UP
Line protocol current state :UP
IPv6 is enabled, link-local address is FE80::20F:E2FF:FE00:1234
  Global unicast address(es):
    3001::2, subnet is 3001::/64
  Joined group address(es):
    FF02::1
    FF02::2
    FF02::1:FF00:2
    FF02::1:FF00:1234
  MTU is 1500 bytes
```

```
  ND DAD is enabled, number of DAD attempts: 1
  ND reachable time is 30000 milliseconds
  ND retransmit interval is 1000 milliseconds
  Hosts use stateless autoconfig for addresses
IPv6 Packet statistics:
  InReceives:                   117
  InTooShorts:                  0
  InTruncatedPkts:              0
  InHopLimitExceeds:            0
  InBadHeaders:                 0
  InBadOptions:                 0
  ReasmReqds:                   0
  ReasmOKs:                     0
  InFragDrops:                  0
  InFragTimeouts:               0
  OutFragFails:                 0
  InUnknownProtos:              0
  InDelivers:                   117
  OutRequests:                  83
  OutForwDatagrams:             0
  InNoRoutes:                   0
  InTooBigErrors:               0
  OutFragOKs:                   0
  OutFragCreates:               0
  InMcastPkts:                  28
  InMcastNotMembers:            0
  OutMcastPkts:                 7
  InAddrErrors:                 0
  InDiscards:                   0
  OutDiscards:                  0
```

Ping Switch A and Switch B on the host, and ping Switch A and the host on Switch B to verify that they are connected.

NOTE:

When you ping a link-local address, use the **-i** parameter to specify an interface for the link-local address.

```
[SwitchB] ping ipv6 -c 1 3001::1
Ping6(56 data bytes) 3001::2 --> 3001::1, press CTRL_C to break
56 bytes from 3001::1, icmp_seq=0 hlim=64 time=4.404 ms

--- Ping6 statistics for 3001::1 ---
1 packet(s) transmitted, 1 packet(s) received, 0.0% packet loss
round-trip min/avg/max/std-dev = 4.404/4.404/4.404/0.000 ms
[SwitchB] ping ipv6 -c 1 2001::15B:E0EA:3524:E791
Ping6(56 data bytes) 3001::2 --> 2001::15B:E0EA:3524:E791, press CTRL_C to break
56 bytes from 2001::15B:E0EA:3524:E791, icmp_seq=0 hlim=64 time=5.404 ms

--- Ping6 statistics for 2001::15B:E0EA:3524:E791 ---
```

```
1 packet(s) transmitted, 1 packet(s) received, 0.0% packet loss
round-trip min/avg/max/std-dev = 5.404/5.404/5.404/0.000 ms
```

The output shows that Switch B can ping Switch A and the host. The host can also ping Switch B and Switch A.

Configuring IPv6 neighbor discovery

About IPv6 neighbor discovery

ICMPv6 messages used by IPv6 neighbor discovery

The IPv6 neighbor discovery (ND) process uses ICMP messages for address resolution, neighbor reachability verification, and neighboring device tracking.

Table 3 describes the ICMPv6 messages used by the IPv6 ND protocol.

Table 3 ICMPv6 messages used by ND

ICMPv6 message	Type	Function
Neighbor Solicitation (NS)	135	Acquires the link-layer address of a neighbor on the local link.
		Verifies the reachability of a neighbor.
		Detects duplicate addresses.
Neighbor Advertisement (NA)	136	Responds to an NS message.
		Notifies the neighboring nodes of link layer changes.
Router Solicitation (RS)	133	Requests an address prefix and other configuration information for autoconfiguration after startup.
Router Advertisement (RA)	134	Responds to an RS message.
		Advertises information, such as the Prefix Information options and flag bits.
Redirect	137	Informs the source host of a better next hop on the path to a particular destination when certain conditions are met.

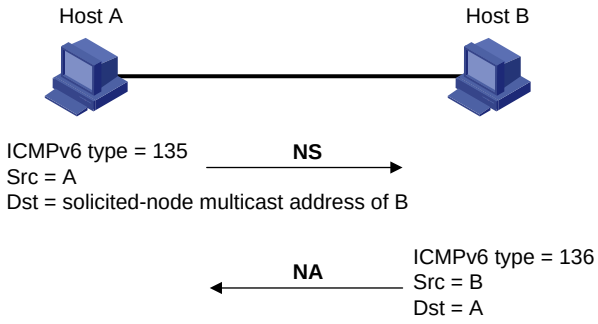
Address resolution

This function is similar to ARP in IPv4. An IPv6 node acquires the link-layer addresses of neighboring nodes on the same link through NS and NA messages.

Figure 5 shows how Host A acquires the link-layer address of Host B on the same link. The address resolution procedure is as follows:

1. Host A multicasts an NS message. The source address of the NS message is the IPv6 address of the sending interface of Host A. The destination address is the solicited-node multicast address of Host B. The NS message body contains the link-layer address of Host A and the target IPv6 address.
2. After receiving the NS message, Host B determines whether the target address of the packet is its IPv6 address. If it is, Host B learns the link-layer address of Host A, and then unicasts an NA message containing its link-layer address.
3. Host A acquires the link-layer address of Host B from the NA message.

Figure 5 Address resolution



Neighbor reachability detection

After Host A acquires the link-layer address of its neighbor Host B, Host A can use NS and NA messages to test the reachability of Host B as follows:

1. Host A sends an NS message whose destination address is the IPv6 address of Host B.
2. If Host A receives an NA message from Host B, Host A decides that Host B is reachable. Otherwise, Host B is unreachable.

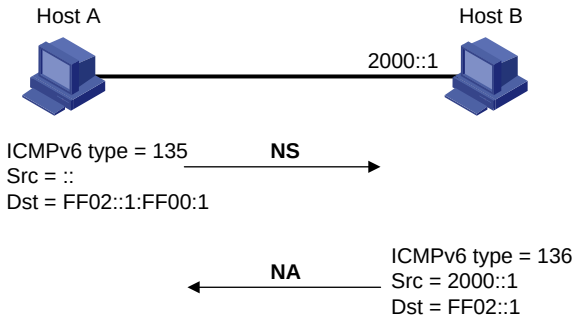
Duplicate address detection

After Host A acquires an IPv6 address, it performs Duplicate Address Detection (DAD) to check whether the address is being used by any other node. This is similar to gratuitous ARP in IPv4. DAD is accomplished through NS and NA messages.

The DAD procedure is as follows:

1. Host A sends an NS message. The source address is the unspecified address and the destination address is the corresponding solicited-node multicast address of the IPv6 address to be detected. The NS message body contains the detected IPv6 address.
2. If Host B uses this IPv6 address, Host B returns an NA message that contains its IPv6 address.
3. Host A knows that the IPv6 address is being used by Host B after receiving the NA message from Host B. If receiving no NA message, Host A decides that the IPv6 address is not in use and uses this address.

Figure 6 Duplicate address detection



Router/prefix discovery and stateless address autoconfiguration

Router/prefix discovery allows an IPv6 node to find the neighboring routers and learn the prefix and network configuration parameters of the network from receiving RA messages.

Stateless address autoconfiguration allows an IPv6 node to automatically generate an IPv6 address based on the information learned through router/prefix discovery.

A node performs router/prefix discovery and stateless address autoconfiguration as follows:

1. At startup, a node sends an RS message to request configuration information from a router.
2. The router returns an RA message containing the Prefix Information option and other configuration information. (The router also periodically sends an RA message.)
3. The node automatically generates an IPv6 address and other configuration parameters according to the configuration information in the RA message.

The Prefix Information option contains an address prefix and the preferred lifetime and valid lifetime of the address prefix. A node updates the preferred lifetime and valid lifetime upon receiving a periodic RA message.

The generated IPv6 address is valid within the valid lifetime and becomes invalid when the valid lifetime expires.

After the preferred lifetime expires, the node cannot use the generated IPv6 address to establish new connections, but can receive packets destined for the IPv6 address. The preferred lifetime cannot be greater than the valid lifetime.

Redirection

Upon receiving a packet from a host, the gateway sends an ICMPv6 redirect message to inform the host of a better next hop when the following conditions are met:

- The interface receiving the packet is the same as the interface forwarding the packet.
- The selected route is not created or modified by an ICMPv6 redirect message.
- The selected route is not a default route on the device.
- The forwarded IPv6 packet does not contain the routing extension header.

Protocols and standards

- RFC 4861, *Neighbor Discovery for IP Version 6 (IPv6)*
- RFC 4862, *IPv6 Stateless Address Autoconfiguration*
- RFC 8106, *IPv6 Router Advertisement Options for DNS Configuration*

IPv6 neighbor discovery tasks at a glance

All IPv6 neighbor discovery tasks are optional.

- Configuring ND entry related features
  - Configuring a static neighbor entry
  - Setting the dynamic neighbor learning limit on an interface
  - Setting the aging timer for ND entries in stale state
  - Minimizing link-local ND entries
- Setting the hop limit

- Configuring RA message sending and parameters
- Setting the maximum number of attempts to send an NS message for DAD
- Configuring ND snooping
  - Configuring ND snooping in a VLAN
- Enabling ND proxy
- Configuring user information recording
  - Enabling recording user IPv6 address conflicts
  - Enabling recording user port migrations
  - Enabling ND logging for user online and offline events

Configuring a static neighbor entry

About static neighbor entries

A neighbor entry stores information about a link-local node. The entry can be created dynamically through NS and NA messages, or configured statically.

The device uniquely identifies a static neighbor entry by using the neighbor's IPv6 address and the number of the Layer 3 interface that connects to the neighbor. You can configure a static neighbor entry by using one of the following methods:

- **Method 1**—Associate a neighbor's IPv6 address and link-layer address with the local Layer 3 interface.
- **Method 2**—Associate a neighbor's IPv6 address and link-layer address with a Layer 2 port in a VLAN.

Restrictions and guidelines

You can use either of the methods to configure a static neighbor entry for a VLAN interface.

- If you use Method 1, the device is required to resolve the Layer 2 port in the related VLAN.
- If you use Method 2, make sure the Layer 2 port belongs to the specified VLAN and the corresponding VLAN interface already exists. After the configuration, the device associates the VLAN interface with the neighbor IPv6 address to identify the static neighbor entry.

Procedure

1. Enter system view.

   system-view

2. Configure a static neighbor entry.

   ipv6 neighbor *ipv6-address mac-address* { *vlan-id port-type port-number* | **interface** *interface-type interface-number* }

   By default, no static neighbor entries exist.

Setting the dynamic neighbor learning limit on an interface

About the dynamic neighbor learning limit on an interface

The device can dynamically acquire the link-layer address of a neighboring node through NS and NA messages and add it into the neighbor table. When the number of dynamic neighbor entries reaches the limit, the interface stops learning neighbor information.

This feature limits the neighbor table size. A large neighbor table will degrade the forwarding performance.

Procedure

1. Enter system view.

   system-view

2. Enter interface view.

   interface *interface-type interface-number*

3. Set the dynamic neighbor learning limit on the interface.

   ipv6 neighbors max-learning-num *max-number*

   The default setting varies by device model. For more information about the default values for the *max-number* argument, see this command in the command reference.

Setting the aging timer for ND entries in stale state

About the aging timer for ND entries in stale state

ND entries in stale state have an aging timer. If an ND entry in stale state is not refreshed before the timer expires, the ND entry changes to the delay state. If it is still not refreshed in 5 seconds, the ND entry changes to the probe state, and the device sends an NS message three times. If no response is received, the device deletes the ND entry.

Restrictions and guidelines

You can set the aging timer for ND entries in stale state in system view and interface view. For ND entries in stale state on an interface, the aging timer in interface view has higher priority than the aging timer in system view.

Procedure

1. Enter system view.

   system-view

2. Set the aging timer for ND entries in stale state.
   - Set the aging timer for ND entries in stale state in system view.

     ipv6 neighbor stale-aging *aging-time*

     The default setting is 240 minutes.
   - Execute the following commands in sequence to set the aging timer in interface view.

     interface *interface-type interface-number*

     ipv6 neighbor timer stale-aging *aging-time*

     By default, the aging timer of ND entries in stale state is not configured on an interface. The aging timer is determined by the configuration of the **ipv6 neighbor stale-aging** command in system view.

Minimizing link-local ND entries

About minimizing link-local ND entries

Perform this task to minimize link-local ND entries assigned to the hardware. Link-local ND entries refer to ND entries that contain link-local addresses.

By default, the device assigns all ND entries to the hardware. With this feature enabled, the newly learned link-local ND entries are not assigned to the hardware if the link-local addresses of the entries are not the next hops of any routes. This feature saves hardware resources.

This feature takes effect only on newly learned link-local ND entries.

Procedure

1. Enter system view.
   system-view
2. Minimize link-local ND entries.
   ipv6 neighbor link-local minimize
   By default, the device assigns all ND entries to the hardware.

Setting the hop limit

About hop limit

You can set the hop limit value to fill in the Hop Limit field for IPv6 packets to be sent.

Procedure

1. Enter system view.
   system-view
2. Set the value for the Hop Limit field in the IP header.
   ipv6 hop-limit *value*
   The default setting is 64.

Configuring RA message sending and parameters

About RA message parameters

You can enable an interface to send RA messages, and configure the interval for sending RA messages and parameters in RA messages. After receiving an RA message, a host can use these parameters to perform corresponding operations. Table 4 describes the configurable parameters in an RA message.

Table 4 Parameters in an RA message and their descriptions

Parameter	Description
Hop Limit	Maximum number of hops in RA messages. A host receiving the RA message fills the value in the Hop Limit field of sent IPv6 packets.
Prefix information	After receiving the prefix information, the hosts on the same link can perform stateless autoconfiguration.
MTU	Guarantees that all nodes on the link use the same MTU.
Boot file URL	Specifies the URL address for downloading the boot file in RA messages. The device can use the ND protocol to obtain both the IPv6 address and the boot file URL for automatic configuration instead of using DHCPv6.
M flag	Determines whether a host uses stateful autoconfiguration to obtain an IPv6 address. If the M flag is set to 1, the host uses stateful autoconfiguration (for example, from a DHCPv6 server) to obtain an IPv6 address. Otherwise, the host uses stateless autoconfiguration to generate an IPv6 address according to its link-layer address and the prefix information in the RA message.
O flag	Determines whether a host uses stateful autoconfiguration to obtain configuration information other than the IPv6 address.

Parameter	Description
	If the O flag is set to 1, the host uses stateful autoconfiguration (for example, from a DHCPv6 server) to obtain configuration information other than the IPv6 address. Otherwise, the host uses stateless autoconfiguration.
Router Lifetime	Tells the receiving hosts how long the advertising router can live. If the lifetime of a router is 0, the router cannot be used as the default gateway.
Retrans Timer	If the device does not receive a response message within the specified time after sending an NS message, it retransmits the NS message.
Reachable Time	If the neighbor reachability detection shows that a neighbor is reachable, the device considers the neighbor reachable within the specified reachable time. If the device needs to send a packet to the neighbor after the specified reachable time expires, the device reconfirms whether the neighbor is reachable.
Router Preference	Specifies the router preference in an RA message. A host selects a router as the default gateway according to the router preference. If router preferences are the same, the host selects the router from which the first RA message is received.
DNS server option	DNS server information for IPv6 hosts. Hosts can obtain DNS server information from received RA messages instead of using DHCPv6.
DNS suffix information in DNS Search List (DNSSL) option	DNS suffix information for IPv6 hosts. Hosts can obtain DNS suffix information from received RA messages instead of using DHCPv6.

Restrictions and guidelines

The maximum interval for sending RA messages should be less than (or equal to) the router lifetime in RA messages. In this way, the router can be updated by an RA message before expiration.

The values of the NS retransmission timer and the reachable time configured for an interface are sent in RA messages to hosts. This interface sends NS messages at the interval of the NS retransmission timer and considers a neighbor reachable within the reachable time.

Enabling the sending of RA messages

1. Enter system view.

   system-view
2. Enter interface view.

   interface *interface-type interface-number*
3. Enable the sending of RA messages.

   undo ipv6 nd ra halt

   The default setting is disabled.
4. Set the maximum and minimum intervals for sending RA messages.

   ipv6 nd ra interval *max-interval min-interval*

   By default, the maximum interval for sending RA messages is 600 seconds, and the minimum interval is 200 seconds.

   The device sends RA messages at random intervals between the maximum interval and the minimum interval.

   The minimum interval should be less than or equal to 0.75 times the maximum interval.

Configuring parameters for RA messages

1. Enter system view.

   system-view

2. Enter interface view.

   interface *interface-type interface-number*

3. Configure the prefix information in RA messages.

   ipv6 nd ra prefix { *ipv6-prefix prefix-length* | *ipv6-prefix*/*prefix-length* } [*valid-lifetime preferred-lifetime* [**no-autoconfig** | **off-link** | **prefix-preference** *level*] * | **no-advertise**]

   By default, no prefix information is configured for RA messages, and the IPv6 address of the interface sending RA messages is used as the prefix information. If the IPv6 address is manually configured, the prefix uses a fixed valid lifetime of 2592000 seconds (30 days) and a preferred lifetime of 604800 seconds (7 days). If the IPv6 address is automatically obtained, the prefix uses the valid lifetime and preferred lifetime configured for the IPv6 address.

4. Configure the default settings for prefixes advertised in RA messages.

   ipv6 nd ra prefix default [*valid-lifetime preferred-lifetime* [**no-autoconfig** | **off-link**] * | **no-advertise**]

   By default, no default settings are configured for prefixes advertised in RA messages.

5. Turn off the MTU option in RA messages.

   ipv6 nd ra no-advlinkmtu

   By default, RA messages contain the MTU option.

6. Specify unlimited hops in RA messages.

   ipv6 nd ra hop-limit unspecified

   By default, the maximum number of hops in RA messages is 64.

7. Specify the URL of the boot file in RA messages.

   ipv6 nd ra boot-file-url *url-string*

   By default, RA messages do not carry the URL of the boot file.

8. Set the M flag bit to 1.

   ipv6 nd autoconfig managed-address-flag

   By default, the M flag bit is set to 0 in RA advertisements. Hosts receiving the advertisements will obtain IPv6 addresses through stateless autoconfiguration.

9. Set the O flag bit to 1.

   ipv6 nd autoconfig other-flag

   By default, the O flag bit is set to 0 in RA advertisements. Hosts receiving the advertisements will acquire other configuration information through stateless autoconfiguration.

10. Set the router lifetime in RA messages.

    ipv6 nd ra router-lifetime *time*

    By default, the router lifetime is three times as long as the maximum interval for advertising RA messages.

11. Set the NS retransmission timer.

    ipv6 nd ns retrans-timer *value*

    By default, an interface sends NS messages every 1000 milliseconds, and the value of the Retrans Timer field in RA messages is 0.

12. Set the router preference in RA messages.

ipv6 nd router-preference { **high** | **low** | **medium** }

By default, the router preference is medium.

13. Set the reachable time.

ipv6 nd nud reachable-time *time*

By default, the neighbor reachable time is 1200000 milliseconds, and the value of the Reachable Time field in sent RA messages is 0.

Specifying DNS server information in RA messages

About specifying DNS server information in RA messages

The DNS server options in RA messages provide DNS server information for IPv6 hosts. The RA messages allow hosts to obtain their IPv6 addresses and the DNS server through stateless autoconfiguration. This method is useful in a network where DHCPv6 infrastructure is not provided.

One DNS server option contains one DNS server. All DNS server options are sorted in ascending order of the DNS server sequence number.

After you execute the **ipv6 nd ra dns server** command, the device immediately sends an RA message with the existing and newly specified DNS server information.

After you execute the **undo ipv6 nd ra dns server** command, the device immediately sends two RA messages.

- The first RA message carries information about all DNS servers, including the DNS servers specified in the **undo** command with their lifetime set to 0 seconds.
- The second RA message carries information about remaining DNS servers.

Each time the device sends an RA message from an interface, it immediately refreshes the RA message advertisement interval for that interface.

Restrictions and guidelines

You can configure a maximum of eight DNS servers on an interface.

The default lifetime of a DNS server is three times the maximum interval for advertising RA messages. To set the maximum interval, use the **ipv6 nd ra interval** command.

Procedure

1. Enter system view.

system-view

2. Enter interface view.

interface *interface-type interface-number*

3. Specify DNS server information to be advertised in RA messages.

ipv6 nd ra dns server *ipv6-address* [*seconds* | **infinite**] **sequence** *seqno*

By default, no DNS server information is specified and RA messages do not carry DNS server options.

Specifying DNS suffix information in RA messages

About specifying DNS suffix information in RA messages

The DNSSL option in RA messages provides suffix information for IPv6 hosts. The RA messages allow hosts to obtain their IPv6 addresses and the DNS suffix through stateless autoconfiguration. This method is useful in a network where DHCPv6 infrastructure is not provided.

One DNSSL option contains one DNS suffix. All DNSSL options are sorted in ascending order of the sequence number of the DNS suffix.

After you execute the **ipv6 nd ra dns search-list** command, the device immediately sends an RA message with the existing and newly specified DNS suffix information.

After you execute the **undo ipv6 nd ra dns search-list** command, the device immediately sends two RA messages.

- The first RA message carries information about all DNS suffixes, including DNS suffixes specified in the **undo** command with their lifetime set to 0 seconds.
- The second RA message carries information about remaining DNS suffixes.

Each time the device sends an RA message from an interface, it immediately refreshes the RA message advertisement interval for that interface.

Restrictions and guidelines

You can configure a maximum of eight DNS suffixes on an interface.

The default lifetime of a DNS suffix is three times the maximum interval for advertising RA messages. To set the maximum interval, use the **ipv6 nd ra interval** command.

Procedure

1. Enter system view.

   system-view
2. Enter interface view.

   interface *interface-type interface-number*
3. Specify DNS suffix information to be advertised in RA messages.

   ipv6 nd ra dns search-list *domain-name* [*seconds* | **infinite**] **sequence** *seqno*

   By default, no DNS suffix information is specified and RA messages do not carry DNS suffix options.

Suppressing advertising DNS information in RA messages

About suppressing advertising DNS information in RA messages

Perform this task to suppress the device from advertising information about DNS server addresses and DNS suffixes in RA messages.

Whether enabling this feature on an interface will trigger sending RA message immediately for DNS server update depends on the interface configuration:

- If the interface has been configured with DNS server information or has obtained an AAA-authorized DNS server address, the device immediately sends two RA messages. In the first message, the lifetime for DNS server addresses is 0 seconds. The second RA message does not carry any DNS server options.
- If the interface has no DNS server information specified or no AAA-authorized DNS server address assigned, no RA messages are triggered.
- If you specify a new DNS server or remove a DNS server, the device immediately sends an RA message without any DNS server address options.

Whether disabling this feature on an interface will trigger sending RA message immediately for DNS server update depends on the interface configuration:

- If the interface has been configured with the DNS server information or has obtained an AAA-authorized DNS server address, the device immediately sends an RA message carrying the DNS server information.

- If the interface has no DNS server information specified or no AAA-authorized DNS server address assigned, no RA messages are triggered.

Each time the device sends an RA message from an interface, it immediately refreshes the RA message advertisement interval for that interface.

The same suppression mechanism applies when you enable or disable DNS suffix suppression in RA messages.

Procedure

1. Enter system view.
   system-view
2. Enter interface view.
   interface *interface-type interface-number*
3. Enable DNS server suppression in RA messages.
   ipv6 nd ra dns server suppress
   By default, DNS server suppression in RA messages is disabled.
4. Enable DNS suffix suppression in RA messages.
   ipv6 nd ra dns search-list suppress
   By default, DNS suffix suppression in RA messages is disabled.

Setting the maximum number of attempts to send an NS message for DAD

About the maximum number of attempts to send an NS message for DAD

An interface sends an NS message for DAD for an obtained IPv6 address. The interface resends the NS message if it does not receive a response within the time specified by the **ipv6 nd ns retrans-timer** command. If the interface receives no response after making the maximum attempts specified by the **ipv6 nd dad attempts** command, the interface uses the IPv6 address.

Procedure

1. Enter system view.
   system-view
2. Enter interface view.
   interface *interface-type interface-number*
3. Set the number of attempts to send an NS message for DAD.
   ipv6 nd dad attempts *times*
   The default setting is 1. When the *times* argument is set to 0, DAD is disabled.

Configuring ND snooping in a VLAN

About ND snooping in a VLAN

The ND snooping feature is used in Layer 2 switching networks. It learns the source MAC addresses, source IPv6 addresses, input interfaces, and VLANs of arriving ND messages and data packets to build the ND snooping table.

ND snooping entries can be used by ND detection to prevent spoofing attacks.

ND detection processes the ND messages received on ND trusted and untrusted interfaces as follows:

- ND detection forwards all ND messages received on an ND trusted interface.
- ND detection compares all ND messages received on an ND untrusted interface with the ND snooping entries except for RA and redirect messages.

You can use the **ipv6 nd detection trust** command to specify a Layer 2 Ethernet or aggregate port as an ND trusted interface. For more information about the **ipv6 nd detection trust** command, see *Security Command Reference*.

ND snooping entries can be used by IPv6 source guard to prevent spoofing attacks. For more information about IPv6 source guard, see *Security Configuration Guide*.

ND snooping provides device liveness tracking so that the ND snooping table can be updated in a timely manner. After ND snooping is enabled for a VLAN, the device uses the following mechanisms to create, update, and delete ND snooping entries. The following example uses ND messages for illustration.

Creation of ND snooping entries

Upon receiving an ND message or data packet from an unknown source, the device creates an ND snooping entry in INVALID status and performs DAD for the source IPv6 address. The device sends NS messages out of the ND trusted interfaces in the receiving VLAN twice. The sending interval is set by the **ipv6 nd snooping dad retrans-timer** command.

- If the device does not receive an NA message within the invalid entry lifetime (set by the **ipv6 nd snooping lifetime invalid** command), the entry becomes valid.
- If the device receives an NA message within the invalid entry lifetime, it deletes this entry.

Updating of ND snooping entries

When the ND untrusted interface that receives an ND message is different from that in the entry for an IPv6 address, the device performs DAD for the entry. It sends NS messages twice. The sending interval is set by the **ipv6 nd snooping dad retrans-timer** command.

- If the device does not receive an NA message within the invalid entry lifetime, it updates the entry with the new receiving interface.
- If the device receives an NA message within the invalid entry lifetime, the ND snooping entry remains unchanged.

Deletion of ND snooping entries

- When an ND trusted interface in the VLAN receives an ND message from the IPv6 address in a learned ND snooping entry, it performs DAD for the entry. The device sends NS messages twice. The sending interval is set by the **ipv6 nd snooping dad retrans-timer** command.
  - If the device does not receive an NA message within the invalid entry lifetime, it deletes the entry.
  - If the device receives an NA message within the invalid entry lifetime, the ND snooping entry remains unchanged.
- If an ND snooping entry has no matching ND messages within the valid entry lifetime (set by the **ipv6 nd snooping lifetime valid** command), the entry becomes invalid. The device then performs DAD for the entry by sending NS messages out of the interface in the entry twice. The sending interval is set by the **ipv6 nd snooping dad retrans-timer** command.
  - If the device does not receive an NA message within the invalid entry lifetime, it deletes the entry.
  - If the device receives an NA message within the invalid entry lifetime, the ND snooping entry remains unchanged and becomes valid.

Enabling ND snooping

1. Enter system view.
   system-view
2. Enter VLAN view.
   vlan *vlan-id*
3. Enable ND snooping for IPv6 addresses. Choose the options to configure as needed:
   - Enable ND snooping for global unicast addresses.
     ipv6 nd snooping enable global
   - Enable ND snooping for link-local addresses.
     ipv6 nd snooping enable link-local

   By default, ND snooping is disabled for IPv6 global unicast addresses and link-local addresses.
4. (Optional.) Enable ND snooping for data packets from unknown sources.
   ipv6 nd snooping glean source

   By default, ND snooping is disabled for data packets from unknown sources.

   Before executing this command for a VLAN, you must configure IPv6 source guard on all untrusted interfaces in the same VLAN. This operation ensures correct forwarding of the data packets received by all these interfaces.
5. Return to system view.
   quit

Setting the maximum number of ND snooping entries

1. Enter system view.
   system-view
2. Enter Layer 2 Ethernet or Layer 2 aggregate interface view.
   interface *interface-type interface-number*
3. (Optional.) Set the maximum number of ND snooping entries that an interface can learn.
   ipv6 nd snooping max-learning-num *max-number*

   By default, an interface can learn a maximum of 1024 ND snooping entries.

Configuring ND snooping entry related parameters

1. Enter system view.
   system-view
2. Enter Layer 2 Ethernet or Layer 2 aggregate interface view.
   interface *interface-type interface-number*
3. (Optional.) Configure the port as an ND snooping uplink port. The ND snooping uplink port cannot learn ND snooping entries.
   ipv6 nd snooping uplink

   By default, the port is not an ND snooping uplink port. After ND snooping is enabled, the port can learn ND snooping entries.
4. Return to system view.
   quit
5. (Optional.) Set timeout timers for ND snooping entries.

ipv6 nd snooping lifetime { **invalid** *invalid-lifetime* | **valid** *valid-lifetime* }

The default settings are as follows:

- The timeout timer for ND snooping entries in INVALID status (TENTATIVE, TESTING_TPLT, or TESTING_VP) is 500 milliseconds.
- The timeout timer for ND snooping entries in VALID status is 300 seconds.

6. (Optional.) Set the interval for retransmitting an NS message for DAD.

   ipv6 nd snooping dad retrans-timer *interval*

   The default value is 250 milliseconds.

Enabling ND proxy

About ND proxy

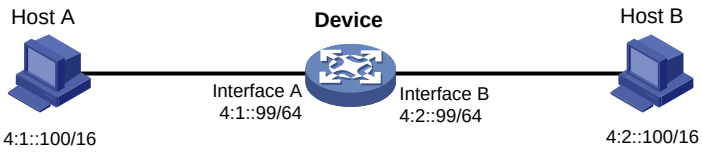
ND proxy enables a device to answer an NS message requesting the hardware address of a host on another network. With ND proxy, hosts in different broadcast domains can communicate with each other as they would on the same network.

ND proxy includes common ND proxy and local ND proxy.

Common ND proxy

As shown in Figure 7, Interface A with IPv6 address 4:1::99/64 and Interface B with IPv6 address 4:2::99/64 belong to different subnets. Host A and Host B reside on the same network but in different broadcast domains.

Figure 7 Application environment of ND proxy



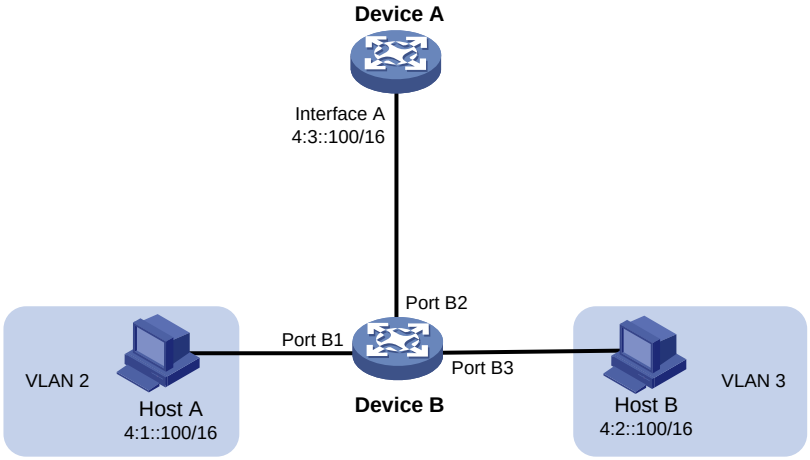
Because Host A's IPv6 address is on the same subnet as Host B's, Host A directly sends an NS message to obtain Host B's MAC address. However, Host B cannot receive the NS message because they belong to different broadcast domains.

To solve this problem, enable common ND proxy on Interface A and Interface B of the device. The device replies to the NS message from Host A, and forwards packets from other hosts to Host B.

Local ND proxy

As shown in Figure 8, Host A belongs to VLAN 2 and Host B belongs to VLAN 3. Host A and Host B connect to Port B1 and Port B3, respectively.

Figure 8 Application environment of local ND proxy



Because Host A's IPv6 address is on the same subnet as Host B's, Host A directly sends an NS message to obtain Host B's MAC address. However, Host B cannot receive the NS message because they belong to different VLANs.

To solve this problem, enable local ND proxy on Interface A of Device A so that Device A can forward messages between Host A and Host B.

Local ND proxy implements Layer 3 communication for two hosts in the following cases:

- The two hosts connect to ports of the same device and the ports must be in different VLANs.
- The two hosts connect to isolated Layer 2 ports in the same isolation group of a VLAN.
- If Private VLAN is used, the two hosts must belong to different secondary VLANs.

Enabling common ND proxy

1. Enter system view.
   `system-view`
2. Enter interface view.
   `interface` *`interface-type interface-number`*
3. Enable common ND proxy.
   `proxy-nd enable`
   By default, common ND proxy is disabled.

Enabling local ND proxy

1. Enter system view.
   `system-view`
2. Enter interface view.
   `interface` *`interface-type interface-number`*
3. Enable local ND proxy.
   `local-proxy-nd enable`
   By default, local ND proxy is disabled.

Enabling recording user IPv6 address conflicts

About recording user IPv6 address conflicts

This feature detects and records user IPv6 address conflicts. A conflict occurs if an incoming NA packet has the same source IP address as an existing ND entry but a different source MAC address. The device generates a user IPv6 address conflict record, logs the conflict, and sends the log to the information center. For information about the log destination and output rule configuration in the information center, see the information center in *Network Management and Monitoring Configuration Guide*.

Procedure

1. Enter system view.
   ```
   system-view
   ```
2. Enable recording user IPv6 address conflicts.
   ```
   ipv6 nd user-ip-conflict record enable
   ```
   By default, recording user IPv6 address conflicts is disabled.

Enabling recording user port migrations

About recording user port migrations

This feature enables the device to detect and record user port migrations. A user port migrates if an incoming NA packet has the same source IPv6 address and source MAC address as an existing ND entry but a different ingress port. The device generates a user port migration record, logs the migration event, and sends the log to the information center. For information about the log destination and output rule configuration in the information center, see the information center in *Network Management and Monitoring Configuration Guide*.

Procedure

1. Enter system view.
   ```
   system-view
   ```
2. Enable recording user port migrations.
   ```
   ipv6 nd user-move record enable
   ```
   By default, recording user port migrations is disabled.

Enabling ND logging for user online and offline events

About ND logging for user online and offline events

This feature enables the device to generate user online or offline logs upon such events and send these logs to the information center. For information about the log destination and output rule configuration in the information center, see the information center in *Network Management and Monitoring Configuration Guide*.

Restrictions and guidelines

A higher log output rate consumes more CPU resources. Adjust the log output rate based the CPU performance and usage.

Procedure

1. Enter system view.

system-view

2. Enable ND logging for user online and offline events.
   ipv6 nd online-offline-log enable [**rate** *rate*]
   By default, ND logging for user online and offline events is disabled.

Display and maintenance commands for IPv6 ND

Execute **display** commands in any view and **reset** commands in user view.

Task	Command
Display the number of IPv6 ND snooping entries in VLANs.	**display ipv6 nd snooping count vlan** [**interface** *interface-type interface-number*]
Display IPv6 ND snooping entries in VLANs.	**display ipv6 nd snooping vlan** [[*vlan-id* | **interface** *interface-type interface-number*] [**global** | **link-local**] | *ipv6-address*] [**verbose**]
Display user IPv6 address conflict records.	**display ipv6 nd user-ip-conflict record** [**slot** *slot-number*]
Display user port migration records.	**display ipv6 nd user-move record** [**slot** *slot-number*]
Display the total number of neighbor entries.	**display ipv6 neighbors** { { **all** | **dynamic** | **static** } [**slot** *slot-number*] | **interface** *interface-type interface-number* | **vlan** *vlan-id* } **count**
Display neighbor information.	**display ipv6 neighbors** { { *ipv6-address* | **all** | **dynamic** | **static** } [**slot** *slot-number*] | **interface** *interface-type interface-number* | **vlan** *vlan-id* } [**verbose**]
Display the maximum number of ND entries that a device supports.	**display ipv6 neighbors entry-limit**
Clear IPv6 ND snooping entries in a VLAN.	**reset ipv6 nd snooping vlan** { [*vlan-id*] [**global** | **link-local**] | *vlan-id ipv6-address* }
Clear IPv6 neighbor information.	**reset ipv6 neighbors** { **all** | **dynamic** | **interface** *interface-type interface-number* | **slot** *slot-number* | **static** }

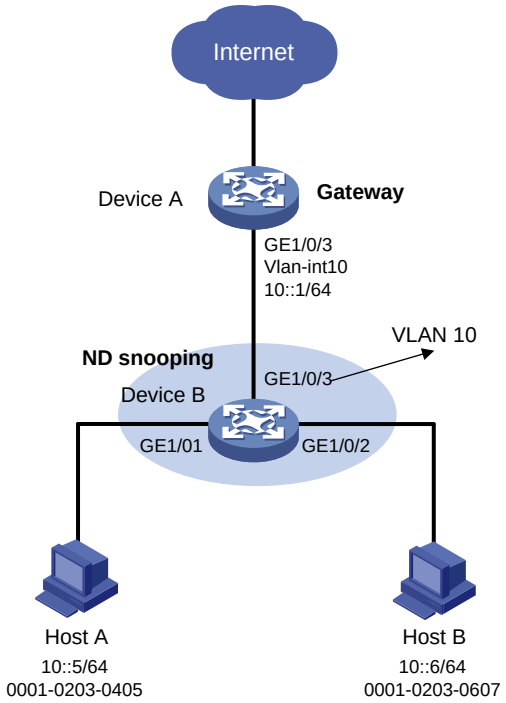
IPv6 ND configuration examples

Example: Configuring ND snooping

Network configuration

As shown in Figure 9, Host A and Host B are connected to the gateway through Device B. Enable ND snooping on Device B to learn ND snooping entries about Host A and Host B.

Figure 9 Network diagram



Procedure

1. Configure Device A:

   # Create VLAN 10.

   ```
   <DeviceA> system-view
   [DeviceA] vlan 10
   [DeviceA-vlan10] quit
   ```

   # Configure GigabitEthernet 1/0/3 to trunk VLAN 10.

   ```
   [DeviceA] interface gigabitethernet 1/0/3
   [DeviceA-GigabitEthernet1/0/3] port link-type trunk
   [DeviceA-GigabitEthernet1/0/3] port trunk permit vlan 10
   [DeviceA-GigabitEthernet1/0/3] quit
   ```

   # Assign IPv6 address 10::1/64 to VLAN-interface 10.

   ```
   [DeviceA] interface vlan-interface 10
   [DeviceA-Vlan-interface10] ipv6 address 10::1/64
   [DeviceA-Vlan-interface10] quit
   ```

2. Configure Device B:

   # Create VLAN 10.

   ```
   [DeviceB] vlan 10
   [DeviceB-vlan10] quit
   ```

   # Configure GigabitEthernet 1/0/1, GigabitEthernet 1/0/2, and GigabitEthernet 1/0/3 to trunk VLAN 10.

   ```
   [DeviceB] interface gigabitethernet 1/0/1
   [DeviceB-GigabitEthernet1/0/1] port link-type access
   [DeviceB-GigabitEthernet1/0/1] port access vlan 10
   [DeviceB-GigabitEthernet1/0/1] quit
   [DeviceB] interface gigabitethernet 1/0/2
   ```

```
[DeviceB-GigabitEthernet1/0/2] port link-type access
[DeviceB-GigabitEthernet1/0/2] port access vlan 10
[DeviceB-GigabitEthernet1/0/2] quit
[DeviceB] interface gigabitethernet 1/0/3
[DeviceB-GigabitEthernet1/0/3] port link-type trunk
[DeviceB-GigabitEthernet1/0/3] port trunk permit vlan 10
[DeviceB-GigabitEthernet1/0/3] quit
```

Enable ND snooping for global unicast addresses and link-local addresses in VLAN 10.

```
[DeviceB] vlan 10
[DeviceB-vlan10] ipv6 nd snooping enable global
[DeviceB-vlan10] ipv6 nd snooping enable link-local
```

Enable ND snooping for data packets from unknown sources in VLAN 10.

```
[DeviceB-vlan10] ipv6 nd snooping glean source
[DeviceB-vlan10] quit
```

Configure GigabitEthernet 1/0/3 as ND trusted interface.

```
[DeviceB] interface gigabitethernet 1/0/3
[DeviceB-GigabitEthernet1/0/3] ipv6 nd detection trust
[DeviceB-GigabitEthernet1/0/3] quit
```

Configure GigabitEthernet 1/0/1 to learn a maximum number of 200 ND snooping entries.

```
[DeviceB] interface gigabitethernet 1/0/1
[DeviceB-GigabitEthernet1/0/1] ipv6 nd snooping max-learning-num 200
[DeviceB-GigabitEthernet1/0/1] quit
```

Configure GigabitEthernet 1/0/2 to learn a maximum number of 200 ND snooping entries.

```
[DeviceB] interface gigabitethernet 1/0/2
[DeviceB-GigabitEthernet1/0/2] ipv6 nd snooping max-learning-num 200
[DeviceB-GigabitEthernet1/0/2] quit
```

Verifying the configuration

Verify that Device B has learned ND snooping entries for Host A and Host B.

```
[DeviceB] display ipv6 nd snooping vlan 10
IPv6 address              MAC address     VID  Interface     Status       Age
10::5                     0001-0203-0405  10   GE1/0/1       VALID        157
10::6                     0001-0203-0607  10   GE1/0/2       VALID        105
```

Contents

DHCPv6 overview

DHCPv6 provides a framework to assign IPv6 prefixes, IPv6 addresses, and other configuration parameters to hosts.

DHCPv6 address/prefix assignment

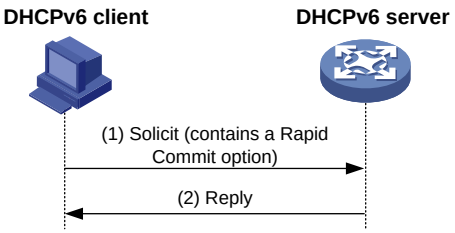
An address/prefix assignment process involves two or four messages.

Rapid assignment involving two messages

As shown in Figure 1, rapid assignment operates in the following steps:

1. The DHCPv6 client sends to the DHCPv6 server a Solicit message that contains a Rapid Commit option to prefer rapid assignment.
2. If the DHCPv6 server supports rapid assignment, it responds with a Reply message containing the assigned IPv6 address/prefix and other configuration parameters. If the DHCPv6 server does not support rapid assignment, Assignment involving four messages is performed.

Figure 1 Rapid assignment involving two messages

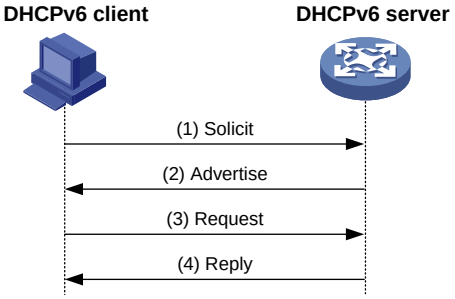


Assignment involving four messages

As shown in Figure 2, four-message assignment operates using the following steps:

1. The DHCPv6 client sends a Solicit message to request an IPv6 address/prefix and other configuration parameters.
2. The DHCPv6 server responds with an Advertise message that contains the assignable address/prefix and other configuration parameters if either of the following conditions exists:
   - The Solicit message does not contain a Rapid Commit option.
   - The DHCPv6 server does not support rapid assignment even though the Solicit message contains a Rapid Commit option.
3. The DHCPv6 client might receive multiple Advertise messages offered by different DHCPv6 servers. It selects an offer according to the receiving sequence and server priority, and sends a Request message to the selected server for confirmation.
4. The DHCPv6 server sends a Reply message to the client, confirming that the address/prefix and other configuration parameters are assigned to the client.

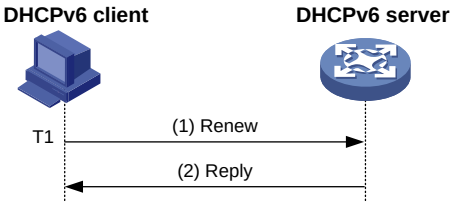
Figure 2 Assignment involving four messages



Address/prefix lease renewal

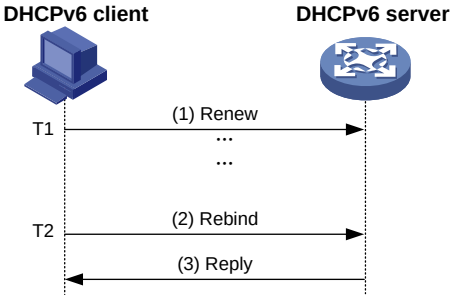
An IPv6 address/prefix assigned by a DHCPv6 server has a valid lifetime. After the valid lifetime expires, the DHCPv6 client cannot use the IPv6 address/prefix. To use the IPv6 address/prefix, the DHCPv6 client must renew the lease time.

Figure 3 Using the Renew message for address/prefix lease renewal



As shown in Figure 3, at T1, the DHCPv6 client sends a Renew message to the DHCPv6 server. The recommended value of T1 is half the preferred lifetime. The DHCPv6 server responds with a Reply message, informing the client whether the lease is renewed.

Figure 4 Using the Rebind message for address/prefix lease renewal



As shown in Figure 4:

- If the DHCPv6 client does not receive a response from the DHCPv6 server after sending a Renew message at T1, it multicasts a Rebind message to all DHCPv6 servers at T2. Typically, the value of T2 is 0.8 times the preferred lifetime.
- The DHCPv6 server responds with a Reply message, informing the client whether the lease is renewed.
- If the DHCPv6 client does not receive a response from any DHCPv6 server before the valid lifetime expires, the client stops using the address/prefix.

For more information about the valid lifetime and the preferred lifetime, see "Configuring basic IPv6 settings."

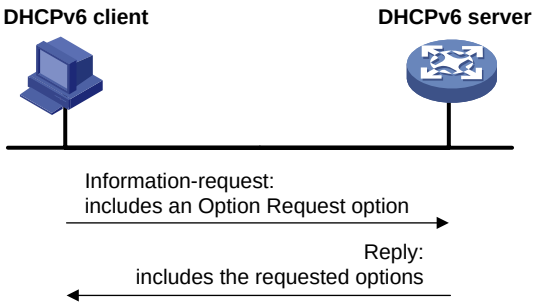
Stateless DHCPv6

Stateless DHCPv6 enables a device that has obtained an IPv6 address/prefix to get other configuration parameters from a DHCPv6 server.

The device performs stateless DHCPv6 if an RA message with the following flags is received from the router during stateless address autoconfiguration:

- The managed address configuration flag (M flag) is set to 0.
- The other stateful configuration flag (O flag) is set to 1.

Figure 5 Stateless DHCPv6 operation



As shown in Figure 5, stateless DHCPv6 operates in the following steps:

1. The DHCPv6 client sends an Information-request message to the multicast address of all DHCPv6 servers and DHCPv6 relay agents. The Information-request message contains an Option Request option that specifies the requested configuration parameters.
2. The DHCPv6 server returns to the client a Reply message containing the requested configuration parameters.
3. The client checks the Reply message. If the obtained configuration parameters match those requested in the Information-request message, the client uses these parameters to complete configuration. If not, the client ignores the configuration parameters. If the client receives multiple replies with configuration parameters matching those requested in the Information-request message, it uses the first received reply.

DHCPv6 options

Option 18

Option 18, also called the interface-ID option, is used by the DHCPv6 relay agent to determine the interface to use to forward RELAY-REPLY message.

The DHCPv6 snooping device adds Option 18 to the received DHCPv6 request message before forwarding it to the DHCPv6 server. The server then assigns IP address to the client based on the client information in Option 18.

Figure 6 Option 18 format

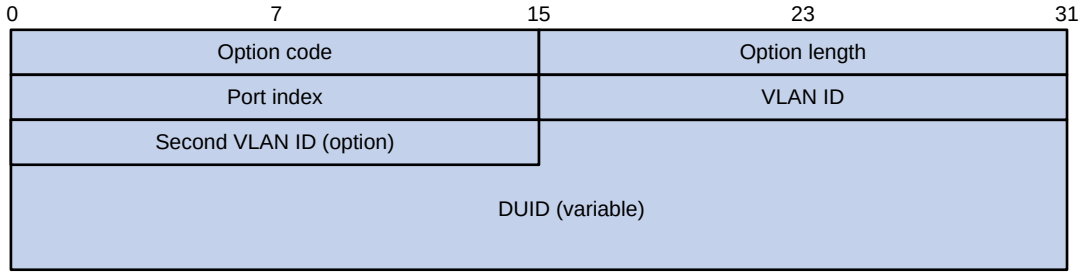


Figure 6 shows the Option 18 format, which includes the following fields:

- **Option code**—Option code. The value is 18.
- **Option length**—Size of the option data.
- **Port index**—Port that receives the DHCPv6 request from the client.
- **VLAN ID**—ID of the outer VLAN.
- **Second VLAN ID**—ID of the inner VLAN. This field is optional. If the received DHCPv6 request does not contain a second VLAN, Option 18 also does not contain it.
- **DUID**—DUID of the DHCPv6 client.

Option 37

Option 37, also called the remote-ID option, is used to identify the client.

The DHCPv6 snooping device adds Option 37 to the received DHCPv6 request message before forwarding it to the DHCPv6 server. This option provides client information about address allocation.

Figure 7 Option 37 format

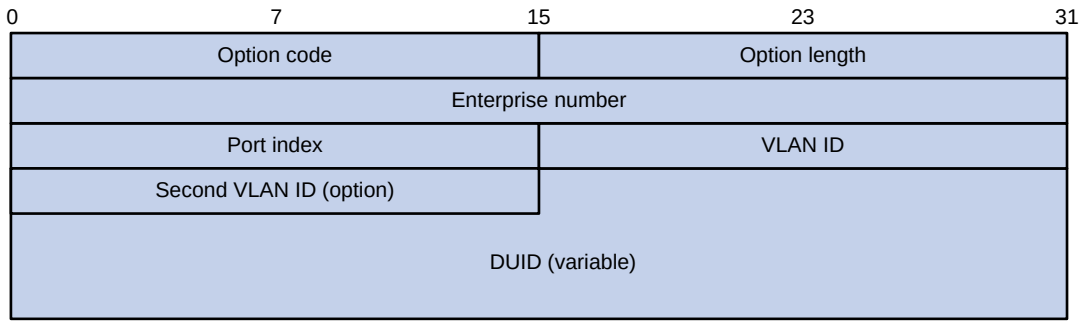


Figure 7 shows the Option 37 format, which includes the following fields:

- **Option code**—Option code. The value is 37.
- **Option length**—Size of the option data.
- **Enterprise number**—Enterprise number.
- **Port index**—Port that receives the DHCPv6 request from the client.
- **VLAN ID**—ID of the outer VLAN.
- **Second VLAN ID**—ID of the inner VLAN. This field is optional. If the received DHCPv6 request does not contain a second VLAN, Option 37 also does not contain it.
- **DUID**—DUID of the DHCPv6 client.

Option 79

Option 79, also called the client link-layer address option, is used to record the MAC address of the DHCPv6 client. The first relay agent that a DHCPv6 request passes learns the MAC address of the client and encapsulates this address into Option 79 in the Relay-Forward message for the request. The DHCPv6 server verifies the client or assigns IPv6 address/prefix to the client based on the MAC address of the client.

Figure 8 Option 79 format

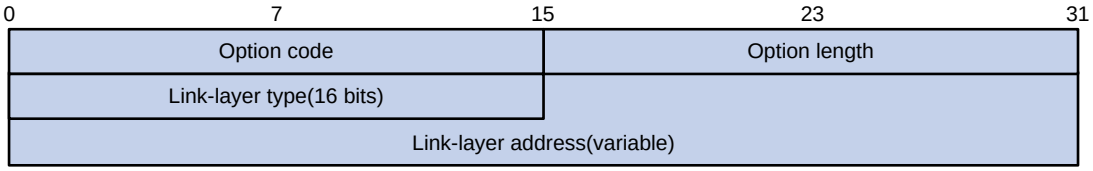


Figure 8 shows the Option 79 format, which includes the following fields:

- **Option code**—Option code. The value is 79.
- **Option length**—Size of the option data.
- **Link-layer type**—Link-layer address type of the client.
- **Link-layer address**—Link-layer address of the client.

Protocols and standards

- RFC 3736, *Stateless Dynamic Host Configuration Protocol (DHCP) Service for IPv6*
- RFC 3315, *Dynamic Host Configuration Protocol for IPv6 (DHCPv6)*
- RFC 2462, *IPv6 Stateless Address Autoconfiguration*
- RFC 3633, *IPv6 Prefix Options for Dynamic Host Configuration Protocol (DHCP) version 6*
- RFC 6939, *Client Link-Layer Address Option in DHCPv6*

Configuring the DHCPv6 server

About DHCPv6 server

A DHCPv6 server can assign IPv6 addresses, IPv6 prefixes, and other configuration parameters to DHCPv6 clients.

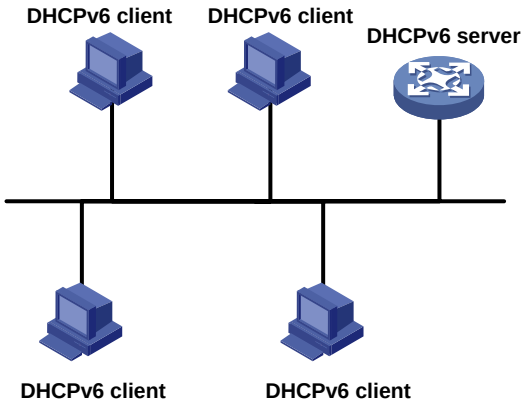
IPv6 address assignment

As shown in Figure 9, the DHCPv6 server assigns IPv6 addresses, domain name suffixes, DNS server addresses, and other configuration parameters to DHCPv6 clients.

The IPv6 addresses assigned to the clients include the following types:

- **Temporary IPv6 addresses**—Frequently changed without lease renewal.
- **Non-temporary IPv6 addresses**—Correctly used by DHCPv6 clients, with lease renewal.

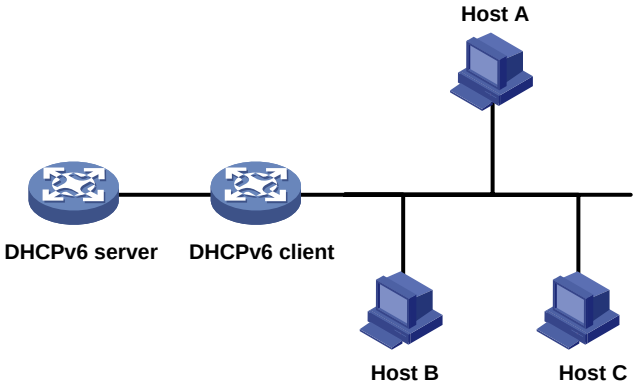
Figure 9 IPv6 address assignment



IPv6 prefix assignment

As shown in Figure 10, the DHCPv6 server assigns an IPv6 prefix to the DHCPv6 client. The client advertises the prefix information in a multicast RA message so that hosts on the subnet can automatically configure their IPv6 addresses by using the prefix.

Figure 10 IPv6 prefix assignment



Concepts

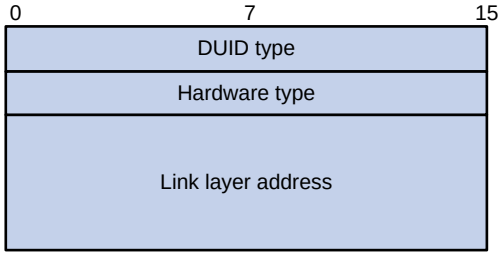
Multicast addresses used by DHCPv6

DHCPv6 uses the multicast address FF05::1:3 to identify all site-local DHCPv6 servers. It uses the multicast address FF02::1:2 to identify all link-local DHCPv6 servers and relay agents.

DUID

A DHCP unique identifier (DUID) uniquely identifies a DHCPv6 device (DHCPv6 client, server, or relay agent). A DHCPv6 device adds its DUID in a sent packet.

Figure 11 DUID-LL format



The device supports the DUID format based on link-layer address (DUID-LL) defined in RFC 3315. Figure 11 shows the DUID-LL format, which includes the following fields:

- **DUID type**—The device supports the DUID type of DUID-LL with the value of 0x0003.
- **Hardware type**—The device supports the hardware type of Ethernet with the value of 0x0001.
- **Link layer address**—Takes the value of the bridge MAC address of the device.

IA

Identified by an IAID, an identity association (IA) provides a construct through which a client manages the obtained addresses, prefixes, and other configuration parameters. A client can have multiple IAs, for example, one for each of its interfaces.

IAID

An IAID uniquely identifies an IA. It is chosen by the client and must be unique on the client.

PD

The DHCPv6 server creates a prefix delegation (PD) for each assigned prefix to record the following details:

- IPv6 prefix.
- Client DUID.
- IAID.
- Valid lifetime.
- Preferred lifetime.
- Lease expiration time.
- IPv6 address of the requesting client.

DHCPv6 address pool

The DHCP server selects IPv6 addresses, IPv6 prefixes, and other parameters from an address pool, and assigns them to the DHCP clients.

Address allocation mechanisms

DHCPv6 supports the following address allocation mechanisms:

- **Static address allocation**—To implement static address allocation for a client, create a DHCPv6 address pool, and manually bind the DUID and IAID of the client to an IPv6 address in the DHCPv6 address pool. When the client requests an IPv6 address, the DHCPv6 server assigns the IPv6 address in the static binding to the client.
- **Dynamic address allocation**—To implement dynamic address allocation for clients, create a DHCPv6 address pool, specify a subnet for the pool, and divide the subnet into temporary and non-temporary IPv6 address ranges. Upon receiving a DHCP request, the DHCPv6 server selects an IPv6 address from the temporary or non-temporary IPv6 address range based on the address type in the client request.

Prefix allocation mechanisms

DHCPv6 supports the following prefix allocation mechanisms:

- **Static prefix allocation**—To implement static prefix allocation for a client, create a DHCPv6 address pool, and manually bind the DUID and IAID of the client to an IPv6 prefix in the DHCPv6 address pool. When the client requests an IPv6 prefix, the DHCPv6 server assigns the IPv6 prefix in the static binding to the client.
- **Dynamic prefix allocation**—To implement dynamic prefix allocation for clients, create a DHCPv6 address pool and a prefix pool, specify a subnet for the address pool, and apply the prefix pool to the address pool. Upon receiving a DHCP request, the DHCPv6 server dynamically selects an IPv6 prefix from the prefix pool in the address pool.

Address pool selection

The DHCPv6 server observes the following principles when selecting an IPv6 address or prefix for a client:

1. If there is an address pool where an IPv6 address is statically bound to the DUID or IAID of the client, the DHCPv6 server selects this address pool. It assigns the statically bound IPv6 address or prefix and other configuration parameters to the client.
2. If the receiving interface has a DHCP policy and the DHCP client matches a user class, the DHCP server selects the address pool that is bound to the matching user class. If no matching user class is found, the server assigns an IP address and other parameters from the default DHCP address pool. If no default address pool is specified or the default address pool does not have assignable IP addresses, the address assignment fails.
3. If the receiving interface has an address pool applied, the DHCP server selects an IPv6 address or prefix and other configuration parameters from this address pool.
4. If the above conditions are not met, the DHCPv6 server selects an address pool depending on the client location.
    - **Client on the same subnet as the server**—The DHCPv6 server compares the IPv6 address of the receiving interface with the subnets of all address pools. It selects the address pool with the longest-matching subnet.
    - **Client on a different subnet than the server**—The DHCPv6 server compares the IPv6 address of the DHCPv6 relay agent interface closest to the client with the subnets of all address pools. It also selects the address pool with the longest-matching subnet.

    To make sure IPv6 address allocation functions correctly, keep the subnet used for dynamic assignment consistent with the subnet where the interface of the DHCPv6 server or DHCPv6 relay agent resides.

IPv6 address/prefix allocation sequence

The DHCPv6 server selects an IPv6 address/prefix for a client in the following sequence:

1. IPv6 address/prefix statically bound to the client's DUID and IAID and expected by the client.

2. IPv6 address/prefix statically bound to the client's DUID and IAID.
3. IPv6 address/prefix statically bound to the client's DUID and expected by the client.
4. IPv6 address/prefix statically bound to the client's DUID.
5. EUI-64 IPv6 address generated based on the client MAC address if EUI-64 address allocation is enabled.
6. Assignable IPv6 address/prefix in the address pool/prefix pool expected by the client.
7. IPv6 address/prefix that was ever assigned to the client.
8. Assignable IPv6 address/prefix in the address pool/prefix pool.
9. IPv6 address/prefix that was a conflict or passed its lease duration. If no IPv6 address/prefix is assignable, the server does not respond.

If a client moves to another subnet, the DHCPv6 server selects an IPv6 address/prefix from the address pool that matches the new subnet.

Conflicted IPv6 addresses can be assigned to other DHCPv6 clients only after the addresses are in conflict for one hour.

Restrictions: Hardware compatibility with DHCPv6 server

S5110V2-SI, S5000V3-EI, S5000V5-EI, S5000E-X, S5000X-EI, and WAS6000 do not support the DHCPv6 server functionality.

DHCPv6 server tasks at a glance

To configure the DHCPv6 server, perform the following tasks:

1. Configuring the DHCPv6 server to assign IPv6 prefixes, IPv6 addresses, and other network parameters

   Choose the following tasks as needed:

   - Configuring IPv6 prefix assignment
   - Configuring IPv6 address assignment
   - Configuring network parameters assignment
2. Modifying the address pool selection method on the DHCPv6 server

   Choose the following tasks as needed:

   - Configuring the DHCPv6 server on an interface
   - Configuring a DHCPv6 policy for IPv6 address and prefix assignment
3. (Optional.) Setting the DSCP value for DHCPv6 packets sent by the DHCPv6 server
4. (Optional.) Configuring DHCPv6 binding auto backup
5. (Optional.) Enabling the DHCPv6 server to advertise IPv6 prefixes
6. (Optional.) Enabling DHCPv6 logging on the DHCPv6 server

Configuring IPv6 prefix assignment

About IPv6 prefix assignment

Use the following methods to configure IPv6 prefix assignment:

- **Configure a static IPv6 prefix binding in an address pool**—If you bind a DUID and an IAID to an IPv6 prefix, the DUID and IAID in a request must match those in the binding before the

DHCPv6 server can assign the IPv6 prefix to the DHCPv6 client. If you only bind a DUID to an IPv6 prefix, the DUID in the request must match the DUID in the binding before the DHCPv6 server can assign the IPv6 prefix to the DHCPv6 client.

- **Apply a prefix pool to an address pool**—The DHCPv6 server dynamically assigns an IPv6 prefix from the prefix pool in the address pool to a DHCPv6 client.

Restrictions and guidelines

When you configure IPv6 prefix assignment, follow these restrictions and guidelines:

- An IPv6 prefix can be bound to only one DHCPv6 client. You cannot modify bindings that have been created. To change the binding for a DHCPv6 client, you must delete the existing binding first.
- One address pool can have only one prefix pool applied. You cannot modify prefix pools that have been applied. To change the prefix pool for an address pool, you must remove the prefix pool application first.
- You can apply a prefix pool that has not been created to an address pool. The setting takes effect after the prefix pool is created.

Procedure

1. Enter system view.

   system-view

2. (Optional.) Specify the IPv6 prefixes excluded from dynamic assignment.

   ipv6 dhcp server forbidden-prefix *start-prefix*/*prefix-len* [*end-prefix*/*prefix-len*]

   By default, no IPv6 prefixes in the prefix pool are excluded from dynamic assignment.

   If the excluded IPv6 prefix is in a static binding, the prefix still can be assigned to the client.

3. Create a prefix pool.

   ipv6 dhcp prefix-pool *prefix-pool-number* **prefix** { *prefix-number* | *prefix*/*prefix-len* } **assign-len** *assign-len*

   This step is required for dynamic prefix assignment.

   If you specify an IPv6 prefix by its ID, make sure the IPv6 prefix is in effect. Otherwise, the configuration does not take effect.

4. Enter DHCP address pool view.

   ipv6 dhcp pool *pool-name*

5. Specify an IPv6 subnet for dynamic assignment.

   network { *prefix/prefix-length* | **prefix** *prefix-number* [*sub-prefix/sub-prefix-length*] } [**preferred-lifetime** *preferred-lifetime* **valid-lifetime** *valid-lifetime*]

   By default, no IPv6 subnet is specified for dynamic assignment.

   The IPv6 subnets cannot be the same in different address pools.

   If you specify an IPv6 prefix by its ID, make sure the IPv6 prefix is in effect. Otherwise, the configuration does not take effect.

6. Configure the prefix assignment. Choose the options to configure as needed:

   - Configure a static prefix binding:

     static-bind prefix *prefix*/*prefix-len* **duid** *duid* [**iaid** *iaid*] [**preferred-lifetime** *preferred-lifetime* **valid-lifetime** *valid-lifetime*]

     By default, no static prefix binding is configured.

     To add multiple static IPv6 prefix bindings, repeat this step.

   - Apply the prefix pool to the address pool:

prefix-pool *prefix-pool-number* [**preferred-lifetime** *preferred-lifetime* **valid-lifetime** *valid-lifetime*]

By default, static or dynamic prefix assignment is not configured for an address pool.

Configuring IPv6 address assignment

About IPv6 address assignment

Use one of the following methods to configure IPv6 address assignment:

- Configure a static IPv6 address binding in an address pool.

  If you bind a DUID and an IAID to an IPv6 address, the DUID and IAID in a request must match those in the binding before the DHCPv6 server can assign the IPv6 address to the requesting client. If you only bind a DUID to an IPv6 address, the DUID in a request must match the DUID in the binding before the DHCPv6 server can assign the IPv6 address to the requesting client.
- Specify a subnet and address ranges in an address pool.
  - **Non-temporary address assignment**—The server selects addresses from the non-temporary address range specified by the **address range** command. If no non-temporary address range is specified, the server selects addresses on the subnet specified by the **network** command.
  - **Temporary address assignment**—The server selects addresses from the temporary address range specified by the **temporary address range** command. If no temporary address range is specified in the address pool, the DHCPv6 server cannot assign temporary addresses to clients.

Restrictions and guidelines

- You can specify only one non-temporary address range and one temporary address range in an address pool.
- The address ranges specified by the **address range** and **temporary address range** commands must be on the subnet specified by the **network** command. Otherwise, the addresses are unassignable.
- An IPv6 address can be bound to only one DHCPv6 client. You cannot modify bindings that have been created. To change the binding for a DHCPv6 client, you must delete the existing binding first.
- Only one subnet can be specified in an address pool. If you use the **network** command multiple times in a DHCPv6 address pool, the most recent configuration takes effect. If you use this command to specify only new lifetimes, the settings do not affect existing leases. The IPv6 addresses assigned after the modification will use the new lifetimes.

Procedure

1. Enter system view.

   system-view
2. (Optional.) Specify the IPv6 addresses excluded from dynamic assignment.

   ipv6 dhcp server forbidden-address *start-ipv6-address* [*end-ipv6-address*]

   By default, all IPv6 addresses except for the DHCPv6 server's IP address in a DHCPv6 address pool are assignable.

   If the excluded IPv6 address is in a static binding, the address still can be assigned to the client.
3. Enter DHCPv6 address pool view.

   ipv6 dhcp pool *pool-name*
4. Specify an IPv6 subnet for dynamic assignment.

network { *prefix/prefix-length* | **prefix** *prefix-number* [*sub-prefix/sub-prefix-length*] } [**preferred-lifetime** *preferred-lifetime* **valid-lifetime** *valid-lifetime*]

By default, no IPv6 address subnet is specified.

The IPv6 subnets cannot be the same in different address pools.

If you specify an IPv6 prefix by its ID, make sure the IPv6 prefix is in effect. Otherwise, the configuration does not take effect.

5. (Optional.) Specify a non-temporary IPv6 address range.

   address range *start-ipv6-address end-ipv6-address* [**preferred-lifetime** *preferred-lifetime* **valid-lifetime** *valid-lifetime*]

   By default, no non-temporary IPv6 address range is specified, and all unicast addresses on the subnet are assignable.

6. (Optional.) Specify a temporary IPv6 address range.

   temporary address range *start-ipv6-address end-ipv6-address* [**preferred-lifetime** *preferred-lifetime* **valid-lifetime** *valid-lifetime*]

   By default, no temporary IPv6 address range is specified, and the DHCPv6 server cannot assign temporary IPv6 addresses.

7. (Optional.) Enable EUI-64 address allocation mode.

   address-alloc-mode eui-64

   By default, EUI-64 address allocation mode is disabled.

   This feature enables the DHCPv6 server to obtain the client MAC address in the DHCP request and generates an EUI-64 IPv6 address to assign to the client.

8. (Optional.) Create a static binding.

   static-bind address *ipv6-address*/*addr-prefix-length* **duid** *duid* [**iaid** *iaid*] [**preferred-lifetime** *preferred-lifetime* **valid-lifetime** *valid-lifetime*]

   By default, no static binding is configured.

   To add more static bindings, repeat this step.

Configuring network parameters assignment

About network parameters assignment

In addition to IPv6 prefixes and IPv6 addresses, you can configure the following network parameters in an address pool:

- A maximum of eight DNS server addresses.
- One domain name.
- A maximum of eight SIP server addresses.
- A maximum of eight SIP server domain names.

You can configure network parameters on a DHCPv6 server by using one of the following methods:

- Configure network parameters in a DHCPv6 address pool.
- Configure network parameters in a DHCPv6 option group, and specify the option group for a DHCPv6 address pool.

Network parameters configured in a DHCPv6 address pool take precedence over those configured in a DHCPv6 option group.

Configuring network parameters in a DHCPv6 address pool

1. Enter system view.
   system-view
2. Enter DHCPv6 address pool view.
   ipv6 dhcp pool *pool-name*
3. Specify an IPv6 subnet for dynamic assignment.
   network { *prefix/prefix-length* | **prefix** *prefix-number* [*sub-prefix/sub-prefix-length*] } [**preferred-lifetime** *preferred-lifetime* **valid-lifetime** *valid-lifetime*]
   By default, no IPv6 subnet is specified.
   The IPv6 subnets cannot be the same in different address pools.
   If you specify an IPv6 prefix by its ID, make sure the IPv6 prefix is in effect. Otherwise, the configuration does not take effect.
4. Specify a DNS server address.
   dns-server *ipv6-address*
   By default, no DNS server address is specified.
5. Specify a domain name.
   domain-name *domain-name*
   By default, no domain name is specified.
6. Specify a SIP server address or domain name.
   sip-server { **address** *ipv6-address* | **domain-name** *domain-name* }
   By default, no SIP server address or domain name is specified.
7. Configure a self-defined DHCPv6 option.
   option *code* **hex** *hex-string*
   By default, no self-defined DHCPv6 option is configured.

Configuring network parameters in a DHCPv6 option group

About network parameters assignment in a DHCPv6 option group

A DHCPv6 option group can be created by using the following methods:

- Create a static DHCPv6 option group by using the **ipv6 dhcp option-group** command. The static DHCPv6 option group takes precedence over the dynamic DHCPv6 option group.
- When the device acts as a DHCPv6 client, it automatically creates a dynamic DHCPv6 option group for saving the obtained parameters. For more information about creating a dynamic DHCPv6 option group, see "Configuring the DHCPv6 client."

Procedure

1. Enter system view.
   system-view
2. Create a static DHCPv6 option group and enter its view.
   ipv6 dhcp option-group *option-group-number*
3. Specify a DNS server address.
   dns-server *ipv6-address*
   By default, no DNS server address is specified.
4. Specify a domain name suffix.

domain-name *domain-name*

By default, no domain name suffix is specified.

5. Specify a SIP server address or domain name.

   sip-server { **address** *ipv6-address* | **domain-name** *domain-name* }

   By default, no SIP server address or domain name is specified.

6. Configure a self-defined DHCPv6 option.

   option *code* **hex** *hex-string*

   By default, no self-defined DHCPv6 option is configured.

7. Return to system view.

   quit

8. Enter DHCPv6 address pool view.

   ipv6 dhcp pool *pool-name*

9. Specify a DHCPv6 option group.

   option-group *option-group-number*

   By default, no DHCPv6 option group is specified.

Configuring the DHCPv6 server on an interface

About configuring the DHCPv6 server on an interface

Enable the DHCP server and configure one of the following address/prefix assignment methods on an interface:

- **Apply an address pool on the interface**—The DHCPv6 server selects an IPv6 address/prefix from the applied address pool for a requesting client. If there is no assignable IPv6 address/prefix in the address pool, the DHCPv6 server cannot assign an IPv6 address/prefix to a client.
- **Configure global address assignment on the interface**—The DHCPv6 server selects an IPv6 address/prefix in the global DHCPv6 address pool that matches the server interface address or the DHCPv6 relay agent address for a requesting client.

If you configure both methods on an interface, the DHCPv6 server uses the specified address pool for address assignment without performing global address assignment.

Restrictions and guidelines

- An interface cannot act as a DHCPv6 server and DHCPv6 relay agent at the same time.
- Do not enable DHCPv6 server and DHCPv6 client on the same interface.
- You can apply an address pool that has not been created to an interface. The setting takes effect after the address pool is created.

Procedure

1. Enter system view.

   system-view

2. Enter interface view.

   interface *interface-type interface-number*

3. Enable the DHCPv6 server on the interface.

   ipv6 dhcp select server

   By default, the interface does not act as a DHCP server or a DHCP relay agent, and discards DHCPv6 packets from DHCPv6 clients.

4. Configure an assignment method.

- Configure global address assignment.

  ipv6 dhcp server { **allow-hint** | **preference** *preference-value* | **rapid-commit** } *

  By default, desired address/prefix assignment and rapid assignment are disabled, and the default preference is 0.
- Apply a DHCPv6 address pool to the interface.

  ipv6 dhcp server apply pool *pool-name* [**allow-hint** | **preference** *preference-value* | **rapid-commit**] *

Configuring a DHCPv6 policy for IPv6 address and prefix assignment

About DHCPv6 policy for IPv6 address and prefix assignment

In a DHCPv6 policy, each DHCPv6 user class has a bound DHCPv6 address pool. Clients matching different user classes obtain IPv6 addresses, IPv6 prefixes, and other parameters from different address pools. When receiving a DHCPv6 request, the DHCPv6 server compares the packet against the user classes in the order that they are configured.

If a match is found and the bound address pool has assignable IPv6 addresses or prefixes, the server uses the address pool for assignment. If the bound address pool does not have assignable IPv6 addresses or prefixes, the assignment fails.

If no match is found, the server uses the default DHCPv6 address pool for assignment. If no default address pool is specified or the default address pool does not have assignable IPv6 addresses or prefixes, the assignment fails.

For successful assignment, make sure the applied DHCPv6 policy and the bound address pools exist.

A match rule cannot match an option added by the DHCPv6 device, for example, Option 18 or Option 37.

Procedure

1. Enter system view.

   system-view
2. Create a DHCPv6 user class and enter DHCPv6 user class view.

   ipv6 dhcp class *class-name*
3. Configure a match rule for the DHCPv6 user class.

   if-match rule *rule-number* { **option** *option-code* [**ascii** *ascii-string* [**offset** *offset* | **partial**] | **hex** *hex-string* [**mask** *mask* | **offset** *offset* **length** *length* | **partial**]] | **relay-agent** *gateway-ipv6-address* }

   By default, no match rule is configured for a DHCPv6 user class.
4. Return to system view.

   quit
5. Create a DHCPv6 policy and enter DHCPv6 policy view.

   ipv6 dhcp policy *policy-name*

   The DHCPv6 policy takes effect only after it is applied to the interface that acts as the DHCPv6 server.
6. Specify a DHCPv6 address pool for a DHCPv6 user class.

   class *class-name* **pool** *pool-name*

   By default, no address pool is specified for a user class.

7. (Optional.) Specify the default DHCPv6 address pool.

   default pool *pool-name*

   By default, the default address pool is not specified.
8. Return to system view.

   quit
9. Enter interface view.

   interface *interface-type interface-number*
10. Apply the DHCPv6 policy to the interface.

    ipv6 dhcp apply-policy *policy-name*

    By default, no DHCPv6 policy is applied to an interface.

Setting the DSCP value for DHCPv6 packets sent by the DHCPv6 server

About setting the DSCP value for DHCPv6 packets sent by the DHCPv6 server

The DSCP value of a packet specifies the priority level of the packet and affects the transmission priority of the packet.

Procedure

1. Enter system view.

   system-view
2. Set the DSCP value for DHCPv6 packets sent by the DHCPv6 server.

   ipv6 dhcp dscp *dscp-value*

   By default, the DSCP value in DHCPv6 packets sent by the DHCPv6 server is 56.

Configuring DHCPv6 binding auto backup

About DHCPv6 binding auto backup

The auto backup feature saves DHCPv6 bindings to a backup file, and allows the DHCPv6 server to download the bindings from the backup file at the server reboot. The bindings include the lease bindings and conflicted IPv6 addresses. They cannot survive a reboot on the DHCPv6 server.

The DHCPv6 server does not provide services during the download process. If a connection error occurs during the process and cannot be repaired in a short amount of time, you can terminate the download operation. Manual interruption allows the DHCPv6 server to provide services without waiting for the connection to be repaired.

Procedure

1. Enter system view.

   system-view
2. Configure the DHCPv6 server to back up the bindings to a file.

   ipv6 dhcp server database filename { *filename* | **url** *url* [**username** *username* [**password** { **cipher** | **simple** } *string*]] }

   By default, the DHCPv6 server does not back up the DHCPv6 bindings.

   With this command executed, the DHCPv6 server backs up its bindings immediately and runs auto backup.
3. (Optional.) Manually save the DHCPv6 bindings to the backup file.

ipv6 dhcp server database update now

4. (Optional.) Set the waiting time after a DHCPv6 binding change for the DHCPv6 server to update the backup file.

   ipv6 dhcp server database update interval *interval*

   By default, the DHCP server waits 300 seconds to update the backup file after a DHCP binding change. If no DHCP binding changes, the backup file is not updated.

5. (Optional.) Terminate the download of DHCPv6 bindings from the backup file.

   ipv6 dhcp server database update stop

   This command only triggers one termination.

Enabling the DHCPv6 server to advertise IPv6 prefixes

About IPv6 prefixes advertisement

A DHCPv6 client can obtain an IPv6 prefix through DHCPv6 and use this IPv6 prefix to assign IPv6 addresses for clients in a downstream network. If the IPv6 prefix is in a different subnet than the IPv6 address of the DHCPv6 client's upstream interface, the clients in the downstream network cannot access the external network. If the DHCPv6 server is on the same link as the DHCPv6 client, enable the DHCPv6 server to advertise the IPv6 prefix.

Procedure

1. Enter system view.

   system-view

2. Enable the DHCPv6 server to advertise IPv6 prefixes.

   ipv6 dhcp advertise pd-route

   By default, the DHCPv6 server does not advertise IPv6 prefixes.

Enabling DHCPv6 logging on the DHCPv6 server

About DHCPv6 server logging

The DHCPv6 logging feature enables the DHCPv6 server to generate DHCPv6 logs and send them to the information center. The information helps administrators locate and solve problems. For information about the log destination and output rule configuration in the information center, see *Network Management and Monitoring Configuration Guide*.

Restrictions and guidelines

As a best practice, disable this feature if the log generation affects the device performance or reduces the address and prefix allocation efficiency. For example, this situation might occur when a large number of clients frequently come online or go offline.

Procedure

1. Enter system view.

   system-view

2. Enable DHCPv6 logging.

   ipv6 dhcp log enable

   By default, DHCPv6 logging is disabled.

Display and maintenance commands for DHCPv6 server

Execute **display** commands in any view and **reset** commands in user view.

Task	Command
Display the DUID of the local device.	**display ipv6 dhcp duid**
Display information about a DHCPv6 option group.	**display ipv6 dhcp option-group** [*option-group-number*]
Display DHCPv6 address pool information.	**display ipv6 dhcp pool** [*pool-name*]
Display prefix pool information.	**display ipv6 dhcp prefix-pool** [*prefix-pool-number*]
Display DHCPv6 server information on an interface.	**display ipv6 dhcp server** [**interface** *interface-type interface-number*]
Display information about IPv6 address conflicts.	**display ipv6 dhcp server conflict** [**address** *ipv6-address*]
Display information about DHCPv6 binding auto backup	**display ipv6 dhcp server database**
Display information about expired IPv6 addresses.	**display ipv6 dhcp server expired** [**address** *ipv6-address* | **pool** *pool-name*]
Display information about IPv6 address bindings.	**display ipv6 dhcp server ip-in-use** [**address** *ipv6-address* | **pool** *pool-name*]
Display information about IPv6 prefix bindings.	**display ipv6 dhcp server pd-in-use** [**pool** *pool-name* | [**prefix** *prefix/prefix-len*]]
Display packet statistics on the DHCPv6 server.	**display ipv6 dhcp server statistics** [**pool** *pool-name*]
Clear information about IPv6 address conflicts.	**reset ipv6 dhcp server conflict** [**address** *ipv6-address*]
Clear information about expired IPv6 address bindings.	**reset ipv6 dhcp server expired** [**address** *ipv6-address* | **pool** *pool-name*]
Clear information about IPv6 address bindings.	**reset ipv6 dhcp server ip-in-use** [**address** *ipv6-address* | **pool** *pool-name*]
Clear information about IPv6 prefix bindings.	**reset ipv6 dhcp server pd-in-use** [**pool** *pool-name* | **prefix** *prefix/prefix-len*]
Clear packets statistics on the DHCPv6 server.	**reset ipv6 dhcp server statistics**

DHCPv6 server configuration examples

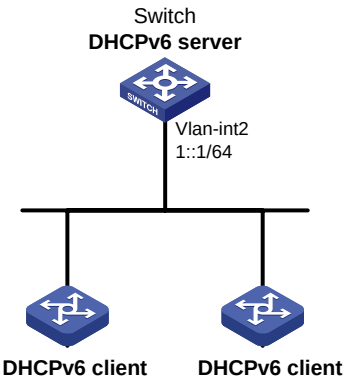
Example: Configuring dynamic IPv6 prefix assignment

Network configuration

As shown in Figure 12, the switch acts as a DHCPv6 server to assign an IPv6 prefix, a DNS server address, a domain name, a SIP server address, and a SIP server name to each DHCPv6 client.

The switch assigns prefix 2001:0410:0201::/48 to the client whose DUID is 00030001CA0006A40000, and assigns prefixes in the range of 2001:0410::/48 to 2001:0410:FFFF::/48 (excluding 2001:0410:0201::/48) to other clients. The DNS server address is 2::2:3. The DHCPv6 clients reside in the domain **aaa.com**. The SIP server address is 2:2::4, and the SIP server name is **bbb.com**.

Figure 12 Network diagram



Procedure

Specify an IPv6 address for VLAN-interface 2.

```
<Switch> system-view
[Switch] interface vlan-interface 2
[Switch-Vlan-interface2] ipv6 address 1::1/64
```

Disable RA message suppression on VLAN-interface 2.

```
[Switch-Vlan-interface2] undo ipv6 nd ra halt
```

Set the M flag to 1 in RA advertisements to be sent on VLAN-interface 2. Hosts that receive the RA advertisements will obtain IPv6 addresses through DHCPv6.

```
[Switch-Vlan-interface2] ipv6 nd autoconfig managed-address-flag
```

Set the O flag to 1 in RA advertisements to be sent on VLAN-interface 2. Hosts that receive the RA advertisements will obtain information other than IPv6 address through DHCPv6.

```
[Switch-Vlan-interface2] ipv6 nd autoconfig other-flag
[Switch-Vlan-interface2] quit
```

Create prefix pool 1, and specify the prefix 2001:0410::/32 with the assigned prefix length 48.

```
[Switch] ipv6 dhcp prefix-pool 1 prefix 2001:0410::/32 assign-len 48
```

Create address pool 1.

```
[Switch] ipv6 dhcp pool 1
```

In address pool 1, configure subnet 1::/64 where VLAN interface-2 resides.

```
[Switch-dhcp6-pool-1] network 1::/64
```

Apply prefix pool 1 to address pool 1, and set the preferred lifetime to one day, and the valid lifetime to three days.

```
[Switch-dhcp6-pool-1] prefix-pool 1 preferred-lifetime 86400 valid-lifetime 259200
```

In address pool 1, bind prefix 2001:0410:0201::/48 to the client DUID 00030001CA0006A40000, and set the preferred lifetime to one day, and the valid lifetime to three days.

```
[Switch-dhcp6-pool-1] static-bind prefix 2001:0410:0201::/48 duid 00030001CA0006A40000
preferred-lifetime 86400 valid-lifetime 259200
```

Configure the DNS server address 2:2::3.

```
[Switch-dhcp6-pool-1] dns-server 2:2::3
```

Configure the domain name as aaa.com.

```
[Switch-dhcp6-pool-1] domain-name aaa.com
```

Configure the SIP server address as 2:2::4, and the SIP server name as bbb.com.

```
[Switch-dhcp6-pool-1] sip-server address 2:2::4
[Switch-dhcp6-pool-1] sip-server domain-name bbb.com
[Switch-dhcp6-pool-1] quit
```

Enable the DHCPv6 server on VLAN-interface 2, enable desired prefix assignment and rapid prefix assignment, and set the preference to the highest.

```
[Switch] interface vlan-interface 2
[Switch-Vlan-interface2] ipv6 dhcp select server
[Switch-Vlan-interface2] ipv6 dhcp server allow-hint preference 255 rapid-commit
```

Verifying the configuration

Display DHCPv6 server configuration on VLAN-interface 2.

```
[Switch-Vlan-interface2] display ipv6 dhcp server interface vlan-interface 2
Using pool: global
Preference value: 255
Allow-hint: Enabled
Rapid-commit: Enabled
```

Display information about address pool 1.

```
[Switch-Vlan-interface2] display ipv6 dhcp pool 1
DHCPv6 pool: 1
  Network: 1::/64
    Preferred lifetime 604800 seconds, valid lifetime 2592000 seconds
  Prefix pool: 1
    Preferred lifetime 86400 seconds, valid lifetime 259200 seconds
  Static bindings:
    DUID: 00030001ca0006a40000
    IAID: Not configured
    Prefix: 2001:410:201::/48
      Preferred lifetime 86400 seconds, valid lifetime 259200 seconds
  DNS server addresses:
    2:2::3
  Domain name:
    aaa.com
  SIP server addresses:
    2:2::4
  SIP server domain names:
    bbb.com
```

Display information about prefix pool 1.

```
[Switch-Vlan-interface2] display ipv6 dhcp prefix-pool 1
Prefix: 2001:410::/32
Assigned length: 48
Total prefix number: 65536
Available: 65535
In-use: 0
Static: 1
```

After the client with the DUID 00030001CA0006A40000 obtains an IPv6 prefix, display the binding information on the DHCPv6 server.

```
[Switch-Vlan-interface2] display ipv6 dhcp server pd-in-use
Pool: 1
 IPv6 prefix                              Type      Lease expiration
 2001:410:201::/48                        Static(C) Jul 10 19:45:01 2009
```

After the other client obtains an IPv6 prefix, display binding information on the DHCPv6 server.

```
[Switch-Vlan-interface2] display ipv6 dhcp server pd-in-use
Pool: 1
 IPv6 prefix                              Type      Lease expiration
 2001:410:201::/48                        Static(C) Jul 10 19:45:01 2009
 2001:410::/48                            Auto(C)   Jul 10 20:44:05 2009
```

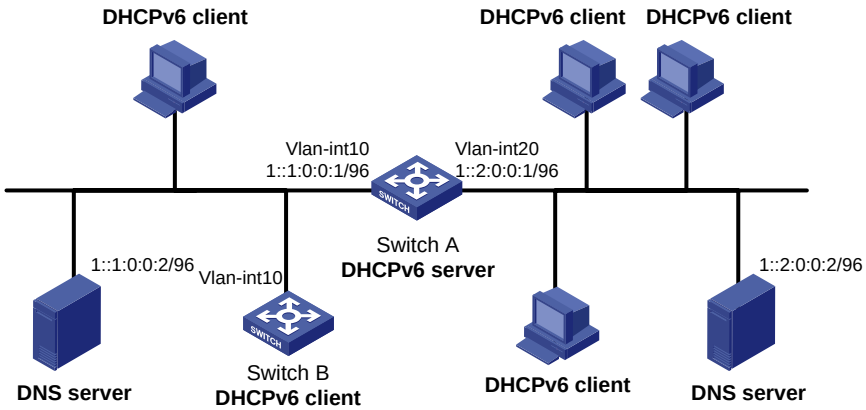
Example: Configuring dynamic IPv6 address assignment

Network configuration

As shown in Figure 13, Switch A acts as a DHCPv6 server to assign IPv6 addresses to the clients on subnets 1::1:0:0:0/96 and 1::2:0:0:0/96.

On Switch A, configure the IPv6 address 1::1:0:0:1/96 for VLAN-interface 10 and 1::2:0:0:1/96 for VLAN-interface 20. The lease duration of the addresses on subnet 1::1:0:0:0/96 is 172800 seconds (two days), the valid time is 345600 seconds (four days), the domain name suffix is aabbcc.com, and the DNS server address is 1::1:0:0:2/96. The lease duration of the addresses on subnet 1::2:0:0:0/96 is 432000 seconds (five days), the valid time is 864000 seconds (ten days), the domain name is aabbcc.com, and the DNS server address is 1::2:0:0:2/96.

Figure 13 Network diagram



Procedure

1. Configure the interfaces on the DHCPv6 server:

Specify an IPv6 address for VLAN-interface 10.

```
<SwitchA> system-view
[SwitchA] interface vlan-interface 10
[SwitchA-Vlan-interface10] ipv6 address 1::1:0:0:1/96
```

Disable RA message suppression on VLAN-interface 10.

```
[SwitchA-Vlan-interface10] undo ipv6 nd ra halt
```

Set the M flag to 1 in RA advertisements to be sent on VLAN-interface 10. Hosts that receive the RA advertisements will obtain IPv6 addresses through DHCPv6.

```
[SwitchA-Vlan-interface10] ipv6 nd autoconfig managed-address-flag
```

Set the O flag to 1 in RA advertisements to be sent on VLAN-interface 10. Hosts that receive the RA advertisements will obtain information other than IPv6 address through DHCPv6.

```
[SwitchA-Vlan-interface10] ipv6 nd autoconfig other-flag
[SwitchA-Vlan-interface10] quit
```

Specify an IPv6 address for VLAN-interface 20.

```
[SwitchA] interface vlan-interface 20
[SwitchA-Vlan-interface20] ipv6 address 1::2:0:0:1/96
```

Disable RA message suppression on VLAN-interface 20.

```
[SwitchA-Vlan-interface20] undo ipv6 nd ra halt
```

Set the M flag to 1 in RA advertisements to be sent on VLAN-interface 20. Hosts that receive the RA advertisements will obtain IPv6 addresses through DHCPv6.

```
[SwitchA-Vlan-interface20] ipv6 nd autoconfig managed-address-flag
```

Set the O flag to 1 in RA advertisements to be sent on VLAN-interface 20. Hosts that receive the RA advertisements will obtain information other than IPv6 address through DHCPv6.

```
[SwitchA-Vlan-interface20] ipv6 nd autoconfig other-flag
[SwitchA-Vlan-interface20] quit
```

2. Enable DHCPv6:

Enable DHCPv6 server on VLAN-interface 10 and VLAN-interface 20.

```
[SwitchA] interface vlan-interface 10
[SwitchA-Vlan-interface10] ipv6 dhcp select server
[SwitchA-Vlan-interface10] quit
[SwitchA] interface vlan-interface 20
[SwitchA-Vlan-interface20] ipv6 dhcp select server
[SwitchA-Vlan-interface20] quit
```

Exclude the DNS server addresses from dynamic assignment.

```
[SwitchA] ipv6 dhcp server forbidden-address 1::1:0:0:2
[SwitchA] ipv6 dhcp server forbidden-address 1::2:0:0:2
```

Configure the DHCPv6 address pool 1 to assign IPv6 addresses and other configuration parameters to clients on subnet 1::1:0:0:0/96.

```
[SwitchA] ipv6 dhcp pool 1
[SwitchA-dhcp6-pool-1] network 1::1:0:0:0/96 preferred-lifetime 172800
valid-lifetime 345600
[SwitchA-dhcp6-pool-1] domain-name aabbcc.com
[SwitchA-dhcp6-pool-1] dns-server 1::1:0:0:2
[SwitchA-dhcp6-pool-1] quit
```

Configure the DHCPv6 address pool 2 to assign IPv6 addresses and other configuration parameters to clients on subnet 1::2:0:0:0/96.

```
[SwitchA] ipv6 dhcp pool 2
[SwitchA-dhcp6-pool-2] network 1::2:0:0:0/96 preferred-lifetime 432000
valid-lifetime 864000
```

```
[SwitchA-dhcp6-pool-2] domain-name aabbcc.com
[SwitchA-dhcp6-pool-2] dns-server 1::2:0:0:2
[SwitchA-dhcp6-pool-2] quit
```

Verifying the configuration

Verify that the clients on subnets 1::1:0:0:0/96 and 1::2:0:0:0/96 can obtain IPv6 addresses and all other configuration parameters from the DHCPv6 server (Switch A). (Details not shown.)

On the DHCPv6 server, display IPv6 addresses assigned to the DHCPv6 clients.

```
[SwitchA] display ipv6 dhcp server ip-in-use
```

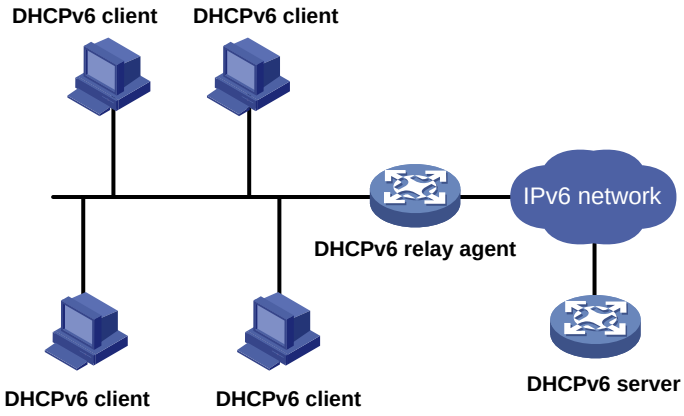
Configuring the DHCPv6 relay agent

About DHCPv6 relay agent

Typical application

A DHCPv6 client usually uses a multicast address to contact the DHCPv6 server on the local link to obtain an IPv6 address and other configuration parameters. As shown in Figure 14, if the DHCPv6 server resides on another subnet, the DHCPv6 clients need a DHCPv6 relay agent to contact the server. The relay agent feature avoids deploying a DHCPv6 server on each subnet.

Figure 14 Typical DHCPv6 relay agent application

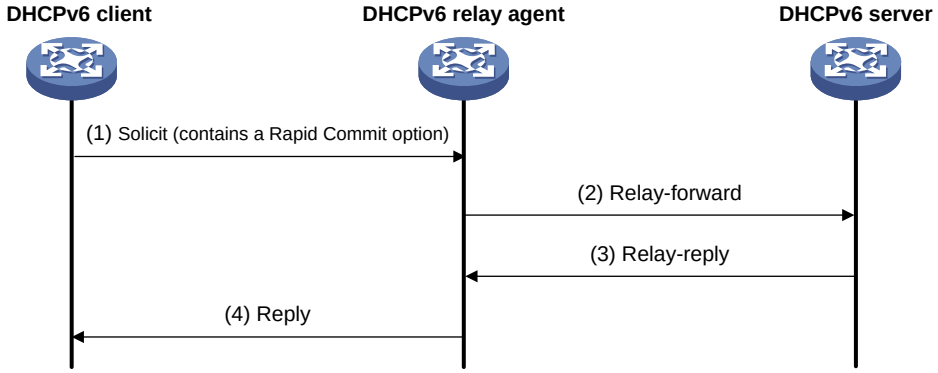


DHCPv6 relay agent operating process

As shown in Figure 15, a DHCPv6 client obtains an IPv6 address and other network configuration parameters from a DHCPv6 server through a DHCPv6 relay agent. The following example uses rapid assignment to describe the process:

- The DHCPv6 client sends a Solicit message containing the Rapid Commit option to the multicast address FF02::1:2 of all the DHCPv6 servers and relay agents.
- After receiving the Solicit message, the DHCPv6 relay agent encapsulates the message into the Relay Message option of a Relay-forward message, and sends the message to the DHCPv6 server.
- After obtaining the Solicit message from the Relay-forward message, the DHCPv6 server performs the following tasks:
  - Selects an IPv6 address and other required parameters.
  - Adds them to a reply that is encapsulated within the Relay Message option of a Relay-reply message.
  - Sends the Relay-reply message to the DHCPv6 relay agent.
- The DHCPv6 relay agent obtains the reply from the Relay-reply message and sends the reply to the DHCPv6 client.
- The DHCPv6 client uses the IPv6 address and other network parameters assigned by the DHCPv6 server to complete network configuration.

Figure 15 Operating process of a DHCPv6 relay agent



DHCPv6 relay agent tasks at a glance

To configure a DHCPv6 relay agent, perform the following tasks:

1. Enabling the DHCPv6 relay agent on an interface
2. Specifying DHCPv6 servers on the relay agent
3. (Optional.) Specifying a gateway address for DHCPv6 clients
4. (Optional.) Setting the DSCP value for DHCPv6 packets sent by the DHCPv6 relay agent
5. (Optional.) Specifying a padding mode for the Interface-ID option
6. (Optional.) Enabling the DHCPv6 relay agent to support Option 79
7. (Optional.) Enabling the DHCPv6 relay agent to advertise IPv6 prefixes
8. (Optional.) Enabling the DHCPv6 relay agent to advertise host routes for assigned IPv6 addresses
9. (Optional.) Specifying the source IPv6 address for relayed DHCPv6 requests

Enabling the DHCPv6 relay agent on an interface

Restrictions and guidelines

As a best practice, do not enable DHCPv6 relay agent and DHCPv6 client on the same interface.

Procedure

1. Enter system view.
   `system-view`
2. Enter interface view.
   `interface` *`interface-type interface-number`*
3. Enable DHCPv6 relay agent on the interface.
   `ipv6 dhcp select relay`
   By default, the DHCPv6 relay agent is disabled on the interface.

Specifying DHCPv6 servers on the relay agent

Specifying DHCPv6 server IP addresses

Restrictions and guidelines

- You can use the **ipv6 dhcp relay server-address** command to specify a maximum of eight DHCPv6 servers on the DHCPv6 relay agent interface. The DHCPv6 relay agent forwards DHCP requests to all the specified DHCPv6 servers.
- If a DHCPv6 server address is a link-local address or multicast address, you must specify an outgoing interface by using the **interface** keyword in this command. Otherwise, DHCPv6 packets might fail to reach the DHCPv6 server.

Procedure

1. Enter system view.

   system-view
2. Enter interface view.

   interface *interface-type interface-number*
3. Specify a DHCPv6 server.

   ipv6 dhcp relay server-address *ipv6-address* [**interface** *interface-type interface-number*]

   By default, no DHCPv6 server is specified.

Specifying DHCPv6 servers for a DHCPv6 address pool on the DHCPv6 relay agent

About specifying DHCPv6 servers for a DHCPv6 address pool on the DHCPv6 relay agent

This feature allows DHCPv6 clients of the same type to obtain IPv6 addresses, IPv6 prefixes, and other configuration parameters from the DHCPv6 servers in the matching DHCPv6 address pool.

It applies to scenarios where the DHCPv6 relay agent connects to clients of the same access type but classified into different types by their locations. In this case, the relay interface typically has no IPv6 address configured. You can use the **gateway-list** command to specify the gateway addresses for clients matching the same DHCPv6 address pool.

Upon receiving a DHCPv6 Solicit or Request from a client that matches a DHCPv6 address pool, the relay agent processes the packet as follows:

- Fills the **link-address** field of the packet with a specified gateway address.
- Forwards the packet to all DHCPv6 servers in the matching DHCPv6 address pool.

The DHCPv6 servers select a DHCPv6 address pool according to the gateway address.

Restrictions and guidelines

- You can specify a maximum of eight DHCPv6 servers for one DHCPv6 address pool for high availability. The relay agent forwards DHCPv6 Solicit and Request packets to all DHCPv6 servers in the DHCPv6 address pool.
- If this feature is used in the PPPoE scenario, execute the **ipv6 dhcp relay client-information record** command to enable the DHCPv6 relay agent to record relay entries. When a PPPoE user gets offline, the DHCPv6 relay agent locates the matching relay entry and sends a Release message to the DHCPv6 server.

- If this feature is used in the PPPoE scenario, you do not need to execute the **ipv6 dhcp select relay** command. This is because the **remote-server** command is a must in this configuration task and it implies that this device is a relay device.

Procedure

1. Enter system view.
   system-view
2. Create a DHCPv6 address pool and enter its view.
   ipv6 dhcp pool *pool-name*
3. Specify gateway addresses for the clients matching the DHCPv6 address pool.
   gateway-list *ipv6-address*&<1-8>
   By default, no gateway address is specified.
4. Specify DHCPv6 servers for the DHCPv6 address pool.
   remote-server *ipv6-address* [**interface** *interface-type interface-number*]
   By default, no DHCPv6 server is specified for the DHCPv6 address pool.

Specifying a gateway address for DHCPv6 clients

About specifying a gateway address for DHCPv6 client

By default, the DHCPv6 relay agent fills the **link-address** field of DHCPv6 Solicit and Request packets with the first IPv6 address of the relay interface. You can specify a gateway address on the relay agent for DHCPv6 clients. The DHCPv6 relay agent uses the specified gateway address to fill the **link-address** field of DHCPv6 Solicit and Request packets.

Procedure

1. Enter system view.
   system-view
2. Enter interface view.
   interface *interface-type interface-number*
3. Specify a gateway address for DHCPv6 clients.
   ipv6 dhcp relay gateway *ipv6-address*
   By default, the DHCPv6 relay agent uses the first IPv6 address of the relay interface as the clients' gateway address.

Setting the DSCP value for DHCPv6 packets sent by the DHCPv6 relay agent

About setting the DSCP value for DHCPv6 packets

The DSCP value of a packet specifies the priority level of the packet and affects the transmission priority of the packet.

Procedure

1. Enter system view.
   system-view
2. Set the DSCP value for DHCPv6 packets sent by the DHCPv6 relay agent.
   ipv6 dhcp dscp *dscp-value*

The default DSCP value is 56.

Specifying a padding mode for the Interface-ID option

About specifying a padding mode for the Interface-ID option

This feature enables the relay agent to fill the Interface-ID option in the specified mode. When receiving a DHCPv6 packet from a client, the relay agent fills the Interface-ID option in the mode and then forwards the packet to the DHCPv6 server.

Procedure

1. Enter system view.
   system-view
2. Enter interface view.
   interface *interface-type interface-number*
3. Specify a padding mode for the Interface-ID option.
   ipv6 dhcp relay interface-id { **bas** | **interface** }
   By default, the relay agent fills the Interface-ID option with the interface index of the interface.

Enabling the DHCPv6 relay agent to support Option 79

About enabling the DHCPv6 relay agent to support Option 79

If DHCPv6 relay agents exist in the network, the DHCPv6 server needs the MAC address of the DHCPv6 client for authentication or for IPv6 address or prefix assignment. To meet the requirement, enable the DHCPv6 relay agent that the client first passes to support Option 79. This feature allows the DHCPv6 relay agent to learn the MAC address in the client request. When the relay agent generates a Relay-Forward packet for the request, it fills the MAC address of the client in Option 79. The Relay-Forward packet is then forwarded to the DHCPv6 server.

Procedure

1. Enter system view.
   system-view
2. Enter interface view.
   interface *interface-type interface-number*
3. Enable the DHCPv6 relay agent to support Option 79.
   ipv6 dhcp relay client-link-address enable
   By default, the DHCPv6 relay agent does not support Option 79.

Enabling the DHCPv6 relay agent to advertise IPv6 prefixes

About enabling the DHCPv6 relay agent to advertise IPv6 prefixes

A DHCPv6 client can obtain an IPv6 prefix through DHCPv6 and use this IPv6 prefix to assign IPv6 address to clients in a downstream network. If the IPv6 prefix is in a different subnet than the IPv6

address of the DHCPv6 client's upstream interface, the clients in the downstream network cannot access the external network. You can enable the DHCPv6 relay agent that is on the same link as the DHCPv6 client to advertise the IPv6 prefix.

Procedure

1. Enter system view.

   `system-view`

2. Enable the DHCPv6 relay agent to advertise IPv6 prefixes.

   `ipv6 dhcp advertise pd-route`

   By default, the DHCPv6 relay agent does not advertise IPv6 prefixes.

   Before using this command, make sure the DHCPv6 relay agent is enabled to record DHCPv6 relay entries.

Enabling the DHCPv6 relay agent to advertise host routes for assigned IPv6 addresses

About enabling the DHCPv6 relay agent to advertise host routes for assigned IPv6 addresses

In a network where ND cannot resolve global unicast addresses, network devices cannot generate ND entries for all global unicast addresses. If a DHCPv6 client obtains a global unicast address, the neighboring devices do not have the ND entries for this global unicast address, thus cannot forward the packets destined for the client. To resolve this problem, enable the DHCPv6 relay agent to advertise host routes for assigned IPv6 addresses in DHCPv6 replies. The advertised route information is as follows:

- The destination IP address is the assigned IPv6 address.
- The next hop is the link-local address of the DHCPv6 client.
- The output interface is the interface that forwards the reply.

After the relay agent receives a packet destined for the assigned IPv6 address, the relay agent looks up the routing table for the next hop. ND resolution can succeed because the next hop is the link-local address of the client. The relay agent searches the ND table for the MAC address of the client based on the next hop and then forwards the packet.

Restrictions and guidelines

Before using this feature on the DHCPv6 relay agent, enable the DHCPv6 relay agent to record DHCPv6 relay entries first.

Procedure

1. Enter system view.

   `system-view`

2. Enable the DHCPv6 relay agent to advertise host routes for IPv6 addresses assigned to DHCPv6 clients.

   `ipv6 dhcp advertise address-route`

   By default, the DHCPv6 relay agent does not advertise host routes for IPv6 addresses assigned to DHCPv6 clients.

Specifying the source IPv6 address for relayed DHCPv6 requests

About specifying the source IPv6 address for relayed DHCPv6 requests

This task is required if a relay interface does not have routes to DHCPv6 servers. You can specify a global unicast address or the IPv6 address of another interface (typically the loopback interface) as the source IPv6 address for DHCPv6 requests. The relay interface inserts the source IPv6 address in the source IPv6 address field of DHCPv6 requests.

Procedure

1. Enter system view.

   system-view

2. Enter interface view.

   interface *interface-type interface-number*

3. Specify the source IPv6 address for relayed DHCPv6 requests.

   ipv6 dhcp relay source-address { *ipv6-address* | **interface** *interface-type interface-number* }

   By default, the DHCPv6 relay agent uses the IPv6 global unicast address of the interface that connects to the DHCPv6 server as the source IPv6 address for relayed DHCPv6 requests.

   If the specified interface does not have an IPv6 global unicast address, the IPv6 address of the output interface is used as the source address for relayed DHCPv6 requests.

Display and maintenance commands for DHCPv6 relay agent

Execute **display** commands in any view and **reset** commands in user view.

Task	Command
Display the DUID of the local device.	**display ipv6 dhcp duid**
Display DHCPv6 relay entries that record clients' IPv6 address information.	**display ipv6 dhcp relay client-information address** [**interface** *interface-type interface-number* | **ipv6** *ipv6-address*]
Display DHCPv6 relay entries that record clients' IPv6 prefix information.	**display ipv6 dhcp relay client-information pd** [**interface** *interface-type interface-number* | **prefix** *prefix/prefix-len*]
Display DHCPv6 server addresses specified on the DHCPv6 relay agent.	**display ipv6 dhcp relay server-address** [**interface** *interface-type interface-number*]
Display packet statistics on the DHCPv6 relay agent.	**display ipv6 dhcp relay statistics** [**interface** *interface-type interface-number*]
Clear DHCPv6 relay entries that record clients' IPv6 address information.	**reset ipv6 dhcp relay client-information address** [**interface** *interface-type*

Task	Command
	interface-number | **ipv6** *ipv6-address*]
Clear DHCPv6 relay entries that record clients' IPv6 prefix information.	**reset ipv6 dhcp relay client-information pd** [**interface** *interface-type interface-number* | **prefix** *prefix/prefix-len*]
Clear packets statistics on the DHCPv6 relay agent.	**reset ipv6 dhcp relay statistics** [**interface** *interface-type interface-number*]

DHCPv6 relay agent configuration examples

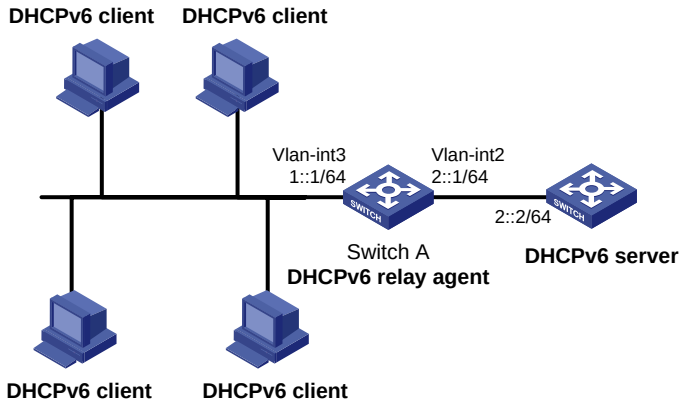
Example: Configuring DHCPv6 relay agent

Network configuration

As shown in Figure 16, configure the DHCPv6 relay agent on Switch A to relay DHCPv6 packets between DHCPv6 clients and the DHCPv6 server.

Switch A acts as the gateway of network 1::/64. It sends RA messages to notify the hosts to obtain IPv6 addresses and other configuration parameters through DHCPv6. For more information about RA messages, see "Configuring basic IPv6 settings."

Figure 16 Network diagram



Procedure

Specify IPv6 addresses for VLAN-interface 2 and VLAN-interface 3.

```
<SwitchA> system-view
[SwitchA] interface vlan-interface 2
[SwitchA-Vlan-interface2] ipv6 address 2::1 64
[SwitchA-Vlan-interface2] quit
[SwitchA] interface vlan-interface 3
[SwitchA-Vlan-interface3] ipv6 address 1::1 64
```

Disable RA message suppression on VLAN-interface 3.

```
[SwitchA-Vlan-interface3] undo ipv6 nd ra halt
```

Set the M flag to 1 in RA advertisements to be sent on VLAN-interface 3. Hosts that receive the RA advertisements will obtain IPv6 addresses through DHCPv6.

```
[SwitchA-Vlan-interface3] ipv6 nd autoconfig managed-address-flag
```

Set the O flag to 1 in RA advertisements to be sent on VLAN-interface 3. Hosts that receive the RA advertisements will obtain information other than IPv6 address through DHCPv6.

```
[SwitchA-Vlan-interface3] ipv6 nd autoconfig other-flag
```

Enable the DHCPv6 relay agent on VLAN-interface 3 and specify the DHCPv6 server on the relay agent.

```
[SwitchA-Vlan-interface3] ipv6 dhcp select relay
[SwitchA-Vlan-interface3] ipv6 dhcp relay server-address 2::2
```

Verifying the configuration

Display DHCPv6 server address information on Switch A.

```
[SwitchA-Vlan-interface3] display ipv6 dhcp relay server-address
Interface: Vlan-interface3
 Server address      Outgoing Interface         Public/VRF name
 2::2                                           --/--
```

Display packet statistics on the DHCPv6 relay agent.

```
[SwitchA-Vlan-interface3] display ipv6 dhcp relay statistics
Packets dropped               :  0
Packets received              :  14
    Solicit                   :  0
    Request                   :  0
    Confirm                   :  0
    Renew                     :  0
    Rebind                    :  0
    Release                   :  0
    Decline                   :  0
    Information-request       :  7
    Relay-forward             :  0
    Relay-reply               :  7
Packets sent                  :  14
    Advertise                 :  0
    Reconfigure               :  0
    Reply                     :  7
    Relay-forward             :  7
    Relay-reply               :  0
```

Configuring the DHCPv6 client

About the DHCPv6 client

With DHCPv6 client configured, an interface can obtain configuration parameters from the DHCPv6 server.

A DHCPv6 client can use DHCPv6 to complete the following functions:

- Obtain an IPv6 address, an IPv6 prefix, or both, and obtain other configuration parameters. If DHCPv6 server is enabled on the device, the client can automatically save the obtained parameters to a DHCPv6 option group. With the obtained IPv6 prefix, the client can generate its global unicast address.
- Support stateless DHCPv6 to obtain configuration parameters except IPv6 address and IPv6 prefix. The client obtains an IPv6 address through stateless IPv6 address autoconfiguration. If the client receives an RA message with the M flag set to 0 and the O flag set to 1 during address acquisition, stateless DHCPv6 starts.

Restrictions and guidelines: DHCPv6 client configuration

Do not configure the DHCPv6 client on the same interface as the DHCPv6 server or the DHCPv6 relay agent.

DHCPv6 client tasks at a glance

To configure a DHCPv6 client, perform the following tasks:

1. (Optional.) Configuring the DHCPv6 client DUID
2. Configuring the DHCPv6 client to obtain IPv6 addresses, IPv6 prefixes and other network parameters

   Choose the following tasks as needed:

   - Configuring IPv6 address acquisition
   - Configuring IPv6 prefix acquisition
   - Configuring IPv6 address and prefix acquisition
   - Configuring acquisition of configuration parameters except IP addresses and prefixes
3. (Optional.) Setting the DSCP value for DHCPv6 packets sent by the DHCPv6 client

Configuring the DHCPv6 client DUID

About the DHCPv6 client DUID

The DUID of a DHCPv6 client is the globally unique identifier of the client. The client pads its DUID into Option 1 of the DHCPv6 packet that it sends to the DHCPv6 server. The DHCPv6 server can assign specific IPv6 addresses or prefixes to DHCPv6 clients with specific DUIDs.

Restrictions and guidelines

Make sure the DUID that you configure is unique.

Procedure

1. Enter system view.
   system-view
2. Enter interface view.
   interface *interface-type interface-number*
3. Configure the DHCPv6 client DUID.
   ipv6 dhcp client duid { **ascii** *ascii-string* | **hex** *hex-string* | **mac** *interface-type interface-number* }
   By default, the interface uses the device bridge MAC address to generate its DHCPv6 client DUID.

Configuring IPv6 address acquisition

1. Enter system view.
   system-view
2. Enter interface view.
   interface *interface-type interface-number*
3. Configure the interface to use DHCPv6 to obtain IPv6 addresses and other network settings.
   ipv6 address dhcp-alloc [**option-group** *group-number* | **rapid-commit**] *
   In a version earlier than R6348P01, an interface does not use DHCPv6 to obtain IPv6 addresses and other network settings by default.
   In R6348P01 or later, the default setting of this command varies by device startup method as follows:
   - When the device starts up with the initial configuration, an interface uses the default settings of software features and does not use DHCPv6 to obtain IPv6 addresses and other network settings.
   - When the device starts up with the factory defaults, only VLAN-interface 1 supports using DHCPv6 to obtain IPv6 addresses and other network settings. Other interfaces do not use DHCPv6 to obtain IPv6 addresses and other network settings.

   For more information about initial configuration and factory defaults, see configuration file management in *Fundamentals Configuration Guide*.

Configuring IPv6 prefix acquisition

1. Enter system view.
   system-view
2. Enter interface view.
   interface *interface-type interface-number*
3. Configure the interface to use DHCPv6 to obtain an IPv6 prefix and other configuration parameters.
   ipv6 dhcp client pd *prefix-number* [**option-group** *group-number* | **rapid-commit**] *
   By default, the interface does not use DHCPv6 for IPv6 prefix acquisition.

Configuring IPv6 address and prefix acquisition

1. Enter system view.

   system-view

2. Enter interface view.

   interface *interface-type interface-number*

3. Configure the interface to use DHCPv6 to obtain an IPv6 address, an IPv6 prefix, and other configuration parameters.

   ipv6 dhcp client stateful prefix *prefix-number* [**option-group** *option-group-number* | **rapid-commit**] *

   By default, the interface does not use DHCPv6 for IPv6 address and prefix acquisition.

Configuring acquisition of configuration parameters except IP addresses and prefixes

About acquisition of configuration parameters except IP addresses and prefixes

When a DHCPv6 client has obtained an IPv6 address and prefix, you can configure the following methods for the client to obtain other network configuration parameters:

- Execute the **ipv6 address auto** command to enable an interface to automatically generate an IPv6 global unicast address and a link-local address. Then stateless DHCPv6 will be triggered when the M flag is set to 0 and the O flag is set to 1 in a received RA message. For more information about the commands, see *Layer 3—IP services Command Reference*.
- Executing the **ipv6 dhcp client stateless enable** command on an interface to enable the interface to act as a DHCPv6 client to obtain configuration parameters from a DHCPv6 server.

If you execute both the **ip address auto** and **ipv6 dhcp client stateless enable** commands, the interface acts as follows:

- Generate a global unicast address and a link-local address.
- Obtain other configuration parameters from a DHCPv6 server.

Procedure

1. Enter system view.

   system-view

2. Enter interface view.

   interface *interface-type interface-number*

3. Configure the interface to support stateless DHCPv6. Choose the options to configure as needed:

   - Enable stateless IPv6 address autoconfiguration:

     ipv6 address auto

   - Configure the client to obtain network parameters from DHCPv6 servers:

     ipv6 dhcp client stateless enable

   By default, the interface does not support stateless DHCPv6.

Setting the DSCP value for DHCPv6 packets sent by the DHCPv6 client

About setting the DSCP value for DHCPv6 packets

The DSCP value of a packet specifies the priority level of the packet and affects the transmission priority of the packet.

Procedure

1. Enter system view.
   system-view
2. Set the DSCP value for DHCPv6 packets sent by the DHCPv6 client.
   ipv6 dhcp client dscp *dscp-value*
   By default, the DSCP value in DHCPv6 packets sent by the DHCPv6 client is 56.

Display and maintenance commands for DHCPv6 client

Execute the **display** commands in any view, and execute the **reset** command in user view.

Task	Command
Display the DHCPv6 client information.	**display ipv6 dhcp client** [**interface** *interface-type interface-number*]
Display the DHCPv6 client statistics.	**display ipv6 dhcp client statistics** [**interface** *interface-type interface-number*]
Clear the DHCPv6 client statistics.	**reset ipv6 dhcp client statistics** [**interface** *interface-type interface-number*]

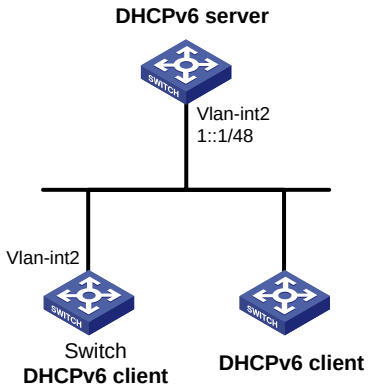
DHCPv6 client configuration examples

Example: Configuring IPv6 address acquisition

Network configuration

As shown in Figure 17, configure the switch to use DHCPv6 to obtain configuration parameters from the DHCPv6 server. The parameters include IPv6 address, DNS server address, domain name suffix, SIP server address, and SIP server domain name.

Figure 17 Network diagram



Procedure

You must configure the DHCPv6 server first before configuring the DHCPv6 client. For information about configuring DHCPv6 server, see "Configuring the DHCPv6 server."

Configure VLAN-interface 2 as a DHCPv6 client for IPv6 address acquisition. Configure the DHCPv6 client to support DHCPv6 rapid address assignment. Configure the DHCPv6 client to create a dynamic DHCPv6 option group for saving configuration parameters.

```
<Switch> system-view
[Switch] interface vlan-interface 2
[Switch-Vlan-interface2] ipv6 address dhcp-alloc rapid-commit option-group 1
[Switch-Vlan-interface2] quit
```

Verifying the configuration

Verify that the client has obtained an IPv6 address and other configuration parameters from the server.

```
[Switch] display ipv6 dhcp client
Vlan-interface2:
  Type: Stateful client requesting address
    State: OPEN
    Client DUID: 0003000100e002000000
    Preferred server:
      Reachable via address: FE80::2E0:1FF:FE00:18
      Server DUID: 0003000100e001000000
    IA_NA: IAID 0x00000642, T1 50 sec, T2 80 sec
      Address: 1:1::2/128
       Preferred lifetime 100 sec, valid lifetime 200 sec
       Will expire on Mar 27 2014 at 08:06:57 (198 seconds left)
    DNS server addresses:
      2000::FF
    Domain name:
      example.com
    SIP server addresses:
      2:2::4
    SIP server domain names:
      bbb.com
```

After DHCPv6 server is enabled on the device, verify that configuration parameters are saved in a dynamic DHCPv6 option group.

```
[Switch] display ipv6 dhcp option-group 1
DHCPv6 option group: 1
  DNS server addresses:
    Type: Dynamic (DHCPv6 address allocation)
    Interface: Vlan-interface2
    2000::FF
  Domain name:
    Type: Dynamic (DHCPv6 address allocation)
    Interface: Vlan-interface2
    example.com
  SIP server addresses:
    Type: Dynamic (DHCPv6 address allocation)
    Interface: Vlan-interface2
    2:2::4
  SIP server domain names:
    Type: Dynamic (DHCPv6 address allocation)
    Interface: Vlan-interface2
    bbb.com
```

Verify that the DHCPv6 client has obtained an IPv6 address..

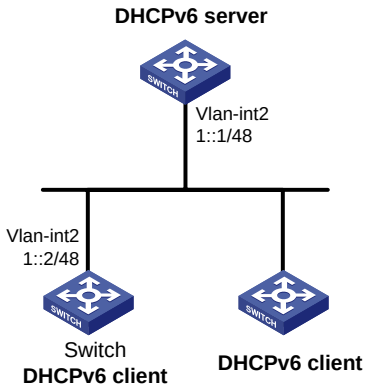
```
[Switch] display ipv6 interface brief
*down: administratively down
(s): spoofing
Interface                          Physical   Protocol   IPv6 Address
Vlan-interface2                    up         up         1:1::2
```

Example: Configuring IPv6 prefix acquisition

Network configuration

As shown in Figure 18, configure the switch to use DHCPv6 to obtain configuration parameters from the DHCPv6 server. The parameters include IPv6 prefix, DNS server address, domain name suffix, SIP server address, and SIP server domain name.

Figure 18 Network diagram



Procedure

You must configure the DHCPv6 server first before configuring the DHCPv6 client. For information about configuring DHCPv6 server, see "Configuring the DHCPv6 server."

Configure an IPv6 address for VLAN-interface 2 that is connected to the DHCPv6 server.

```
<Switch> system-view
[Switch] interface vlan-interface 2
[Switch-Vlan-interface2] ipv6 address 1::2/48
```

Configure VLAN-interface 2 as a DHCPv6 client for IPv6 prefix acquisition. Configure the DHCPv6 client to support DHCPv6 rapid prefix assignment. Configure the DHCPv6 client to assign an ID to the obtained IPv6 prefix and create a dynamic DHCPv6 option group for saving configuration parameters.

```
[Switch-Vlan-interface2] ipv6 dhcp client pd 1 rapid-commit option-group 1
[Switch-Vlan-interface2] quit
```

Verifying the configuration

Verify that the DHCPv6 client has obtained an IPv6 prefix and other configuration parameters from the DHCPv6 server.

```
[Switch] display ipv6 dhcp client
Vlan-interface2:
  Type: Stateful client requesting prefix
    State: OPEN
    Client DUID: 0003000100e002000000
    Preferred server:
      Reachable via address: FE80::2E0:1FF:FE00:18
      Server DUID: 0003000100e001000000
    IA_PD: IAID 0x00000642, T1 50 sec, T2 80 sec
      Prefix: 12:34::/48
        Preferred lifetime 100 sec, valid lifetime 200 sec
        Will expire on Feb 4 2014 at 15:37:20(80 seconds left)
    DNS server addresses:
      2000::FF
    Domain name:
      example.com
    SIP server addresses:
      2:2::4
    SIP server domain names:
      bbb.com
```

Verify that the client has obtained an IPv6 prefix.

```
[Switch] display ipv6 prefix 1
Number: 1
Type  : Dynamic
Prefix: 12:34::/48
Preferred lifetime 100 sec, valid lifetime 200 sec
```

After DHCPv6 server is enabled on the device, verify that configuration parameters are saved in a dynamic DHCPv6 option group.

```
[Switch] display ipv6 dhcp option-group 1
DHCPv6 option group: 1
  DNS server addresses:
    Type: Dynamic (DHCPv6 prefix allocation)
    Interface: Vlan-interface2
    2000::FF
  Domain name:
```

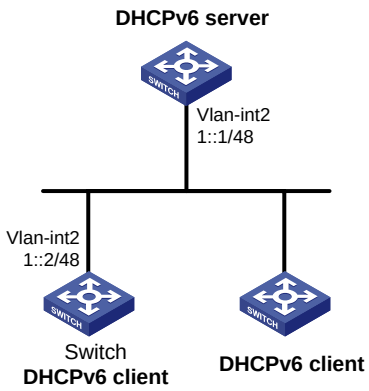
```
  Type: Dynamic (DHCPv6 prefix allocation)
  Interface: Vlan-interface2
  example.com
SIP server addresses:
  Type: Dynamic (DHCPv6 prefix allocation)
  Interface: Vlan-interface2
  2:2::4
SIP server domain names:
  Type: Dynamic (DHCPv6 prefix allocation)
  Interface: Vlan-interface2
  bbb.com
```

Example: Configuring IPv6 address and prefix acquisition

Network configuration

As shown in Figure 19, configure the switch to use DHCPv6 to obtain configuration parameters from the DHCPv6 server. The parameters include IPv6 address, IPv6 prefix, DNS server address, domain name suffix, SIP server address, and SIP server domain name.

Figure 19 Network diagram



Procedure

You must configure the DHCPv6 server before configuring the DHCPv6 client. For information about configuring the DHCPv6 server, see "Configuring the DHCPv6 server."

Configure an IPv6 address for VLAN-interface 2 that is connected to the DHCPv6 server.

```
<Switch> system-view
[Switch] interface vlan-interface 2
[Switch-Vlan-interface2] ipv6 address 1::2/48
```

Configure VLAN-interface 2 as a DHCPv6 client for IPv6 address and prefix acquisition. Specify IDs for the dynamic IPv6 prefix and dynamic DHCPv6 option group, and configure the client to support rapid address and prefix assignment.

```
[Switch-Vlan-interface2] ipv6 dhcp client stateful prefix 1 rapid-commit option-group 1
[Switch-Vlan-interface2] quit
```

Verifying the configuration

Verify that the DHCPv6 client has obtained an IPv6 address, an IPv6 prefix, and other configuration parameters from the DHCPv6 server.

```
[Switch] display ipv6 dhcp client
```

```
Vlan-interface2:
  Type: Stateful client requesting address and prefix
    State: OPEN
    Client DUID: 0003000100e002000000
    Preferred server:
      Reachable via address: FE80::2E0:1FF:FE00:18
      Server DUID: 0003000100e001000000
    IA_NA: IAID 0x00000642, T1 50 sec, T2 80 sec
      Address: 1:1::2/128
        Preferred lifetime 100 sec, valid lifetime 200 sec
        Will expire on Mar 27 2014 at 08:02:00 (199 seconds left)
    IA_PD: IAID 0x00000642, T1 50 sec, T2 80 sec
      Prefix: 12:34::/48
        Preferred lifetime 100 sec, valid lifetime 200 sec
        Will expire on Mar 27 2014 at 08:02:00 (199 seconds left)
    DNS server addresses:
      2000::FF
    Domain name:
      example.com
    SIP server addresses:
      2:2::4
    SIP server domain names:
      bbb.com
```

Verify that the DHCPv6 client has obtained an IPv6 address.

```
[Switch] display ipv6 interface brief
*down: administratively down
(s): spoofing
Interface                              Physical   Protocol   IPv6 Address
Vlan-interface2                        up         up         1:1::2
```

Verify that the client has obtained an IPv6 prefix.

```
[Switch] display ipv6 prefix 1
Number: 1
Type  : Dynamic
Prefix: 12:34::/48
Preferred lifetime 100 sec, valid lifetime 200 sec
```

After DHCPv6 server is enabled on the device, verify that configuration parameters are saved in a dynamic DHCPv6 option group.

```
[Switch] display ipv6 dhcp option-group 1
DNS server addresses:
    Type: Dynamic (DHCPv6 address and prefix allocation)
    Interface: Vlan-interface2
    2000::FF
  Domain name:
    Type: Dynamic (DHCPv6 address and prefix allocation)
    Interface: Vlan-interface2
    example.com
  SIP server addresses:
    Type: Dynamic (DHCPv6 address and prefix allocation)
```

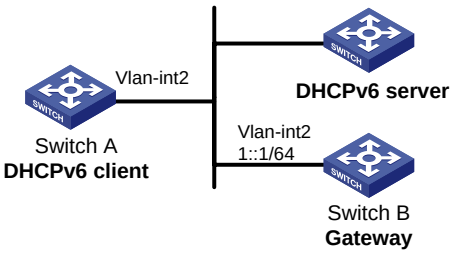
```
  Interface: Vlan-interface2
  2:2::4
SIP server domain names:
  Type: Dynamic (DHCPv6 address and prefix allocation)
  Interface: Vlan-interface2
  bbb.com
```

Example: Configuring stateless DHCPv6

Network configuration

As shown in Figure 20, configure Switch A to use stateless DHCPv6 to obtain configuration parameters except IPv6 address and IPv6 prefix. Switch B acts as the gateway and advertises RA messages periodically.

Figure 20 Network diagram



Procedure

You must configure the DHCPv6 server first before configuring the DHCPv6 client. For information about configuring DHCPv6 server, see "Configuring the DHCPv6 server."

1. Configure the gateway Switch B.

   # Configure an IPv6 address for VLAN-interface 2.

   ```
   <SwitchB> system-view
   [SwitchB] interface vlan-interface 2
   [SwitchB-Vlan-interface2] ipv6 address 1::1 64
   ```

   # Set the O flag to 1 in RA advertisements to be sent on VLAN-interface 2. Hosts that receive the RA advertisements will obtain information other than IPv6 address through DHCPv6.

   ```
   [SwitchB-Vlan-interface2] ipv6 nd autoconfig other-flag
   ```

   # Disable RA message suppression on VLAN-interface 2.

   ```
   [SwitchB-Vlan-interface2] undo ipv6 nd ra halt
   ```

2. Configure the DHCPv6 client Switch A.

   # Enable stateless IPv6 address autoconfiguration on VLAN-interface 2.

   ```
   <SwitchA> system-view
   [SwitchA] interface vlan-interface 2
   [SwitchA-Vlan-interface2] ipv6 address auto
   ```

   With stateless IPv6 address autoconfiguration enabled, but no IPv6 address configured for VLAN-interface 2, Switch A automatically generates a link-local address. It sends an RS message to Switch B to request configuration information for IPv6 address generation. Upon receiving the RS message, Switch B sends back an RA message. After receiving an RA message with the M flag set to 0 and the O flag set to 1, Switch A performs stateless DHCPv6 to get other configuration parameters.

Verifying the configuration

Display the DHCPv6 client information.

```
[SwitchA-Vlan-interface2] display ipv6 dhcp client interface vlan-interface 2
Vlan-interface2:
 Type: Stateless client
    State: OPEN
    Client DUID: 00030001000fe2ff0000
    Preferred server:
      Reachable via address: FE80::213:7FFF:FEF6:C818
      Server DUID: 0003000100137ff6c818
    DNS server addresses:
      1:2:4::5
      1:2:4::7
    Domain name:
      abc.com
```

Display the DHCPv6 client statistics.

```
[SwitchA-Vlan-interface2] display ipv6 dhcp client statistics
Interface                    :  Vlan-interface2
Packets received             :  1
        Reply                :  1
        Advertise            :  0
        Reconfigure          :  0
        Invalid              :  0
Packets sent                 :  5
        Solicit              :  0
        Request              :  0
        Renew                :  0
        Rebind               :  0
        Information-request  :  5
        Release              :  0
        Decline              :  0
```

Configuring DHCPv6 snooping

About DHCPv6 snooping

It guarantees that DHCPv6 clients obtain IPv6 addresses or prefixes from authorized DHCPv6 servers. Also, it records IP-to-MAC bindings of DHCPv6 clients (called DHCPv6 snooping address entries) and prefix-to-port bindings of DHCPv6 clients (called DHCPv6 snooping prefix entries) for security purposes.

DHCPv6 snooping defines trusted and untrusted ports to make sure that clients obtain IPv6 addresses only from authorized DHCPv6 servers.

- **Trusted**—A trusted port can forward DHCPv6 messages correctly to make sure the clients get IPv6 addresses from authorized DHCPv6 servers.
- **Untrusted**—An untrusted port discards received messages sent by DHCPv6 servers to prevent unauthorized servers from assigning IPv6 addresses.

DHCPv6 snooping reads DHCP-ACK messages received from trusted ports and DHCP-REQUEST messages to create DHCPv6 snooping entries. A DHCPv6 snooping entry can be an address entry or a prefix entry.

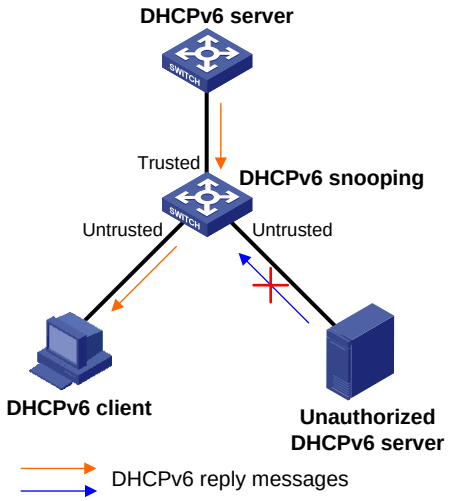
- A DHCPv6 address entry includes the MAC and IP addresses of a client, the port that connects to the DHCPv6 client, and the VLAN. You can use the **`display ipv6 dhcp snooping binding`** command to display the IP addresses of users for management.
- A DHCPv6 prefix entry includes the prefix and lease information assigned to the client, the port that connects to the DHCPv6 client, and the VLAN. You can use the **`display ipv6 dhcp snooping pd binding`** command to display the prefixes of the users for management.

Application of trusted and untrusted ports

Configure ports facing the DHCPv6 server as trusted ports, and configure other ports as untrusted ports.

As shown in Figure 21, configure the DHCPv6 snooping device's port that is connected to the DHCPv6 server as a trusted port. The trusted port forwards response messages from the DHCPv6 server to the client. The untrusted port connected to the unauthorized DHCPv6 server discards incoming DHCPv6 response messages.

Figure 21 Trusted and untrusted ports



Restrictions and guidelines: DHCPv6 snooping configuration

DHCPv6 snooping works between the DHCPv6 client and server, or between the DHCPv6 client and DHCPv6 relay agent.

DHCPv6 snooping does not work between the DHCPv6 server and DHCPv6 relay agent.

To make sure DHCPv6 clients can obtain valid IPv6 addresses, specify the ports connected to authorized DHCPv6 servers as trusted ports. The trusted ports and the ports connected to DHCPv6 clients must be in the same VLAN.

If you configure DHCPv6 snooping settings on a Layer 2 Ethernet interface that is a member port of a Layer 2 aggregate interface, the settings do not take effect unless the interface is removed from the aggregation group.

DHCPv6 snooping tasks at a glance

To configure DHCPv6 snooping, perform the following tasks:

1. Configuring basic DHCPv6 snooping features
2. (Optional.) Configuring DHCP snooping support for Option 18
3. (Optional.) Configuring DHCP snooping support for Option 37
4. (Optional.) Configuring DHCPv6 snooping entry auto backup
5. (Optional.) Setting the maximum number of DHCPv6 snooping entries
6. (Optional.) Configuring DHCPv6 packet rate limit
7. (Optional.) Configuring DHCPv6 snooping security features
8. (Optional.) Enabling DHCPv6 snooping logging and alarm
9. (Optional.) Disabling DHCPv6 snooping on an interface

Configuring basic DHCPv6 snooping features

Configuring basic DHCPv6 snooping features in a common network

About basic DHCPv6 snooping features in a common network

Basic DHCPv6 snooping features include enabling DHCPv6 snooping, configuring trusted ports, and enabling recording DHCPv6 snooping entries.

When you enable DHCPv6 snooping globally on a device, DHCPv6 snooping is also enabled in all VLANs on the device. Enable snooping in specific VLANs if you do not need to enable DHCPv6 snooping globally in some networks. You can also other basic DHCP snooping features in these VLANs.

Restrictions and guidelines

If the basic DHCPv6 snooping features are configured globally, you can only use the undo form of the global configuration commands to disable the settings globally. The VLAN-specific configuration commands cannot disable the settings.

If the basic DHCPv6 snooping features are configured in a VLAN, you can only use the undo form of the VLAN-specific configuration commands to disable the settings in the VLAN. The global configuration command cannot disable the settings.

Configuring basic DHCPv6 snooping features globally

1. Enter system view.
   system-view
2. Enable DHCPv6 snooping globally.
   ipv6 dhcp snooping enable
   By default, DHCPv6 snooping is disabled globally.
3. Enter interface view.
   interface *interface-type interface-number*
   This interface must connect to the DHCPv6 server.
4. Specify the port as a trusted port.
   ipv6 dhcp snooping trust
   By default, all ports are untrusted ports after DHCPv6 snooping is enabled.
5. Enable recording DHCPv6 snooping entries.
   a. Return to system view.
      quit
   b. Enter interface view.
      interface *interface-type interface-number*
      This interface must connect to the DHCPv6 client.
   c. Enable recording DHCPv6 snooping entries. Choose the following tasks as needed:
      - Enable recording DHCPv6 snooping address entries.
        ipv6 dhcp snooping binding record
        By default, recording of DHCPv6 snooping address entries is disabled.
      - Enable recording DHCPv6 snooping prefix entries.
        ipv6 dhcp snooping pd binding record
        By default, recording of DHCPv6 snooping prefix entries is disabled.

Configuring basic DHCPv6 snooping features for VLANs

1. Enter system view.
   system-view
2. Enable DHCPv6 snooping for VLANs.
   ipv6 dhcp snooping enable vlan *vlan-id-list*
   By default, DHCPv6 snooping is disabled in all VLANs.
3. Enter VLAN view.
   vlan *vlan-id*
   Make sure DHCP snooping is enabled for the VLAN.
4. Specify a port as a trusted port.
   ipv6 dhcp snooping trust interface *interface-type interface-number*
   By default, all ports are untrusted ports after DHCPv6 snooping is enabled.
5. (Optional.) Enable recording DHCPv6 snooping entries in the VLAN. Choose the following tasks as needed:
   - Enable recording DHCPv6 snooping address entries.
     ipv6 dhcp snooping binding record
     By default, recording of DHCPv6 snooping address entries is disabled in a VLAN.
   - Enable recording DHCPv6 snooping prefix entries.
     ipv6 dhcp snooping pd binding record
     By default, recording of DHCPv6 snooping prefix entries is disabled in a VLAN.

Configuring DHCP snooping support for Option 18

1. Enter system view.
   system-view
2. Enter interface view.
   interface *interface-type interface-number*
3. Enable DHCP snooping support for Option 18.
   ipv6 dhcp snooping option interface-id enable
   By default, DHCP snooping support for Option 18 is disabled.
4. (Optional.) Specify the content as the interface ID.
   ipv6 dhcp snooping option interface-id [**vlan** *vlan-id*] **string** *interface-id*
   By default, the DHCPv6 snooping device uses its DUID as the content for Option 18.

Configuring DHCP snooping support for Option 37

1. Enter system view.
   system-view
2. Enter interface view.
   interface *interface-type interface-number*
3. Enable DHCP snooping support for Option 37.
   ipv6 dhcp snooping option remote-id enable
   By default, DHCP snooping support for Option 37 is disabled.

4. (Optional.) Specify the content as the remote ID.

   ipv6 dhcp snooping option remote-id [**vlan** *vlan-id*] **string** *remote-id*

   By default, the DHCPv6 snooping device uses its DUID as the content for Option 37.

Configuring DHCPv6 snooping entry auto backup

About DHCPv6 snooping entry auto backup

The auto backup feature saves DHCPv6 snooping entries to a backup file, and allows the DHCPv6 snooping device to download the entries from the backup file at reboot. The entries on the DHCPv6 snooping device cannot survive a reboot. The auto backup helps the security features provide services if these features (such as IP source guard) must use DHCPv6 snooping entries for user authentication.

Restrictions and guidelines

- If you disable DHCPv6 snooping with the **undo ipv6 dhcp snooping enable** command, the device deletes all DHCPv6 snooping entries, including those stored in the backup file.
- If you execute the **ipv6 dhcp snooping binding database filename** command, the DHCPv6 snooping device backs up DHCPv6 snooping entries immediately and runs auto backup. This command automatically creates the file if you specify a non-existent file.
- The waiting period starts when a DHCPv6 snooping entry is learned, updated, or removed. The DHCPv6 snooping device updates the backup file when the specified waiting period is reached. All changed entries during the period will be saved to the backup file. If no DHCPv6 snooping entry changes, the backup file is not updated.

Procedure

1. Enter system view.

   system-view

2. Configure the DHCPv6 snooping device to back up DHCPv6 snooping entries to a file.

   ipv6 dhcp snooping binding database filename { *filename* | **url** *url* [**username** *username* [**password** { **cipher** | **simple** } *string*]] }

   By default, the DHCPv6 snooping device does not back up the DHCPv6 snooping entries.

3. (Optional.) Manually save DHCPv6 snooping entries to the backup file.

   ipv6 dhcp snooping binding database update now

4. (Optional.) Set the waiting time after a DHCPv6 snooping entry change for the DHCPv6 snooping device to update the backup file.

   ipv6 dhcp snooping binding database update interval *interval*

   By default, the DHCP snooping device waits 300 seconds to update the backup file after a DHCP snooping entry change. If no DHCP snooping entry changes, the backup file is not updated.

Setting the maximum number of DHCPv6 snooping entries

About setting the maximum number of DHCPv6 snooping entries

Perform this task to prevent the system resources from being overused.

Procedure

1. Enter system view.

system-view

2. Enter interface view.
   interface *interface-type interface-number*
3. Set the maximum number of DHCPv6 snooping entries for the interface to learn.
   ipv6 dhcp snooping max-learning-num *max-number*
   By default, the number of DHCPv6 snooping entries for an interface to learn is not limited.

Configuring DHCPv6 packet rate limit

About DHCPv6 packet rate limit

This DHCPv6 packet rate limit feature discards exceeding DHCPv6 packets to prevent attacks that send large numbers of DHCPv6 packets.

Restrictions and guidelines

The rate set on the Layer 2 aggregate interface applies to all members of the aggregate interface. If a member interface leaves the aggregation group, it uses the rate set in its Ethernet interface view.

Procedure

1. Enter system view.
   system-view
2. Enter interface view.
   interface *interface-type interface-number*
3. Set the maximum rate at which an interface can receive DHCPv6 packets.
   ipv6 dhcp snooping rate-limit *rate*
   By default, incoming DHCPv6 packets on an interface are not rate limited.

Configuring DHCPv6 snooping security features

Enabling DHCPv6-REQUEST check

About DHCPv6-REQUEST check

Perform this task to use the DHCPv6-REQUEST check feature to protect the DHCPv6 server against DHCPv6 client spoofing attacks. Attackers can forge DHCPv6-RENEW messages to renew leases for legitimate DHCPv6 clients that no longer need the IP addresses. The forged messages disable the victim DHCPv6 server from releasing the IP addresses. Attackers can also forge DHCPv6-DECLINE or DHCPv6-RELEASE messages to terminate leases for legitimate DHCPv6 clients that still need the IP addresses.

The DHCPv6-REQUEST check feature enables the DHCPv6 snooping device to check every received DHCPv6-RENEW, DHCPv6-DECLINE, or DHCPv6-RELEASE message against DHCPv6 snooping entries.

- If any criterion in an entry is matched, the device compares the entry with the message information.
  - If they are consistent, the device considers the message valid and forwards it to the DHCPv6 server.
  - If they are different, the device considers the message forged and discards it.
- If no matching entry is found, the device forwards the message to the DHCPv6 server.

Procedure

1. Enter system view.
   system-view
2. Enter interface view.
   interface *interface-type interface-number*
3. Enable DHCPv6-REQUEST check.
   ipv6 dhcp snooping check request-message
   By default, DHCPv6-REQUEST check is disabled.

Configuring a DHCPv6 packet blocking port

About DHCPv6 packet blocking port

Perform this task to configure a port as a DHCPv6 packet blocking port. The DHCPv6 packet blocking port drops all incoming DHCP requests.

Procedure

1. Enter system view.
   system-view
2. Enter interface view.
   interface *interface-type interface-number*
3. Configure the port to block DHCPv6 requests.
   ipv6 dhcp snooping deny
   By default, the port does not block DHCPv6 requests.

CAUTION:
To avoid IPv6 address and prefix acquisition failure, configure a port to block DHCPv6 packets only if no DHCPv6 clients are connected to it.

Enabling DHCPv6 snooping logging and alarm

Enabling DHCPv6 snooping logging

About DHCPv6 snooping logging

The DHCPv6 snooping logging feature enables the DHCPv6 snooping device to generate DHCPv6 snooping logs and send them to the information center. The information helps administrators locate and solve problems. For information about the log destination and output rule configuration in the information center, see *Network Management and Monitoring Configuration Guide*.

Restrictions and guidelines

As a best practice, disable this feature if the log generation affects the device performance.

Procedure

1. Enter system view.
   system-view
2. Enable DHCPv6 snooping logging.
   ipv6 dhcp snooping log enable
   By default, DHCPv6 snooping logging is disabled.

Disabling DHCPv6 snooping on an interface

About disabling DHCPv6 snooping on an interface

This feature allows you to narrow down the interface range where DHCPv6 snooping takes effect. For example, to enable DHCP snooping globally except for a specific interface, you can enable DHCPv6 snooping globally and disable DHCPv6 snooping on the target interface.

Procedure

1. Enter system view.
   system-view
2. Enter interface view
   interface *interface-type interface-number*
3. Disable DHCPv6 snooping on the interface.
   ipv6 dhcp snooping disable
   By default:
   - If you enable DHCPv6 snooping globally or for a VLAN, DHCPv6 snooping is enabled on all interfaces on the device or on all interfaces in the VLAN.
   - If you do not enable DHCPv6 snooping globally or for a VLAN, DHCPv6 snooping is disabled on all interfaces on the device or on all interfaces in the VLAN.

Display and maintenance commands for DHCPv6 snooping

Execute **display** commands in any view, and **reset** commands in user view.

Task	Command
Display DHCPv6 snooping address entries.	**display ipv6 dhcp snooping binding** [**address** *ipv6-address* [**vlan** *vlan-id*]]
Display information about the file that stores DHCPv6 snooping entries.	**display ipv6 dhcp snooping binding database**
Display DHCPv6 packet statistics for DHCPv6 snooping.	**display ipv6 dhcp snooping packet statistics** [**slot** *slot-number*]
Display DHCPv6 snooping prefix entries.	**display ipv6 dhcp snooping pd binding** [**prefix** *prefix/prefix-length* [**vlan** *vlan-id*]]
Display information about trusted ports.	**display ipv6 dhcp snooping trust**

Task	Command
Clear DHCPv6 snooping address entries.	**reset ipv6 dhcp snooping binding** { **all** | **address** *ipv6-address* [**vlan** *vlan-id*] }
Clear DHCPv6 packet statistics for DHCPv6 snooping.	**reset ipv6 dhcp snooping packet statistics** [**slot** *slot-number*]
Clear DHCPv6 snooping prefix entries.	**reset ipv6 dhcp snooping pd binding** { **all** | **prefix** *prefix/prefix-length* [**vlan** *vlan-id*] }

DHCPv6 snooping configuration examples

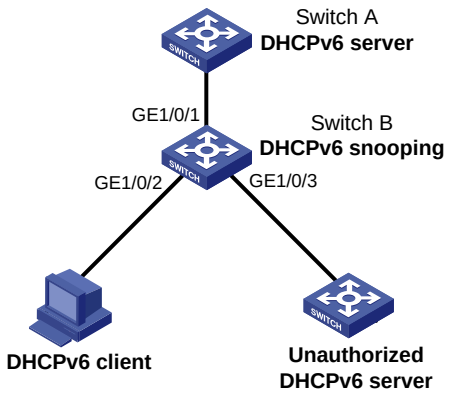
Example: Configuring DHCPv6 snooping globally

Network configuration

As shown in Figure 22, Switch B is connected to the authorized DHCPv6 server through GigabitEthernet 1/0/1, to the unauthorized DHCPv6 server through GigabitEthernet 1/0/3, and to the DHCPv6 client through GigabitEthernet 1/0/2.

Configure only the port connected to the authorized DHCPv6 server to forward the responses from the DHCPv6 server. Enable the DHCPv6 snooping device to record DHCPv6 snooping address entries.

Figure 22 Network diagram



Procedure

Enable DHCPv6 snooping.

```
<SwitchB> system-view
[SwitchB] ipv6 dhcp snooping enable
```

Specify GigabitEthernet 1/0/1 as a trusted port.

```
[SwitchB] interface gigabitethernet 1/0/1
[SwitchB-GigabitEthernet1/0/1] ipv6 dhcp snooping trust
[SwitchB-GigabitEthernet1/0/1] quit
```

Enable recording DHCPv6 snooping address entries on GigabitEthernet 1/0/2.

```
[SwitchB]interface gigabitethernet 1/0/2
[SwitchB-GigabitEthernet1/0/2] ipv6 dhcp snooping binding record
[SwitchB-GigabitEthernet1/0/2] quit
```

Verifying the configuration

Verify that the DHCPv6 client obtains an IPv6 address and all other configuration parameters only from the authorized DHCPv6 server. (Details not shown.)

Display DHCPv6 snooping address entries on the DHCPv6 snooping device.

```
[SwitchB] display ipv6 dhcp snooping binding
```

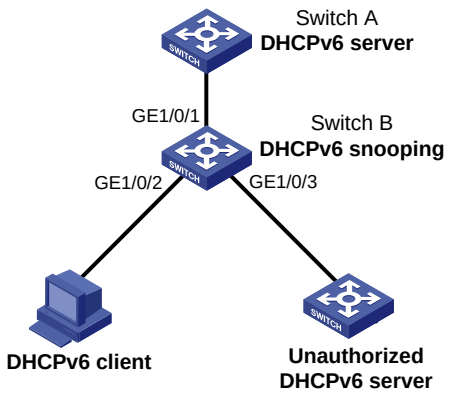
Example: Configuring DHCPv6 snooping for a VLAN

Network configuration

As shown in Figure 23, Switch B is connected to the authorized DHCPv6 server through GigabitEthernet 1/0/1, to the unauthorized DHCPv6 server through GigabitEthernet 1/0/3, and to the DHCPv6 client through GigabitEthernet 1/0/2.

In VLAN 100, configure only the port connected to the authorized DHCPv6 server to forward the responses from the DHCPv6 server. Enable the DHCPv6 snooping device to record DHCPv6 snooping address entries.

Figure 23 Network diagram



Procedure

Assign access ports GigabitEthernet 1/0/1, GigabitEthernet 1/0/2, and GigabitEthernet 1/0/3 to VLAN 100.

```
<SwitchB> system-view
[SwitchB] vlan 100
[SwitchB-vlan100] port gigabitethernet 1/0/1 to gigabitethernet 1/0/3
[SwitchB-vlan100] quit
```

Enable DHCPv6 snooping for VLAN 100.

```
[SwitchB] ipv6 dhcp snooping enable vlan 100
```

Configure GigabitEthernet 1/0/1 as a trusted port in VLAN 100.

```
[SwitchB] vlan 100
```

```
[SwitchB-vlan100] ipv6 dhcp snooping trust interface gigabitethernet 1/0/1
```

Enable recording DHCPv6 snooping entries in VLAN 100.

```
[SwitchB-vlan100] ipv6 dhcp snooping binding record
[SwitchB-vlan100] quit
```

Verifying the configuration

Verify that the DHCPv6 client obtains an IPv6 address and all other configuration parameters only from the authorized DHCPv6 server. (Details not shown.)

Display DHCPv6 snooping address entries on the DHCPv6 snooping device.

```
[SwitchB] display ipv6 dhcp snooping binding
```

Configuring DHCPv6 guard

About DHCPv6 guard

The DHCPv6 guard feature filters DHCPv6 Advertise and Reply messages by using DHCPv6 guard policies to make sure DHCPv6 clients obtain addresses/prefixes from authorized DHCPv6 servers. To provide finer level of filtering granularity, you can specify the following parameters for a DHCPv6 guard policy:

- Device role of the device that attached to the target interface or VLAN. The interface or VLAN to which the DHCPv6 guard policy is applied is called the target interface or VLAN.
- DHCPv6 server match criterion.
- Match criterion for IPv6 addresses/prefixes assigned by DHCPv6 servers.
- Allowed DHCPv6 server preference range.

To meet requirements of DHCPv6 clients in different locations, apply DHCPv6 guard policies to different interfaces or VLANs on the same device.

DHCPv6 guard operating mechanism

Upon receiving a DHCPv6 Solicit or Request message, the DHCPv6 guard device forwards the message without performing the DHCPv6 guard policy check.

When receiving a DHCPv6 reply, the DHCPv6 guard device performs the DHCPv6 guard policy check in the following order:

1. Examines whether the receiving port is a trusted port. The device forwards the message if the message is from the a trusted port.

   Configure trusted ports in a DHCPv6 guard policy only in one of the following conditions:

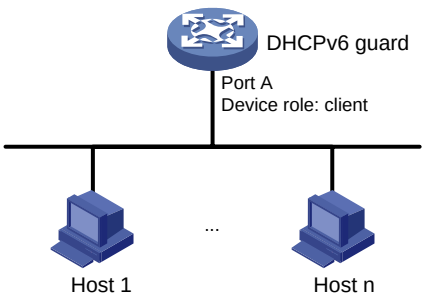
   - The port to which the DHCPv6 guard policy applies is connected to an authorized server.
   - All ports in the VLAN to which the DHCPv6 guard policy applies are connected to authorized servers.

2. Examines the message based on the device role:

   - If the message is received from the device with the DHCPv6 client device role, the device drops the message.

     If the interface to which the DHCPv6 guard policy applies is not connected to any authorized DHCPv6 servers, set the device role to **client** for the policy, as shown in Figure 24.

     Figure 24 Setting the device role to client

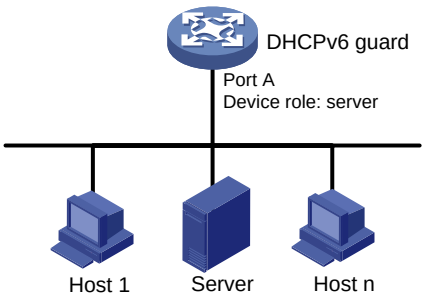
     

   - If the message is received from the device with the DHCPv6 server device role, the device examines the message as follows:

- For an Advertise message, the message passes the policy check if the source IP address in the message is permitted by the ACL and the server preference is in the match range.
- For a Reply message, the message passes the policy check if the assigned IPv6 addresses/prefixes in the message are permitted by the ACL.

If the interface to which the DHCPv6 guard policy applies is connected to an authorized DHCPv6 server, set the device role to **server** for the policy, as shown in Figure 25.

Figure 25 Setting the device role to server



The device forwards the reply after the message passes the DHCPv6 guard policy check.

Restrictions and guidelines: DHCPv6 guard configuration

The DHCPv6 guard feature operates correctly only when the device is located between the DHCPv6 client and the DHCPv6 server or between the DHCPv6 client and the DHCPv6 relay agent. If the device is located between the DHCPv6 server and the DHCPv6 relay agent, the DHCPv6 guard feature cannot operate correctly.

When the DHCPv6 guard feature is configured on a DHCPv6 snooping device, both features can take effect. The device forwards DHCPv6 reply packets received on a DHCPv6 snooping trusted port only if they pass the DHCPv6 guard check. These packets are dropped if they fail the DHCPv6 guard check.

DHCPv6 guard tasks at a glance

To configure DHCPv6 guard, perform the following tasks:

1. Configuring a DHCPv6 guard policy
2. Applying the DHCPv6 guard policy

   Choose the following tasks as needed:

   - Applying a DHCPv6 guard policy to an interface
   - Applying a DHCPv6 guard policy to a VLAN

   If DHCPv6 guard polices are applied to both an interface and the VLAN of the interface, the interface-specific policy is used on the interface.

Configuring a DHCPv6 guard policy

1. Enter system view.

   ```
   system-view
   ```

2. Create a DHCPv6 guard policy and enter its view.
   ipv6 dhcp guard policy *policy-name*
3. Specify the role of the device attached to the target interface or VLAN.
   device-role { **client** | **server** }
   By default, the device role is DHCPv6 client for the device attached to the target interface or VLAN.
4. Configure a DHCPv6 guard policy.
   - Configure a DHCPv6 server match criterion.
     if-match server acl { *acl-number* | **name** *acl-name* }
     By default, no DHCPv6 server match criterion is configured, and all DHCPv6 servers are authorized.
   - Configure a match criterion for the assigned IPv6 addresses/prefixes.
     if-match reply acl { *acl-number* | **name** *acl-name* }
     By default, no match criterion is configured for the assigned IPv6 addresses/prefixes, and all assigned IPv6 addresses/prefixes can pass the address/prefix check.
   - Configure an allowed DHCPv6 server preference range.
     preference { **max** *max-value* | **min** *min-value* } *
     By default, no DHCPv6 server preference range is configured, and DHCPv6 servers with preferences 1 to 255 can pass the preference check.
   - Configure the port to which the policy applies as a trusted port for the policy.
     trust port
     By default, no trusted port is configured for a DHCPv6 guard policy.

Applying a DHCPv6 guard policy to an interface

1. Enter system view.
   system-view
2. Enter Layer 2 interface view.
   interface *interface-type interface-number*
3. Apply a DHCPv6 guard policy to the interface.
   ipv6 dhcp guard apply policy *policy-name*
   By default, no DHCPv6 guard policy is applied to the interface.

Applying a DHCPv6 guard policy to a VLAN

1. Enter system view.
   system-view
2. Create a VLAN and enter its view.
   vlan *vlan-number*
3. Apply a DHCPv6 guard policy to the VLAN.
   ipv6 dhcp guard apply policy *policy-name*
   By default, no DHCPv6 guard policy is applied to the VLAN.

Display and maintenance commands for DHCPv6 guard

Execute **display** commands in any view.

Task	Command
Display information about DHCPv6 guard policies.	**display ipv6 dhcp guard policy** [*policy-name*]

DHCPv6 guard configuration examples

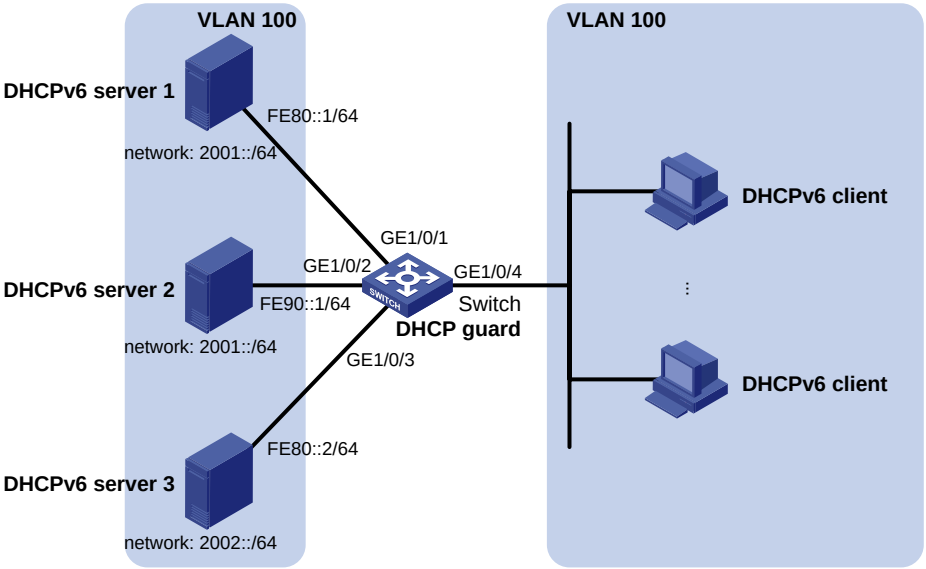
Example: Configuring DHCPv6 guard

Network configuration

As shown in Figure 26, all DHCPv6 servers and clients are in VLAN 100. The assignable IPv6 address ranges on the DHCPv6 server 1, server 2, and server 3 are 2001::/64, 2001::/64, and 2002::/64, respectively.

Configure DHCPv6 guard on the switch, so that the switch forwards only DHCPv6 replies with the source IPv6 address in the range of FE80::/12 and assigned prefixes in the range of 2001::/16.

Figure 26 Network diagram



Procedure

Before you configure DHCPv6 guard, complete the configuration on DHCPv6 servers.

Create VLAN 100, and assign GigabitEthernet 1/0/1, GigabitEthernet 1/0/2, GigabitEthernet 1/0/3, and GigabitEthernet 1/0/4 to VLAN 100.

```
<Switch> system-view
[Switch] vlan 100
[Switch-vlan100] port gigabitethernet 1/0/1 to gigabitethernet 1/0/4
[Switch-vlan100] quit
```

Create an IPv6 basic ACL numbered 2001.

```
[Switch] acl ipv6 number 2001
```

Create rule **1** to permit only packets with source IPv6 addresses in the range of FE80::/12.

```
[Switch-acl-ipv6-basic-2001] rule 1 permit source fe80:: 12
[Switch-acl-ipv6-basic-2001] quit
```

Create an IPv6 basic ACL numbered 2002.

```
[Switch] acl ipv6 number 2002
```

Create rule **1** to permit only packets with source IPv6 addresses in the range of 2001::/16.

```
[Switch-acl-ipv6-basic-2002] rule 1 permit source 2001:: 16
[Switch-acl-ipv6-basic-2002] quit
```

Create DHCPv6 guard policy named **p1**.

```
[Switch] ipv6 dhcp guard policy p1
```

Set the device role to the DHCPv6 server for the device attached to the target VLAN.

```
[Switch-dhcp6-guard-policy-p1] device-role server
```

Specify ACL 2001 to match DHCPv6 servers.

```
[Switch-dhcp6-guard-policy-p1] if-match server acl 2001
```

Specify ACL 2002 to match IPv6 addresses/prefixes assigned by DHCPv6 servers.

```
[Switch-dhcp6-guard-policy-p1] if-match reply acl 2002
[Switch-dhcp6-guard-policy-p1] quit
```

Create DHCPv6 guard policy named **p2**.

```
[Switch] ipv6 dhcp guard policy p2
```

Set the device role to the DHCPv6 client for the device attached to the target interface.

```
[Switch-dhcp6-guard-policy-p2] device-role client
[Switch-dhcp6-guard-policy-p2] quit
```

Apply DHCPv6 guard policy **p1** to VLAN 100.

```
[Switch] vlan 100
[Switch-vlan100] ipv6 dhcp guard apply policy p1
[Switch-vlan100] quit
```

Apply DHCPv6 guard policy **p2** to GigabitEthernet 1/0/4.

```
[Switch]interface gigabitethernet 1/0/4
[Switch-GigabitEthernet1/0/4] ipv6 dhcp guard apply policy p2
[Switch-GigabitEthernet1/0/4] quit
```

Verifying the configuration

Verify that the switch forwards DHCPv6 replies with the source IPv6 address in the range of FE80::/12 and the assigned IPv6 prefixes in the range of 2001::/16. The switch forwards DHCPv6 replies from the DHCPv6 server 1 and drops replies from DHCPv6 server 2 and server 3.

Contents

Configuring IPv6 fast forwarding

About IPv6 fast forwarding

Fast forwarding reduces route lookup time and improves packet forwarding efficiency by using a high-speed cache and data-flow-based technology. It identifies a data flow by using the following fields:

- Source IPv6 address.
- Destination IPv6 address.
- Source port number.
- Destination port number.
- Protocol number.

After a flow's first packet is forwarded through the routing table, fast forwarding creates an entry and uses the entry to forward subsequent packets of the flow.

Configuring the aging time for IPv6 fast forwarding entries

About aging time for IPv6 fast forwarding entries

The IPv6 fast forwarding table uses an aging timer for each forwarding entry. If an entry is not updated before the timer expires, the device deletes the entry. If an entry has a hit within the aging time, the aging timer restarts.

Procedure

1. Enter system view.
   `system-view`
2. Set the aging time for IPv6 fast forwarding entries.
   `ipv6 fast-forwarding aging-time` *`aging-time`*
   By default, the aging time is 30 seconds.

Configuring IPv6 fast forwarding load sharing

About IPv6 fast forwarding load sharing

IPv6 fast forwarding load sharing enables the device to identify a data flow by using the packet information.

If IPv6 fast forwarding load sharing is disabled, the device identifies a data flow by the packet information and the input interface.

Procedure

1. Enter system view.
   `system-view`
2. Configure IPv6 fast forwarding load sharing. Choose one option as needed:
   - Enable IPv6 fast forwarding load sharing.
     `Ipv6 fast-forwarding load-sharing`

- Disable IPv6 fast forwarding load sharing.
  undo ipv6 fast-forwarding load-sharing

By default, IPv6 fast forwarding load sharing is enabled.

Display and maintenance commands for IPv6 fast forwarding

Execute **display** commands in any view and **reset** commands in user view.

Task	Command
Display the aging time of the IPv6 fast forwarding entries.	**display ipv6 fast-forwarding aging-time**
Display IPv6 fast forwarding entries.	**display ipv6 fast-forwarding cache** [*ipv6-address*] [**slot** *slot-number*]
Clear the IPv6 fast forwarding table.	**reset ipv6 fast-forwarding cache** [**slot** *slot-number*]

Contents

Configuring HTTP redirect

About HTTP redirect

HTTP redirect is a method to redirect users' HTTP or HTTPS requests to a specific URL. It is used in the following features:

- Redirect URL assignment in 802.1X authentication, MAC authentication, Web authentication, and port security.
- EAD assistant URL redirection in 802.1X authentication.
- URL redirection services in portal.

Restrictions and guidelines: HTTP redirect configuration

For URL redirection to function correctly in 802.1X authentication, MAC authentication, Web authentication, port security, and EAD assistant, make sure the packet incoming VLANs have Layer 3 interfaces (VLAN interfaces) configured. Otherwise, redirection of HTTPS requests will fail.

HTTP redirect tasks at a glance

No configuration is required to redirect HTTP requests.

To redirect HTTPS requests, perform the following tasks:

1. Specifying the HTTPS redirect listening port number
2. (Optional.) Associating an SSL server policy with the HTTPS redirect service

Specifying the HTTPS redirect listening port number

About the HTTPS redirect listening port number

The device can redirect HTTPS requests only after you specify the TCP port number on which the HTTPS redirect service listens for HTTPS requests.

Restrictions and guidelines

To avoid service unavailability caused by port conflict, do not specify a TCP port number used by a well-known protocol or used by any other TCP-based service. To display TCP port numbers that have been used by services, use the **`display tcp`** command. For more information about this command, see IP performance optimization commands in *Layer 3—IP Services Command Reference*.

If you perform this task multiple times, the most recent configuration takes effect.

Procedure

1. Enter system view.

   `system-view`
2. Specify the HTTPS redirect listening port number.

http-redirect https-port *port-number*

By default, the HTTPS redirect listening port number is 6654.

Associating an SSL server policy with the HTTPS redirect service

About associating an SSL server policy with the HTTPS redirect service

To improve the security of HTTPS redirect, you can associate an SSL server policy with the HTTPS redirect service. For more information about the SSL server policy configuration, see SSL in *Security Configuration Guide*.

Restrictions and guidelines

HTTPS redirect is unavailable if the associated SSL server policy does not exist. You can first associate a nonexistent SSL server policy with the HTTPS redirect service and then configure the SSL server policy.

If you change the SSL server policy associated with the HTTPS redirect service, the new policy takes effect immediately.

If you perform this task multiple times, the most recent configuration takes effect.

Procedure

1. Enter system view.

   system-view

2. Associate an SSL server policy with the HTTPS redirect service.

   http-redirect ssl-server-policy *policy-name*

   By default, no SSL server policy is associated with the HTTPS redirect service. The HTTPS redirect service uses the self-assigned certificate and the default SSL parameters.

Contents

NAT overview

Network Address Translation (NAT) translates an IP address in the IP packet header to another IP address. Typically, NAT is configured on gateways to enable private hosts to access external networks and external hosts to access private network resources such as a Web server.

Basic NAT concepts

The following describes basic NAT concepts:

- **NAT device**—A device configured with NAT. Typically, NAT is configured on the edge device that connects the internal and external networks.
- **NAT interface**—An interface configured with NAT.
- **NAT address**—A public IP address used for address translation, and this address is reachable from the external network.
- **NAT entry**—Stores the mapping between a private IP address and a public IP address.

Basic NAT operating mechanism

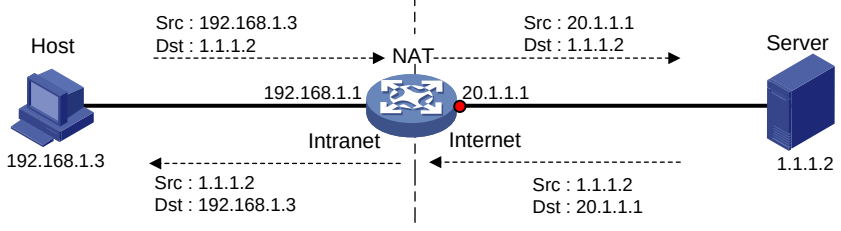
Figure 1 shows the basic NAT operating mechanism.

1. Upon receiving a request from the host to the server, NAT translates the private source address 192.168.1.3 to the public address 20.1.1.1 and forwards the NATed packet. NAT adds a mapping for the two addresses to its NAT table.
2. Upon receiving a response from the server, NAT translates the destination public address to the private address, and forwards the packet to the host.

The NAT operation is transparent to the terminals (the host and the server). NAT hides the private network from the external users and shows that the IP address of the internal host is 20.1.1.1.

Figure 1 Basic NAT operation

Direction	Before NAT	After NAT
Outbound	192.168.1.3	20.1.1.1
Inbound	20.1.1.1	192.168.1.3



Restrictions: Software version compatibility with NAT

The NAT feature is supported only in Release 6328 and later.

Configuring outbound one-to-one static NAT

About this task

Static NAT creates a fixed mapping between a private address and a public address. It supports connections initiated from internal users to the external network and from external users to the internal network. Static NAT applies to regular communications.

For address translation from a private IP address to a public IP address, configure outbound one-to-one static NAT on the interface connected to the external network.

- When the source IP address of an outgoing packet matches the *local-ip*, the source IP address is translated into the *global-ip*.
- When the destination IP address of an incoming packet matches the *global-ip*, the destination IP address is translated into the *local-ip*.

Restrictions and guidelines

If you configure modular QoS configuration (MQC) on a device enabled with static NAT, packets that match an ACL rule are sent to the CPU. If the packet IP addresses match a NAT rule, the device generates NAT sessions and performs forwarding in software, which might cause packet loss of established NAT sessions.

Procedure

1. Enter system view.
   system-view
2. Configure a one-to-one mapping for outbound static NAT.
   nat static outbound *local-ip global-ip*
3. Enter interface view.
   interface *interface-type interface-number*
4. Enable static NAT on the interface.
   nat static enable
   By default, static NAT is disabled.

Display and maintenance commands for NAT

Execute **display** commands in any view and **reset** commands in user view.

Task	Command
Display NAT sessions.	**display nat session** [{ **source-ip** *source-ip* | **destination-ip** *destination-ip* } *] [**slot** *slot-number*] [**verbose**]
Display static NAT mappings.	**display nat static**
Clear NAT sessions.	**reset nat session**

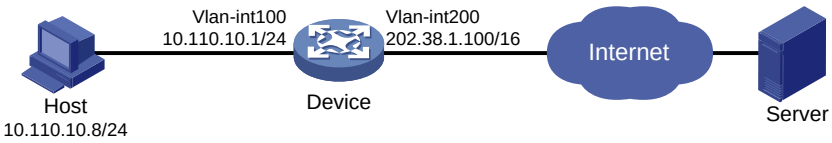
NAT configuration examples

Example: Configuring outbound one-to-one static NAT

Network configuration

Configure static NAT to allow the host at 10.110.10.8/24 to access the Internet.

Figure 2 Network diagram



Procedure

Specify IP addresses for the interfaces on the device. (Details not shown.)

Configure a one-to-one static NAT mapping between the private address 10.110.10.8 and the public address 202.38.1.100.

```
<Device> system-view
[Device] nat static outbound 10.110.10.8 202.38.1.100
```

Enable static NAT on VLAN-interface 200.

```
[Device] interface vlan-interface 200
[Device-Vlan-interface200] nat static enable
[Device-Vlan-interface200] quit
```

Verifying the configuration

Verify that the host at 10.110.10.8/24 can access the server on the Internet. (Details not shown.)

Display static NAT configuration.

```
[Device] display nat static
Static NAT mappings:
  Totally 1 outbound static NAT mappings.
  IP-to-IP:
    Local IP     : 10.110.10.8
    Global IP    : 202.38.1.100
    Config status: Active

Interfaces enabled with static NAT:
  Totally 1 interfaces enabled with static NAT.
  Interface: Vlan-interface200
    Service card : ---
    Config status: Active
```

Display NAT session information.

```
[Device] display nat session verbose
Initiator:
  Source      IP/port: 10.110.10.8/42496
  Destination IP/port: 202.38.1.111/2048
  DS-Lite tunnel peer: -
  VPN instance/VLAN ID/VLL ID: -/-/-
```

```
  Protocol: ICMP(1)
  Inbound interface: Vlan-interface100
Responder:
  Source      IP/port: 202.38.1.111/42496
  Destination IP/port: 202.38.1.100/0
  DS-Lite tunnel peer: -
  VPN instance/VLAN ID/VLL ID: -/-/-
  Protocol: ICMP(1)
  Inbound interface: Vlan-interface200
State: ICMP_REPLY
Application: INVALID
Start time: 2021-04-13 09:30:49  TTL: 27s
Initiator->Responder:            5 packets        420 bytes
Responder->Initiator:            5 packets        420 bytes

Total sessions found: 1
```

Layer 3—IP Routing Configuration Guide

This command reference is applicable to the following switches and software versions:

H3C S5120V2-LI switch series (Release 6308P01 and later)
H3C S3100V3-SI switch series (Release 6309P01 and later)
H3C S5110V2 switch series (Release 6310 and later)
H3C S5110V2-SI switch series (Release 6310 and later)
H3C S5000V3-EI switch series (Release 6310 and later)
H3C S5000V5-EI switch series (Release 6319P01 and later)
H3C S5000E-X switch series (Release 6310 and later)
H3C S5130S-LI switch series (Release 6310 and later)
H3C MS4320V2 switch series (Release 6308P01 and later)
H3C MS4320 switch series (Release 6308P01 and later)
H3C MS4300V2 switch series (Release 6308P01 and later)
H3C MS4200 switch series (Release 6310 and later)
H3C WS5810-WiNet switch series (Release 6308P01 and later)
H3C WS5820-WiNet switch series (Release 6308P01 and later)
H3C WAS6000 switch series (Release 6308P01 and later)
H3C S5000X-EI switch series (Release 6329 and later)
H3C MS4320V3 switch series (Release 6329 and later)
H3C S5120V3-SI switch series (Release 6329 and later)
H3C S5120V3-LI switch series (Release 6329 and later)

New H3C Technologies Co., Ltd.
http://www.h3c.com

Software version: Release 63xx
Document version: 6W105-20230524

Preface

This configuration guide describes the routing fundamentals and configuration procedures. It covers the mainstream routing protocols for IPv4 and IPv6 networks, and describes how to use policies to filter routes and affect routing decisions.

This preface includes the following topics about the documentation:

Audience

This documentation is intended for:

- Network planners.
- Field technical support and servicing engineers.
- Network administrators.

Conventions

The following information describes the conventions used in the documentation.

Command conventions

Convention	Description
Boldface	**Bold** text represents commands and keywords that you enter literally as shown.
Italic	*Italic* text represents arguments that you replace with actual values.
[ ]	Square brackets enclose syntax choices (keywords or arguments) that are optional.
{ x | y | ... }	Braces enclose a set of required syntax choices separated by vertical bars, from which you select one.
[x | y | ...]	Square brackets enclose a set of optional syntax choices separated by vertical bars, from which you select one or none.
{ x | y | ... } *	Asterisk marked braces enclose a set of required syntax choices separated by vertical bars, from which you select a minimum of one.
[x | y | ...] *	Asterisk marked square brackets enclose optional syntax choices separated by vertical bars, from which you select one choice, multiple choices, or none.
&<1-n>	The argument or keyword and argument combination before the ampersand (&) sign can be entered 1 to n times.
#	A line that starts with a pound (#) sign is comments.

GUI conventions

Convention	Description
Boldface	Window names, button names, field names, and menu items are in Boldface. For example, the **New User** window opens; click **OK**.
>	Multi-level menus are separated by angle brackets. For example, **File** > **Create** >

Convention	Description
	Folder.

Symbols

Convention	Description
⚠ **WARNING!**	An alert that calls attention to important information that if not understood or followed can result in personal injury.
△ **CAUTION:**	An alert that calls attention to important information that if not understood or followed can result in data loss, data corruption, or damage to hardware or software.
ⓘ **IMPORTANT:**	An alert that calls attention to essential information.
NOTE:	An alert that contains additional or supplementary information.
TIP:	An alert that provides helpful information.

Network topology icons

Convention	Description
	Represents a generic network device, such as a router, switch, or firewall.
	Represents a routing-capable device, such as a router or Layer 3 switch.
	Represents a generic switch, such as a Layer 2 or Layer 3 switch, or a router that supports Layer 2 forwarding and other Layer 2 features.
	Represents an access controller, a unified wired-WLAN module, or the access controller engine on a unified wired-WLAN switch.
	Represents an access point.
	Represents a wireless terminator unit.
	Represents a wireless terminator.
	Represents a mesh access point.
	Represents omnidirectional signals.
	Represents directional signals.
	Represents a security product, such as a firewall, UTM, multiservice security gateway, or load balancing device.
	Represents a security module, such as a firewall, load balancing, NetStream, SSL VPN, IPS, or ACG module.

Examples provided in this document

Examples in this document might use devices that differ from your device in hardware model, configuration, or software version. It is normal that the port numbers, sample output, screenshots, and other information in the examples differ from what you have on your device.

Documentation feedback

You can e-mail your comments about product documentation to info@h3c.com.

We appreciate your comments.

Contents

Configuring basic IP routing

This chapter focuses on unicast routing protocols. For more information about multicast routing protocols, see *IP Multicast Configuration Guide*.

About IP routing

IP routing directs IP packet forwarding on routers. Based on the destination IP address in the packet, a router looks up a route for the packet in a routing table and forwards the packet to the next hop. Routes are path information used to direct IP packets.

Routing table

A RIB contains the global routing information and related information, including route recursion, route redistribution, and route extension information. The router selects optimal routes from the routing table and puts them into the FIB table. It uses the FIB table to forward packets. For more information about the FIB table, see *Layer 3—IP Services Configuration Guide*.

Route categories

Table 1 categorizes routes by different criteria.

Table 1 Route categories

Criterion	Categories
Origin	• **Direct route**—A direct route is discovered by the data link protocol on an interface, and is also called an interface route. • **Static route**—A static route is manually configured by an administrator. • **Dynamic route**—A dynamic route is dynamically discovered by a routing protocol.
Destination	• **Network route**—The destination is a network. The subnet mask is less than 32 bits. • **Host route**—The destination is a host. The subnet mask is 32 bits.
Whether the destination is directly connected	• **Direct route**—The destination is directly connected. • **Indirect route**—The destination is indirectly connected.

Dynamic routing protocols

Static routes work well in small, stable networks. They are easy to configure and require fewer system resources. However, in networks where topology changes occur frequently, a typical practice is to configure a dynamic routing protocol. Compared with static routing, a dynamic routing protocol is complicated to configure, requires more router resources, and consumes more network resources.

Dynamic routing protocols dynamically collect and report reachability information to adapt to topology changes. They are suitable for large networks.

Dynamic routing protocols can be classified by different criteria, as shown in Table 2.

Table 2 Categories of dynamic routing protocols

Criterion	Categories
Operation scope	• **IGPs**—Work within an AS. Examples include RIP, OSPF, and IS-IS. • **EGPs**—Work between ASs. The most popular EGP is BGP.
Routing algorithm	• **Distance-vector protocols**—Examples include RIP and BGP. BGP is also considered a path-vector protocol. • **Link-state protocols**—Examples include OSPF and IS-IS.
Destination address type	• **Unicast routing protocols**—Examples include RIP, OSPF, BGP, and IS-IS. • **Multicast routing protocols**—Examples include PIM-SM and PIM-DM.
IP version	• **IPv4 routing protocols**—Examples include RIP, OSPF, BGP, and IS-IS. • **IPv6 routing protocols**—Examples include RIPng, OSPFv3, IPv6 BGP, and IPv6 IS-IS.

An AS refers to a group of routers that use the same routing policy and work under the same administration.

Route preference

Routing protocols, including static and direct routing, each by default have a preference. If they find multiple routes to the same destination, the router selects the route with the highest preference as the optimal route.

The preference of a direct route is always 0 and cannot be changed. You can configure a preference for each static route and each dynamic routing protocol. The following table lists the route types and default preferences. The smaller the value, the higher the preference.

Table 3 Route types and default route preferences

Route type	Preference
Direct route	0
Multicast static route	1
OSPF	10
IS-IS	15
Unicast static route	60
RIP	100
OSPF ASE	150
OSPF NSSA	150
IBGP	255
EBGP	255
Unknown (route from an untrusted source)	256

Route backup

Route backup can improve network availability. Among multiple routes to the same destination, the route with the highest priority is the primary route and others are secondary routes.

The router forwards matching packets through the primary route. When the primary route fails, the route with the highest preference among the secondary routes is selected to forward packets. When the primary route recovers, the router uses it to forward packets.

Route recursion

To use a BGP, static, or RIP route that has an indirectly connected next hop, a router must perform route recursion to find the output interface to reach the next hop.

Link-state routing protocols, such as OSPF and IS-IS, do not need route recursion, because they obtain directly connected next hops through route calculation.

The RIB records and saves route recursion information, including brief information about related routes, recursive paths, and recursion depth.

Route redistribution

Route redistribution enables routing protocols to learn routing information from each other. A dynamic routing protocol can redistribute routes from other routing protocols, including direct and static routing. For more information, see the respective chapters on those routing protocols in this configuration guide.

The RIB records redistribution relationships of routing protocols.

Extension attribute redistribution

Extension attribute redistribution enables routing protocols to learn route extension attributes from each other, including BGP extended community attributes, OSPF area IDs, route types, and router IDs.

The RIB records extended attributes of each routing protocol and redistribution relationships of different routing protocol extended attributes.

Setting the maximum lifetime for routes and labels in the RIB

About setting the maximum lifetime for routes and labels in the RIB

Perform this task to prevent routes of a certain protocol from being aged out due to slow protocol convergence resulting from a large number of route entries or long GR period.

Restrictions and guidelines

The configuration takes effect at the next protocol or RIB process switchover.

Procedure (IPv4)

1. Enter system view.
   system-view
2. Enter RIB view.
   rib
3. Create the RIB IPv4 address family and enter its view.
   address-family ipv4
4. Set the maximum lifetime for IPv4 routes and labels in the RIB.
   protocol *protocol* [**instance** *instance-name*] **lifetime** *seconds*

By default, the maximum lifetime for routes and labels in the RIB is 480 seconds.

Procedure (IPv6)

1. Enter system view.
   system-view
2. Enter RIB view.
   rib
3. Create the RIB IPv6 address family and enter its view.
   address-family ipv6
4. Set the maximum lifetime for IPv6 routes and labels in the RIB.
   protocol *protocol* [**instance** *instance-name*] **lifetime** *seconds*
   By default, the maximum lifetime for routes and labels in the RIB is 480 seconds.

Setting the maximum lifetime for routes in the FIB

About setting the maximum lifetime for routes in the FIB

When GR or NSR is disabled, FIB entries must be retained for some time after a protocol process switchover or RIB process switchover. When GR or NSR is enabled, FIB entries must be removed immediately after a protocol or RIB process switchover to avoid routing issues. Perform this task to meet such requirements.

Procedure (IPv4)

1. Enter system view.
   system-view
2. Enter RIB view.
   rib
3. Create the RIB IPv4 address family and enter its view.
   address-family ipv4
4. Set the maximum lifetime for IPv4 routes in the FIB.
   fib lifetime *seconds*
   By default, the maximum lifetime for routes in the FIB is 600 seconds.

Procedure (IPv6)

1. Enter system view.
   system-view
2. Enter RIB view.
   rib
3. Create the RIB IPv6 address family and enter its view.
   address-family ipv6
4. Set the maximum lifetime for IPv6 routes in the FIB.
   fib lifetime *seconds*
   By default, the maximum lifetime for routes in the FIB is 600 seconds.

Configuring RIB NSR

About RIB NSR

When an active/standby switchover occurs, nonstop routing (NSR) backs up routing information from the active process to the standby process to avoid routing flapping and ensure forwarding continuity.

RIB NSR provides faster route convergence than protocol NSR during an active/standby switchover.

Restrictions and guidelines

Use this feature with protocol GR or NSR to avoid route timeouts and traffic interruption.

Procedure (IPv4)

1. Enter system view.
   `system-view`
2. Enter RIB view.
   `rib`
3. Create the RIB IPv4 address family and enter its view.
   `address-family ipv4`
4. Enable IPv4 RIB NSR.
   `non-stop-routing`
   By default, RIB NSR is disabled.

Procedure (IPv6)

1. Enter system view.
   `system-view`
2. Enter RIB view.
   `rib`
3. Create the RIB IPv6 address family and enter its view.
   `address-family ipv6`
4. Enable IPv6 RIB NSR.
   `non-stop-routing`
   By default, RIB NSR is disabled.

Configuring inter-protocol FRR

About inter-protocol FRR

Inter-protocol fast reroute (FRR) enables fast rerouting between routes of different protocols. A backup next hop is automatically selected to reduce the service interruption time caused by unreachable next hops. When the next hop of the primary link fails, the traffic is redirected to the backup next hop.

Among the routes to the same destination in the RIB, a router adds the route with the highest preference to the FIB table. For example, if a static route and an OSPF route in the RIB have the same destination, the router adds the OSPF route to the FIB table by default. The next hop of the static route is selected as the backup next hop for the OSPF route. When the next hop of the OSPF route is unreachable, the backup next hop is used.

Restrictions and guidelines

This feature uses the next hop of a route from a different protocol as the backup next hop, which might cause loops.

Procedure (IPv4)

1. Enter system view.
   system-view
2. Enter RIB view.
   rib
3. Create the RIB IPv4 address family and enter its view.
   address-family ipv4
4. Enable IPv4 RIB inter-protocol FRR.
   inter-protocol fast-reroute
   By default, inter-protocol FRR is disabled.

Procedure (IPv6)

1. Enter system view.
   system-view
2. Enter RIB view.
   rib
3. Create the RIB IPv6 address family and enter its view.
   address-family ipv6
4. Enable IPv6 RIB inter-protocol FRR.
   inter-protocol fast-reroute
   By default, inter-protocol FRR is disabled.

Enabling route fast switchover

About enabling route fast switchover

This feature applies to a device that provides the same physical output interface for large numbers of routes, including primary/secondary routes. When a link failure occurs on the interface, the device must perform the following tasks before switching the traffic to another route:

1. Deletes all ARP or ND entries for the link.
2. Instructs the FIB to delete the associated FIB entries.

This procedure is time consuming and interrupts traffic for a long time. To resolve this problem, you can enable route fast switchover. This feature allows the device to instruct the FIB to delete the invalid FIB entries for route switchover first.

Procedure (IPv4)

1. Enter system view.
   system-view
2. Enable IPv4 route fast switchover.
   ip route fast-switchover enable
   By default, IPv4 route fast switchover is disabled.

Procedure (IPv6)

1. Enter system view.

system-view

2. Enable IPv6 route fast switchover.

   ipv6 route fast-switchover enable

   By default, IPv6 route fast switchover is disabled.

Configuring routing policy-based recursive lookup

About routing policy-based recursive lookup

Configure routing policy-based recursive lookup to control route recursion results. For example, when a route changes, the routing protocol has to perform a route recursion if the next hop is indirectly connected. The routing protocol might select an incorrect path, which can cause traffic loss. To resolve this issue, you can use a routing policy to filter out incorrect routes. The routes that pass the filtering of the routing policy will be used for route recursion.

Restrictions and guidelines

The **apply** clauses in the specified routing policy cannot take effect.

Make sure a minimum of one related route can match the routing policy for correct traffic forwarding.

Procedure

1. Enter system view.

   system-view

2. Enter RIB view.

   rib

3. Create the RIB IPv4 address family and enter its view.

   address-family ipv4

4. Configure routing policy-based recursive lookup.

   protocol *protocol* **nexthop recursive-lookup route-policy** *route-policy-name*

   By default, routing policy-based recursive lookup is not configured.

Setting the maximum number of active routes supported by the device

About setting the maximum number of active routes supported by the device

The feature allows you to set the maximum number of active IPv4/IPv6 routes supported by the device. When the maximum number of active IPv4/IPv6 routes is exceeded, the device still accepts new active routes but generates a system log message. You can take relevant actions based on the message to save system resources.

Procedure (IPv4)

1. Enter system view.

   system-view

2. Enter RIB view.

   rib

3. Create the RIB IPv4 address family and enter its view.

   address-family ipv4

4. Set the maximum number of active IPv4 routes supported by the device.

routing-table limit *number* **simply-alert**

By default, the maximum number of active IPv4 routes is not set for the device.

Configuration in RIB IPv4 address family view limits the number of active IPv4 routes for the public network.

Procedure (IPv6)

1. Enter system view.
   system-view
2. Enter RIB view.
   rib
3. Create the RIB IPv6 address family and enter its view.
   address-family ipv6
4. Set the maximum number of active IPv6 routes supported by the device.
   routing-table limit *number* **simply-alert**

   By default, the maximum number of active IPv6 routes is not set for the device.

   Configuration in RIB IPv6 address family view limits the number of active IPv6 routes for the public network.

Enabling MTP

About this task

Use maintenance probe (MTP) to locate faults for routing protocols depending on your network maintenance requirements. MTP enables the device to automatically perform the following operations upon expiration of a neighbor's hold timer:

1. Ping the neighbor or trace the route to the neighbor.
2. Record the ping or tracert results.

To view fault information, use the **display** commands of routing protocols, for example, the **display ospf troubleshooting** command. To view detailed MTP information, use the **display logbuffer** command.

Procedure

1. Enter system view.
   system-view
2. Enable MTP.
   maintenance-probe enable

   By default, MTP is disabled.

Display and maintenance commands for basic IP routing

Execute **display** commands in any view and **reset** commands in user view.

Task	Command
Display routing table information.	**display ip routing-table** [**verbose**] **display ip routing-table** [**all-routes**]

Task	Command
Display information about routes permitted by an IPv4 basic ACL.	**display ip routing-table acl** *ipv4-acl-number* [**verbose**]
Display information about routes to a specific destination address.	**display ip routing-table** *ip-address* [*mask-length* | *mask*] [**longer-match**] [**verbose**]
Display information about routes to a range of destination addresses.	**display ip routing-table** *ip-address1* **to** *ip-address2* [**verbose**]
Display information about routes permitted by an IP prefix list.	**display ip routing-table prefix-list** *prefix-list-name* [**verbose**]
Display information about routes installed by a protocol.	**display ip routing-table protocol** *protocol* [**inactive** | **verbose**]
Display IPv4 route statistics.	**display ip routing-table** [**all-routes**] **statistics**
Display brief IPv4 routing table information.	**display ip routing-table summary**
Display IPv6 RIB GR state information.	**display ipv6 rib graceful-restart**
Display next hop information in the IPv6 RIB.	**display ipv6 rib nib** [**self-originated**] [*nib-id*] [**verbose**] **display ipv6 rib nib protocol** *protocol* [**verbose**]
Display next hop information for IPv6 direct routes.	**display ipv6 route-direct nib** [*nib-id*] [**verbose**]
Display IPv6 routing table information.	**display ipv6 routing-table** [**verbose**] **display ipv6 routing-table** [**all-routes**]
Display information about routes permitted by an IPv6 basic ACL.	**display ipv6 routing-table acl** *ipv6-acl-number* [**verbose**]
Display information about routes to an IPv6 destination address.	**display ipv6 routing-table** *ipv6-address* [*prefix-length*] [**longer-match**] [**verbose**]
Display information about routes to a range of IPv6 destination addresses.	**display ipv6 routing-table** *ipv6-address1* **to** *ipv6-address2* [**verbose**]
Display information about routes permitted by an IPv6 prefix list.	**display ipv6 routing-table prefix-list** *prefix-list-name* [**verbose**]
Display information about routes installed by an IPv6 protocol.	**display ipv6 routing-table protocol** *protocol* [**inactive** | **verbose**]
Display IPv6 route statistics.	**display ipv6 routing-table** [**all-routes**] **statistics**
Display brief IPv6 routing table information.	**display ipv6 routing-table summary**
Display RIB GR state information.	**display rib graceful-restart**

Task	Command
Display next hop information in the RIB.	**display rib nib** [**self-originated**] [*nib-id*] [**verbose**] **display rib nib protocol** *protocol* [**verbose**]
Display next hop information for direct routes.	**display route-direct nib** [*nib-id*] [**verbose**]
Clear IPv4 route statistics.	**reset ip routing-table statistics protocol** { *protocol* | **all** } **reset ip routing-table** [**all-routes**] **statistics protocol** { *protocol* | **all** }
Clear IPv6 route statistics.	**reset ipv6 routing-table statistics protocol** { *protocol* | **all** } **reset ipv6 routing-table** [**all-routes**] **statistics protocol** { **protocol** | **all** }

Contents

Configuring static routing

About static routes

Static routes are manually configured. If a network's topology is simple, you only need to configure static routes for the network to work correctly.

Static routes cannot adapt to network topology changes. If a fault or a topological change occurs in the network, the network administrator must modify the static routes manually.

Configuring a static route

1. Enter system view.

   system-view

2. Configure a static route.

   ip route-static *dest-address* { *mask-length* | *mask* } { *interface-type interface-number* [*next-hop-address* [**nexthop-index** *index-string*]] | *next-hop-address* [**nexthop-index** *index-string*] [**recursive-lookup host-route**] } [**permanent** | **track** *track-entry-number*] [**preference** *preference*] [**tag** *tag-value*] [**description** *text*]

   By default, no static route is configured.

   You can associate Track with a static route to monitor the reachability of the next hops. For more information about Track, see *High Availability Configuration Guide*.

3. (Optional.) Enable periodic sending of ARP requests to the next hops of static routes.

   ip route-static arp-request interval *interval*

   By default, the device does not send ARP requests to the next hops of static routes.

4. (Optional.) Configure the default preference for static routes.

   ip route-static default-preference *default-preference*

   The default setting is 60.

Configuring a static route group

About static route groups

This task allows you to batch create static routes with different prefixes but the same output interface and next hop.

You can create a static route group, and specify the static group in the **ip route-static** command. All prefixes in the static route group will be assigned the next hop and output interface specified in the **ip route-static** command.

Procedure

1. Enter system view.

   system-view

2. Create a static route group and enter its view.

   ip route-static-group *group-name*

   By default, no static route group is configured.

3. Add a static route prefix to the static route group.

prefix *dest-address* { *mask-length* | *mask* }

By default, no static route prefix is added to the static route group.

4. Return to system view.

   quit

5. Configure a static route.

   ip route-static group *group-name* { *interface-type interface-number* [*next-hop-address*] | *next-hop-address* [**recursive-lookup host-route**] } [**permanent** | **track** *track-entry-number*] [**preference** *preference*] [**tag** *tag-value*] [**description** *text*]

   By default, no static route is configured.

Deleting static routes

About deleting static routes

To delete a static route, use the **undo ip route-static** command. To delete all static routes including the default route, use the **delete static-routes all** command.

Procedure

1. Enter system view.

   system-view

2. Delete all static routes.

   delete static-routes all

CAUTION:

This command might interrupt network communication and cause packet forwarding failure. Before executing the command, make sure you fully understand the potential impact on the network.

Configuring BFD for static routes

IMPORTANT:

Enabling BFD for a flapping route could worsen the situation.

About BFD

BFD provides a general-purpose, standard, medium-, and protocol-independent fast failure detection mechanism. It can uniformly and quickly detect the failures of the bidirectional forwarding paths between two routers for protocols, such as routing protocols.

For more information about BFD, see *High Availability Configuration Guide*.

Configuring BFD control packet mode

About BFD control packet mode

This mode uses BFD control packets to detect the status of a link bidirectionally at a millisecond level.

BFD control packet mode can be applied to static routes with a direct next hop or with an indirect next hop.

Restrictions and guidelines for BFD control packet mode

If you use BFD control packet mode at the local end, you must use this mode also at the peer end.

Configuring BFD control packet mode for a static route (direct next hop)

1. Enter system view.

   system-view

2. Configure BFD control packet mode for a static route.

   ip route-static *dest-address* { *mask-length* | *mask* } *interface-type interface-number next-hop-address* **bfd control-packet** [**preference** *preference*] [**tag** *tag-value*] [**description** *text*]

   By default, BFD control packet mode for a static route is not configured.

Configuring BFD control packet mode for a static route (indirect next hop)

1. Enter system view.

   system-view

2. Configure BFD control packet mode for a static route.

   ip route-static *dest-address* { *mask-length* | *mask* } { *next-hop-address* **bfd control-packet bfd-source** *ip-address* [**preference** *preference*] [**tag tag-value**] [**description** *text*]

   By default, BFD control packet mode for a static route is not configured.

Configuring BFD echo packet mode

About BFD echo packet mode

With BFD echo packet mode enabled for a static route, the output interface sends BFD echo packets to the destination device, which loops the packets back to test the link reachability.

Restrictions and guidelines

You do not need to configure BFD echo packet mode at the peer end.

Do not use BFD for a static route with the output interface in spoofing state.

Procedure

1. Enter system view.

   system-view

2. Configure the source address of echo packets.

   bfd echo-source-ip *ip-address*

   By default, the source address of echo packets is not configured.

   For more information about this command, see *High Availability Command Reference*.

3. Configure BFD echo packet mode for a static route.

   ip route-static *dest-address* { *mask-length* | *mask* } *interface-type interface-number next-hop-address* **bfd echo-packet** [**preference** *preference*] [**tag** *tag-value*] [**description** *text*]

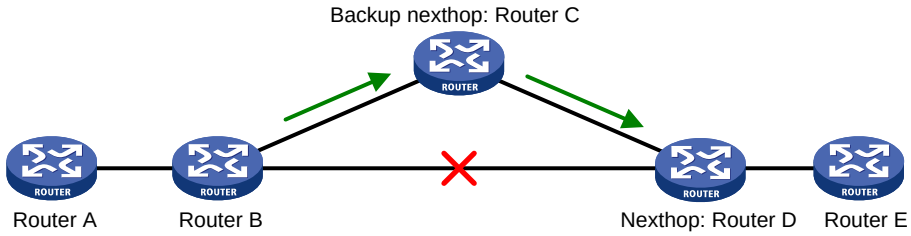
   By default, BFD echo packet mode for a static route is not configured.

Configuring static route FRR

About static route FRR

A link or router failure on a path can cause packet loss. Static route fast reroute (FRR) enables fast rerouting to minimize the impact of link or node failures.

Figure 1 Network diagram



As shown in Figure 1, upon a link failure, packets are directed to the backup next hop to avoid traffic interruption. You can either specify a backup next hop for FRR or enable FRR to automatically select a backup next hop (which must be configured in advance).

Restrictions and guidelines for static route FRR

- Do not use static route FRR and BFD (for a static route) at the same time.
- In addition to the configured static route for FRR, the device must have another route to reach the destination.

  When the state of the primary link (with Layer 3 interfaces staying up) changes from bidirectional to unidirectional or down, static route FRR quickly redirects traffic to the backup next hop. When the Layer 3 interfaces of the primary link are down, static route FRR temporarily redirects traffic to the backup next hop. In addition, the device searches for another route to reach the destination and redirects traffic to the new path if a route is found. If no route is found, traffic interruption occurs.

Configuring static route FRR by specifying a backup next hop

Restrictions and guidelines

A static route does not take effect when the backup output interface is unavailable.

To change the backup output interface or next hop, you must first remove the current setting. The backup output interface and next hop must be different from the primary output interface and next hop.

Procedure

1. Enter system view.

   system-view

2. Configure static route FRR.

   ip route-static *dest-address* { *mask-length* | *mask* } *interface-type interface-number* [*next-hop-address* [**backup-interface** *interface-type interface-number* [**backup-nexthop** *backup-nexthop-address*]]] [**permanent**] [**preference** *preference*] [**tag** *tag-value*] [**description** *text*]

   By default, static route FRR is disabled.

Configuring static route FRR to automatically select a backup next hop

1. Enter system view.
   system-view
2. Configure static route FRR to automatically select a backup next hop.
   ip route-static fast-reroute auto
   By default, static route FRR is disabled from automatically selecting a backup next hop.

Enabling BFD echo packet mode for static route FRR

About BFD echo packet mode

By default, static route FRR uses ARP to detect primary link failures. Perform this task to enable static route FRR to use BFD echo packet mode for fast failure detection on the primary link.

Procedure

1. Enter system view.
   system-view
2. Configure the source IP address of BFD echo packets.
   bfd echo-source-ip *ip-address*
   By default, the source IP address of BFD echo packets is not configured.
   The source IP address cannot be on the same network segment as any local interface's IP address.
   For more information about this command, see *High Availability Command Reference*.
3. Enable BFD echo packet mode for static route FRR.
   ip route-static primary-path-detect bfd echo
   By default, BFD echo packet mode for static route FRR is disabled.

Display and maintenance commands for static routing

Execute **display** commands in any view.

Task	Command
Display static route information.	**display ip routing-table protocol static** [**inactive** | **verbose**]
Display static route next hop information.	**display route-static nib** [*nib-id*] [**verbose**]
Display static routing table information.	**display route-static routing-table** [*ip-address* { *mask-length* | *mask* }]

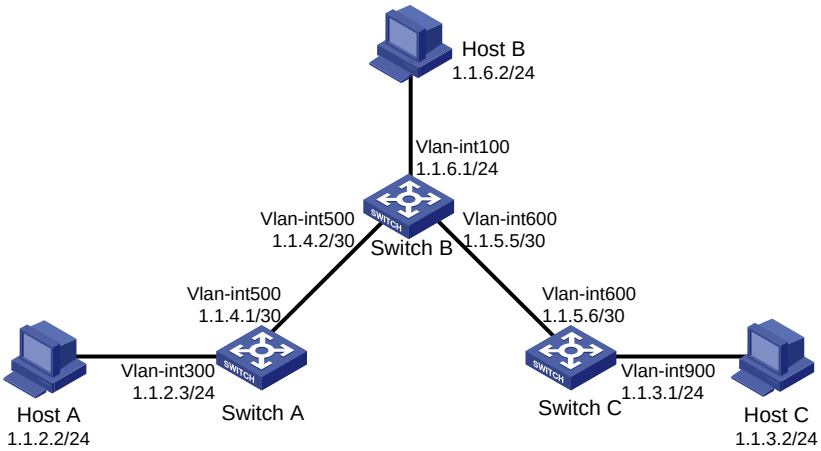
Static route configuration examples

Example: Configuring basic static routes

Network configuration

As shown in Figure 2, configure static routes on the switches for interconnections between any two hosts.

Figure 2 Network diagram



Procedure

1. Configure IP addresses for interfaces. (Details not shown.)
2. Configure static routes:

   # Configure a default route on Switch A.

   ```
   <SwitchA> system-view
   [SwitchA] ip route-static 0.0.0.0 0.0.0.0 1.1.4.2
   ```

   # Configure two static routes on Switch B.

   ```
   <SwitchB> system-view
   [SwitchB] ip route-static 1.1.2.0 255.255.255.0 1.1.4.1
   [SwitchB] ip route-static 1.1.3.0 255.255.255.0 1.1.5.6
   ```

   # Configure a default route on Switch C.

   ```
   <SwitchC> system-view
   [SwitchC] ip route-static 0.0.0.0 0.0.0.0 1.1.5.5
   ```

3. Configure the default gateways of Host A, Host B, and Host C as 1.1.2.3, 1.1.6.1, and 1.1.3.1. (Details not shown.)

Verifying the configuration

Display static routes on Switch A.

```
[SwitchA] display ip routing-table protocol static

Summary count : 1

Static Routing table status : <Active>
Summary count : 1
```

```
Destination/Mask    Proto  Pre  Cost         NextHop         Interface
0.0.0.0/0           Static 60   0            1.1.4.2         Vlan500

Static Routing table status : <Inactive>
Summary count : 0
```

Display static routes on Switch B.

```
[SwitchB] display ip routing-table protocol static

Summary count : 2

Static Routing table status : <Active>
Summary count : 2

Destination/Mask    Proto  Pre  Cost         NextHop         Interface
1.1.2.0/24          Static 60   0            1.1.4.1         Vlan500

Static Routing table status : <Inactive>
Summary count : 0
```

Use the **`ping`** command on Host B to test the reachability of Host A (Windows XP runs on the two hosts).

```
C:\Documents and Settings\Administrator>ping 1.1.2.2

Pinging 1.1.2.2 with 32 bytes of data:

Reply from 1.1.2.2: bytes=32 time=1ms TTL=126
Reply from 1.1.2.2: bytes=32 time=1ms TTL=126
Reply from 1.1.2.2: bytes=32 time=1ms TTL=126
Reply from 1.1.2.2: bytes=32 time=1ms TTL=126

Ping statistics for 1.1.2.2:
    Packets: Sent = 4, Received = 4, Lost = 0 (0% loss),
Approximate round trip times in milli-seconds:
    Minimum = 1ms, Maximum = 1ms, Average = 1ms
```

Use the **`tracert`** command on Host B to test the reachability of Host A.

```
C:\Documents and Settings\Administrator>tracert 1.1.2.2

Tracing route to 1.1.2.2 over a maximum of 30 hops

  1    <1 ms    <1 ms    <1 ms  1.1.6.1
  2    <1 ms    <1 ms    <1 ms  1.1.4.1
  3     1 ms    <1 ms    <1 ms  1.1.2.2

Trace complete.
```

Example: Configuring BFD for static routes (direct next hop)

Network configuration

Configure the following, as shown in Figure 3:

- Configure a static route to subnet 120.1.1.0/24 on Switch A.
- Configure a static route to subnet 121.1.1.0/24 on Switch B.
- Enable BFD for both routes.
- Configure a static route to subnet 120.1.1.0/24 and a static route to subnet 121.1.1.0/24 on Switch C.

When the link between Switch A and Switch B through the Layer 2 switch fails, BFD can detect the failure immediately. Switch A then communicates with Switch B through Switch C.

Figure 3 Network diagram

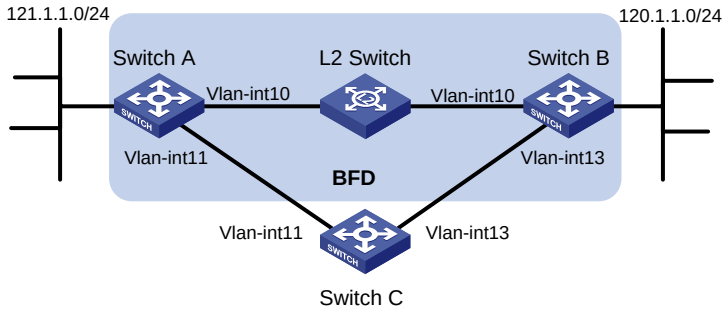


Table 1 Interface and IP address assignment

Device	Interface	IP address
Switch A	VLAN-interface 10	12.1.1.1/24
Switch A	VLAN-interface 11	10.1.1.102/24
Switch B	VLAN-interface 10	12.1.1.2/24
Switch B	VLAN-interface 13	13.1.1.1/24
Switch C	VLAN-interface 11	10.1.1.100/24
Switch C	VLAN-interface 13	13.1.1.2/24

Procedure

1. Configure IP addresses for the interfaces. (Details not shown.)
2. Configure static routes and BFD:

   # Configure static routes on Switch A and enable BFD control packet mode for the static route that traverses the Layer 2 switch.

```
<SwitchA> system-view
[SwitchA] interface vlan-interface 10
[SwitchA-vlan-interface10] bfd min-transmit-interval 500
[SwitchA-vlan-interface10] bfd min-receive-interval 500
[SwitchA-vlan-interface10] bfd detect-multiplier 9
[SwitchA-vlan-interface10] quit
[SwitchA] ip route-static 120.1.1.0 24 vlan-interface 10 12.1.1.2 bfd control-packet
[SwitchA] ip route-static 120.1.1.0 24 vlan-interface 11 10.1.1.100 preference 65
```

```
[SwitchA] quit
```

Configure static routes on Switch B and enable BFD control packet mode for the static route that traverses the Layer 2 switch.

```
<SwitchB> system-view
[SwitchB] interface vlan-interface 10
[SwitchB-vlan-interface10] bfd min-transmit-interval 500
[SwitchB-vlan-interface10] bfd min-receive-interval 500
[SwitchB-vlan-interface10] bfd detect-multiplier 9
[SwitchB-vlan-interface10] quit
[SwitchB] ip route-static 121.1.1.0 24 vlan-interface 10 12.1.1.1 bfd control-packet
[SwitchB] ip route-static 121.1.1.0 24 vlan-interface 13 13.1.1.2 preference 65
[SwitchB] quit
```

Configure static routes on Switch C.

```
<SwitchC> system-view
[SwitchC] ip route-static 120.1.1.0 24 13.1.1.1
[SwitchC] ip route-static 121.1.1.0 24 10.1.1.102
```

Verifying the configuration

Display BFD sessions on Switch A.

```
<SwitchA> display bfd session

 Total Session Num: 1     Up Session Num: 1     Init Mode: Active

 IPv4 Session Working Under Ctrl Mode:

 LD/RD          SourceAddr      DestAddr        State    Holdtime    Interface
 4/7            12.1.1.1        12.1.1.2        Up       2000ms      Vlan10
```

The output shows that the BFD session has been created.

Display the static routes on Switch A.

```
<SwitchA> display ip routing-table protocol static

Summary count : 1

Static Routing table status : <Active>
Summary count : 1

Destination/Mask    Proto  Pre  Cost         NextHop         Interface
120.1.1.0/24        Static 60   0            12.1.1.2        Vlan10

Static Routing table status : <Inactive>
Summary count : 0
```

The output shows that Switch A communicates with Switch B through VLAN-interface 10. Then the link over VLAN-interface 10 fails.

Display static routes on Switch A.

```
<SwitchA> display ip routing-table protocol static

Summary count : 1
```

```
Static Routing table status : <Active>
Summary count : 1

Destination/Mask    Proto  Pre  Cost         NextHop         Interface
120.1.1.0/24        Static 65   0            10.1.1.100      Vlan11

Static Routing table status : <Inactive>
Summary count : 0
```

The output shows that Switch A communicates with Switch B through VLAN-interface 11.

Example: Configuring BFD for static routes (indirect next hop)

Network configuration

Figure 4 shows the network topology as follows:

- Switch A has a route to interface Loopback 1 (2.2.2.9/32) on Switch B, with the output interface VLAN-interface 10.
- Switch B has a route to interface Loopback 1 (1.1.1.9/32) on Switch A, with the output interface VLAN-interface 12.
- Switch D has a route to 1.1.1.9/32, with the output interface VLAN-interface 10, and a route to 2.2.2.9/32, with the output interface VLAN-interface 12.

Configure the following:

- Configure a static route to subnet 120.1.1.0/24 on Switch A.
- Configure a static route to subnet 121.1.1.0/24 on Switch B.
- Enable BFD for both routes.
- Configure a static route to subnet 120.1.1.0/24 and a static route to subnet 121.1.1.0/24 on both Switch C and Switch D.

When the link between Switch A and Switch B through Switch D fails, BFD can detect the failure immediately. Switch A then communicates with Switch B through Switch C.

Figure 4 Network diagram

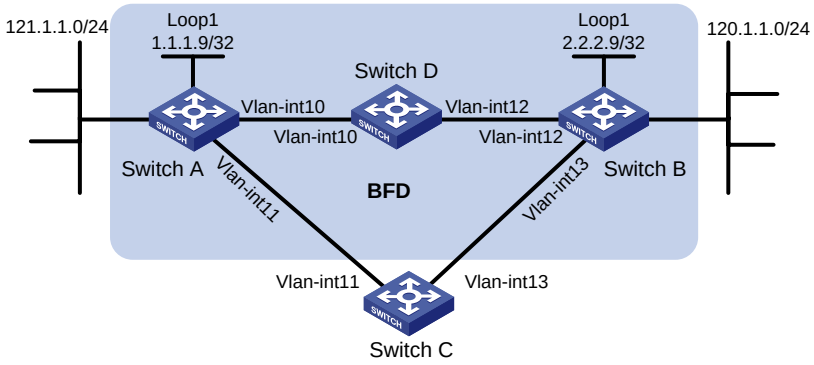


Table 2 Interface and IP address assignment

Device	Interface	IP address
Switch A	VLAN-interface 10	12.1.1.1/24

Device	Interface	IP address
Switch A	VLAN-interface 11	10.1.1.102/24
Switch A	Loopback 1	1.1.1.9/32
Switch B	VLAN-interface 12	11.1.1.1/24
Switch B	VLAN-interface 13	13.1.1.1/24
Switch B	Loopback 1	2.2.2.9/32
Switch C	VLAN-interface 11	10.1.1.100/24
Switch C	VLAN-interface 13	13.1.1.2/24
Switch D	VLAN-interface 10	12.1.1.2/24
Switch D	VLAN-interface 12	11.1.1.2/24

Procedure

1. Configure IP addresses for interfaces. (Details not shown.)
2. Configure static routes and BFD:

   # Configure static routes on Switch A and enable BFD control packet mode for the static route that traverses Switch D.

   ```
   <SwitchA> system-view
   [SwitchA] bfd multi-hop min-transmit-interval 500
   [SwitchA] bfd multi-hop min-receive-interval 500
   [SwitchA] bfd multi-hop detect-multiplier 9
   [SwitchA] ip route-static 120.1.1.0 24 2.2.2.9 bfd control-packet bfd-source 1.1.1.9
   [SwitchA] ip route-static 120.1.1.0 24 vlan-interface 11 10.1.1.100 preference 65
   [SwitchA] quit
   ```

   # Configure static routes on Switch B and enable BFD control packet mode for the static route that traverses Switch D.

   ```
   <SwitchB> system-view
   [SwitchB] bfd multi-hop min-transmit-interval 500
   [SwitchB] bfd multi-hop min-receive-interval 500
   [SwitchB] bfd multi-hop detect-multiplier 9
   [SwitchB] ip route-static 121.1.1.0 24 1.1.1.9 bfd control-packet bfd-source 2.2.2.9
   [SwitchB] ip route-static 121.1.1.0 24 vlan-interface 13 13.1.1.2 preference 65
   [SwitchB] quit
   ```

   # Configure static routes on Switch C.

   ```
   <SwitchC> system-view
   [SwitchC] ip route-static 120.1.1.0 24 13.1.1.1
   [SwitchC] ip route-static 121.1.1.0 24 10.1.1.102
   ```

   # Configure static routes on Switch D.

   ```
   <SwitchD> system-view
   [SwitchD] ip route-static 120.1.1.0 24 11.1.1.1
   [SwitchD] ip route-static 121.1.1.0 24 12.1.1.1
   ```

Verifying the configuration

Display BFD sessions on Switch A.

```
<SwitchA> display bfd session
```

```
Total Session Num: 1     Up Session Num: 1     Init Mode: Active

IPv4 Session Working Under Ctrl Mode:

LD/RD          SourceAddr      DestAddr        State    Holdtime    Interface
4/7            1.1.1.9         2.2.2.9         Up       2000ms      N/A
```

The output shows that the BFD session has been created.

Display the static routes on Switch A.

```
<SwitchA> display ip routing-table protocol static

Summary count : 1

Static Routing table status : <Active>
Summary count : 1

Destination/Mask    Proto  Pre  Cost         NextHop         Interface
120.1.1.0/24        Static 60   0            12.1.1.2        Vlan10

Static Routing table status : <Inactive>
Summary count : 0
```

The output shows that Switch A communicates with Switch B through VLAN-interface 10. Then the link over VLAN-interface 10 fails.

Display static routes on Switch A.

```
<SwitchA> display ip routing-table protocol static

Summary count : 1

Static Routing table status : <Active>
Summary count : 1

Destination/Mask    Proto  Pre  Cost         NextHop         Interface
120.1.1.0/24        Static 65   0            10.1.1.100      Vlan11

Static Routing table status : <Inactive>
Summary count : 0
```

The output shows that Switch A communicates with Switch B through VLAN-interface 11.

Example: Configuring static route FRR

Network configuration

As shown in Figure 5, configure static routes on Switch A, Switch B, and Switch C, and configure static route FRR. When Link A becomes unidirectional, traffic can be switched to Link B immediately.

Figure 5 Network diagram

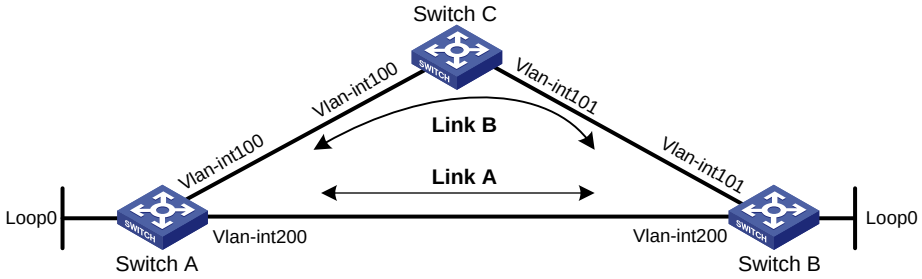


Table 3 Interface and IP address assignment

Device	Interface	IP address
Switch A	VLAN-interface 100	12.12.12.1/24
Switch A	VLAN-interface 200	13.13.13.1/24
Switch A	Loopback 0	1.1.1.1/32
Switch B	VLAN-interface 101	24.24.24.4/24
Switch B	VLAN-interface 200	13.13.13.2/24
Switch B	Loopback 0	4.4.4.4/32
Switch C	VLAN-interface 100	12.12.12.2/24
Switch C	VLAN-interface 101	24.24.24.2/24

Procedure

1. Configure IP addresses for interfaces. (Details not shown.)
2. Configure static route FRR on link A by using one of the following methods:
   - (Method 1.) Specify a backup next hop for static route FRR:

     # Configure a static route on Switch A, and specify VLAN-interface 100 as the backup output interface and 12.12.12.2 as the backup next hop.

     ```
     <SwitchA> system-view
     [SwitchA] ip route-static 4.4.4.4 32 vlan-interface 200 13.13.13.2
     backup-interface vlan-interface 100 backup-nexthop 12.12.12.2
     ```

     # Configure a static route on Switch B, and specify VLAN-interface 101 as the backup output interface and 24.24.24.2 as the backup next hop.

     ```
     <SwitchB> system-view
     [SwitchB] ip route-static 1.1.1.1 32 vlan-interface 200 13.13.13.1
     backup-interface vlan-interface 101 backup-nexthop 24.24.24.2
     ```

   - (Method 2.) Configure static route FRR to automatically select a backup next hop:

     # Configure static routes on Switch A, and enable static route FRR.

     ```
     <SwitchA> system-view
     [SwitchA] ip route-static 4.4.4.4 32 vlan-interface 200 13.13.13.2
     [SwitchA] ip route-static 4.4.4.4 32 vlan-interface 100 12.12.12.2 preference 70
     [SwitchA] ip route-static fast-reroute auto
     ```

     # Configure static routes on Switch B, and enable static route FRR.

     ```
     <SwitchB> system-view
     [SwitchB] ip route-static 1.1.1.1 32 vlan-interface 200 13.13.13.1
     [SwitchB] ip route-static 1.1.1.1 32 vlan-interface 101 24.24.24.2 preference 70
     ```

```
[SwitchB] ip route-static fast-reroute auto
```

3. Configure static routes on Switch C.

```
<SwitchC> system-view
[SwitchC] ip route-static 4.4.4.4 32 vlan-interface 101 24.24.24.4
[SwitchC] ip route-static 1.1.1.1 32 vlan-interface 100 12.12.12.1
```

Verifying the configuration

Display route 4.4.4.4/32 on Switch A to view the backup next hop information.

```
[SwitchA] display ip routing-table 4.4.4.4 verbose

Summary count : 1

Destination: 4.4.4.4/32
   Protocol: Static
 Process ID: 0
  SubProtID: 0x0                  Age: 04h20m37s
       Cost: 0              Preference: 60
      IpPre: N/A            QosLocalID: N/A
        Tag: 0                 State: Active Adv
  OrigTblID: 0x0              OrigVrf: default-vrf
    TableID: 0x2               OrigAs: 0
      NibID: 0x26000002        LastAs: 0
     AttrID: 0xffffffff       Neighbor: 0.0.0.0
      Flags: 0x1008c       OrigNextHop: 13.13.13.2
      Label: NULL          RealNextHop: 13.13.13.2
    BkLabel: NULL            BkNextHop: 12.12.12.2
    SRLabel: NULL            BkSRLabel: NULL
  Tunnel ID: Invalid         Interface: Vlan-interface200
BkTunnel ID: Invalid       BkInterface: Vlan-interface100
   FtnIndex: 0x0           TrafficIndex: N/A
  Connector: N/A                PathID: 0x0
```

Display route 1.1.1.1/32 on Switch B to view the backup next hop information.

```
[SwitchB] display ip routing-table 1.1.1.1 verbose

Summary count : 1

Destination: 1.1.1.1/32
   Protocol: Static
 Process ID: 0
  SubProtID: 0x0                  Age: 04h20m37s
       Cost: 0              Preference: 60
      IpPre: N/A            QosLocalID: N/A
        Tag: 0                 State: Active Adv
  OrigTblID: 0x0              OrigVrf: default-vrf
    TableID: 0x2               OrigAs: 0
      NibID: 0x26000002        LastAs: 0
     AttrID: 0xffffffff       Neighbor: 0.0.0.0
      Flags: 0x1008c       OrigNextHop: 13.13.13.1
      Label: NULL          RealNextHop: 13.13.13.1
```

```
    BkLabel: NULL             BkNextHop: 24.24.24.2
    SRLabel: NULL             BkSRLabel: NULL
  Tunnel ID: Invalid          Interface: Vlan-interface200
BkTunnel ID: Invalid        BkInterface: Vlan-interface101
   FtnIndex: 0x0           TrafficIndex: N/A
  Connector: N/A                 PathID: 0x0
```

Configuring a default route

A default route is used to forward packets that do not match any specific routing entry in the routing table. Without a default route, packets that do not match any routing entries are discarded and an ICMP destination-unreachable packet is sent to the source.

A default route can be configured in either of the following ways:

- The network administrator can configure a default route with both destination and mask being 0.0.0.0. For more information, see "Configuring static routing."
- Some dynamic routing protocols (such as OSPF and RIP) can generate a default route. For example, an upstream router running OSPF can generate a default route and advertise it to other routers. These routers install the default route with the next hop being the upstream router. For more information, see the respective chapters on these routing protocols in this configuration guide.

Contents

Configuring RIP

About RIP

Routing Information Protocol (RIP) is a distance-vector IGP suited to small-sized networks. It employs UDP to exchange route information through port 520.

RIP routing metrics

RIP uses a hop count to measure the distance to a destination. The hop count from a router to a directly connected network is 0. The hop count from a router to a directly connected router is 1. To limit convergence time, RIP restricts the value range of the metric from 0 to 15. A destination with a metric value of 16 (or greater) is considered unreachable. For this reason, RIP is not suitable for large-sized networks.

RIP route entries

RIP stores routing entries in a database. Each routing entry contains the following elements:

- **Destination address**—IP address of a destination host or a network.
- **Next hop**—IP address of the next hop.
- **Egress interface**—Egress interface of the route.
- **Metric**—Cost from the local router to the destination.
- **Route time**—Time elapsed since the last update. The time is reset to 0 when the routing entry is updated.
- **Route tag**—Used for route control. For more information, see "Configuring routing policies."

RIP operation

RIP works as follows:

1. RIP sends request messages to neighboring routers. Neighboring routers return response messages that contain their routing tables.
2. RIP uses the received responses to update the local routing table and sends triggered update messages to its neighbors. All RIP routers on the network do this to learn latest routing information.
3. RIP periodically sends the local routing table to its neighbors. After a RIP neighbor receives the message, it updates its routing table, selects optimal routes, and sends an update to other neighbors. RIP ages routes to keep only valid routes.

Routing loop prevention

RIP uses the following mechanisms to prevent routing loops:

- **Counting to infinity**—A destination with a metric value of 16 is considered unreachable. When a routing loop occurs, the metric value of a route will increment to 16 to avoid endless looping.
- **Triggered updates**—RIP immediately advertises triggered updates for topology changes to reduce the possibility of routing loops and to speed up convergence.
- **Split horizon**—Disables RIP from sending routes through the interface where the routes were learned to prevent routing loops and save bandwidth.

- **Poison reverse**—Enables RIP to set the metric of routes received from a neighbor to 16 and sends these routes back to the neighbor. The neighbor can delete such information from its routing table to prevent routing loops.

RIP versions

There are two RIP versions, RIPv1 and RIPv2.

RIPv1 is a classful routing protocol. It advertises messages only through broadcast. RIPv1 messages do not carry mask information, so RIPv1 can only recognize natural networks such as Class A, B, and C. For this reason, RIPv1 does not support discontiguous subnets.

RIPv2 is a classless routing protocol. It has the following advantages over RIPv1:

- Supports route tags to implement flexible route control through routing policies.
- Supports masks, route summarization, and CIDR.
- Supports designated next hops to select the best ones on broadcast networks.
- Supports multicasting route updates so only RIPv2 routers can receive these updates to reduce resource consumption.
- Supports plain text authentication and MD5 authentication to enhance security.

RIPv2 supports two transmission modes: broadcast and multicast. Multicast is the default mode using 224.0.0.9 as the multicast address. An interface operating in RIPv2 broadcast mode can also receive RIPv1 messages.

Protocols and standards

- RFC 1058, *Routing Information Protocol*
- RFC 1723, *RIP Version 2 - Carrying Additional Information*
- RFC 1721, *RIP Version 2 Protocol Analysis*
- RFC 1722, *RIP Version 2 Protocol Applicability Statement*
- RFC 1724, *RIP Version 2 MIB Extension*
- RFC 2082, *RIPv2 MD5 Authentication*
- RFC 2091, *Triggered Extensions to RIP to Support Demand Circuits*
- RFC 2453, *RIP Version 2*

Restrictions: Hardware compatibility with RIP

The S5000V3-EI, S5000V5-EI, S5000E-X, S5000X-EI, and WAS6000 switch series do not support RIP.

RIP tasks at a glance

To configure RIP, perform the following tasks:

1. Configuring basic RIP
   a. Enabling RIP
   b. (Optional.) Controlling RIP reception and advertisement on interfaces
   c. (Optional.) Configuring a RIP version
   d. Specifying a RIP neighbor

To enable RIP on a link that does not support broadcast or multicast, you must manually specify a RIP neighbor.

2. (Optional.) Configuring RIP route control
   - Configuring an additional routing metric
   - Configuring RIPv2 route summarization
   - Disabling host route reception
   - Advertising a default route
   - Configuring received/redistributed route filtering
   - Setting a preference for RIP
   - Configuring RIP route redistribution
3. (Optional.) Tuning and optimizing RIP networks
   - Setting RIP timers
   - Enabling split horizon and poison reverse
   - Setting the RIP triggered update interval
   - Configuring the RIP packet sending rate
   - Setting the maximum length of RIP packets
   - Setting the DSCP value for outgoing RIP packets
4. (Optional.) Configuring RIP network management
5. Enhancing RIP availability
   - Configuring RIP GR
   - Enabling RIP NSR
   - Configuring BFD for RIP
   - Configuring RIP FRR
6. (Optional.) Enhancing RIP security
   - Enabling zero field check for incoming RIPv1 messages
   - Enabling source IP address check for incoming RIP updates
   - Configuring RIPv2 message authentication

Configuring basic RIP

Restrictions and guidelines for configuring basic RIP

To enable multiple RIP processes on a router, you must specify an ID for each process. A RIP process ID has only local significance. Two RIP routers having different process IDs can also exchange RIP packets.

Enabling RIP

About enabling RIP

You can enable RIP on a network and specify a wildcard mask for the network. After that, only the interface attached to the network runs RIP.

Restrictions and guidelines

If you configure RIP settings in interface view before enabling RIP, the settings do not take effect until RIP is enabled.

If a physical interface is attached to multiple networks, you cannot advertise these networks in different RIP processes.

You cannot enable multiple RIP processes on a physical interface.

The **rip enable** command takes precedence over the **network** command.

Enabling RIP on a network

1. Enter system view.
   system-view
2. Enable RIP and enter RIP view.
   rip [*process-id*]
   By default, RIP is disabled.
3. Enable RIP on a network.
   network *network-address* [*wildcard-mask*]
   By default, RIP is disabled on a network.
   The **network** 0.0.0.0 command can enable RIP on all interfaces in a single process, but does not apply to multiple RIP processes.

Enabling RIP on an interface

1. Enter system view.
   system-view
2. Enable RIP and enter RIP view.
   rip [*process-id*]
   By default, RIP is disabled.
3. Return to system view.
   quit
4. Enter interface view.
   interface *interface-type interface-number*
5. Enable RIP on the interface.
   rip *process-id* **enable** [**exclude-subip**]
   By default, RIP is disabled on an interface.

Controlling RIP reception and advertisement on interfaces

About RIP reception and advertisement control on interfaces

You can perform this task to configure the following features:

- Suppressing an interface. The suppressed interface can receive RIP messages but cannot send RIP messages.
- Disabling an interface from sending RIP messages.
- Disabling an interface from receiving RIP messages.

Restrictions and guidelines for RIP reception and advertisement control on interfaces

An interface suppressed by using the **silent-interface** command can only receive RIP messages. It cannot send RIP messages. You can use the **silent-interface all** command to suppress all interfaces. The **silent-interface** command takes precedence over the **rip input** and **rip output** commands.

Suppressing an interface

1. Enter system view.
   system-view
2. Enter RIP view.
   rip [*process-id*]
3. Suppress an interface.
   silent-interface { *interface-type interface-number* | **all** }
   By default, all RIP-enabled interfaces can send RIP messages.
   The suppressed interface can still receive RIP messages and respond to unicast requests containing unknown ports.

Disabling an interface from receiving RIP messages

1. Enter system view.
   system-view
2. Enter interface view.
   interface *interface-type interface-number*
3. Disable an interface from receiving RIP messages.
   undo rip input
   By default, a RIP-enabled interface can receive RIP messages.

Disabling an interface from sending RIP messages

1. Enter system view.
   system-view
2. Enter interface view.
   interface *interface-type interface-number*
3. Disable an interface from sending RIP messages.
   undo rip output
   By default, a RIP-enabled interface can send RIP messages.

Configuring a RIP version

About RIP version configuration

You can configure a global RIP version in RIP view or an interface-specific RIP version in interface view.

An interface preferentially uses the interface-specific RIP version. If no interface-specific version is specified, the interface uses the global RIP version. If neither a global nor interface-specific RIP version is configured, the interface sends RIPv1 broadcasts and can receive the following:

- RIPv1 broadcasts and unicasts.
- RIPv2 broadcasts, multicasts, and unicasts.

Procedure

1. Enter system view.
   system-view
2. Specify a RIP version.
   - Execute the following commands in sequence to specify a global RIP version:
     rip [*process-id*]

version { **1** | **2** }

By default, no global version is specified. An interface sends RIPv1 broadcasts, and can receive RIPv1 broadcasts and unicasts, and RIPv2 broadcasts, multicasts, and unicasts.

- Execute the following commands in sequence to specify a RIP version on an interface:

  interface *interface-type interface-number*

  rip version { **1** | **2** [**broadcast** | **multicast**] }

  By default, no interface-specific RIP version is specified. The interface sends RIPv1 broadcasts, and can receive RIPv1 broadcasts and unicasts, and RIPv2 broadcasts, multicasts, and unicasts.

Specifying a RIP neighbor

About RIP neighbors

Typically RIP messages are sent in broadcast or multicast. To enable RIP on a link that does not support broadcast or multicast, you must manually specify a RIP neighbor.

Restrictions and guidelines

As a best practice, do not use the **peer** *ip-address* command to specify a directly connected neighbor. The neighbor might receive a route update in both unicast and multicast (or broadcast) messages from the device.

Procedure

1. Enter system view.

   system-view

2. Enter RIP view.

   rip [*process-id*]

3. Specify a RIP neighbor.

   peer *ip-address*

   By default, RIP does not unicast updates to any peer.

4. Disable source IP address check on inbound RIP updates.

   undo validate-source-address

   By default, source IP address check is enabled on inbound RIP updates.

   If the specified neighbor is not directly connected, disable source address check on incoming updates.

Configuring RIP route control

Configuring an additional routing metric

About additional routing metrics

An additional routing metric (hop count) can be added to the metric of an inbound or outbound RIP route.

- An outbound additional metric is added to the metric of a sent route, and it does not change the route's metric in the routing table.
- An inbound additional metric is added to the metric of a received route before the route is added into the routing table, and the route's metric is changed. If the sum of the additional metric and the original metric is greater than 16, the metric of the route is 16.

Procedure

1. Enter system view.
   system-view
2. Enter interface view.
   interface *interface-type interface-number*
3. Specify an inbound additional routing metric.
   rip metricin [**route-policy** *route-policy-name*] *value*
   By default, the additional metric of an inbound route is 0.
4. Specify an outbound additional routing metric.
   rip metricout [**route-policy** *route-policy-name*] *value*
   By default, the additional metric of an outbound route is 1.

Configuring RIPv2 route summarization

About RIPv2 route summarization

Perform this task to summarize contiguous subnets into a summary network and sends the network to neighbors. The smallest metric among all summarized routes is used as the metric of the summary route.

You can use the following methods to summarize routes in RIPv2:

- **Automatic summarization**—Configure RIPv2 to generate a natural network for contiguous subnets. For example, suppose there are three subnet routes 10.1.1.0/24, 10.1.2.0/24, and 10.1.3.0/24. Automatic summarization automatically creates and advertises a summary route 10.0.0.0/8 instead of the more specific routes.
- **Manual summarization**—Manually configure a summary route. RIPv2 advertises the summary route rather than more specific routes. For example, suppose contiguous subnets routes 10.1.1.0/24, 10.1.2.0/24, and 10.1.3.0/24 exist in the routing table. You can create a summary route 10.1.0.0/16 on GigabitEthernet 1/0/1 to advertise the summary route instead of the more specific routes. By default, natural masks are used to advertise summary routes. To manually configure a summary route on an interface, you must first disable RIPv2 automatic route summarization.

Restrictions and guidelines

To prevent loops caused by route summarization, create a black hole route by specifying interface NULL 0 as the output interface of the summary route. Packets that match the black hole route are dropped.

Enabling RIPv2 automatic route summarization

1. Enter system view.
   system-view
2. Enter RIP view.
   rip [*process-id*]
3. Enable RIPv2 automatic route summarization.
   summary
   By default, RIPv2 automatic route summarization is enabled.
   If subnets in the routing table are not contiguous, disable automatic route summarization to advertise more specific routes.

Advertising a summary route

1. Enter system view.

system-view

2. Enter RIP view.
   rip [*process-id*]
3. Disable RIPv2 automatic route summarization.
   undo summary
   By default, RIPv2 automatic route summarization is enabled.
4. Return to system view.
   quit
5. Enter interface view.
   interface *interface-type interface-number*
6. Configure a summary route.
   rip summary-address *ip-address* { *mask-length* | *mask* }
   By default, no summary route is configured.

Disabling host route reception

About disabling host route reception

This task disables RIPv2 from receiving host routes from the same network to save network resources. This feature does not apply to RIPv1.

Procedure

1. Enter system view.
   system-view
2. Enter RIP view.
   rip [*process-id*]
3. Disable RIP from receiving host routes.
   undo host-route
   By default, RIP receives host routes.

Advertising a default route

About default route advertisement

You can advertise a default route on all RIP interfaces in RIP view or on a specific RIP interface in interface view. The interface view setting takes precedence over the RIP view settings.

To disable an interface from advertising a default route, use the **rip default-route no-originate** command on the interface.

The router enabled to advertise a default route does not accept default routes from RIP neighbors.

Procedure

1. Enter system view.
   system-view
2. Advertise a default route.
   - Execute the following commands in sequence to configure RIP to advertise a default route:
     rip [*process-id*]
     default-route { **only** | **originate** } [**cost** *cost-value* | **route-policy** *route-policy-name*] *

By default, RIP does not advertise a default route.

- Execute the following commands in sequence to configure a RIP interface to advertise a default route:

  interface *interface-type interface-number*

  rip default-route { { **only** | **originate** } [**cost** *cost-value* | **route-policy** *route-policy-name*] * | **no-originate** }

  By default, a RIP interface can advertise a default route if the RIP process is enabled to advertise a default route.

Configuring received/redistributed route filtering

About received/redistributed route filtering

This task allows you to create a policy to filter received or redistributed routes that match specific criteria such as an ACL or IP prefix list.

Procedure

1. Enter system view.

   system-view

2. Enter RIP view.

   rip [*process-id*]

3. Configure the filtering of received routes.

   filter-policy { *ipv4-acl-number* | **gateway** *prefix-list-name* | **prefix-list** *prefix-list-name* [**gateway** *prefix-list-name*] } **import** [*interface-type interface-number*]

   By default, the filtering of received routes is not configured.

   This command filters received routes. Filtered routes are not installed into the routing table or advertised to neighbors.

4. Configure the filtering of redistributed routes.

   filter-policy { *ipv4-acl-number* | **prefix-list** *prefix-list-name* } **export** [*protocol* [*process-id*] | *interface-type interface-number*]

   By default, the filtering of redistributed routes is not configured.

   This command filters redistributed routes, including routes redistributed with the **import-route** command.

Setting a preference for RIP

About setting a preference for RIP

If multiple IGPs find routes to the same destination, the route found by the IGP that has the highest priority is selected as the optimal route. Perform this task to assign a preference to RIP. The smaller the preference value, the higher the priority.

Procedure

1. Enter system view.

   system-view

2. Enter RIP view.

   rip [*process-id*]

3. Set a preference for RIP.

   preference { *preference* | **route-policy** *route-policy-name* } *

The default preference for RIP is 100.

Configuring RIP route redistribution

About RIP route redistribution

Perform this task to configure RIP to redistribute routes from other routing protocols, including OSPF, static, and direct.

Procedure

1. Enter system view.

   system-view
2. Enter RIP view.

   rip [*process-id*]
3. Redistribute routes from another routing protocol.
   - Redistribute direct or static routes.

     import-route { **direct** | **static** } [**cost** *cost-value* | **route-policy** *route-policy-name* | **tag** *tag*] *
   - Redistribute routes from OSPF or other RIP processes.

     import-route { **ospf** | **rip** } [*process-id* | **all-processes**] [**allow-direct** | **cost** *cost-value* | **route-policy** *route-policy-name* | **tag** *tag*] *

   By default, RIP route redistribution is disabled.

   This command can redistribute only active routes. To view active routes, use the **display ip routing-table protocol** command.
4. (Optional.) Set a default cost for redistributed routes.

   default cost *cost-value*

   The default cost for redistributed routes is 0.

Tuning and optimizing RIP networks

Setting RIP timers

About RIP timers

You can change the RIP network convergence speed by adjusting the following RIP timers:

- **Update timer**—Specifies the interval between route updates.
- **Timeout timer**—Specifies the route aging time. If no update for a route is received within the aging time, the metric of the route is set to 16.
- **Suppress timer**—Specifies how long a RIP route stays in suppressed state. When the metric of a route is 16, the route enters the suppressed state. A suppressed route can be replaced by an updated route that is received from the same neighbor before the suppress timer expires and has a metric less than 16.
- **Garbage-collect timer**—Specifies the interval from when the metric of a route becomes 16 to when it is deleted from the routing table. RIP advertises the route with a metric of 16. If no update is announced for that route before the garbage-collect timer expires, the route is deleted from the routing table.

Restrictions and guidelines

To avoid unnecessary traffic or route flapping, configure identical RIP timer settings on RIP routers.

Procedure

1. Enter system view.
   system-view
2. Enter RIP view.
   rip [*process-id*]
3. Set RIP timers.
   timers { **garbage-collect** *garbage-collect-value* | **suppress** *suppress-value* | **timeout** *timeout-value* | **update** *update-value* } *
   The default settings are as follows:
   - The garbage-collect timer is 120 seconds.
   - The suppress timer is 120 seconds.
   - The timeout timer is 180 seconds.
   - The update timer is 30 seconds.

Enabling split horizon and poison reverse

About split horizon and poison reverse

The split horizon and poison reverse features can prevent routing loops.

- Split horizon disables RIP from sending routes through the interface where the routes were learned to prevent routing loops between adjacent routers.
- Poison reverse allows RIP to send routes through the interface where the routes were learned. The metric of these routes is always set to 16 (unreachable) to avoid routing loops between neighbors.

Restrictions and guidelines

If both split horizon and poison reverse are configured, only the poison reverse feature takes effect.

Enabling split horizon

1. Enter system view.
   system-view
2. Enter interface view.
   interface *interface-type interface-number*
3. Enable split horizon.
   rip split-horizon
   By default, split horizon is enabled.

Enabling poison reverse

1. Enter system view.
   system-view
2. Enter interface view.
   interface *interface-type interface-number*
3. Enable poison reverse.
   rip poison-reverse
   By default, poison reverse is disabled.

Setting the RIP triggered update interval

About RIP triggered update interval

Perform this task to avoid network overhead and reduce system resource consumption caused by frequent RIP triggered updates.

You can use the **timer triggered** command to set the maximum interval, minimum interval, and incremental interval for sending RIP triggered updates.

- For a stable network, the *minimum-interval* is used.
- If network changes become frequent, the incremental interval *incremental-interval* is used to extend the triggered update sending interval until the *maximum-interval* is reached.

Procedure

1. Enter system view.

   system-view
2. Enter RIP view.

   rip [*process-id*]
3. Set the RIP triggered update interval.

   timer triggered *maximum-interval* [*minimum-interval* [*incremental-interval*]]

   The default settings are as follows:

   - The maximum interval is 5 seconds.
   - The minimum interval is 50 milliseconds.
   - The incremental interval is 200 milliseconds.

Configuring the RIP packet sending rate

About RIP packet sending rate configuration

Perform this task to set the interval for sending RIP packets and the maximum number of RIP packets that can be sent at each interval. This feature can avoid excessive RIP packets from affecting system performance and consuming too much bandwidth.

Procedure

1. Enter system view.

   system-view
2. Configure the RIP packet sending rate.

   - Execute the following commands in sequence to configure the RIP packet sending rate for all interfaces:

     rip [*process-id*]

     output-delay *time* **count** *count*

     By default, an interface sends up to three RIP packets every 20 milliseconds.
   - Execute the following commands in sequence to configure the RIP packet sending rate for an interface:

     interface *interface-type interface-number*

     rip output-delay *time* **count** *count*

     By default, the interface uses the RIP packet sending rate configured for the RIP process that the interface runs.

Setting the maximum length of RIP packets

About setting the maximum length of RIP packets

The packet length of RIP packets determines how many routes can be carried in a RIP packet. Set the maximum length of RIP packets to make good use of link bandwidth.

When authentication is enabled, follow these guidelines to ensure packet forwarding:

- For simple authentication, the maximum length of RIP packets must be no less than 52 bytes.
- For MD5 authentication (with packet format defined in RFC 2453), the maximum length of RIP packets must be no less than 56 bytes.
- For MD5 authentication (with packet format defined in RFC 2082), the maximum length of RIP packets must be no less than 72 bytes.

Procedure

1. Enter system view.
   system-view
2. Enter interface view.
   interface *interface-type interface-number*
3. Set the maximum length of RIP packets.
   rip max-packet-length *value*
   By default, the maximum length of RIP packets is 512 bytes.

Setting the DSCP value for outgoing RIP packets

About the DSCP value

The DSCP value specifies the precedence of outgoing packets.

Procedure

1. Enter system view.
   system-view
2. Enter RIP view.
   rip [*process-id*]
3. Set the DSCP value for outgoing RIP packets.
   dscp *dscp-value*
   By default, the DSCP value for outgoing RIP packets is 48.

Configuring RIP network management

About RIP network management

You can use network management software to manage the RIP process to which MIB is bound.

Procedure

1. Enter system view.
   system-view
2. Bind MIB to a RIP process.
   rip mib-binding *process-id*
   By default, MIB is bound to the RIP process with the smallest process ID.

Configuring RIP GR

About RIP GR

GR ensures forwarding continuity when a routing protocol restarts or an active/standby switchover occurs.

Two routers are required to complete a GR process. The following are router roles in a GR process:

- **GR restarter**—Graceful restarting router. It must have GR capability.
- **GR helper**—A neighbor of the GR restarter. It helps the GR restarter to complete the GR process.

After RIP restarts on a router, the router must learn RIP routes again and update its FIB table, which causes network disconnections and route reconvergence.

With the GR feature, the restarting router (known as the GR restarter) can notify the event to its GR capable neighbors. GR capable neighbors (known as GR helpers) maintain their adjacencies with the router within a GR interval. During this process, the FIB table of the router does not change. After the restart, the router contacts its neighbors to retrieve its FIB.

By default, a RIP-enabled device acts as the GR helper. Perform this task on the GR restarter.

Restrictions and guidelines

You cannot enable RIP NSR on a device that acts as GR restarter.

Procedure

1. Enter system view.
   system-view
2. Enter RIP view.
   rip [*process-id*]
3. Enable GR for RIP.
   graceful-restart
   By default, RIP GR is disabled.
4. (Optional.) Set the GR interval.
   graceful-restart interval *interval*
   By default, the GR interval is 60 seconds.

Enabling RIP NSR

About RIP NSR

Nonstop Routing (NSR) allows the device to back up the routing information from the active RIP process to the standby RIP process. After an active/standby switchover, NSR can complete route regeneration without tearing down adjacencies or impacting forwarding services.

NSR does not require the cooperation of neighboring devices to recover routing information, and it is typically used more often than GR.

Restrictions and guidelines

A device that has RIP NSR enabled cannot act as GR restarter.

Procedure

1. Enter system view.
   system-view

2. Enter RIP view.

   rip [*process-id*]

3. Enable RIP NSR.

   non-stop-routing

   By default, RIP NSR is disabled.

   RIP NSR enabled for a RIP process takes effect only on that process. As a best practice, enable RIP NSR for each process if multiple RIP processes exist.

Configuring BFD for RIP

About BFD for RIP

RIP detects route failures by periodically sending requests. If it receives no response for a route within a certain time, RIP considers the route unreachable. To speed up convergence, perform this task to enable BFD for RIP. For more information about BFD, see *High Availability Configuration Guide*.

RIP supports the following BFD detection modes:

- **Single-hop echo detection**—Detection mode for a directly connected neighbor. In this mode, a BFD session is established only when the directly connected neighbor has route information to send.
- **Single-hop echo detection for a specific destination**—Detection mode for a directly connected neighbor. In this mode, a BFD session is established to the specified RIP neighbor when RIP is enabled on the local interface. When BFD detects a unidirectional link, the local device will not receive or send any RIP packets through the interface to improve convergence speed. When the link recovers, the interface can send RIP packets again.
- **Bidirectional control detection**—Detection mode for indirectly connected neighbors. In this mode, a BFD session is established only when both ends have routes to send and BFD is enabled on the receiving interface.

Restrictions and guidelines

The **rip bfd enable** and **rip bfd enable destination** commands are mutually exclusive.

Configuring single-hop echo detection (for a directly connected RIP neighbor)

1. Enter system view.

   system-view

2. Configure the source IP address of BFD echo packets.

   bfd echo-source-ip *ip-address*

   By default, the source IP address of BFD echo packets is not configured.

3. Enter interface view.

   interface *interface-type interface-number*

4. Enable BFD for RIP.

   rip bfd enable

   By default, BFD for RIP is disabled.

Configuring single-hop echo detection (for a specific destination)

Restrictions and guidelines

This feature applies only to RIP neighbors that are directly connected.

Procedure

1. Enter system view.
   system-view
2. Configure the source IP address of BFD echo packets.
   bfd echo-source-ip *ip-address*
   By default, no source IP address is configured for BFD echo packets.
3. Enter interface view.
   interface *interface-type interface-number*
4. Enable BFD for RIP.
   rip bfd enable destination *ip-address*
   By default, BFD for RIP is disabled.

Configuring bidirectional control detection

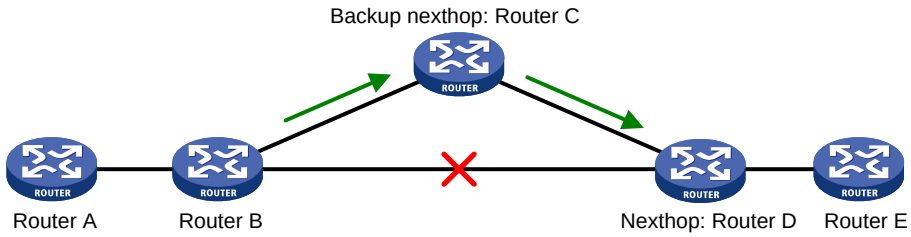
1. Enter system view.
   system-view
2. Enter RIP view.
   rip [*process-id*]
3. Specify a RIP neighbor.
   peer *ip-address*
   By default, RIP does not unicast updates to any peer.
   Because the **undo peer** command does not remove the neighbor relationship immediately, executing the command cannot bring down the BFD session immediately.
4. Enter interface view.
   interface *interface-type interface-number*
5. Enable BFD for RIP.
   rip bfd enable
   By default, BFD for RIP is disabled.

Configuring RIP FRR

About RIP FRR

A link or router failure on a path can cause packet loss and even routing loop until RIP completes routing convergence based on the new network topology. FRR enables fast rerouting to minimize the impact of link or node failures.

Figure 1 Network diagram for RIP FRR



As shown in Figure 1, configure FRR on Router B by using a routing policy to specify a backup next hop. When the primary link fails, RIP directs packets to the backup next hop. At the same time, RIP calculates the shortest path based on the new network topology, and forwards packets over that path after network convergence.

Restrictions and guidelines for RIP FRR

RIP FRR takes effect only for RIP routes learned from directly connected neighbors.

RIP FRR is available only when the state of primary link (with Layer 3 interfaces staying up) changes from bidirectional to unidirectional or down.

Enabling RIP FRR

1. Enter system view.
   `system-view`
2. Configure a routing policy for FRR.
   You must specify a next hop by using the **`apply fast-reroute backup-interface`** command in the routing policy.
   For more information about routing policy configuration, see "Configuring routing policies."
3. Enter RIP view.
   `rip` [*`process-id`*]
4. Enable RIP FRR.
   `fast-reroute route-policy` *`route-policy-name`*
   By default, RIP FRR is disabled.

Enabling BFD for RIP FRR

About BFD single-hop echo detection

By default, RIP FRR does not use BFD to detect primary link failures. For quicker RIP FRR, use BFD single-hop echo detection on the primary link of redundant links to detect link failure.

Procedure

1. Enter system view.
   `system-view`
2. Configure the source IP address of BFD echo packets.
   `bfd echo-source-ip` *`ip-address`*
   By default, the source IP address of BFD echo packets is not configured.
   The source IP address cannot be on the same network segment as any local interfaces.
   For more information about this command, see *High Availability Command Reference*.

3. Enter interface view.
   interface *interface-type interface-number*
4. Enable BFD for RIP FRR.
   rip primary-path-detect bfd echo
   By default, BFD for RIP FRR is disabled.

Enhancing RIP security

Enabling zero field check for incoming RIPv1 messages

About zero field check for incoming RIPv1 messages

Some fields in the RIPv1 message must be set to zero. These fields are called "zero fields." You can enable zero field check for incoming RIPv1 messages. If a zero field of a message contains a non-zero value, RIP does not process the message. If you are certain that all messages are trustworthy, disable zero field check to save CPU resources.

This feature does not apply to RIPv2 packets, because they have no zero fields.

Procedure

1. Enter system view.
   system-view
2. Enter RIP view.
   rip [*process-id*]
3. Enable zero field check for incoming RIPv1 messages.
   checkzero
   By default, zero field check is disabled for incoming RIPv1 messages.

Enabling source IP address check for incoming RIP updates

About source IP address check for incoming RIP updates

Perform this task to enable source IP address check for incoming RIP updates.

- Upon receiving a message on an Ethernet interface, RIP compares the source IP address of the message with the IP address of the interface. If they are not in the same network segment, RIP discards the message.
- Upon receiving a message on a PPP interface, RIP checks whether the source address of the message is the IP address of the peer interface. If not, RIP discards the message.

Procedure

1. Enter system view.
   system-view
2. Enter RIP view.
   rip [*process-id*]
3. Enable source IP address check for incoming RIP messages.
   validate-source-address
   By default, source IP address check is disabled for incoming RIP updates.

Configuring RIPv2 message authentication

About RIPv2 message authentication

Perform this task to enable authentication on RIPv2 messages.

RIPv2 supports simple authentication and MD5 authentication.

Procedure

1. Enter system view.

   system-view

2. Enter interface view.

   interface *interface-type interface-number*

3. Configure RIPv2 authentication.

   rip authentication-mode { **md5** { **rfc2082** { **cipher** | **plain** } *string key-id* | **rfc2453** { **cipher** | **plain** } *string* } | **simple** { **cipher** | **plain** } *string* }

   By default, RIPv2 authentication is not configured.

   RIPv1 does not support authentication. Although you can specify an authentication mode for RIPv1 in interface view, the configuration does not take effect.

Display and maintenance commands for RIP

Execute **display** commands in any view and execute **reset** commands in user view.

Task	Command
Display RIP current status and configuration information.	**display rip** [*process-id*]
Display RIP GR information.	**display rip** [*process-id*] **graceful-restart**
Display RIP NSR information.	**display rip** [*process-id*] **non-stop-routing**
Display active routes in the RIP database.	**display rip** *process-id* **database** [*ip-address* { *mask-length* | *mask* }]
Display RIP interface information.	**display rip** *process-id* **interface** [*interface-type interface-number*]
Display neighbor information for a RIP process.	**display rip** *process-id* **neighbor** [*interface-type interface-number*]
Display routing information for a RIP process.	**display rip** *process-id* **route** [*ip-address* { *mask-length* | *mask* } [**verbose**] | **peer** *ip-address* | **statistics**]
Reset a RIP process.	**reset rip** *process-id* **process**
Clear the statistics for a RIP process.	**reset rip** *process-id* **statistics**

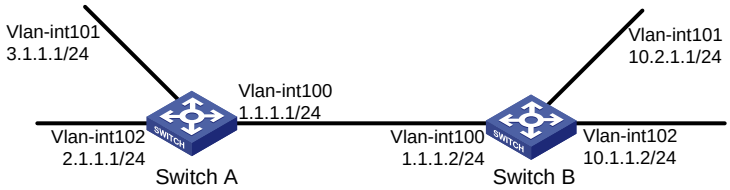
RIP configuration examples

Example: Configuring basic RIP

Network configuration

As shown in Figure 2, enable RIPv2 on all interfaces on Switch A and Switch B. Configure Switch B to not advertise route 10.2.1.0/24 to Switch A, and to accept only route 2.1.1.0/24 from Switch A.

Figure 2 Network diagram



Procedure

1. Configure IP addresses for the interfaces. (Details not shown.)
2. Enable RIP.

   # Enable RIP on the specified networks on Switch A.

```
<SwitchA> system-view
[SwitchA] rip
[SwitchA-rip-1] network 1.0.0.0
[SwitchA-rip-1] network 2.0.0.0
[SwitchA-rip-1] network 3.0.0.0
[SwitchA-rip-1] quit
```

   # Enable RIP on the specified interfaces on Switch B.

```
<SwitchB> system-view
[SwitchB] rip
[SwitchB-rip-1] quit
[SwitchB] interface vlan-interface 100
[SwitchB-Vlan-interface100] rip 1 enable
[SwitchB-Vlan-interface100] quit
[SwitchB] interface vlan-interface 101
[SwitchB-Vlan-interface101] rip 1 enable
[SwitchB-Vlan-interface101] quit
[SwitchB] interface vlan-interface 102
[SwitchB-Vlan-interface102] rip 1 enable
[SwitchB-Vlan-interface102] quit
```

   # Display the RIP routing table of Switch A.

```
[SwitchA] display rip 1 route
 Route Flags: R - RIP, T - TRIP
              P - Permanent, A - Aging, S - Suppressed, G - Garbage-collect
              D - Direct, O - Optimal, F - Flush to RIB
------------------------------------------------------------------------------
 Peer 1.1.1.2 on Vlan-interface100
      Destination/Mask        Nexthop          Cost    Tag     Flags   Sec
      10.0.0.0/8              1.1.1.2          1       0       RAOF    11
```

```
 Local route
      Destination/Mask        Nexthop           Cost    Tag     Flags   Sec
      1.1.1.0/24              0.0.0.0           0       0       RDOF    -
      2.1.1.0/24              0.0.0.0           0       0       RDOF    -
      3.1.1.0/24              0.0.0.0           0       0       RDOF    -
```

The output shows that RIPv1 uses a natural mask.

3. Configure a RIP version:

Configure RIPv2 on Switch A.

```
[SwitchA] rip
[SwitchA-rip-1] version 2
[SwitchA-rip-1] undo summary
[SwitchA-rip-1] quit
```

Configure RIPv2 on Switch B.

```
[SwitchB] rip
[SwitchB-rip-1] version 2
[SwitchB-rip-1] undo summary
[SwitchB-rip-1] quit
```

Display the RIP routing table on Switch A.

```
[SwitchA] display rip 1 route
 Route Flags: R - RIP, T - TRIP
              P - Permanent, A - Aging, S - Suppressed, G - Garbage-collect
              D - Direct, O - Optimal, F - Flush to RIB
------------------------------------------------------------------------------

 Peer 1.1.1.2 on Vlan-interface100
      Destination/Mask        Nexthop           Cost    Tag     Flags   Sec
      10.0.0.0/8              1.1.1.2           1       0       RAOF    50
      10.2.1.0/24             1.1.1.2           1       0       RAOF    16
      10.1.1.0/24             1.1.1.2           1       0       RAOF    16
 Local route
      Destination/Mask        Nexthop           Cost    Tag     Flags   Sec
      1.1.1.0/24              0.0.0.0           0       0       RDOF    -
      2.1.1.0/24              0.0.0.0           0       0       RDOF    -
      3.1.1.0/24              0.0.0.0           0       0       RDOF    -
```

The output shows that RIPv2 uses classless subnet masks.

NOTE:

After RIPv2 is configured, RIPv1 routes might still exist in the routing table until they are aged out.

Display the RIP routing table on Switch B.

```
[SwitchB] display rip 1 route
 Route Flags: R - RIP, T - TRIP
              P - Permanent, A - Aging, S - Suppressed, G - Garbage-collect
              D - Direct, O - Optimal, F - Flush to RIB
------------------------------------------------------------------------------
 Peer 1.1.1.1 on Vlan-interface100
      Destination/Mask        Nexthop           Cost    Tag     Flags   Sec
```

```
     2.1.1.0/24              1.1.1.1           1       0       RAOF    19
     3.1.1.0/24              1.1.1.1           1       0       RAOF    19
 Local route
     Destination/Mask        Nexthop           Cost    Tag     Flags   Sec
     1.1.1.0/24              0.0.0.0           0       0       RDOF    -
     10.1.1.0/24             0.0.0.0           0       0       RDOF    -
     10.2.1.0/24             0.0.0.0           0       0       RDOF    -
```

4. Configure route filtering:

Reference IP prefix lists on Switch B to filter received and redistributed routes.

```
[SwitchB] ip prefix-list aaa index 10 permit 2.1.1.0 24
[SwitchB] ip prefix-list bbb index 10 deny 10.2.1.0 24
[SwitchB] ip prefix-list bbb index 11 permit 0.0.0.0 0 less-equal 32
[SwitchB] rip 1
[SwitchB-rip-1] filter-policy prefix-list aaa import
[SwitchB-rip-1] filter-policy prefix-list bbb export
[SwitchB-rip-1] quit
```

Display the RIP routing table on Switch A.

```
[SwitchA] display rip 100 route
 Route Flags: R - RIP, T - TRIP
              P - Permanent, A - Aging, S - Suppressed, G - Garbage-collect
------------------------------------------------------------------------------
 Peer 1.1.1.2 on Vlan-interface100
     Destination/Mask        Nexthop           Cost    Tag     Flags   Sec
     10.1.1.0/24             1.1.1.2           1       0       RAOF    19
 Local route
     Destination/Mask        Nexthop           Cost    Tag     Flags   Sec
     1.1.1.0/24              0.0.0.0           0       0       RDOF    -
     2.1.1.0/24              0.0.0.0           0       0       RDOF    -
     3.1.1.0/24              0.0.0.0           0       0       RDOF    -
```

Display the RIP routing table on Switch B.

```
[SwitchB] display rip 1 route
 Route Flags: R - RIP, T - TRIP
              P - Permanent, A - Aging, S - Suppressed, G - Garbage-collect
              D - Direct, O - Optimal, F - Flush to RIB
------------------------------------------------------------------------------
 Peer 1.1.1.1 on Vlan-interface100
     Destination/Mask        Nexthop           Cost    Tag     Flags   Sec
     2.1.1.0/24              1.1.1.1           1       0       RAOF    19
 Local route
     Destination/Mask        Nexthop           Cost    Tag     Flags   Sec
     1.1.1.0/24              0.0.0.0           0       0       RDOF    -
     10.1.1.0/24             0.0.0.0           0       0       RDOF    -
     10.2.1.0/24             0.0.0.0           0       0       RDOF    -
```

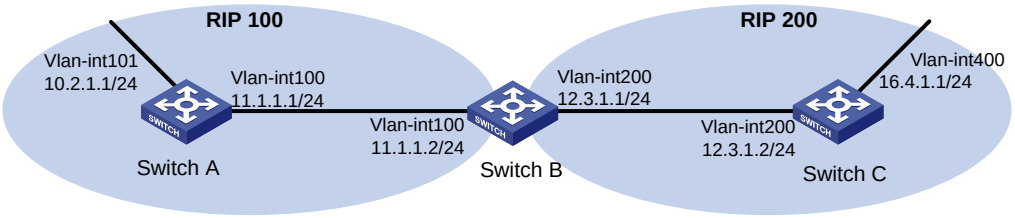
Example: Configuring RIP route redistribution

Network configuration

As shown in Figure 3, Switch B communicates with Switch A through RIP 100 and with Switch C through RIP 200.

Configure RIP 200 to redistribute direct routes and routes from RIP 100 on Switch B so Switch C can learn routes destined for 10.2.1.0/24 and 11.1.1.0/24. Switch A cannot learn routes destined for 12.3.1.0/24 and 16.4.1.0/24.

Figure 3 Network diagram



Procedure

1. Configure IP addresses for the interfaces. (Details not shown.)
2. Configure basic RIP settings:

   # Enable RIP 100, and configure RIPv2 on Switch A.

```
<SwitchA> system-view
[SwitchA] rip 100
[SwitchA-rip-100] network 10.0.0.0
[SwitchA-rip-100] network 11.0.0.0
[SwitchA-rip-100] version 2
[SwitchA-rip-100] undo summary
[SwitchA-rip-100] quit
```

   # Enable RIP 100 and RIP 200, and configure RIPv2 on Switch B.

```
<SwitchB> system-view
[SwitchB] rip 100
[SwitchB-rip-100] network 11.0.0.0
[SwitchB-rip-100] version 2
[SwitchB-rip-100] undo summary
[SwitchB-rip-100] quit
[SwitchB] rip 200
[SwitchB-rip-200] network 12.0.0.0
[SwitchB-rip-200] version 2
[SwitchB-rip-200] undo summary
[SwitchB-rip-200] quit
```

   # Enable RIP 200, and configure RIPv2 on Switch C.

```
<SwitchC> system-view
[SwitchC] rip 200
[SwitchC-rip-200] network 12.0.0.0
[SwitchC-rip-200] network 16.0.0.0
[SwitchC-rip-200] version 2
[SwitchC-rip-200] undo summary
[SwitchC-rip-200] quit
```

Display the IP routing table on Switch C.

```
[SwitchC] display ip routing-table

Destinations : 13        Routes : 13

Destination/Mask    Proto  Pre  Cost         NextHop         Interface
0.0.0.0/32          Direct 0    0            127.0.0.1       InLoop0
12.3.1.0/24         Direct 0    0            12.3.1.2        Vlan200
12.3.1.0/32         Direct 0    0            12.3.1.2        Vlan200
12.3.1.2/32         Direct 0    0            127.0.0.1       InLoop0
12.3.1.255/32       Direct 0    0            12.3.1.2        Vlan200
16.4.1.0/24         Direct 0    0            16.4.1.1        Vlan400
16.4.1.0/32         Direct 0    0            16.4.1.1        Vlan400
16.4.1.1/32         Direct 0    0            127.0.0.1       InLoop0
16.4.1.255/32       Direct 0    0            16.4.1.1        Vlan400
127.0.0.0/8         Direct 0    0            127.0.0.1       InLoop0
127.0.0.0/32        Direct 0    0            127.0.0.1       InLoop0
127.0.0.1/32        Direct 0    0            127.0.0.1       InLoop0
127.255.255.255/32  Direct 0    0            127.0.0.1       InLoop0
```

3. Configure route redistribution:

Configure RIP 200 to redistribute routes from RIP 100 and direct routes on Switch B.

```
[SwitchB] rip 200
[SwitchB-rip-200] import-route rip 100
[SwitchB-rip-200] import-route direct
[SwitchB-rip-200] quit
```

Display the IP routing table on Switch C.

```
[SwitchC] display ip routing-table

Destinations : 15        Routes : 15

Destination/Mask    Proto  Pre  Cost         NextHop         Interface
0.0.0.0/32          Direct 0    0            127.0.0.1       InLoop0
10.2.1.0/24         RIP    100  1            12.3.1.1        Vlan200
11.1.1.0/24         RIP    100  1            12.3.1.1        Vlan200
12.3.1.0/24         Direct 0    0            12.3.1.2        Vlan200
12.3.1.0/32         Direct 0    0            12.3.1.2        Vlan200
12.3.1.2/32         Direct 0    0            127.0.0.1       InLoop0
12.3.1.255/32       Direct 0    0            12.3.1.2        Vlan200
16.4.1.0/24         Direct 0    0            16.4.1.1        Vlan400
16.4.1.0/32         Direct 0    0            16.4.1.1        Vlan400
16.4.1.1/32         Direct 0    0            127.0.0.1       InLoop0
16.4.1.255/32       Direct 0    0            16.4.1.1        Vlan400
127.0.0.0/8         Direct 0    0            127.0.0.1       InLoop0
127.0.0.0/32        Direct 0    0            127.0.0.1       InLoop0
127.0.0.1/32        Direct 0    0            127.0.0.1       InLoop0
127.255.255.255/32  Direct 0    0            127.0.0.1       InLoop0
```

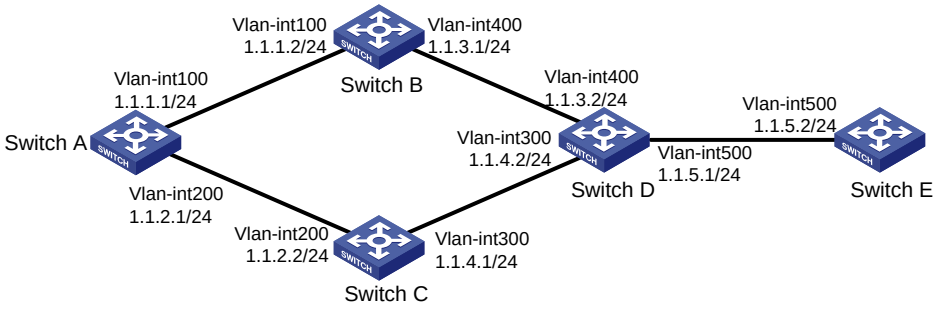
Example: Configuring an additional metric for a RIP interface

Network configuration

As shown in Figure 4, run RIPv2 on all the interfaces of Switch A, Switch B, Switch C, Switch D, and Switch E.

Switch A has two links to Switch D. The link from Switch B to Switch D is more stable than that from Switch C to Switch D. Configure an additional metric for RIP routes received from VLAN-interface 200 on Switch A so Switch A prefers route 1.1.5.0/24 learned from Switch B.

Figure 4 Network diagram



Procedure

1. Configure IP addresses for the interfaces. (Details not shown.)
2. Configure basic RIP settings:

   # Configure Switch A.

   ```
   <SwitchA> system-view
   [SwitchA] rip 1
   [SwitchA-rip-1] network 1.0.0.0
   [SwitchA-rip-1] version 2
   [SwitchA-rip-1] undo summary
   [SwitchA-rip-1] quit
   ```

   # Configure Switch B.

   ```
   <SwitchB> system-view
   [SwitchB] rip 1
   [SwitchB-rip-1] network 1.0.0.0
   [SwitchB-rip-1] version 2
   [SwitchB-rip-1] undo summary
   ```

   # Configure Switch C.

   ```
   <SwitchC> system-view
   [SwitchB] rip 1
   [SwitchC-rip-1] network 1.0.0.0
   [SwitchC-rip-1] version 2
   [SwitchC-rip-1] undo summary
   ```

   # Configure Switch D.

   ```
   <SwitchD> system-view
   [SwitchD] rip 1
   [SwitchD-rip-1] network 1.0.0.0
   [SwitchD-rip-1] version 2
   [SwitchD-rip-1] undo summary
   ```

Configure Switch E.

```
<SwitchE> system-view
[SwitchE] rip 1
[SwitchE-rip-1] network 1.0.0.0
[SwitchE-rip-1] version 2
[SwitchE-rip-1] undo summary
```

Display all active routes in the RIP database on Switch A.

```
[SwitchA] display rip 1 database
   1.0.0.0/8, auto-summary
       1.1.1.0/24, cost 0, nexthop 1.1.1.1, RIP-interface
       1.1.2.0/24, cost 0, nexthop 1.1.2.1, RIP-interface
       1.1.3.0/24, cost 1, nexthop 1.1.1.2
       1.1.4.0/24, cost 1, nexthop 1.1.2.2
       1.1.5.0/24, cost 2, nexthop 1.1.1.2
       1.1.5.0/24, cost 2, nexthop 1.1.2.2
```

The output shows two RIP routes destined for network 1.1.5.0/24, with the next hops as Switch B (1.1.1.2) and Switch C (1.1.2.2), and with the same cost of 2.

3. Configure an additional metric for a RIP interface:

Configure an inbound additional metric of 3 for RIP-enabled interface VLAN-interface 200 on Switch A.

```
[SwitchA] interface vlan-interface 200
[SwitchA-Vlan-interface200] rip metricin 3
```

Display all active routes in the RIP database on Switch A.

```
[SwitchA-Vlan-interface200] display rip 1 database
   1.0.0.0/8, auto-summary
       1.1.1.0/24, cost 0, nexthop 1.1.1.1, RIP-interface
       1.1.2.0/24, cost 0, nexthop 1.1.2.1, RIP-interface
       1.1.3.0/24, cost 1, nexthop 1.1.1.2
       1.1.4.0/24, cost 2, nexthop 1.1.1.2
       1.1.5.0/24, cost 2, nexthop 1.1.1.2
```

The output shows that only one RIP route reaches network 1.1.5.0/24, with the next hop as Switch B (1.1.1.2) and a cost of 2.

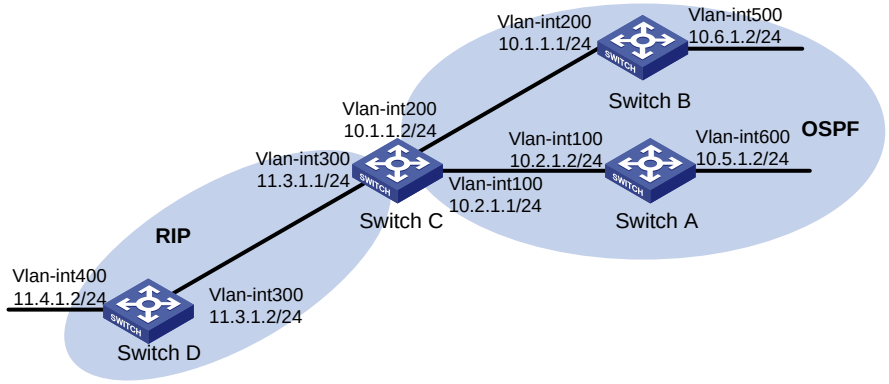
Example: Configuring RIP to advertise a summary route

Network configuration

As shown in Figure 5, Switch A and Switch B run OSPF, Switch D runs RIP, and Switch C runs OSPF and RIP. Configure RIP to redistribute OSPF routes on Switch C so Switch D can learn routes destined for networks 10.1.1.0/24, 10.2.1.0/24, 10.5.1.0/24, and 10.6.1.0/24.

To reduce the routing table size of Switch D, configure route summarization on Switch C to advertise only the summary route 10.0.0.0/8 to Switch D.

Figure 5 Network diagram



Procedure

1. Configure IP addresses for the interfaces. (Details not shown.)
2. Configure basic OSPF settings:

   # Configure Switch A.

   ```
   <SwitchA> system-view
   [SwitchA] ospf
   [SwitchA-ospf-1] area 0
   [SwitchA-ospf-1-area-0.0.0.0] network 10.5.1.0 0.0.0.255
   [SwitchA-ospf-1-area-0.0.0.0] network 10.2.1.0 0.0.0.255
   [SwitchA-ospf-1-area-0.0.0.0] quit
   ```

   # Configure Switch B.

   ```
   <SwitchB> system-view
   [SwitchB] ospf
   [SwitchB-ospf-1] area 0
   [SwitchB-ospf-1-area-0.0.0.0] network 10.1.1.0 0.0.0.255
   [SwitchB-ospf-1-area-0.0.0.0] network 10.6.1.0 0.0.0.255
   [SwitchB-ospf-1-area-0.0.0.0] quit
   ```

   # Configure Switch C.

   ```
   <SwitchC> system-view
   [SwitchC] ospf
   [SwitchC-ospf-1] area 0
   [SwitchC-ospf-1-area-0.0.0.0] network 10.1.1.0 0.0.0.255
   [SwitchC-ospf-1-area-0.0.0.0] network 10.2.1.0 0.0.0.255
   [SwitchC-ospf-1-area-0.0.0.0] quit
   [SwitchC-ospf-1] quit
   ```

3. Configure basic RIP settings:

   # Configure Switch C.

   ```
   [SwitchC] rip 1
   [SwitchC-rip-1] network 11.3.1.0
   [SwitchC-rip-1] version 2
   [SwitchC-rip-1] undo summary
   ```

   # Configure Switch D.

   ```
   <SwitchD> system-view
   [SwitchD] rip 1
   ```

```
[SwitchD-rip-1] network 11.0.0.0
[SwitchD-rip-1] version 2
[SwitchD-rip-1] undo summary
[SwitchD-rip-1] quit
```

Configure RIP to redistribute routes from OSPF process 1 and direct routes on Switch C.

```
[SwitchC-rip-1] import-route direct
[SwitchC-rip-1] import-route ospf 1
[SwitchC-rip-1] quit
```

Display the IP routing table on Switch D.

```
[SwitchD] display ip routing-table

Destinations : 15        Routes : 15

Destination/Mask    Proto  Pre  Cost         NextHop         Interface
0.0.0.0/32          Direct 0    0            127.0.0.1       InLoop0
10.1.1.0/24         RIP    100  1            11.3.1.1        Vlan300
10.2.1.0/24         RIP    100  1            11.3.1.1        Vlan300
10.5.1.0/24         RIP    100  1            11.3.1.1        Vlan300
10.6.1.0/24         RIP    100  1            11.3.1.1        Vlan300
11.3.1.0/24         Direct 0    0            11.3.1.2        Vlan300
11.3.1.0/32         Direct 0    0            11.3.1.2        Vlan300
11.3.1.2/32         Direct 0    0            127.0.0.1       InLoop0
11.4.1.0/24         Direct 0    0            11.4.1.2        Vlan400
11.4.1.0/32         Direct 0    0            11.4.1.2        Vlan400
11.4.1.2/32         Direct 0    0            127.0.0.1       InLoop0
127.0.0.0/8         Direct 0    0            127.0.0.1       InLoop0
127.0.0.0/32        Direct 0    0            127.0.0.1       InLoop0
127.0.0.1/32        Direct 0    0            127.0.0.1       InLoop0
127.255.255.255/32  Direct 0    0            127.0.0.1       InLoop0
```

4. Configure route summarization:

Configure route summarization on Switch C and advertise only the summary route 10.0.0.0/8.

```
[SwitchC] interface vlan-interface 300
[SwitchC-Vlan-interface300] rip summary-address 10.0.0.0 8
```

Display the IP routing table on Switch D.

```
[SwitchD] display ip routing-table

Destinations : 12        Routes : 12

Destination/Mask    Proto  Pre  Cost         NextHop         Interface
0.0.0.0/32          Direct 0    0            127.0.0.1       InLoop0
10.0.0.0/8          RIP    100  1            11.3.1.1        Vlan300
11.3.1.0/24         Direct 0    0            11.3.1.2        Vlan300
11.3.1.0/32         Direct 0    0            11.3.1.2        Vlan300
11.3.1.2/32         Direct 0    0            127.0.0.1       InLoop0
11.4.1.0/24         Direct 0    0            11.4.1.2        Vlan400
11.4.1.0/32         Direct 0    0            11.4.1.2        Vlan400
11.4.1.2/32         Direct 0    0            127.0.0.1       InLoop0
127.0.0.0/8         Direct 0    0            127.0.0.1       InLoop0
```

```
127.0.0.0/32        Direct 0    0           127.0.0.1       InLoop0
127.0.0.1/32        Direct 0    0           127.0.0.1       InLoop0
127.255.255.255/32  Direct 0    0           127.0.0.1       InLoop0
```

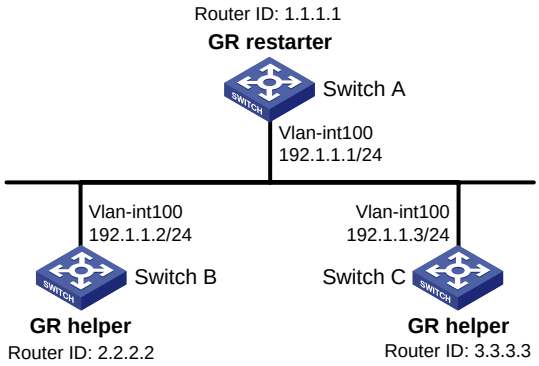
Example: Configuring RIP GR

Network configuration

As shown in Figure 6, Switch A, Switch B, and Switch C all run RIPv2.

- Enable GR on Switch A. Switch A acts as the GR restarter.
- Switch B and Switch C act as GR helpers to synchronize their routing tables with Switch A by using GR.

Figure 6 Network diagram



Procedure

1. Configure IP addresses and subnet masks for the interfaces on the switches. (Details not shown.)
2. Configure RIPv2 on the switches to ensure the following: (Details not shown.)
   - Switch A, Switch B, and Switch C can communicate with each other at Layer 3.
   - Dynamic route update can be implemented among them with RIPv2.
3. Enable RIP GR on Switch A.

```
<SwitchA> system-view
[SwitchA] rip
[SwitchA-rip-1] graceful-restart
```

Verifying the configuration

Restart RIP or trigger an active/standby switchover, and then display GR status on Switch A.

```
<SwitchA> display rip graceful-restart
 RIP process: 1
 Graceful Restart capability     : Enabled
 Current GR state                : Normal
 Graceful Restart period         : 60  seconds
 Graceful Restart remaining time : 0   seconds
```

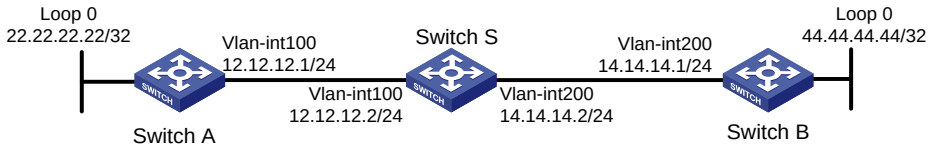
Example: Configuring RIP NSR

Network configuration

As shown in Figure 7, Switch A, Switch B, and Switch S all run RIPv2.

Enable RIP NSR on Switch S to ensure correct routing when an active/standby switchover occurs on Switch S.

Figure 7 Network diagram



Procedure

1. Configure IP addresses and subnet masks for the interfaces on the switches. (Details not shown.)
2. Configure RIPv2 on the switches to ensure the following: (Details not shown.)
   - Switch A, Switch B, and Switch S can communicate with each other at Layer 3.
   - Dynamic route update can be implemented among them with RIPv2.
3. Enable RIP NSR on Switch S.

```
<SwitchS> system-view
[SwitchS] rip 100
[SwitchS-rip-100] non-stop-routing
[SwitchS-rip-100] quit
```

Verifying the configuration

Perform an active/standby switchover on Switch S.

```
[SwitchS] placement reoptimize
Predicted changes to the placement
Program                             Current location       New location
--------------------------------------------------------------------------
lb                                  0/0                    0/0
lsm                                 0/0                    0/0
slsp                                0/0                    0/0
rib6                                0/0                    0/0
routepolicy                         0/0                    0/0
rib                                 0/0                    0/0
staticroute6                        0/0                    0/0
staticroute                         0/0                    0/0
eviisis                             0/0                    0/0
ospf                                0/0                    1/0
Continue? [y/n]:y
Re-optimization of the placement start. You will be notified on completion
Re-optimization of the placement complete. Use 'display placement' to view the new
placement
```

Display neighbor information and route information on Switch A.

```
[SwitchA] display rip 1 neighbor
 Neighbor Address: 12.12.12.2
     Interface  : Vlan-interface200
     Version    : RIPv2     Last update: 00h00m13s
     Relay nbr  : No        BFD session: None
     Bad packets: 0         Bad routes : 0
```

```
[SwitchA] display rip 1 route
 Route Flags: R - RIP, T - TRIP
              P - Permanent, A - Aging, S - Suppressed, G - Garbage-collect
              D - Direct, O - Optimal, F - Flush to RIB
 ------------------------------------------------------------------------------
 Peer 12.12.12.2 on Vlan-interface200
      Destination/Mask        Nexthop          Cost    Tag     Flags   Sec
      14.0.0.0/8              12.12.12.2       1       0       RAOF    16
      44.0.0.0/8              12.12.12.2       2       0       RAOF    16
 Local route
      Destination/Mask        Nexthop          Cost    Tag     Flags   Sec
      12.12.12.0/24           0.0.0.0          0       0       RDOF    -
      22.22.22.22/32          0.0.0.0          0       0       RDOF    -
```

Display neighbor information and route information on Switch B.

```
[SwitchB] display rip 1 neighbor
 Neighbor Address: 14.14.14.2
     Interface  : Vlan-interface200
     Version    : RIPv2     Last update: 00h00m32s
     Relay nbr  : No        BFD session: None
     Bad packets: 0         Bad routes : 0
[SwitchB] display rip 1 route
 Route Flags: R - RIP, T - TRIP
              P - Permanent, A - Aging, S - Suppressed, G - Garbage-collect
              D - Direct, O - Optimal, F - Flush to RIB
 ------------------------------------------------------------------------------
 Peer 14.14.14.2 on Vlan-interface200
      Destination/Mask        Nexthop          Cost    Tag     Flags   Sec
      12.0.0.0/8              14.14.14.2       1       0       RAOF    1
      22.0.0.0/8              14.14.14.2       2       0       RAOF    1
 Local route
      Destination/Mask        Nexthop          Cost    Tag     Flags   Sec
      44.44.44.44/32          0.0.0.0          0       0       RDOF    -
      14.14.14.0/24           0.0.0.0          0       0       RDOF    -
```

The output shows that the neighbor and route information on Switch A and Switch B keep unchanged during the active/standby switchover on Switch S. The traffic from Switch A to Switch B has not been impacted.

Example: Configuring BFD for RIP (single-hop echo detection for a directly connected neighbor)

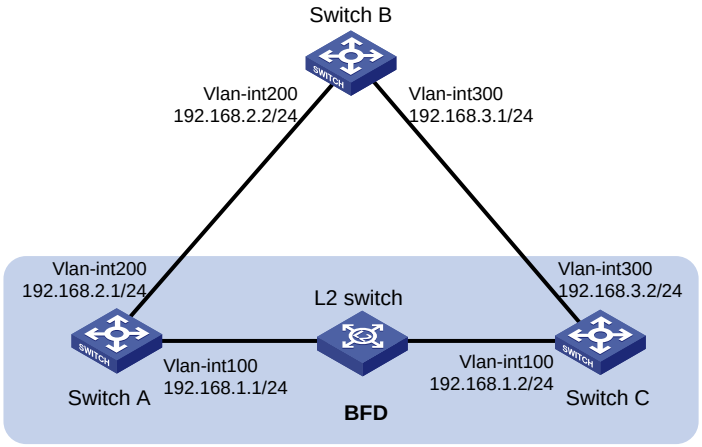
Network configuration

As shown in Figure 8, VLAN-interface 100 of Switch A and Switch C runs RIP process 1. VLAN-interface 200 of Switch A runs RIP process 2. VLAN-interface 300 of Switch C and VLAN-interface 200 and VLAN-interface 300 of Switch B run RIP process 1.

- Configure a static route destined for 100.1.1.1/24 and enable static route redistribution into RIP on Switch C. This allows Switch A to learn two routes destined for 100.1.1.1/24 through VLAN-interface 100 and VLAN-interface 200 respectively, and uses the one through VLAN-interface 100.

- Enable BFD for RIP on VLAN-interface 100 of Switch A. When the link over VLAN-interface 100 fails, BFD can quickly detect the failure and notify RIP. RIP deletes the neighbor relationship and route information learned on VLAN-interface 100, and uses the route destined for 100.1.1.1 24 through VLAN-interface 200.

Figure 8 Network diagram



Procedure

1. Configure IP addresses for the interfaces. (Details not shown.)
2. Configure basic RIP settings:

   # Configure Switch A.

```
<SwitchA> system-view
[SwitchA] rip 1
[SwitchA-rip-1] version 2
[SwitchA-rip-1] undo summary
[SwitchA-rip-1] network 192.168.1.0
[SwitchA-rip-1] quit
[SwitchA] interface vlan-interface 100
[SwitchA-Vlan-interface100] rip bfd enable
[SwitchA-Vlan-interface100] quit
[SwitchA] rip 2
[SwitchA-rip-2] version 2
[SwitchA-rip-2] undo summary
[SwitchA-rip-2] network 192.168.2.0
[SwitchA-rip-2] quit
```

   # Configure Switch B.

```
<SwitchB> system-view
[SwitchB] rip 1
[SwitchB-rip-1] version 2
[SwitchB-rip-1] undo summary
[SwitchB-rip-1] network 192.168.2.0
[SwitchB-rip-1] network 192.168.3.0
[SwitchB-rip-1] quit
```

   # Configure Switch C.

```
<SwitchC> system-view
[SwitchC] rip 1
```

```
[SwitchC-rip-1] version 2
[SwitchC-rip-1] undo summary
[SwitchC-rip-1] network 192.168.1.0
[SwitchC-rip-1] network 192.168.3.0
[SwitchC-rip-1] import-route static
[SwitchC-rip-1] quit
```

3. Configure BFD parameters on VLAN-interface 100 of Switch A.

```
[SwitchA] bfd echo-source-ip 11.11.11.11
[SwitchA] interface vlan-interface 100
[SwitchA-Vlan-interface100] bfd min-echo-receive-interval 500
[SwitchA-Vlan-interface100] bfd detect-multiplier 7
[SwitchA-Vlan-interface100] quit
[SwitchA] quit
```

4. Configure a static route on Switch C.

```
[SwitchC] ip route-static 120.1.1.1 24 null 0
```

Verifying the configuration

Display the BFD session information on Switch A.

```
<SwitchA> display bfd session

 Total Session Num: 1     Up Session Num: 1     Init Mode: Active

 IPv4 Session Working Under Echo Mode:

 LD           SourceAddr      DestAddr        State    Holdtime    Interface
 4             192.168.1.1     192.168.1.2     Up       2000ms      Vlan100
```

Display RIP routes destined for 120.1.1.0/24 on Switch A.

```
<SwitchA> display ip routing-table 120.1.1.0 24

Summary count : 1

Destination/Mask   Proto   Pre Cost        NextHop         Interface
120.1.1.0/24       RIP     100 1           192.168.1.2     Vlan-interface100
```

The output shows that Switch A communicates with Switch C through VLAN-interface 100. Then the link over VLAN-interface 100 fails.

Display RIP routes destined for 120.1.1.0/24 on Switch A.

```
<SwitchA> display ip routing-table 120.1.1.0 24

Summary count : 1

Destination/Mask   Proto   Pre Cost        NextHop         Interface
120.1.1.0/24       RIP     100 1           192.168.2.2     Vlan-interface200
```

The output shows that Switch A communicates with Switch C through VLAN-interface 200.

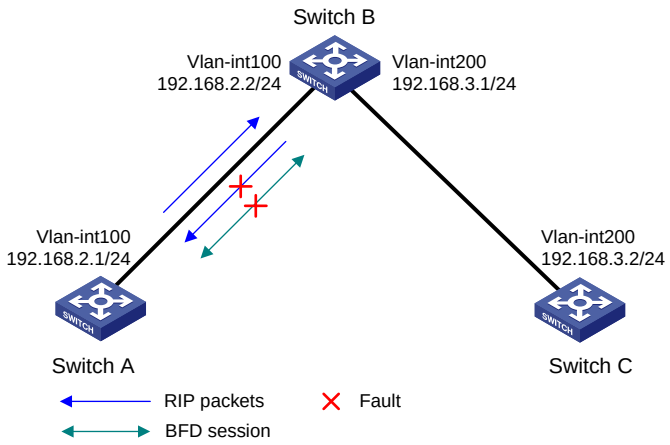
Example: Configuring BFD for RIP (single hop echo detection for a specific destination)

Network configuration

As shown in Figure 9, VLAN-interface 100 of Switch A and Switch B runs RIP process 1. VLAN-interface 200 of Switch B and Switch C runs RIP process 1.

- Configure a static route destined for 100.1.1.0/24 and enable static route redistribution into RIP on both Switch A and Switch C. This allows Switch B to learn two routes destined for 100.1.1.0/24 through VLAN-interface 100 and VLAN-interface 200. The route redistributed from Switch A has a smaller cost than that redistributed from Switch C, so Switch B uses the route through VLAN-interface 200.
- Enable BFD for RIP on VLAN-interface 100 of Switch A, and specify VLAN-interface 100 of Switch B as the destination. When a unidirectional link occurs between Switch A and Switch B, BFD can quickly detect the link failure and notify RIP. Switch B then deletes the neighbor relationship and the route information learned on VLAN-interface 100. It does not receive or send any packets from VLAN-interface 100. When the route learned from Switch A ages out, Switch B uses the route destined for 100.1.1.1 24 through VLAN-interface 200.

Figure 9 Network diagram



Procedure

1. Configure IP addresses for the interfaces. (Details not shown.)
2. Configure basic RIP settings and enable BFD on the interfaces:

   # Configure Switch A.

```
<SwitchA> system-view
[SwitchA] rip 1
[SwitchA-rip-1] network 192.168.2.0
[SwitchA-rip-1] import-route static
[SwitchA-rip-1] quit
[SwitchA] interface vlan-interface 100
[SwitchA-Vlan-interface100] rip bfd enable destination 192.168.2.2
[SwitchA-Vlan-interface100] quit
```

   # Configure Switch B.

```
<SwitchB> system-view
[SwitchB] rip 1
[SwitchB-rip-1] network 192.168.2.0
```

```
[SwitchB-rip-1] network 192.168.3.0
[SwitchB-rip-1] quit
```

Configure Switch C.

```
<SwitchC> system-view
[SwitchC] rip 1
[SwitchC-rip-1] network 192.168.3.0
[SwitchC-rip-1] import-route static cost 3
[SwitchC-rip-1] quit
```

3. Configure BFD parameters on VLAN-interface 100 of Switch A.

```
[SwitchA] bfd echo-source-ip 11.11.11.11
[SwitchA] interface vlan-interface 100
[SwitchA-Vlan-interface100] bfd min-echo-receive-interval 500
[SwitchA-Vlan-interface100] return
```

4. Configure static routes:

Configure a static route on Switch A.

```
[SwitchA] ip route-static 100.1.1.0 24 null 0
```

Configure a static route on Switch C.

```
[SwitchA] ip route-static 100.1.1.0 24 null 0
```

Verifying the configuration

Display BFD session information on Switch A.

```
<SwitchA> display bfd session

 Total Session Num: 1     Up Session Num: 1     Init Mode: Active

 IPv4 session working under Echo mode:

 LD              SourceAddr      DestAddr        State    Holdtime    Interface
 3               192.168.2.1     192.168.2.2     Up       2000ms      vlan100
```

Display routes destined for 100.1.1.0/24 on Switch B.

```
<SwitchB> display ip routing-table 100.1.1.0 24 verbose

Summary Count : 1

Destination: 100.1.1.0/24
   Protocol: RIP
 Process ID: 1
  SubProtID: 0x1                  Age: 00h02m47s
       Cost: 1              Preference: 100
      IpPre: N/A            QosLocalID: N/A
        Tag: 0                   State: Active Adv
  OrigTblID: 0x0               OrigVrf: default-vrf
    TableID: 0x2                OrigAs: 0
      NibID: 0x12000002         LastAs: 0
     AttrID: 0xffffffff       Neighbor: 192.168.2.1
      Flags: 0x1008c        OrigNextHop: 192.168.2.1
      Label: NULL           RealNextHop: 192.168.2.1
    BkLabel: NULL             BkNextHop: N/A
```

```
    SRLabel: NULL             BkSRLabel: NULL
  Tunnel ID: Invalid          Interface: vlan-interface 100
BkTunnel ID: Invalid        BkInterface: N/A
   FtnIndex: 0x0           TrafficIndex: N/A
  Connector: N/A                 PathID: 0x0
```

Display routes destined for 100.1.1.0/24 on Switch B when the link between Switch A and Switch B fails.

```
<SwitchB> display ip routing-table 100.1.1.0 24 verbose

Summary Count : 1

Destination: 100.1.1.0/24
   Protocol: RIP
 Process ID: 1
  SubProtID: 0x1                    Age: 00h21m23s
       Cost: 4               Preference: 100
      IpPre: N/A             QosLocalID: N/A
        Tag: 0                    State: Active Adv
  OrigTblID: 0x0                OrigVrf: default-vrf
    TableID: 0x2                 OrigAs: 0
      NibID: 0x12000002          LastAs: 0
     AttrID: 0xffffffff        Neighbor: 192.168.3.2
      Flags: 0x1008c         OrigNextHop: 192.168.3.2
      Label: NULL            RealNextHop: 192.168.3.2
    BkLabel: NULL              BkNextHop: N/A
    SRLabel: NULL              BkSRLabel: NULL
  Tunnel ID: Invalid           Interface: vlan-interface 200
BkTunnel ID: Invalid         BkInterface: N/A
   FtnIndex: 0x0            TrafficIndex: N/A
  Connector: N/A                 PathID: 0x0
```

Example: Configuring BFD for RIP (bidirectional detection in BFD control packet mode)

Network configuration

As shown in Figure 10, VLAN-interface 100 of Switch A and VLAN-interface 200 of Switch C run RIP process 1.

VLAN-interface 300 of Switch A runs RIP process 2. VLAN-interface 400 of Switch C, and VLAN-interface 300 and VLAN-interface 400 of Switch D run RIP process 1.

- Configure a static route destined for 100.1.1.0/24 on Switch A.
- Configure a static route destined for 101.1.1.0/24 on Switch C.
- Enable static route redistribution into RIP on Switch A and Switch C. This allows Switch A to learn two routes destined for 100.1.1.0/24 through VLAN-interface 100 and VLAN-interface 300. It uses the route through VLAN-interface 100.
- Enable BFD on VLAN-interface 100 of Switch A and VLAN-interface 200 of Switch C.

When the link over VLAN-interface 100 fails, BFD can quickly detect the link failure and notify RIP. RIP deletes the neighbor relationship and the route information received learned on VLAN-interface 100. It uses the route destined for 100.1.1.0/24 through VLAN-interface 300.

Figure 10 Network diagram

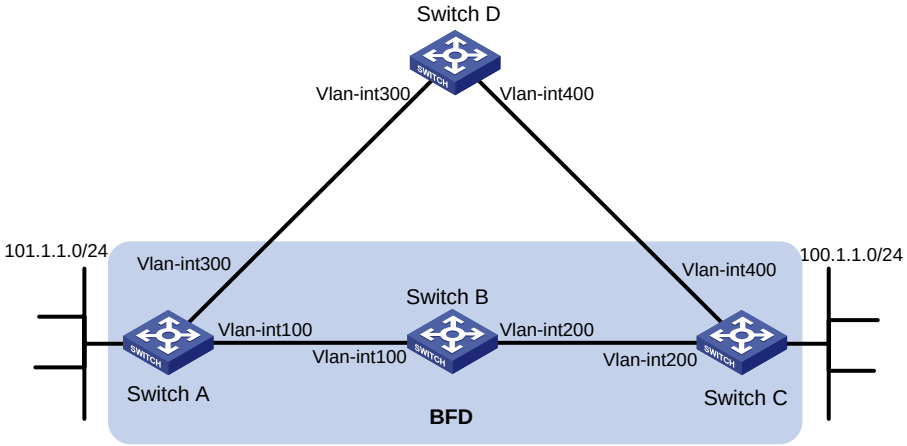


Table 1 Interface and IP address assignment

Device	Interface	IP address
Switch A	VLAN-interface 300	192.168.3.1/24
Switch A	VLAN-interface 100	192.168.1.1/24
Switch B	VLAN-interface 100	192.168.1.2/24
Switch B	VLAN-interface 200	192.168.2.1/24
Switch C	VLAN-interface 200	192.168.2.2/24
Switch C	VLAN-interface 400	192.168.4.2/24
Switch D	VLAN-interface 300	192.168.3.2/24
Switch D	VLAN-interface 400	192.168.4.1/24

Procedure

1. Configure IP addresses for the interfaces. (Details not shown.)
2. Configure basic RIP settings and enable static route redistribution into RIP so Switch A and Switch C have routes to send to each other:

   # Configure Switch A.

```
<SwitchA> system-view
[SwitchA] rip 1
[SwitchA-rip-1] version 2
[SwitchA-rip-1] undo summary
[SwitchA-rip-1] network 192.168.1.0
[SwitchA-rip-1] network 101.1.1.0
[SwitchA-rip-1] peer 192.168.2.2
[SwitchA-rip-1] undo validate-source-address
[SwitchA-rip-1] import-route static
[SwitchA-rip-1] quit
[SwitchA] interface vlan-interface 100
[SwitchA-Vlan-interface100] rip bfd enable
```

```
[SwitchA-Vlan-interface100] quit
[SwitchA] rip 2
[SwitchA-rip-2] version 2
[SwitchA-rip-2] undo summary
[SwitchA-rip-2] network 192.168.3.0
[SwitchA-rip-2] quit
```

Configure Switch C.

```
<SwitchC> system-view
[SwitchC] rip 1
[SwitchC-rip-1] version 2
[SwitchC-rip-1] undo summary
[SwitchC-rip-1] network 192.168.2.0
[SwitchC-rip-1] network 192.168.4.0
[SwitchC-rip-1] network 100.1.1.0
[SwitchC-rip-1] peer 192.168.1.1
[SwitchC-rip-1] undo validate-source-address
[SwitchC-rip-1] import-route static
[SwitchC-rip-1] quit
[SwitchC] interface vlan-interface 200
[SwitchC-Vlan-interface200] rip bfd enable
[SwitchC-Vlan-interface200] quit
```

Configure Switch D.

```
<SwitchD> system-view
[SwitchD] rip 1
[SwitchD-rip-1] version 2
[SwitchD-rip-1] undo summary
[SwitchD-rip-1] network 192.168.3.0
[SwitchD-rip-1] network 192.168.4.0
```

3. Configure BFD parameters:

Configure Switch A.

```
[SwitchA] bfd session init-mode active
[SwitchA] interface vlan-interface 100
[SwitchA-Vlan-interface100] bfd min-transmit-interval 500
[SwitchA-Vlan-interface100] bfd min-receive-interval 500
[SwitchA-Vlan-interface100] bfd detect-multiplier 7
[SwitchA-Vlan-interface100] quit
```

Configure Switch C.

```
[SwitchC] bfd session init-mode active
[SwitchC] interface vlan-interface 200
[SwitchC-Vlan-interface200] bfd min-transmit-interval 500
[SwitchC-Vlan-interface200] bfd min-receive-interval 500
[SwitchC-Vlan-interface200] bfd detect-multiplier 7
[SwitchC-Vlan-interface200] quit
```

4. Configure static routes:

Configure a static route to Switch C on Switch A.

```
[SwitchA] ip route-static 192.168.2.0 24 vlan-interface 100 192.168.1.2
[SwitchA] quit
```

Configure a static route to Switch A on Switch C.

```
[SwitchC] ip route-static 192.168.1.0 24 vlan-interface 200 192.168.2.1
```

Verifying the configuration

Display the BFD session information on Switch A.

```
<SwitchA> display bfd session

 Total Session Num: 1     Up Session Num: 1     Init Mode: Active

 IPv4 session working under Ctrl mode:

 LD/RD              SourceAddr      DestAddr        State    Holdtime    Interface
 513/513            192.168.1.1     192.168.2.2     Up       1700ms      vlan100
```

Display RIP routes destined for 100.1.1.0/24 on Switch A.

```
<SwitchA> display ip routing-table 100.1.1.0 24

Summary count : 1

Destination/Mask   Proto   Pre Cost        NextHop         Interface
100.1.1.0/24       RIP     100 1           192.168.2.2     vlan-interface 100
```

The output shows that Switch A communicates with Switch C through VLAN-interface 100. Then the link over VLAN-interface 100 fails.

Display RIP routes destined for 100.1.1.0/24 on Switch A.

```
<SwitchA> display ip routing-table 100.1.1.0 24

Summary count : 1

Destination/Mask   Proto   Pre Cost        NextHop         Interface
100.1.1.0/24       RIP     100 2           192.168.3.2     vlan-interface 300
```

The output shows that Switch A communicates with Switch C through VLAN-interface 300.

Example: Configuring RIP FRR

Network configuration

As shown in Figure 11, Switch A, Switch B, and Switch C run RIPv2. Configure RIP FRR so that when Link A becomes unidirectional, services can be switched to Link B immediately.

Figure 11 Network diagram

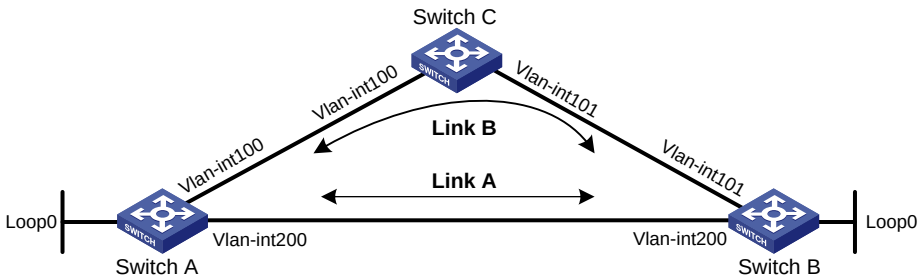


Table 2 Interface and IP address assignment

Device	Interface	IP address
Switch A	VLAN-interface 100	12.12.12.1/24
Switch A	VLAN-interface 200	13.13.13.1/24
Switch A	Loopback 0	1.1.1.1/32
Switch B	VLAN-interface 101	24.24.24.4/24
Switch B	VLAN-interface 200	13.13.13.2/24
Switch B	Loopback 0	4.4.4.4/32
Switch C	VLAN-interface 100	12.12.12.2/24
Switch C	VLAN-interface 101	24.24.24.2/24

Procedure

1. Configure IP addresses and subnet masks for the interfaces on the switches. (Details not shown.)
2. Configure RIPv2 on the switches to make sure Switch A, Switch B, and Switch C can communicate with each other at Layer 3. (Details not shown.)
3. Configure RIP FRR:

   # Configure Switch A.

```
<SwitchA> system-view
[SwitchA] ip prefix-list abc index 10 permit 4.4.4.4 32
[SwitchA] route-policy frr permit node 10
[SwitchA-route-policy-frr-10] if-match ip address prefix-list abc
[SwitchA-route-policy-frr-10] apply fast-reroute backup-interface vlan-interface
100 backup-nexthop 12.12.12.2
[SwitchA-route-policy-frr-10] quit
[SwitchA] rip 1
[SwitchA-rip-1] fast-reroute route-policy frr
[SwitchA-rip-1] quit
```

   # Configure Switch B.

```
<SwitchB> system-view
[SwitchB] ip prefix-list abc index 10 permit 1.1.1.1 32
[SwitchB] route-policy frr permit node 10
[SwitchB-route-policy-frr-10] if-match ip address prefix-list abc
[SwitchB-route-policy-frr-10] apply fast-reroute backup-interface vlan-interface
101 backup-nexthop 24.24.24.2
[SwitchB-route-policy-frr-10] quit
[SwitchB] rip 1
[SwitchB-rip-1] fast-reroute route-policy frr
[SwitchB-rip-1] quit
```

Verifying the configuration

Display route 4.4.4.4/32 on Switch A to view the backup next hop information.

```
[SwitchA] display ip routing-table 4.4.4.4 verbose

Summary Count : 1
```

```
Destination: 4.4.4.4/32
   Protocol: RIP
 Process ID: 1
  SubProtID: 0x1                  Age: 04h20m37s
       Cost: 1              Preference: 100
      IpPre: N/A            QosLocalID: N/A
        Tag: 0                 State: Active Adv
  OrigTblID: 0x0              OrigVrf: default-vrf
    TableID: 0x2               OrigAs: 0
      NibID: 0x26000002        LastAs: 0
     AttrID: 0xffffffff       Neighbor: 13.13.13.2
      Flags: 0x1008c       OrigNextHop: 13.13.13.2
      Label: NULL          RealNextHop: 13.13.13.2
    BkLabel: NULL            BkNextHop: 12.12.12.2
    SRLabel: NULL            BkSRLabel: NULL
  Tunnel ID: Invalid         Interface: Vlan-interface200
BkTunnel ID: Invalid       BkInterface: Vlan-interface100
   FtnIndex: 0x0           TrafficIndex: N/A
  Connector: N/A                PathID: 0x0
```

Display route 1.1.1.1/32 on Switch B to view the backup next hop information.

```
[SwitchB] display ip routing-table 1.1.1.1 verbose

Summary Count : 1

Destination: 1.1.1.1/32
   Protocol: RIP
 Process ID: 1
  SubProtID: 0x1                  Age: 04h20m37s
       Cost: 1              Preference: 100
      IpPre: N/A            QosLocalID: N/A
        Tag: 0                 State: Active Adv
  OrigTblID: 0x0              OrigVrf: default-vrf
    TableID: 0x2               OrigAs: 0
      NibID: 0x26000002        LastAs: 0
     AttrID: 0xffffffff       Neighbor: 13.13.13.1
      Flags: 0x1008c       OrigNextHop: 13.13.13.1
      Label: NULL          RealNextHop: 13.13.13.1
    BkLabel: NULL            BkNextHop: 24.24.24.2
    SRLabel: NULL            BkSRLabel: NULL
  Tunnel ID: Invalid         Interface: Vlan-interface200
BkTunnel ID: Invalid       BkInterface: Vlan-interface101
   FtnIndex: 0x0           TrafficIndex: N/A
  Connector: N/A                PathID: 0x0
```

Contents

Configuring OSPF

About OSPF

Open Shortest Path First (OSPF) is a link-state IGP developed by the OSPF working group of the IETF. OSPF version 2 is used for IPv4. OSPF refers to OSPFv2 throughout this chapter.

OSPF features

OSPF has the following features:

- **Wide scope**—Supports multiple network sizes and several hundred routers in an OSPF routing domain.
- **Fast convergence**—Advertises routing updates instantly upon network topology changes.
- **Loop free**—Computes routes with the SPF algorithm to avoid routing loops.
- **Area-based network partition**—Splits an AS into multiple areas to facilitate management. This feature reduces the LSDB size on routers to save memory and CPU resources, and reduces route updates transmitted between areas to save bandwidth.
- **Routing hierarchy**—Supports a 4-level routing hierarchy that prioritizes routes into intra-area, inter-area, external Type-1, and external Type-2 routes.
- **Authentication**—Supports area- and interface-based packet authentication to ensure secure packet exchange.
- **Support for multicasting**—Multicasts protocol packets on some types of links to avoid impacting other devices.

OSPF packets

OSPF messages are carried directly over IP. The protocol number is 89.

OSPF uses the following packet types:

- **Hello**—Periodically sent to find and maintain neighbors, containing timer values, information about the DR, BDR, and known neighbors.
- **Database description (DD)**—Describes the digest of each LSA in the LSDB, exchanged between two routers for data synchronization.
- **Link state request (LSR)**—Requests needed LSAs from a neighbor. After exchanging the DD packets, the two routers know which LSAs of the neighbor are missing from their LSDBs. They then exchange LSR packets requesting the missing LSAs. LSR packets contain the digest of the missing LSAs.
- **Link state update (LSU)**—Transmits the requested LSAs to the neighbor.
- **Link state acknowledgment (LSAck)**—Acknowledges received LSU packets. It contains the headers of received LSAs (an LSAck packet can acknowledge multiple LSAs).

LSA types

OSPF advertises routing information in Link State Advertisements (LSAs). The following LSAs are commonly used:

- **Router LSA**—Type-1 LSA, originated by all routers and flooded throughout a single area only. This LSA describes the collected states of the router's interfaces to an area.

- **Network LSA**—Type-2 LSA, originated for broadcast and NBMA networks by the designated router, and flooded throughout a single area only. This LSA contains the list of routers connected to the network.
- **Network Summary LSA**—Type-3 LSA, originated by Area Border Routers (ABRs), and flooded throughout the LSA's associated area. Each summary-LSA describes a route to a destination outside the area, yet still inside the AS (an inter-area route).
- **ASBR Summary LSA**—Type-4 LSA, originated by ABRs and flooded throughout the LSA's associated area. Type 4 summary-LSAs describe routes to Autonomous System Boundary Router (ASBR).
- **AS External LSA**—Type-5 LSA, originated by ASBRs, and flooded throughout the AS (except stub and NSSA areas). Each AS-external-LSA describes a route to another AS.
- **NSSA LSA**—Type-7 LSA, as defined in RFC 1587, originated by ASBRs in NSSAs and flooded throughout a single NSSA. NSSA LSAs describe routes to other ASs.
- **Opaque LSA**—LSA for OSPF extensions. Its format consists of a standard LSA header and application specific information. The opaque LSA includes Type 9, Type 10, and Type 11. The Type 9 opaque LSA is flooded into the local subnet. Grace LSA, used by graceful restart, is Type 9 LSA. The Type 10 is flooded into the local area. The Type 11 is flooded throughout the AS.

OSPF areas

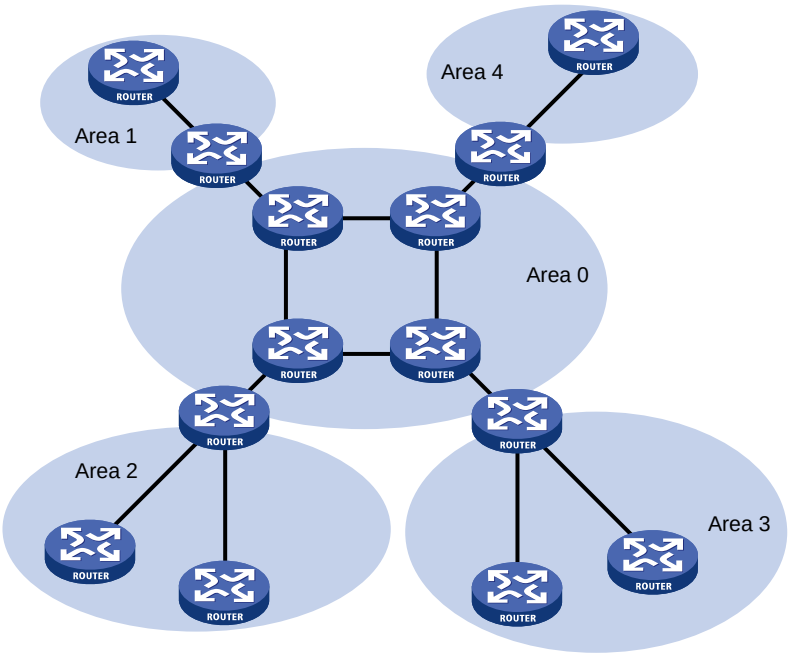
Area-based OSPF network partition

In large OSPF routing domains, SPF route computations consume too many storage and CPU resources, and enormous OSPF packets generated for route synchronization occupy excessive bandwidth.

To resolve these issues, OSPF splits an AS into multiple areas. Each area is identified by an area ID. The boundaries between areas are routers rather than links. A network segment (or a link) can only reside in one area as shown in Figure 1.

You can configure route summarization on ABRs to reduce the number of LSAs advertised to other areas and minimize the effect of topology changes.

Figure 1 Area-based OSPF network partition



Backbone area

Each AS has a backbone area that distributes routing information between non-backbone areas. Routing information between non-backbone areas must be forwarded by the backbone area. OSPF has the following requirements:

- All non-backbone areas must maintain connectivity to the backbone area.
- The backbone area must maintain connectivity within itself.

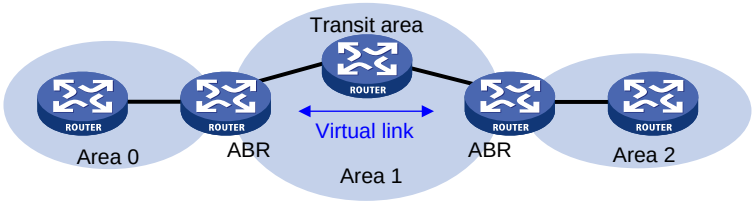
In practice, these requirements might not be met due to lack of physical links. OSPF virtual links can solve this issue.

Virtual links

A virtual link is established between two ABRs through a non-backbone area. It must be configured on both ABRs to take effect. The non-backbone area is called a transit area.

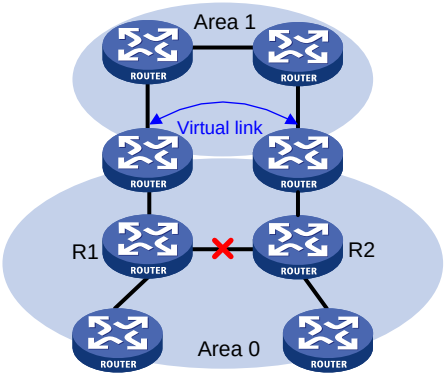
As shown in Figure 2, Area 2 has no direct physical link to the backbone Area 0. You can configure a virtual link between the two ABRs to connect Area 2 to the backbone area.

Figure 2 Virtual link application 1



Virtual links can also be used as redundant links. If a physical link failure breaks the internal connectivity of the backbone area, you can configure a virtual link to replace the failed physical link, as shown in Figure 3.

Figure 3 Virtual link application 2



The virtual link between the two ABRs acts as a point-to-point connection. You can configure interface parameters, such as hello interval, on the virtual link as they are configured on a physical interface.

The two ABRs on the virtual link unicast OSPF packets to each other, and the OSPF routers in between convey these OSPF packets as normal IP packets.

Stub area and totally stub area

A stub area does not distribute Type-5 LSAs to reduce the routing table size and LSAs advertised within the area. The ABR of the stub area advertises a default route in a Type-3 LSA so that the routers in the area can reach external networks through the default route.

To further reduce the routing table size and advertised LSAs, you can configure the stub area as a totally stub area. The ABR of a totally stub area does not advertise inter-area routes or external

routes. It advertises a default route in a Type-3 LSA so that the routers in the area can reach external networks through the default route.

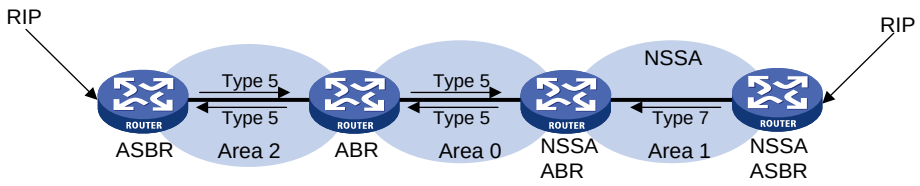
NSSA area and totally NSSA area

An NSSA area does not import AS external LSAs (Type-5 LSAs) but can import Type-7 LSAs generated by the NSSA ASBR. The NSSA ABR translates Type-7 LSAs into Type-5 LSAs and advertises the Type-5 LSAs to other areas.

As shown in Figure 4, the OSPF AS contains Area 1, Area 2, and Area 0. The other two ASs run RIP. Area 1 is an NSSA area where the ASBR redistributes RIP routes in Type-7 LSAs into Area 1. Upon receiving the Type-7 LSAs, the NSSA ABR translates them to Type-5 LSAs, and advertises the Type-5 LSAs to Area 0.

The ASBR of Area 2 redistributes RIP routes in Type-5 LSAs into the OSPF routing domain. However, Area 1 does not receive Type-5 LSAs because it is an NSSA area.

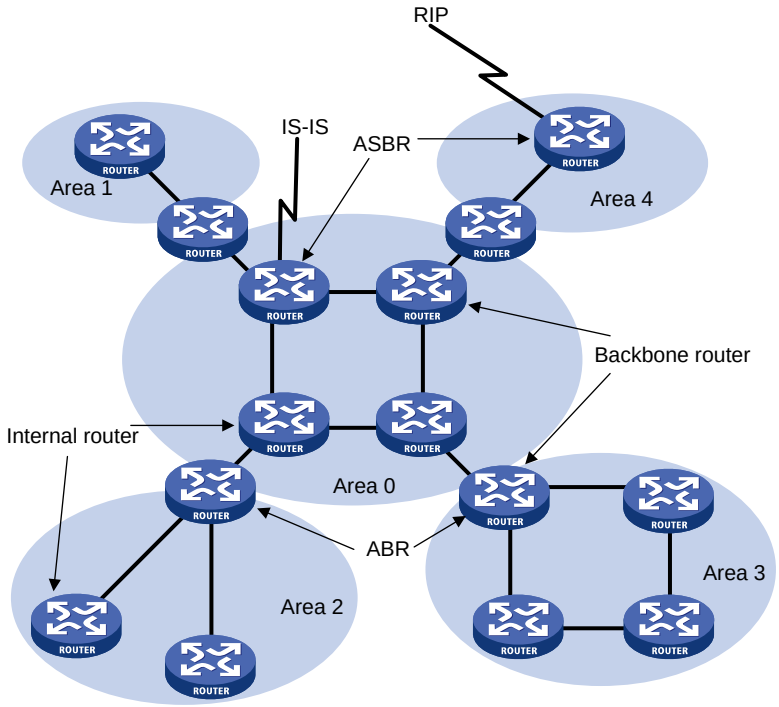
Figure 4 NSSA area



Router types

As shown in Figure 5, OSPF routers are classified into different types, including internal routers, ABRs, backbone routers, and ASBRs.

Figure 5 OSPF router types



Internal router

All interfaces on an internal router belong to one OSPF area.

ABR

An ABR belongs to more than two areas, one of which must be the backbone area. ABR connects the backbone area to a non-backbone area. An ABR and the backbone area can be connected through a physical or logical link.

Backbone router

No less than one interface of a backbone router must reside in the backbone area. All ABRs and internal routers in Area 0 are backbone routers.

ASBR

An ASBR exchanges routing information with another AS. An ASBR might not reside on the border of the AS. It can be an internal router or an ABR.

Route types

OSPF prioritizes routes into the following route levels:

- Intra-area route.
- Inter-area route.
- Type-1 external route.
- Type-2 external route.

The intra-area and inter-area routes describe the network topology of the AS. The external routes describe routes to external ASs.

A Type-1 external route has high credibility. The cost of a Type-1 external route = the cost from the router to the corresponding ASBR + the cost from the ASBR to the destination of the external route.

A Type-2 external route has low credibility. OSPF considers that the cost from the ASBR to the destination of a Type-2 external route is much greater than the cost from the ASBR to an OSPF internal router. The cost of a Type-2 external route = the cost from the ASBR to the destination of the Type-2 external route. If two Type-2 routes to the same destination have the same cost, OSPF takes the cost from the router to the ASBR into consideration to determine the best route.

Router ID

A router ID uniquely identifies a router in an AS. For a router to run OSPF, it must have a router ID. You can choose to manually specify a router ID or use the global router ID for an OSPF process.

Manual configuration

When you create an OSPF process, you can manually specify a router ID. To make sure the router ID is unique in the AS, you can specify the IP address of an interface on the router as the router ID.

Using the global router ID

If you do not specify a router ID when creating an OSPF process, the global router ID is used. As a best practice, manually specify a router ID or enable the OSPF process to automatically obtain a router ID when you create the OSPF process.

Route calculation

OSPF computes routes in an area as follows:

- Each router generates LSAs based on the network topology around itself, and sends them to other routers in update packets.

- Each OSPF router collects LSAs from other routers to compose an LSDB. An LSA describes the network topology around a router, and the LSDB describes the entire network topology of the area.
- Each router transforms the LSDB to a weighted directed graph that shows the topology of the area. All the routers within the area have the same graph.
- Each router uses the SPF algorithm to compute a shortest path tree that shows the routes to the nodes in the area. The router itself is the root of the tree.

OSPF network types

OSPF classifies networks into the following types, depending on different link layer protocols:

- **Broadcast**—If the link layer protocol is Ethernet or FDDI, OSPF considers the network type as broadcast by default. On a broadcast network, hello, LSU, and LSAck packets are multicast to 224.0.0.5 that identifies all OSPF routers or to 224.0.0.6 that identifies the DR and BDR. DD packets and LSR packets are unicast.
- **NBMA**—If the link layer protocol is Frame Relay, ATM, or X.25, OSPF considers the network type as NBMA by default. OSPF packets are unicast on an NBMA network.
- **P2MP**—No link is P2MP type by default. P2MP must be a conversion from other network types such as NBMA. On a P2MP network, OSPF packets are multicast to 224.0.0.5.
- **P2P**—If the link layer protocol is PPP or HDLC, OSPF considers the network type as P2P. On a P2P network, OSPF packets are multicast to 224.0.0.5.

The following are the differences between NBMA and P2MP networks:

- NBMA networks are fully meshed. P2MP networks are not required to be fully meshed.
- NBMA networks require DR and BDR election. P2MP networks do not have DR or BDR.
- On an NBMA network, OSPF packets are unicast, and neighbors are manually configured. On a P2MP network, OSPF packets are multicast by default, and you can configure OSPF to unicast protocol packets.

DR and BDR

DR and BDR mechanism

On a broadcast or NBMA network, any two routers must establish an adjacency to exchange routing information with each other. If n routers are present on the network, n(n-1)/2 adjacencies are established. Any topology change on the network results in an increase in traffic for route synchronization, which consumes a large amount of system and bandwidth resources.

Using the DR and BDR mechanisms can solve this problem.

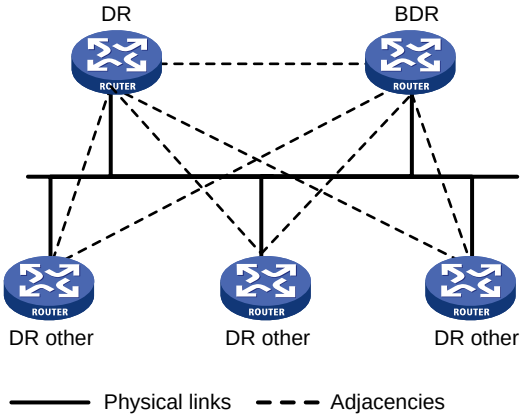
- **DR**—Elected to advertise routing information among other routers. If the DR fails, routers on the network must elect another DR and synchronize information with the new DR. Using this mechanism without BDR is time-consuming and is prone to route calculation errors.
- **BDR**—Elected along with the DR to establish adjacencies with all other routers. If the DR fails, the BDR immediately becomes the new DR, and other routers elect a new BDR.

Routers other than the DR and BDR are called DR Others. They do not establish adjacencies with one another, so the number of adjacencies is reduced.

The role of a router is subnet (or interface) specific. It might be a DR on one interface and a BDR or DR Other on another interface.

As shown in Figure 6, solid lines are Ethernet physical links, and dashed lines represent OSPF adjacencies. With the DR and BDR, only seven adjacencies are established.

Figure 6 DR and BDR in a network



NOTE:

In OSPF, neighbor and adjacency are different concepts. After startup, OSPF sends a hello packet on each OSPF interface. A receiving router checks parameters in the packet. If the parameters match its own, the receiving router considers the sending router an OSPF neighbor. Two OSPF neighbors establish an adjacency relationship after they synchronize their LSDBs through exchange of DD packets and LSAs.

DR and BDR election

DR election is performed on broadcast or NBMA networks but not on P2P and P2MP networks.

Routers in a broadcast or NBMA network elect the DR and BDR by router priority and ID. Routers with a router priority value higher than 0 are candidates for DR and BDR election.

The election votes are hello packets. Each router sends the DR elected by itself in a hello packet to all the other routers. If two routers on the network declare themselves as the DR, the router with the higher router priority wins. If router priorities are the same, the router with the higher router ID wins.

If a router with a higher router priority becomes active after DR and BDR election, the router cannot replace the DR or BDR until a new election is performed. Therefore, the DR of a network might not be the router with the highest priority, and the BDR might not be the router with the second highest priority.

Protocols and standards

- RFC 1245, *OSPF protocol analysis*
- RFC 1246, *Experience with the OSPF protocol*
- RFC 1370, *Applicability Statement for OSPF*
- RFC 1765, *OSPF Database Overflow*
- RFC 1793, *Extending OSPF to Support Demand Circuits*
- RFC 2154, *OSPF with Digital Signatures*
- RFC 2328, *OSPF Version 2*
- RFC 3101, *OSPF Not-So-Stubby Area (NSSA) Option*
- RFC 3166, *Request to Move RFC 1403 to Historic Status*
- RFC 3509, *Alternative Implementations of OSPF Area Border Routers*
- RFC 4167, *Graceful OSPF Restart Implementation Report*
- RFC 4750, *OSPF Version 2 Management Information Base*

- RFC 4811, *OSPF Out-of-Band LSDB Resynchronization*
- RFC 4812, *OSPF Restart Signaling*
- RFC 5088, *OSPF Protocol Extensions for Path Computation Element (PCE) Discovery*
- RFC 5250, *The OSPF Opaque LSA Option*
- RFC 5613, *OSPF Link-Local Signaling*
- RFC 5642, *Dynamic Hostname Exchange Mechanism for OSPF*
- RFC 5709, *OSPFv2 HMAC-SHA Cryptographic Authentication*
- RFC 5786, *Advertising a Router's Local Addresses in OSPF Traffic Engineering (TE) Extensions*
- RFC 6571, *Loop-Free Alternate (LFA) Applicability in Service Provider (SP) Networks*
- RFC 6860, *Hiding Transit-Only Networks in OSPF*
- RFC 6987, *OSPF Stub Router Advertisement*

Restrictions: Hardware compatibility with OSPF

The S5110V2-SI, S5000V3-EI, S5000V5-EI, S5000E-X, S5000X-EI, and WAS6000 switch series do not support OSPF.

Restrictions and guidelines: OSPF configuration

To run OSPF, you must first enable OSPF on the router. Make a proper configuration plan to avoid incorrect settings that can result in route blocking and routing loops.

OSPF tasks at a glance

To configure OSPF, perform the following tasks:

1. Configuring basic OSPF functions
   - Enabling an OSPF process
   - Creating an OSPF area
   - Enabling OSPF
2. (Optional.) Configuring OSPF stub and NSSA areas
   - Configuring a stub area
   - Configuring an NSSA area
   - Configuring a virtual link
3. (Optional.) Configuring OSPF network types
   - Configuring the broadcast network type for an interface
   - Configuring the NBMA network type for an interface
   - Configuring the P2MP network type for an interface
   - Configuring the P2P network type for an interface
4. (Optional.) Configuring OSPF route control
   - Configuring OSPF inter-area route summarization
   - Configuring redistributed route summarization
   - Configuring received OSPF route filtering
   - Configuring Type-3 LSA filtering

- Setting an OSPF cost for an interface
- Setting OSPF preference
- Configuring discard routes for summary networks
- Redistributing routes from another routing protocol
- Redistributing a default route
- Advertising a host route

5. (Optional.) Setting OSPF timers
   - Configuring OSPF packet timers
   - Setting LSA transmission delay
   - Setting SPF calculation interval
   - Setting the minimum LSA arrival interval
   - Setting the LSA generation interval
   - Setting OSPF exit overflow interval
6. (Optional.) Configuring OSPF packet parameters
   - Disabling interfaces from receiving and sending OSPF packets
   - Adding the interface MTU into DD packets
   - Setting the DSCP value for outgoing OSPF packets
   - Setting the maximum length of OSPF packets that can be sent by an interface
   - Setting the LSU transmit rate
7. (Optional.) Controlling LSA generation, advertisement, and reception
   - Setting the maximum number of external LSAs in LSDB
   - Filtering outbound LSAs on an interface
   - Filtering LSAs for the specified neighbor
8. (Optional.) Accelerating OSPF convergence speed
   - Enabling OSPF ISPF
   - Configuring prefix suppression
   - Configuring prefix prioritization
   - Configuring OSPF PIC
9. (Optional.) Configuring advanced OSPF features
   - Configuring stub routers
   - Enabling compatibility with RFC 1583
10. (Optional.) Enhancing OSPF availability
    - Configuring OSPF GR
    - Configuring OSPF NSR
    - Configuring BFD for OSPF
    - Configuring OSPF FRR
11. (Optional.) Configuring OSPF security features
    - Configuring OSPF authentication
    - Configuring GTSM for OSPF
12. (Optional.) Configuring OSPF logging and SNMP notifications
    - Logging neighbor state changes
    - Configuring the OSPF logging feature
    - Configuring OSPF network management
    - Setting the maximum number of OSPF neighbor relationship troubleshooting entries

Configuring basic OSPF functions

Enabling an OSPF process

1. Enter system view.
   system-view
2. (Optional.) Configure a global router ID.
   router id *router-id*
   By default, no global router ID is configured.
   If no global router ID is configured, the highest loopback interface IP address, if any, is used as the router ID. If no loopback interface IP address is available, the highest physical interface IP address is used, regardless of the interface status (up or down).
3. Enter OSPF view.
   ospf [*process-id* | **router-id** *router-id*] *
   By default, OSPF is disabled.
4. (Optional.) Configure a description for the OSPF process.
   description *text*
   By default, no description is configured for the OSPF process.
   As a best practice, configure a description for each OSPF process.

Creating an OSPF area

1. Enter system view.
   system-view
2. (Optional.) Configure a global router ID.
   router id *router-id*
   By default, no global router ID is configured.
3. Enter OSPF view.
   ospf [*process-id* | **router-id** *router-id*] *
   By default, OSPF is disabled.
4. (Optional.) Configure a description for the OSPF process.
   description *text*
   By default, no description is configured for the OSPF process.
   As a best practice, configure a description for each OSPF process.
5. Create an OSPF area, and enter OSPF area view.
   area *area-id*
6. (Optional.) Configure a description for the area.
   description *text*
   By default, no description is configured for the area.
   As a best practice, configure a description for each OSPF area.
7. (Optional.) Exclude interfaces in the OSPF area from the base topology:
   capability default-exclusion
   By default, interfaces in an OSPF area belong to the base topology.

For correct neighbor relationship establishment, perform this task on both the local device and the neighbor device.

Enabling OSPF

About multiple processes and VPNs

To enable OSPF on a router, you must perform the following tasks:

1. Create an OSPF process.
2. Create an OSPF area for the process.
3. Specify a network in the area.

The interface attached to the network will run the OSPF process in the area. OSPF advertises direct routes of the interface.

OSPF supports multiple processes. To run multiple OSPF processes, you must specify an ID for each process. The process IDs take effect locally and has no influence on packet exchange between routers. Two routers with different process IDs can exchange packets.

Restrictions and guidelines for enabling OSPF

When you configure OSPF on an interface, follow these restrictions and guidelines:

- You can enable OSPF on the network where the interface resides or directly enable OSPF on that interface. If you configure both, the latter takes precedence.
- If the specified OSPF process and area do not exist, the operation creates an OSPF process and area for the interface. Disabling an OSPF process on an interface does not delete the OSPF process or the area.

Enabling OSPF on a network

1. Enter system view.

   system-view
2. Enter OSPF view.

   ospf [*process-id* | **router-id** *router-id*] *
3. Enter OSPF area view.

   area *area-id*
4. Specify a network to enable the interface attached to the network to run the OSPF process in the area.

   network *ip-address wildcard-mask*

   By default, no network is specified to enable OSPF on the interface attached to the network.

   A network can be added to only one area.

Enabling OSPF on an interface

1. Enter system view.

   system-view
2. Enter interface view.

   interface *interface-type interface-number*
3. Enable an OSPF process on the interface.

   ospf *process-id* **area** *area-id* [**exclude-subip**]

   By default, OSPF is disabled on an interface.

Configuring OSPF stub and NSSA areas

About OSPF stub and NSSA area configuration

This task allows you to configure an OSPF area as a stub area or NSSA area. It also allows you to create a virtual link if no connectivity can be achieved between a non-backbone area and backbone area, or in the backbone area.

Configuring a stub area

About stub area configuration

You can configure a non-backbone area at an AS edge as a stub area. To do so, execute the **stub** command on all routers attached to the area. The routing table size is reduced because Type-5 LSAs will not be flooded within the stub area. The ABR generates a default route into the stub area so all packets destined outside of the AS are sent through the default route.

To further reduce the routing table size and routing information exchanged in the stub area, configure a totally stub area by using the **stub no-summary** command on the ABR. AS external routes and inter-area routes will not be distributed into the area. All the packets destined for outside of the AS or area will be sent to the ABR for forwarding.

A stub or totally stub area cannot have an ASBR because external routes cannot be distributed into the area.

Restrictions and guidelines

Do not configure the backbone area as a stub area or totally stub area.

To configure an area as a stub area, execute the **stub** command on all routers attached to the area.

To configure an area as a totally stub area, execute the **stub** command on all routers attached to the area, and execute the **stub no-summary** command on the ABR.

Procedure

1. Enter system view.
   system-view
2. Enter OSPF view.
   ospf [*process-id* | **router-id** *router-id*] *
3. Enter area view.
   area *area-id*
4. Configure the area as a stub area.
   stub [**default-route-advertise-always** | **no-summary**] *
   By default, no stub area is configured.
5. (Optional.) Set a cost for the default route advertised to the stub area.
   default-cost *cost-value*
   By default, the cost for the default route advertised to the stub area is 1.
   This command takes effect only on the ABR of a stub area or totally stub area.

Configuring an NSSA area

About NSSA area configuration

A stub area cannot import external routes, but an NSSA area can import external routes into the OSPF routing domain while retaining other stub area characteristics.

To configure an area as a totally NSSA area, use the **nssa no-summary** command. The ABR of the area does not advertise inter-area routes into the area.

Restrictions and guidelines

Do not configure the backbone area as an NSSA area or totally NSSA area.

To configure an NSSA area, configure the **nssa** command on all the routers attached to the area.

To configure a totally NSSA area, configure the **nssa** command on all the routers attached to the area and configure the **nssa no-summary** command on the ABR.

Procedure

1. Enter system view.
   system-view
2. Enter OSPF view.
   ospf [*process-id* | **router-id** *router-id*] *
3. Enter area view.
   area *area-id*
4. Configure the area as an NSSA area.
   nssa [**default-route-advertise** [**cost** *cost-value* | **nssa-only** | **route-policy** *route-policy-name* | **type** *type*] * | **no-import-route** | **no-summary** | **suppress-fa** | [[[**translate-always**] [**translate-ignore-checking-backbone**]] | **translate-never**] | **translator-stability-interval** *value*] *
   By default, no area is configured as an NSSA area.
5. (Optional.) Set a cost for the default route advertised to the NSSA area.
   default-cost *cost-value*
   By default, the cost for the default route advertised to the NSSA area is 1.
   This command takes effect only on the ABR/ASBR on an NSSA area or totally NSSA area.

Configuring a virtual link

About virtual link configuration

You can configure a virtual link to maintain connectivity between a non-backbone area and the backbone, or in the backbone itself.

Restrictions and guidelines

A virtual link cannot traverse a stub area, totally stub area, NSSA area, or totally NSSA area.

Procedure

1. Enter system view.
   system-view
2. Enter OSPF view.
   ospf [*process-id* | **router-id** *router-id*] *

3. Enter OSPF area view.

   area *area-id*

4. Configure a virtual link.

   vlink-peer *router-id* [**dead** *seconds* | **hello** *seconds* | { { **hmac-md5** | **md5** } *key-id* { **cipher** | **plain** } *string* | **simple** { **cipher** | **plain** } *string* } | **retransmit** *seconds* | **trans-delay** *seconds*] *

   Configure this command on both ends of a virtual link. The **hello** and **dead** intervals must be identical on both ends of the virtual link.

Configuring OSPF network types

Based on the link layer protocol, OSPF classifies networks into different types, including broadcast, NBMA, P2MP, and P2P.

Restrictions and guidelines for configuring OSPF network types

If any routers in a broadcast network do not support multicasting, change the network type to NBMA.

If only two routers running OSPF exist on a network segment, you can change the network type to P2P to save costs.

Two broadcast-, NBMA-, and P2MP-interfaces can establish a neighbor relationship only when they are on the same network segment.

Configuring the broadcast network type for an interface

1. Enter system view.

   system-view

2. Enter interface view.

   interface *interface-type interface-number*

3. Configure the OSPF network type for the interface as broadcast.

   ospf network-type broadcast

   By default, the network type of an interface is broadcast.

4. (Optional.) Set a router priority for the interface.

   ospf dr-priority *priority*

   The default router priority is 1.

Configuring the NBMA network type for an interface

Restrictions and guidelines

After you configure the network type as NBMA, you must specify neighbors and their router priorities because NBMA interfaces cannot find neighbors by broadcasting hello packets.

Procedure

1. Enter system view.

   system-view

2. Enter interface view.

interface *interface-type interface-number*

3. Configure the OSPF network type for the interface as NBMA.
   ospf network-type nbma
   By default, the network type of an interface is broadcast.
4. (Optional.) Set a router priority for the interface.
   ospf dr-priority *priority*
   The default router priority for an interface is 1.
   The router priority configured with this command is for DR election.
5. Return to system view.
   quit
6. Enter OSPF view.
   ospf [*process-id* | **router-id** *router-id*] *
7. Specify an NBMA neighbor.
   peer *ip-address* [**dr-priority** *priority*]
   By default, no neighbor is specified.
   The priority configured with this command indicates whether a neighbor has the election right or not. If you configure the router priority for a neighbor as 0, the local router determines the neighbor has no election right. It does not send hello packets to this neighbor. However, if the local router is the DR or BDR, it still sends hello packets to the neighbor for neighbor relationship establishment.

Configuring the P2MP network type for an interface

1. Enter system view.
   system-view
2. Enter interface view.
   interface *interface-type interface-number*
3. Configure the OSPF network type for the interface as P2MP.
   ospf network-type p2mp [**unicast**]
   By default, the network type of an interface is broadcast.
4. Return to system view.
   quit
5. Enter OSPF view.
   ospf [*process-id* | **router-id** *router-id*] *
6. Specify a P2MP neighbor.
   peer *ip-address* [**cost** *cost-value*]
   By default, no neighbor is specified
   This step is required if the interface network type is P2MP unicast.

Configuring the P2P network type for an interface

1. Enter system view.
   system-view
2. Enter interface view.
   interface *interface-type interface-number*

3. Configure the OSPF network type for the interface as P2P.

   ospf network-type p2p [**peer-address-check**]

   By default, the network type of an interface is broadcast.

Configuring OSPF route control

This section describes how to control the advertisement and reception of OSPF routing information, as well as route redistribution from other protocols.

Configuring OSPF inter-area route summarization

About OSPF inter-area route summarization

OSPF inter-area route summarization reduces the routing information exchanged between areas and the size of routing tables, and improves routing performance.

OSPF inter-area route summarization enables an ABR to summarize contiguous networks into a single network and advertise the network to other areas. For example, three internal networks 19.1.1.0/24, 19.1.2.0/24, and 19.1.3.0/24 are available within an area. You can configure the ABR to summarize the three networks into network 19.1.0.0/16, and advertise the summary network to other areas in a Type-3 LSA. This configuration reduces the scale of LSDBs on routers in other areas and the influence of topology changes.

Procedure

1. Enter system view.

   system-view

2. Enter OSPF view.

   ospf [*process-id* | **router-id** *router-id*] *

3. Enter OSPF area view.

   area *area-id*

4. Configure ABR route summarization.

   abr-summary *ip-address* { *mask-length* | *mask* } [**advertise** | **not-advertise**] [**cost** *cost-value*]

   By default, route summarization is not configured on an ABR.

Configuring redistributed route summarization

About redistributed route summarization

Perform this task to enable an ASBR to summarize external routes within the specified address range into a single route. The ASBR advertises only Type-5 LSAs to reduce the number of LSAs in the LSDB.

An ASBR can summarize routes in the following LSAs:

- Type-5 LSAs.
- Type-7 LSAs in an NSSA area.

Restrictions and guidelines

If an ASBR (also an ABR) is a translator in an NSSA area, it summarizes routes in Type-5 LSAs translated from Type-7 LSAs. If it is not a translator, it does not summarize routes in in Type-5 LSAs translated from Type-7 LSAs.

Procedure

1. Enter system view.
   system-view
2. Enter OSPF view.
   ospf [*process-id* | **router-id** *router-id*] *
3. Configure ASBR route summarization.
   asbr-summary *ip-address* { *mask-length* | *mask* } [**cost** *cost-value* | **not-advertise** | **nssa-only** | **tag** *tag*] *
   By default, route summarization is not configured on an ASBR.

Configuring received OSPF route filtering

About filtering methods

Perform this task to filter routes calculated using received LSAs.

The following filtering methods are available:

- Use an ACL or IP prefix list to filter routing information by destination address.
- Use the **gateway** *prefix-list-name* option to filter routing information by next hop.
- Use an ACL or IP prefix list to filter routing information by destination address. At the same time use the **gateway** *prefix-list-name* option to filter routing information by next hop.
- Use the **route-policy** *route-policy-name* option to filter routing information.

Procedure

1. Enter system view.
   system-view
2. Enter OSPF view.
   ospf [*process-id* | **router-id** *router-id*] *
3. Configure OSPF to filter routes calculated using received LSAs.
   filter-policy { *ipv4-acl-number* [**gateway** *prefix-list-name*] | **gateway** *prefix-list-name* | **prefix-list** *prefix-list-name* [**gateway** *prefix-list-name*] | **route-policy** *route-policy-name* } **import**
   By default, OSPF accepts all routes calculated by using received LSAs.

Configuring Type-3 LSA filtering

About Type-3 LSA filtering

Perform this task to filter Type-3 LSAs advertised into the local area or other areas on an ABR.

Procedure

1. Enter system view.
   system-view
2. Enter OSPF view.
   ospf [*process-id* | **router-id** *router-id*] *
3. Enter OSPF area view.
   area *area-id*
4. Configure Type-3 LSA filtering.

filter { *ipv4-acl-number* | **prefix-list** *prefix-list-name* | **route-policy** *route-policy-name* } { **export** | **import** }

By default, the ABR does not filter Type-3 LSAs.

Setting an OSPF cost for an interface

About setting an OSPF cost for an interface

Set an OSPF cost for an interface by using either of the following methods:

- Set the cost value in interface view.
- Set a bandwidth reference value for the interface. OSPF computes the cost with this formula: Interface OSPF cost = Bandwidth reference value (100 Mbps) / Expected interface bandwidth (Mbps). The expected bandwidth of an interface is configured with the **bandwidth** command (see *Interface Command Reference*).
  - If the calculated cost is greater than 65535, the value of 65535 is used. If the calculated cost is less than 1, the value of 1 is used.
  - If no cost or bandwidth reference value is configured for an interface, OSPF computes the interface cost based on the interface bandwidth and default bandwidth reference value.

Setting an OSPF cost for an interface

1. Enter system view.

   system-view
2. Enter interface view.

   interface *interface-type interface-number*
3. Set an OSPF cost for the interface.

   ospf cost *cost-value*

   By default, the OSPF cost is calculated according to the interface bandwidth. For a loopback interface, the OSPF cost is 0 by default.

Setting a bandwidth reference value

1. Enter system view.

   system-view
2. Enter OSPF view.

   ospf [*process-id* | **router-id** *router-id*] *
3. Set a bandwidth reference value.

   bandwidth-reference *value*

   The default setting is 100 Mbps.

Setting OSPF preference

About OSPF preference

A router can run multiple routing protocols, and each protocol is assigned a preference. If multiple routes are available to the same destination, the one with the highest protocol preference is selected as the best route.

Procedure

1. Enter system view.

   system-view
2. Enter OSPF view.

ospf [*process-id* | **router-id** *router-id*] *

3. Set a preference for OSPF.

   preference [**ase**] { *preference* | **route-policy** *route-policy-name* } *

   By default, the preference of OSPF internal routes is 10 and the preference of OSPF external routes is 150.

Configuring discard routes for summary networks

About discarding routes for summary networks

Perform this task on an ABR or ASBR to specify whether to generate discard routes for summary networks. You can also specify a preference for the discard routes.

Procedure

1. Enter system view.

   system-view

2. Enter OSPF view.

   ospf [*process-id* | **router-id** *router-id*] *

3. Configure discard routes for summary networks.

   discard-route { **external** { *preference* | **suppression** } | **internal** { *preference* | **suppression** } } *

   By default, the ABR or ASBR generates discard routes for summary networks and the default preference of discard routes is 255.

Redistributing routes from another routing protocol

About redistributing routes from another routing protocol

On a router running OSPF and other routing protocols, you can configure OSPF to redistribute routes from other protocols. OSPF advertises the routes in Type-5 LSAs or Type-7 LSAs. In addition, you can configure OSPF to filter redistributed routes so that OSPF advertises only permitted routes.

Restrictions and guidelines

OSPF redistributes only active routes. To view route status information, use the **display ip routing-table protocol** command.

Procedure

1. Enter system view.

   system-view

2. Enter OSPF view.

   ospf [*process-id* | **router-id** *router-id*] *

3. Configure OSPF to redistribute routes from another routing protocol.

   import-route { **direct** | **static** } [**cost** *cost-value* | **nssa-only** | **route-policy** *route-policy-name* | **tag** *tag* | **type** *type*] *

   import-route { **ospf** | **rip** } [*process-id* | **all-processes**] [**allow-direct** | **cost** *cost-value* | **nssa-only** | **route-policy** *route-policy-name* | **tag** *tag* | **type** *type*] *

   By default, no route redistribution is configured.

4. (Optional.) Configure OSPF to filter redistributed routes.

   filter-policy { *ipv4-acl-number* | **prefix-list** *prefix-list-name* } **export** [*protocol* [*process-id*]]

By default, OSPF accepts all redistributed routes.

5. Configure the default parameters for redistributed routes (cost, tag, and type).
   default { **cost** *cost-value* | **tag** *tag* | **type** *type* } *
   By default, the cost is 1, the tag is 1, and the route type is 2

Redistributing a default route

About default route redistribution

The **import-route** command cannot redistribute a default external route. Perform this task to redistribute a default route.

Procedure

1. Enter system view.
   system-view
2. Enter OSPF view.
   ospf [*process-id* | **router-id** *router-id*] *
3. Redistribute a default route.
   default-route-advertise [[**always** | **permit-calculate-other**] | **cost** *cost-value* | **route-policy** *route-policy-name* | **type** *type*] *
   By default, no default route is redistributed.
4. Configure the default parameters for redistributed routes (cost, tag, and type).
   default { **cost** *cost-value* | **tag** *tag* | **type** *type* } *
   By default, the cost is 1, the tag is 1, and the route type is 2

Advertising a host route

1. Enter system view.
   system-view
2. Enter OSPF view.
   ospf [*process-id* | **router-id** *router-id*] *
3. Enter area view.
   area *area-id*
4. Advertise a host route.
   host-advertise *ip-address cost*
   By default, OSPF does not advertise host routes that are not in the area.

Setting OSPF timers

About setting OSPF timers

This task allows you to change OSPF packet timers to adjust the convergence speed and network load and tune the delay time for sending LSAs on low-speed links.

Configuring OSPF packet timers

About OSPF packet timers

An OSPF interface includes the following timers:

- **Hello timer**—Interval for sending hello packets. It must be identical on OSPF neighbors.
- **Poll timer**—Interval for sending hello packets to a neighbor that is down on the NBMA network.
- **Dead timer**—Interval within which if the interface does not receive any hello packet from the neighbor, it declares the neighbor is down.
- **LSA retransmission timer**—Interval within which if the interface does not receive any acknowledgment packets after sending an LSA to the neighbor, it retransmits the LSA.

Restrictions and guidelines

The default value for the hello interval and neighbor dead interval depends on the network type. When the network type for an interface is changed, the default hello interval and neighbor dead interval are restored. Make sure two neighboring interfaces are configured with the same hello interval and neighbor dead interval. Inconsistent settings will affect the OSPF neighbor relationship establishment.

Procedure

1. Enter system view.

   system-view

2. Enter interface view.

   interface *interface-type interface-number*

3. Set the hello interval.

   ospf timer hello *seconds*

   The default hello interval on P2P and broadcast interfaces is 10 seconds. The default hello interval on P2MP and NBMA interfaces is 30 seconds.

4. Set the poll interval.

   ospf timer poll *seconds*

   The default setting is 120 seconds.

   The poll interval is a minimum of four times the hello interval.

5. Set the dead interval.

   ospf timer dead *seconds*

   The default dead interval on P2P and broadcast interfaces is 40 seconds. The default dead interval on P2MP and NBMA interfaces is 120 seconds.

   The dead interval must be a minimum of four times the hello interval on an interface.

6. Set the retransmission interval.

   ospf timer retransmit *interval*

   The default retransmission interval is 5 seconds.

   A retransmission interval setting that is too small can cause unnecessary LSA retransmissions. Typically set a bigger interval than the round-trip time of a packet between two neighbors.

Setting LSA transmission delay

About setting LSA transmission delay

To avoid LSAs from aging out during transmission, set an LSA retransmission delay especially for low speed links.

Procedure

1. Enter system view.
   system-view
2. Enter interface view.
   interface *interface-type interface-number*
3. Set the LSA transmission delay.
   ospf trans-delay *seconds*
   The default LSA transmission delay is 1 second.

Setting SPF calculation interval

About setting SPF calculation interval

LSDB changes result in SPF calculations. When the topology changes frequently, a large amount of network and router resources are occupied by SPF calculation. You can adjust the SPF calculation interval to reduce the impact.

For a stable network, the minimum interval is used. If network changes become frequent, the SPF calculation interval increases by the incremental interval × 2^{n-2} for each calculation until the maximum interval is reached. The value *n* is the number of calculation times.

Procedure

1. Enter system view.
   system-view
2. Enter OSPF view.
   ospf [*process-id* | **router-id** *router-id*] *
3. Set the SPF calculation interval.
   spf-schedule-interval *maximum-interval* [*minimum-interval* [*incremental-interval*]]
   By default, the maximum interval is 5 seconds, the minimum interval is 50 milliseconds, and the incremental interval is 200 milliseconds.

Setting the minimum LSA arrival interval

About setting the minimum LSA arrival interval

OSPF drops any duplicate LSAs (with the same LSA type, LS ID, and router ID) within the minimum LSA arrival interval. This helps avoid overuse of bandwidth and router resources due to frequent network changes.

Procedure

1. Enter system view.
   system-view
2. Enter OSPF view.
   ospf [*process-id* | **router-id** *router-id*] *
3. Set the minimum LSA arrival interval.
   lsa-arrival-interval *interval*
   By default, the minimum LSA arrival interval is 1000 milliseconds.

Setting the LSA generation interval

About setting the LSA generation interval

Adjust the LSA generation interval to protect network resources and routers from being overwhelmed by LSAs at the time of frequent network changes.

For a stable network, the minimum interval is used. If network changes become frequent, the LSA generation interval is incremented by the incremental interval × 2^{n-2} for each generation until the maximum interval is reached. The value *n* is the number of generation times.

Procedure

1. Enter system view.

   system-view

2. Enter OSPF view.

   ospf [*process-id* | **router-id** *router-id*] *

3. Set the LSA generation interval.

   lsa-generation-interval *maximum-interval* [*minimum-interval* [*incremental-interval*]]

   By default, the maximum interval is 5 seconds, the minimum interval is 50 milliseconds, and the incremental interval is 200 milliseconds.

Setting OSPF exit overflow interval

About setting OSPF exit overflow interval

When the number of LSAs in the LSDB exceeds the upper limit, the LSDB is in an overflow state. In this state, OSPF does not receive any external LSAs and deletes the external LSAs generated by itself to save system resources.

This task allows you to configure the interval that OSPF exits overflow state.

Procedure

1. Enter system view.

   system-view

2. Enter OSPF view.

   ospf [*process-id* | **router-id** *router-id*] *

3. Set the interval that OSPF exits overflow state.

   lsdb-overflow-interval *interval*

   By default, the OSPF exit overflow interval is 300 seconds. An interval of 0 means that OSPF does not exit overflow state.

Configuring OSPF packet parameters

Disabling interfaces from receiving and sending OSPF packets

About disabling interfaces from receiving and sending OSPF packets

To enhance OSPF adaptability and reduce resource consumption, you can set an OSPF interface to "silent." A silent OSPF interface blocks OSPF packets and cannot establish any OSPF neighbor

relationship. However, other interfaces on the router can still advertise direct routes of the interface in Router LSAs.

Procedure

1. Enter system view.

   system-view

2. Enter OSPF view.

   ospf [*process-id* | **router-id** *router-id*] *

3. Disable interfaces from receiving and sending OSPF packets.

   silent-interface { *interface-type interface-number* | **all** }

   By default, an OSPF interface can receive and send OSPF packets.

   This command disables only the interfaces associated with the current process rather than other processes. Multiple OSPF processes can disable the same interface from receiving and sending OSPF packets.

Adding the interface MTU into DD packets

About adding the interface MTU into DD packets

By default, an OSPF interface adds a value of 0 into the interface MTU field of a DD packet rather than the actual interface MTU. You can enable an interface to add its MTU into DD packets.

Procedure

1. Enter system view.

   system-view

2. Enter interface view.

   interface *interface-type interface-number*

3. Enable the interface to add its MTU into DD packets.

   ospf mtu-enable

   By default, the interface adds an MTU value of 0 into DD packets.

Setting the DSCP value for outgoing OSPF packets

About DSCP value

The DSCP value specifies the precedence of outgoing packets.

Procedure

1. Enter system view.

   system-view

2. Enter OSPF view.

   ospf [*process-id* | **router-id** *router-id*] *

3. Set the DSCP value for outgoing OSPF packets.

   dscp *dscp-value*

   By default, the DSCP value for outgoing OSPF packets is 48.

Setting the maximum length of OSPF packets that can be sent by an interface

About setting the maximum length of OSPF packets that can be sent by an interface

This task allows you to limit the length of OSPF packets sent over an interface.

Procedure

1. Enter system view.

   system-view

2. Enter interface view.

   interface *interface-type interface-number*

3. Set the maximum length of OSPF packets that can be sent by an interface.

   ospf packet-size *value*

   By default, the maximum length of OSPF packets that an interface can send equals the interface's MTU.

Setting the LSU transmit rate

About LSU transmit rate configuration

During LSDB synchronization, if the local router has multiple neighbors, it must send many LSUs to each neighbor. When a neighbor receives excessive LSUs within a short time period, the following events might occur:

- The neighbor experiences degraded performance because it uses too many system resources to process the received LSU packets.
- The neighbor drops hello packets used for maintaining the neighbor relationship because it is busy dealing with the LSUs. As a result, the neighbor relationship is torn down. To reestablish a relationship to the neighbor, the local router must send more LSUs to the neighbor. This exacerbates the performance degradation.

This task allows you to limit the LSU transmit rate by setting the LSU transmit interval and the maximum number of LSUs that can be sent at each interval.

Procedure

1. Enter system view.

   system-view

2. Enable OSPF to limit the LSU transmit rate.

   ospf lsu-flood-control [*interval count*]

   By default, OSPF does not limit the LSU transmit rate.

   Inappropriate use of this command might cause abnormal routing. As a best practice, execute this command with the default values.

3. Enter OSPF view.

   ospf [*process-id* | **router-id** *router-id*] *

4. (Optional.) Set the LSU transmit interval and the maximum number of LSUs that can be sent at each interval.

   transmit-pacing interval *interval* **count** *count*

   By default, an OSPF interface sends a maximum of three LSU packets every 20 milliseconds.

Controlling LSA generation, advertisement, and reception

Setting the maximum number of external LSAs in LSDB

1. Enter system view.
   system-view
2. Enter OSPF view.
   ospf [*process-id* | **router-id** *router-id*] *
3. Set the maximum number of external LSAs in the LSDB.
   lsdb-overflow-limit *number*
   By default, the maximum number of external LSAs in the LSDB is not limited.

Filtering outbound LSAs on an interface

About filtering outbound LSAs on an interface

To reduce the LSDB size for the neighbor and save bandwidth, you can perform this task on an interface to filter LSAs to be sent to the neighbor.

Procedure

1. Enter system view.
   system-view
2. Enter interface view.
   interface *interface-type interface-number*
3. Filter outbound LSAs on the interface.
   ospf database-filter { **all** | { **ase** [**acl** *ipv4-acl-number*] | **nssa** [**acl** *ipv4-acl-number*] | **summary** [**acl** *ipv4-acl-number*] } * }
   By default, the outbound LSAs are not filtered on the interface.

Filtering LSAs for the specified neighbor

About filtering LSAs for the specified neighbor

On a P2MP network, a router might have multiple P2MP type OSPF neighbors. Perform this task to prevent the router from sending LSAs to the specified P2MP neighbor.

Procedure

1. Enter system view.
   system-view
2. Enter OSPF view.
   ospf [*process-id* | **router-id** *router-id*] *
3. Filter LSAs for the specified P2MP neighbor.
   database-filter peer *ip-address* { **all** | { **ase** [**acl** *ipv4-acl-number*] | **nssa** [**acl** *ipv4-acl-number*] | **summary** [**acl** *ipv4-acl-number*] } * }
   By default, the LSAs for the specified P2MP neighbor are not filtered.

Accelerating OSPF convergence speed

Enabling OSPF ISPF

About ISPF

When the topology changes, Incremental Shortest Path First (ISPF) computes only the affected part of the SPT, instead of the entire SPT.

Procedure

1. Enter system view.
   system-view
2. Enter OSPF view.
   ospf [*process-id* | **router-id** *router-id*] *
3. Enable OSPF ISPF.
   ispf enable
   By default, OSPF ISPF is enabled.

Configuring prefix suppression

About prefix suppression

By default, an OSPF interface advertises all of its prefixes in LSAs. To speed up OSPF convergence, you can suppress interfaces from advertising all of their prefixes. This feature helps improve network security by preventing IP routing to the suppressed networks.

When prefix suppression is enabled:

- On P2P and P2MP networks, OSPF does not advertise Type-3 links in Type-1 LSAs. Other routing information can still be advertised to ensure traffic forwarding.
- On broadcast and NBMA networks, the DR generates Type-2 LSAs with a mask length of 32 to suppress network routes. Other routing information can still be advertised to ensure traffic forwarding. If no neighbors exist, the DR does not advertise Type-3 links in Type-1 LSAs.

Restrictions and guidelines for prefix suppression

As a best practice, configure prefix suppression on all OSPF routers if you want to use prefix suppression.

Configuring prefix suppression for an OSPF process

1. Enter system view.
   system-view
2. Enter OSPF view.
   ospf [*process-id* | **router-id** *router-id*] *
3. Enable prefix suppression for the OSPF process.
   prefix-suppression
   By default, prefix suppression is disabled for an OSPF process.
   This feature does not suppress the prefixes of secondary IP addresses, loopback interfaces, and passive interfaces.

Configuring prefix suppression for an interface

1. Enter system view.
   system-view

2. Enter interface view.
   interface *interface-type interface-number*
3. Enable prefix suppression for the interface.
   ospf prefix-suppression [**disable**]
   By default, prefix suppression is disabled on an interface.
   This feature does not suppress prefixes of secondary IP addresses.

Configuring prefix prioritization

About prefix prioritization

This feature enables the device to install prefixes in descending priority order: critical, high, medium, and low. The prefix priorities are assigned through routing policies. When a route is assigned multiple prefix priorities, the route uses the highest priority.

By default, the 32-bit OSPF host routes have a medium priority and other routes have a low priority.

Procedure

1. Enter system view.
   system-view
2. Enter OSPF view.
   ospf [*process-id* | **router-id** *router-id*] *
3. Enable prefix prioritization.
   prefix-priority route-policy *route-policy-name*
   By default, prefix prioritization is disabled.

Configuring OSPF PIC

About PIC

Prefix Independent Convergence (PIC) enables the device to speed up network convergence by ignoring the number of prefixes.

Restrictions and guidelines for OSPF PIC

When both OSPF PIC and OSPF FRR are configured, OSPF FRR takes effect.

OSPF PIC applies only to inter-area routes and external routes.

Enabling OSPF PIC

1. Enter system view.
   system-view
2. Enter OSPF view.
   ospf [*process-id* | **router-id** *router-id*] *
3. Enable PIC for OSPF.
   pic [**additional-path-always**]
   By default, OSPF PIC is enabled.

Configuring BFD control packet mode for OSPF PIC

1. Enter system view.
   system-view
2. Enter interface view.

interface *interface-type interface-number*

3. Enable BFD control packet mode for OSPF PIC.
   ospf primary-path-detect bfd ctrl
   By default, BFD control packet mode is disabled for OSPF PIC.
   This mode requires BFD configuration on both OSPF routers on the link.

Configuring BFD echo packet mode for OSPF PIC

1. Enter system view.
   system-view
2. Configure the source IP address of BFD echo packets.
   bfd echo-source-ip *ip-address*
   By default, the source IP address of BFD echo packets is not configured.
   The source IP address cannot be on the same network segment as any local interfaces.
   For more information about this command, see *High Availability Command Reference*.
3. Enter interface view.
   interface *interface-type interface-number*
4. Enable BFD echo packet mode for OSPF PIC.
   ospf primary-path-detect bfd echo
   By default, BFD echo packet mode is disabled for OSPF PIC.
   This mode requires BFD configuration on one OSPF router on the link.

Configuring advanced OSPF features

Configuring stub routers

About stub routers

A stub router is used for traffic control. It reports its status as a stub router to neighboring OSPF routers. The neighboring routers can have a route to the stub router, but they do not use the stub router to forward data.

Router LSAs from the stub router might contain different link type values. A value of 3 means a link to a stub network, and the cost of the link will not be changed by default. To set the cost of the link to 65535, specify the **include-stub** keyword in the **stub-router** command. A value of 1, 2 or 4 means a point-to-point link, a link to a transit network, or a virtual link. On such links, a maximum cost value of 65535 is used. Neighbors do not send packets to the stub router as long as they have a route with a smaller cost.

Procedure

1. Enter system view.
   system-view
2. Enter OSPF view.
   ospf [*process-id* | **router-id** *router-id*] *
3. Configure the router as a stub router.
   stub-router [**external-lsa** [*max-metric-value*] | **include-stub** | **on-startup** *seconds* | **summary-lsa** [*max-metric-value*]] *
   By default, the router is not configured as a stub router.
   A stub router is not related to a stub area.

Enabling compatibility with RFC 1583

About compatibility with RFC 1583

RFC 1583 specifies a different method than RFC 2328 for selecting the optimal route to a destination in another AS. When multiple routes are available to the ASBR, OSPF selects the optimal route by using the following procedure:

1. Selects the route with the highest preference.
   - If RFC 2328 is compatible with RFC 1583, all these routes have equal preference.
   - If RFC 2328 is not compatible with RFC 1583, the intra-area route in a non-backbone area is preferred to reduce the burden of the backbone area. The inter-area route and intra-area route in the backbone area have equal preference.
2. Selects the route with the lower cost if two routes have equal preference.
3. Selects the route with the larger originating area ID if two routes have equal cost.

Restrictions and guidelines

To avoid routing loops, set identical RFC 1583-compatibility on all routers in a routing domain.

Procedure

1. Enter system view.

   system-view
2. Enter OSPF view.

   ospf [*process-id* | **router-id** *router-id*] *
3. Enable compatibility with RFC 1583.

   rfc1583 compatible

   By default, compatibility with RFC 1583 is enabled.

Configuring OSPF GR

About OSPF GR

GR ensures forwarding continuity when a routing protocol restarts or an active/standby switchover occurs.

Two routers are required to complete a GR process. The following are router roles in a GR process:

- **GR restarter**—Graceful restarting router. It must have GR capability.
- **GR helper**—A neighbor of the GR restarter. It helps the GR restarter to complete the GR process.

OSPF GR has the following types:

- **IETF GR**—Uses Opaque LSAs to implement GR.
- **Non-IETF GR**—Uses link local signaling (LLS) to advertise GR capability and uses out of band synchronization to synchronize the LSDB.

A device can act as a GR restarter and GR helper at the same time.

Restrictions and guidelines for OSPF GR

You cannot enable OSPF NSR on a device that acts as GR restarter.

Configuring OSPF GR restarter

Configuring the IETF OSPF GR restarter

1. Enter system view.
   system-view
2. Enable OSPF and enter its view.
   ospf [*process-id* | **router-id** *router-id*] *
3. Enable opaque LSA reception and advertisement capability.
   opaque-capability enable
   By default, opaque LSA reception and advertisement capability is enabled.
4. Enable the IETF GR.
   graceful-restart ietf [**global** | **planned-only**] *
   By default, the IETF GR capability is disabled.
5. (Optional.) Set the GR interval.
   graceful-restart interval *interval*
   By default, the GR interval is 120 seconds.

Configuring the non-IETF OSPF GR restarter

1. Enter system view.
   system-view
2. Enable OSPF and enter its view.
   ospf [*process-id* | **router-id** *router-id*] *
3. Enable the link-local signaling capability.
   enable link-local-signaling
   By default, the link-local signaling capability is disabled.
4. Enable the out-of-band re-synchronization capability.
   enable out-of-band-resynchronization
   By default, the out-of-band re-synchronization capability is disabled.
5. Enable non-IETF GR.
   graceful-restart [**nonstandard**] [**global** | **planned-only**] *
   By default, non-IETF GR capability is disabled.
6. (Optional.) Set the GR interval.
   graceful-restart interval *interval*
   By default, the GR interval is 120 seconds.

Configuring OSPF GR helper

Configuring the IETF OSPF GR helper

1. Enter system view.
   system-view
2. Enable OSPF and enter its view.
   ospf [*process-id* | **router-id** *router-id*] *
3. Enable opaque LSA reception and advertisement capability.
   opaque-capability enable

By default, opaque LSA reception and advertisement capability is enabled.

4. Enable GR helper capability.

   graceful-restart helper enable [**planned-only**]

   By default, GR helper capability is enabled.

5. (Optional.) Enable strict LSA checking for the GR helper.

   graceful-restart helper strict-lsa-checking

   By default, strict LSA checking for the GR helper is disabled.

   When an LSA change on the GR helper is detected, the GR helper device exits the GR helper mode.

Configuring the non-IETF OSPF GR helper

1. Enter system view.

   system-view

2. Enable OSPF and enter its view.

   ospf [*process-id* | **router-id** *router-id*] *

3. Enable the link-local signaling capability.

   enable link-local-signaling

   By default, the link-local signaling capability is disabled.

4. Enable the out-of-band re-synchronization capability.

   enable out-of-band-resynchronization

   By default, the out-of-band re-synchronization capability is disabled.

5. Enable GR helper.

   graceful-restart helper enable

   By default, GR helper is enabled.

6. (Optional.) Enable strict LSA checking for the GR helper.

   graceful-restart helper strict-lsa-checking

   By default, strict LSA checking for the GR helper is disabled.

   When an LSA change on the GR helper is detected, the GR helper device exits the GR helper mode.

Triggering OSPF GR

About triggering OSPF GR

You can trigger OSPF GR by performing an active/standby switchover or using the **reset ospf process** command.

Procedure

To trigger OSPF GR, execute the **reset ospf** [*process-id*] **process graceful-restart** command in user view.

Configuring OSPF NSR

About OSPF NSR

Nonstop routing (NSR) backs up OSPF link state information from the active process to the standby process. After an active/standby switchover, NSR can complete link state recovery and route regeneration without tearing down adjacencies or impacting forwarding services.

NSR does not require the cooperation of neighboring devices to recover routing information, and it is typically used more often than GR.

Restrictions and guidelines

A device that has OSPF NSR enabled cannot act as GR restarter.

Procedure

1. Enter system view.
   system-view
2. Enter OSPF view.
   ospf [*process-id* | **router-id** *router-id*] *
3. Enable OSPF NSR.
   non-stop-routing
   By default, OSPF NSR is disabled.
   This command takes effect only for the current process. As a best practice, enable OSPF NSR for each process if multiple OSPF processes exist.

Configuring BFD for OSPF

About BFD for OSPF

BFD provides a single mechanism to quickly detect and monitor the connectivity of links between OSPF neighbors, which improves the network convergence speed. For more information about BFD, see *High Availability Configuration Guide*.

OSPF supports the following BFD detection modes:

- **Bidirectional control detection**—Requires BFD configuration to be made on both OSPF routers on the link.
- **Single-hop echo detection**—Requires BFD configuration to be made on one OSPF router on the link.

Configuring bidirectional control detection

1. Enter system view.
   system-view
2. Enter interface view.
   interface *interface-type interface-number*
3. Enable BFD bidirectional control detection.
   ospf bfd enable
   By default, BFD bidirectional control detection is disabled.
   Both ends of a BFD session must be on the same network segment and in the same area.

Configuring single-hop echo detection

1. Enter system view.
   system-view
2. Configure the source address of echo packets.
   bfd echo-source-ip *ip-address*

By default, the source address of echo packets is not configured.

The source IP address cannot be on the same network segment as any local interfaces.

For more information about this command, see *High Availability Command Reference*.

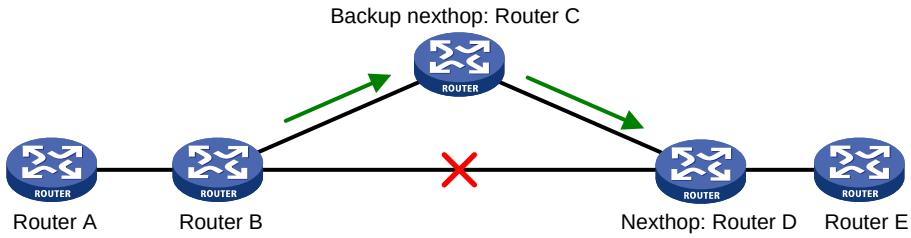
3. Enter interface view.
   `interface` *`interface-type interface-number`*
4. Enable BFD single-hop echo detection.
   `ospf bfd enable echo`
   By default, BFD single-hop echo detection is disabled.

Configuring OSPF FRR

About OSPF FRR

A link or router failure on a path can cause packet loss until OSPF completes routing convergence based on the new network topology. FRR enables fast rerouting to minimize the impact of link or node failures.

Figure 7 Network diagram for OSPF FRR



As shown in Figure 7, configure FRR on Router B by using a routing policy to specify a backup next hop. When the primary link fails, OSPF directs packets to the backup next hop. At the same time, OSPF calculates the shortest path based on the new network topology. It forwards packets over the path after network convergence.

You can configure OSPF FRR to calculate a backup next hop by using the loop free alternate (LFA) algorithm, or specify a backup next hop by using a routing policy.

Restrictions and guidelines for OSPF FRR

When both OSPF PIC and OSPF FRR are configured, OSPF FRR takes effect.

Configuring OSPF FRR to use the LFA algorithm to calculate a backup next hop

Restrictions and guidelines

Do not use the **`fast-reroute lfa`** command together with the **`vlink-peer`** command.

Procedure

1. Enter system view.
   `system-view`
2. Enter interface view.
   `interface` *`interface-type interface-number`*

3. (Optional.) Enable LFA on an interface.
   ospf fast-reroute lfa-backup
   By default, the interface is enabled with LFA and it can be selected as a backup interface.
4. Return to system view.
   quit
5. Enter OSPF view.
   ospf [*process-id* | **router-id** *router-id*] *
6. Enable OSPF FRR to use the LFA algorithm to calculate a backup next hop.
   fast-reroute lfa [**abr-only**]
   By default, OSPF FRR is disabled.
   If **abr-only** is specified, the route to the ABR is selected as the backup path.

Configuring OSPF FRR to use a backup next hop specified in a routing policy

About specifying a backup next hop in a routing policy

Before you perform this task, use the **apply fast-reroute backup-interface** command to specify a backup next hop in a routing policy for OSPF FRR. For more information about the **apply fast-reroute backup-interface** command and routing policy configuration, see "Configuring routing policies."

Procedure

1. Enter system view.
   system-view
2. Enter OSPF view.
   ospf [*process-id* | **router-id** *router-id*] *
3. Enable OSPF FRR to use a backup next hop specified in a routing policy.
   fast-reroute route-policy *route-policy-name*
   By default, OSPF FRR is disabled.

Configuring BFD control packet mode for OSPF FRR

About BFD control packet mode for OSPF FRR

By default, OSPF FRR does not use BFD to detect primary link failures. To speed up OSPF convergence, enable BFD control packet mode for OSPF FRR to detect primary link failures. This mode requires BFD configuration on both OSPF routers on the link.

Procedure

1. Enter system view.
   system-view
2. Enter interface view.
   interface *interface-type interface-number*
3. Enable BFD control packet mode for OSPF FRR.
   ospf primary-path-detect bfd ctrl
   By default, BFD control packet mode is disabled for OSPF FRR.

Configuring BFD echo packet mode for OSPF FRR

About BFD echo packet mode for OSPF FRR

By default, OSPF FRR does not use BFD to detect primary link failures. To speed up OSPF convergence, enable BFD echo packet mode for OSPF FRR to detect primary link failures. This mode requires BFD configuration on one OSPF router on the link.

Procedure

1. Enter system view.
   system-view
2. Configure the source IP address of BFD echo packets.
   bfd echo-source-ip *ip-address*
   By default, the source IP address of BFD echo packets is not configured.
   The source IP address cannot be on the same network segment as any local interface's IP address.
   For more information about this command, see *High Availability Command Reference*.
3. Enter interface view.
   interface *interface-type interface-number*
4. Enable BFD echo packet mode for OSPF FRR.
   ospf primary-path-detect bfd echo
   By default, BFD echo packet mode is disabled for OSPF FRR.

Configuring OSPF authentication

About OSPF area and interface authentication

Perform this task to configure OSPF area and interface authentication.

OSPF adds the configured key into sent packets, and uses the key to authenticate received packets. Only packets that pass the authentication can be received. If a packet fails the authentication, the OSPF neighbor relationship cannot be established.

If you configure OSPF authentication for both an area and an interface in that area, the interface uses the OSPF authentication configured on it.

Restrictions and guidelines for configuring OSPF authentication

OSPF supports the MD5 and HMAC-MD5 authentication algorithms.

The ID of keys used for authentication can only be in the range of 0 to 255.

Configuring OSPF area authentication

1. Enter system view.
   system-view
2. Enter OSPF view.
   ospf [*process-id* | **router-id** *router-id*] *
3. Enter area view.

area *area-id*

4. Configure area authentication mode.
   - Configure HMAC-MD5/MD5 authentication.
     authentication-mode { **hmac-md5** | **md5** } *key-id* { **cipher** | **plain** } *string*
   - Configure simple authentication.
     authentication-mode simple { **cipher** | **plain** } *string*

   By default, no authentication is configured.

   You must configure the same authentication mode and key on all the routers in an area.

Configuring OSPF interface authentication

1. Enter system view.
   system-view
2. Enter interface view.
   interface *interface-type interface-number*
3. Configure interface authentication mode.
   - Configure simple authentication.
     ospf authentication-mode simple { **cipher** | **plain** } *string*
   - Configure HMAC-MD5/MD5 authentication.
     ospf authentication-mode { **hmac-md5** | **md5** } *key-id* { **cipher** | **plain** } *string*

   By default, no authentication is configured.

   You must configure the same authentication mode and key on both the local interface and its peer interface.

Configuring GTSM for OSPF

About GTSM

The Generalized TTL Security Mechanism (GTSM) protects the device by comparing the TTL value in the IP header of incoming OSPF packets against a valid TTL range. If the TTL value is within the valid TTL range, the packet is accepted. If not, the packet is discarded.

The valid TTL range is from 255 – the configured hop count + 1 to 255.

When GTSM is configured, the OSPF packets sent by the device have a TTL of 255.

GTSM checks OSPF packets from common neighbors and virtual link neighbors. It does not check OSPF packets from sham link neighbors. For information about GTSM for OSPF sham links, see *MPLS Configuration Guide*.

You can configure GTSM in OSPF area view or interface view.

- The configuration in OSPF area view applies to all OSPF interfaces in the area.
- The configuration in interface view takes precedence over OSPF area view.

Restrictions and guidelines for GTSM

To use GTSM, you must configure GTSM on both the local and peer devices. You can specify different *hop-count* values for them.

Configuring GTSM in OSPF area view

Restrictions and guidelines

GTSM in OSPF area view applies to all OSPF interfaces in the area. GTSM checks OSPF packets from common neighbors and virtual link neighbors.

Procedure

1. Enter system view.
   system-view
2. Enter OSPF view.
   ospf [*process-id* | **router-id** *router-id*] *
3. Enter OSPF area view.
   area *area-id*
4. Enable GTSM for the OSPF area.
   ttl-security [**hops** *hop-count*]
   By default, GTSM is disabled for the OSPF area.

Configuring GTSM in interface view

Restrictions and guidelines

GTSM in interface view applies only to the current interface. GTSM checks OSPF packets from common neighbors and virtual link neighbors.

Procedure

1. Enter system view.
   system-view
2. Enter interface view.
   interface *interface-type interface-number*
3. Enable GTSM for the interface.
   ospf ttl-security [**hops** *hop-count* | **disable**]
   By default, GTSM is disabled for the interface.

Configuring OSPF logging and SNMP notifications

Logging neighbor state changes

About logging neighbor state changes

Perform this task to enable output of neighbor state change logs to the information center. The information center processes the logs according to user-defined output rules (whether and where to output logs). For more information about the information center, see *Network Management and Monitoring Configuration Guide*.

Procedure

1. Enter system view.
   system-view

2. Enter OSPF view.

   ospf [*process-id* | **router-id** *router-id*] *

3. Enable the logging of neighbor state changes.

   log-peer-change

   By default, this feature of logging neighbor state changes is enabled.

Configuring the OSPF logging feature

About OSPF logs

OSPF logs include hello packet logs, route calculation logs, neighbor logs, OSPF route logs, and self-originated and received LSA logs.

Procedure

1. Enter system view.

   system-view

2. Enter OSPF view.

   ospf [*process-id* | **router-id** *router-id*] *

3. Set the number of OSPF logs.

   event-log { **hello** { **received** [**abnormal** | **dropped**] | **sent** [**abnormal** | **failed**] } | **lsa-flush** | **peer** | **spf** } **size** *count*

   By default, the device can generate a maximum of 100 OSPF logs for each type.

Configuring OSPF network management

About OSPF network management

This task involves the following configurations:

- Bind an OSPF process to MIB so that you can use network management software to manage the specified OSPF process.
- Enable SNMP notifications for OSPF to report important events.
- Configure the SNMP notification output interval and the maximum number of SNMP notifications that can be output at each interval.

To report critical OSPF events to an NMS, enable SNMP notifications for OSPF. For SNMP notifications to be sent correctly, you must also configure SNMP on the device. For more information about SNMP configuration, see the network management and monitoring configuration guide for the device.

Procedure

1. Enter system view.

   system-view

2. Bind MIB to an OSPF process.

   ospf mib-binding *process-id*

   By default, MIB is bound to the process with the smallest process ID.

3. Enable SNMP notifications for OSPF.

   snmp-agent trap enable ospf [**authentication-failure** | **bad-packet** | **config-error** | **grhelper-status-change** | **grrestarter-status-change** | **if-state-change** | **lsa-maxage** | **lsa-originate** | **lsdb-approaching-overflow** | **lsdb-overflow** | **neighbor-state-change** | **nssatranslator-status-change** | **retransmit** |

virt-authentication-failure | **virt-bad-packet** | **virt-config-error** | **virt-retransmit** | **virtgrhelper-status-change** | **virtif-state-change** | **virtneighbor-state-change**] *

By default, SNMP notifications for OSPF are enabled.

4. Enter OSPF view.

   ospf [*process-id* | **router-id** *router-id*] *

5. Configure the SNMP notification output interval and the maximum number of SNMP notifications that can be output at each interval.

   snmp trap rate-limit interval *trap-interval* **count** *trap-number*

   By default, OSPF outputs a maximum of seven SNMP notifications within 10 seconds.

Setting the maximum number of OSPF neighbor relationship troubleshooting entries

About this task

Perform this task to set the maximum number of neighbor relationship troubleshooting entries that OSPF can record.

Software version and feature compatibility

This feature is supported only in Release 6342 and later.

Procedure

1. Enter system view.

   system-view

2. Set the maximum number of neighbor relationship troubleshooting entries that OSPF can record.

   ospf troubleshooting max-number *number*

   By default, OSPF can record a maximum of 100 neighbor relationship troubleshooting entries.

Display and maintenance commands for OSPF

Execute **display** commands in any view and **reset** commands in user view.

Task	Command
Display OSPF log information about received or sent hello packets.	**display ospf** [*process-id*] **event-log hello** { **received** [**abnormal**	**dropped**]	**sent** } [*neighbor-id*] **display ospf** [*process-id*] **event-log hello sent** { **abnormal**	**failed** } [*neighbor-address*]
Display summary route information on the OSPF ABR.	**display ospf** [*process-id*] [**area** *area-id*] **abr-summary** [*ip-address* { *mask-length*	*mask* }] [**verbose**]
Display OSPF FRR backup next hop information.	**display ospf** [*process-id*] [**area** *area-id*] **fast-reroute lfa-candidate**
Display OSPF topology information.	**display ospf** [*process-id*] [**area** *area-id*] **spf-tree** [**verbose**]
Display OSPF process information.	**display ospf** [*process-id*] [**verbose**]

Task	Command
Display OSPF ABR and ASBR information.	**display ospf** [*process-id*] **abr-asbr** [**verbose**]
Display OSPF ASBR route summarization information.	**display ospf** [*process-id*] **asbr-summary** [*ip-address* { *mask-length* | *mask* }]
Display OSPF log information.	**display ospf** [*process-id*] **event-log** { **lsa-flush** | **peer** | **spf** }
Display OSPF GR information.	**display ospf** [*process-id*] **graceful-restart** [**verbose**]
Display OSPF interface information.	**display ospf** [*process-id*] **interface** [*interface-type interface-number* | **verbose**]
Display information about hello packets sent by OSPF interfaces.	**display ospf** [*process-id*] **interface** [*interface-type interface-number*] **hello**
Display OSPF LSDB information.	**display ospf** [*process-id*] [**area** *area-id*] **lsdb** { **asbr** | **network** | **nssa** | **opaque-area** | **opaque-link** | **router** | **summary** } [*link-state-id*] [**originate-router** *advertising-router-id* | **self-originate**] **display ospf** [*process-id*] **lsdb** [**brief** | **originate-router** *advertising-router-id* | **self-originate**] **display ospf** [*process-id*] **lsdb** { **ase** | **opaque-as ase** } [*link-state-id*] [**originate-router** *advertising-router-id* | **self-originate**]
Display OSPF next hop information.	**display ospf** [*process-id*] **nexthop**
Display OSPF NSR information.	**display ospf** [*process-id*] **non-stop-routing status**
Display OSPF neighbor information.	**display ospf** [*process-id*] **peer** [**hello** | **verbose**] [*interface-type interface-number*] [*neighbor-id*]
Display neighbor statistics for OSPF areas.	**display ospf** [*process-id*] **peer statistics**
Display OSPF request queue information.	**display ospf** [*process-id*] **request-queue** [*interface-type interface-number*] [*neighbor-id*]
Display OSPF retransmission queue information.	**display ospf** [*process-id*] **retrans-queue** [*interface-type interface-number*] [*neighbor-id*]
Display OSPF routing table information.	**display ospf** [*process-id*] **routing** [*ip-address* { *mask-length* | *mask* }] [**interface** *interface-type interface-number*] [**nexthop** *nexthop-address*] [**verbose**]
Display OSPF statistics.	**display ospf** [*process-id*] **statistics** [**error** | **packet hello** | [*interface-type interface-number*]]

Task	Command
Display OSPF neighbor relationship troubleshooting information.	**display ospf troubleshooting**
Display OSPF virtual link information.	**display ospf** [*process-id*] **vlink**
Display the global route ID.	**display router id**
Clear OSPF log information.	**reset ospf** [*process-id*] **event-log** [**lsa-flush** | **peer** | **spf**]
Clear OSPF log information about received or sent hello packets.	**reset ospf** [*process-id*] **event-log hello** { **received** [**abnormal** | **dropped**] | **sent** [**abnormal** | **failed**] }
Restart an OSPF process.	**reset ospf** [*process-id*] **process** [**graceful-restart**]
Re-enable OSPF route redistribution.	**reset ospf** [*process-id*] **redistribution**
Clear OSPF statistics.	**reset ospf** [*process-id*] **statistics**
Clear OSPF neighbor relationship troubleshooting information.	**reset ospf troubleshooting**

OSPF configuration examples

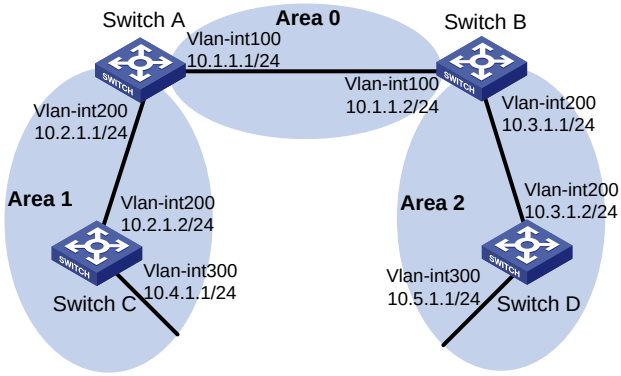
Example: Configuring basic OSPF

Network configuration

As shown in Figure 8:

- Enable OSPF on all switches, and split the AS into three areas.
- Configure Switch A and Switch B as ABRs.

Figure 8 Network diagram



Procedure

1. Configure IP addresses for interfaces. (Details not shown.)
2. Enable OSPF:

   # Configure Switch A.

```
<SwitchA> system-view
[SwitchA] router id 10.2.1.1
[SwitchA] ospf
[SwitchA-ospf-1] area 0
[SwitchA-ospf-1-area-0.0.0.0] network 10.1.1.0 0.0.0.255
[SwitchA-ospf-1-area-0.0.0.0] quit
[SwitchA-ospf-1] area 1
[SwitchA-ospf-1-area-0.0.0.1] network 10.2.1.0 0.0.0.255
[SwitchA-ospf-1-area-0.0.0.1] quit
[SwitchA-ospf-1] quit
```

Configure Switch B.

```
<SwitchB> system-view
[SwitchB] router id 10.3.1.1
[SwitchB] ospf
[SwitchB-ospf-1] area 0
[SwitchB-ospf-1-area-0.0.0.0] network 10.1.1.0 0.0.0.255
[SwitchB-ospf-1-area-0.0.0.0] quit
[SwitchB-ospf-1] area 2
[SwitchB-ospf-1-area-0.0.0.2] network 10.3.1.0 0.0.0.255
[SwitchB-ospf-1-area-0.0.0.2] quit
[SwitchB-ospf-1] quit
```

Configure Switch C.

```
<SwitchC> system-view
[SwitchC] router id 10.4.1.1
[SwitchC] ospf
[SwitchC-ospf-1] area 1
[SwitchC-ospf-1-area-0.0.0.1] network 10.2.1.0 0.0.0.255
[SwitchC-ospf-1-area-0.0.0.1] network 10.4.1.0 0.0.0.255
[SwitchC-ospf-1-area-0.0.0.1] quit
[SwitchC-ospf-1] quit
```

Configure Switch D.

```
<SwitchD> system-view
[SwitchD] router id 10.5.1.1
[SwitchD] ospf
[SwitchD-ospf-1] area 2
[SwitchD-ospf-1-area-0.0.0.2] network 10.3.1.0 0.0.0.255
[SwitchD-ospf-1-area-0.0.0.2] network 10.5.1.0 0.0.0.255
[SwitchD-ospf-1-area-0.0.0.2] quit
[SwitchD-ospf-1] quit
```

Verifying the configuration

Display information about neighbors on Switch A.

```
[SwitchA] display ospf peer verbose

          OSPF Process 1 with Router ID 10.2.1.1
                  Neighbors

 Area 0.0.0.0 interface 10.1.1.1(Vlan-interface100)'s neighbors
 Router ID: 10.3.1.1         Address: 10.1.1.2         GR State: Normal
```

```
  State: Full  Mode: Nbr is master  Priority: 1
  DR: 10.1.1.1  BDR: 10.1.1.2  MTU: 0
  Options is 0x02 (-|-|-|-|-|-|E|-)
  Dead timer due in 37  sec
  Neighbor is up for 06:03:59
  Authentication Sequence: [ 0 ]
  Neighbor state change count: 5
  BFD status: Disabled

 Area 0.0.0.1 interface 10.2.1.1(Vlan-interface200)'s neighbors
 Router ID: 10.4.1.1         Address: 10.2.1.2         GR State: Normal
  State: Full  Mode: Nbr is master  Priority: 1
  DR: 10.2.1.1  BDR: 10.2.1.2  MTU: 0
  Options is 0x02 (-|-|-|-|-|-|E|-)
  Dead timer due in 32  sec
  Neighbor is up for 06:03:12
  Authentication Sequence: [ 0 ]
  Neighbor state change count: 5
  BFD status: Disabled
```

Display OSPF routing information on Switch A.

```
[SwitchA] display ospf routing

          OSPF Process 1 with Router ID 10.2.1.1
                  Routing Table

                Topology base (MTID 0)

 Routing for network
 Destination        Cost     Type    NextHop         AdvRouter       Area
 10.2.1.0/24        1        Transit 10.2.1.1        10.2.1.1        0.0.0.1
 10.3.1.0/24        2        Inter   10.1.1.2        10.3.1.1        0.0.0.0
 10.4.1.0/24        2        Stub    10.2.1.2        10.4.1.1        0.0.0.1
 10.5.1.0/24        3        Inter   10.1.1.2        10.3.1.1        0.0.0.0
 10.1.1.0/24        1        Transit 10.1.1.1        10.2.1.1        0.0.0.0

 Total nets: 5
 Intra area: 3  Inter area: 2  ASE: 0  NSSA: 0
```

Display OSPF routing information on Switch D.

```
[SwitchD] display ospf routing

          OSPF Process 1 with Router ID 10.5.1.1
                  Routing Table

                Topology base (MTID 0)

 Routing for network
 Destination        Cost     Type    NextHop         AdvRouter       Area
 10.2.1.0/24        3        Inter   10.3.1.1        10.3.1.1        0.0.0.2
```

```
10.3.1.0/24        1        Transit 10.3.1.2        10.3.1.1        0.0.0.2
10.4.1.0/24        4        Inter   10.3.1.1        10.3.1.1        0.0.0.2
10.5.1.0/24        1        Stub    10.5.1.1        10.5.1.1        0.0.0.2
10.1.1.0/24        2        Inter   10.3.1.1        10.3.1.1        0.0.0.2

Total nets: 5
Intra area: 2  Inter area: 3  ASE: 0  NSSA: 0
```

On Switch D, ping the IP address 10.4.1.1 to test reachability.

```
[SwitchD] ping 10.4.1.1
Ping 10.4.1.1 (10.4.1.1): 56 data bytes, press CTRL_C to break
56 bytes from 10.4.1.1: icmp_seq=0 ttl=253 time=1.549 ms
56 bytes from 10.4.1.1: icmp_seq=1 ttl=253 time=1.539 ms
56 bytes from 10.4.1.1: icmp_seq=2 ttl=253 time=0.779 ms
56 bytes from 10.4.1.1: icmp_seq=3 ttl=253 time=1.702 ms
56 bytes from 10.4.1.1: icmp_seq=4 ttl=253 time=1.471 ms

--- Ping statistics for 10.4.1.1 ---
5 packet(s) transmitted, 5 packet(s) received, 0.0% packet loss
round-trip min/avg/max/std-dev = 0.779/1.408/1.702/0.323 ms
```

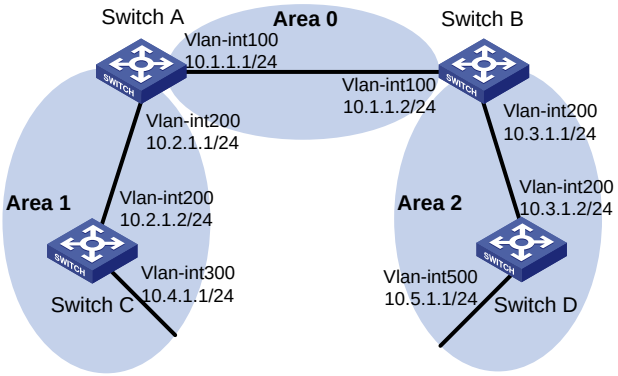
Example: Configuring OSPF route redistribution

Network configuration

As shown in Figure 9:

- Enable OSPF on all the switches.
- Split the AS into three areas.
- Configure Switch A and Switch B as ABRs.
- Configure Switch C as an ASBR to redistribute external routes (static routes).

Figure 9 Network diagram



Procedure

1. Configure IP addresses for interfaces. (Details not shown.)
2. Enable OSPF (see "Example: Configuring basic OSPF").
3. Configure OSPF to redistribute routes:

   # On Switch C, configure a static route destined for network 3.1.2.0/24.

   ```
   <SwitchC> system-view
   ```

```
[SwitchC] ip route-static 3.1.2.1 24 10.4.1.2
```

On Switch C, configure OSPF to redistribute static routes.

```
[SwitchC] ospf 1
[SwitchC-ospf-1] import-route static
```

Verifying the configuration

Display the ABR/ASBR information on Switch D.

```
<SwitchD> display ospf abr-asbr

          OSPF Process 1 with Router ID 10.5.1.1
                  Routing Table to ABR and ASBR


                Topology base (MTID 0)
 Type        Destination     Area            Cost  Nexthop         RtType
 Intra       10.3.1.1        0.0.0.2         10    10.3.1.1        ABR
 Inter       10.4.1.1        0.0.0.2         22    10.3.1.1        ASBR
```

Display the OSPF routing table on Switch D.

```
<SwitchD> display ospf routing

          OSPF Process 1 with Router ID 10.5.1.1
                   Routing Table

                Topology base (MTID 0)

 Routing for network
 Destination        Cost     Type    NextHop         AdvRouter       Area
 10.2.1.0/24        22       Inter   10.3.1.1        10.3.1.1        0.0.0.2
 10.3.1.0/24        10       Transit 10.3.1.2        10.3.1.1        0.0.0.2
 10.4.1.0/24        25       Inter   10.3.1.1        10.3.1.1        0.0.0.2
 10.5.1.0/24        10       Stub    10.5.1.1        10.5.1.1        0.0.0.2
 10.1.1.0/24        12       Inter   10.3.1.1        10.3.1.1        0.0.0.2

 Routing for ASEs
 Destination        Cost     Type    Tag         NextHop         AdvRouter
 3.1.2.0/24         1        Type2   1           10.3.1.1        10.4.1.1

 Total nets: 6
 Intra area: 2  Inter area: 3  ASE: 1  NSSA: 0
```

Example: Configuring OSPF route summarization on an ASBR

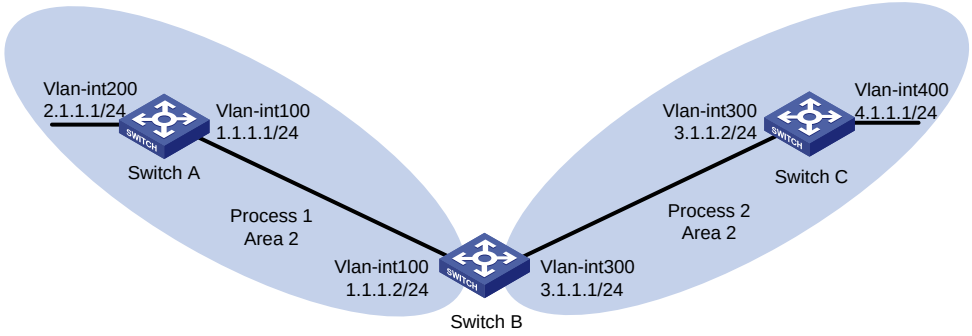
Network configuration

As shown in Figure 10:

- Configure OSPF on Switch A, Switch B, and Switch C in Area 2.

- Enable OSPF process 1 and process 2 on Switch B. Switch B uses OSPF process 1 to exchange routing information with Switch A, and uses OSPF process 2 to exchange routing information with Switch C.
- Assign IP addresses 2.1.2.1/24, 2.1.3.1/24, and 2.1.4.1/24 to VLAN-interface 200 of Switch A. To enable Switch C to learn routes destined for 2.1.2.0/24, 2.1.3.0/24, 2.1.4.0/24, configure OSPF process 2 on Switch B to redistribute routes from process 1 and direct routes.
- To minimize the size of the routing table on Switch C, configure ASBR route summarization on Switch B. Switch B advertises only the summary route 2.0.0.0/8.

Figure 10 Network diagram



Procedure

1. Configure IP addresses for interfaces. (Details not shown.)
2. Configure OSPF:

   # Enable OSPF process 1 on Switch A.

```
<SwitchA> system-view
[SwitchA] router id 11.2.1.1
[SwitchA] interface vlan-interface 200
[SwitchA-Vlan-interface200] ip address 2.1.2.1 24
[SwitchA-Vlan-interface200] ip address 2.1.3.1 24 sub
[SwitchA-Vlan-interface200] ip address 2.1.4.1 24 sub
[SwitchA-Vlan-interface200] quit
[SwitchA] ospf 1
[SwitchA-ospf-1] area 2
[SwitchA-ospf-1-area-0.0.0.2] network 1.1.1.0 0.0.0.255
[SwitchA-ospf-1-area-0.0.0.2] network 2.1.0.0 0.0.255.255
[SwitchA-ospf-1-area-0.0.0.2] quit
[SwitchA-ospf-1] quit
```

   # Enable OSPF process 1 and process 2 on Switch B.

```
<SwitchB> system-view
[SwitchB] router id 11.2.1.2
[SwitchB] ospf 1
[SwitchB-ospf-1] area 2
[SwitchB-ospf-1-area-0.0.0.2] network 1.1.1.0 0.0.0.255
[SwitchB-ospf-1-area-0.0.0.2] quit
[SwitchB-ospf-1] quit
[SwitchB] ospf 2
[SwitchB-ospf-2] area 2
[SwitchB-ospf-2-area-0.0.0.2] network 3.1.1.0 0.0.0.255
```

```
[SwitchB-ospf-2-area-0.0.0.2] quit
[SwitchB-ospf-2] quit
```

Enable OSPF process 2 on Switch C.

```
<SwitchC> system-view
[SwitchC] router id 11.1.1.2
[SwitchC] ospf 2
[SwitchC-ospf-2] area 2
[SwitchC-ospf-2-area-0.0.0.2] network 3.1.1.0 0.0.0.255
[SwitchC-ospf-2-area-0.0.0.2] network 4.1.0.0 0.0.255.255
[SwitchC-ospf-2-area-0.0.0.2] quit
[SwitchC-ospf-2] quit
```

3. Configure OSPF to redistribute routes:

Configure OSPF process 2 on Switch B to redistribute routes from OSPF process 1 and direct routes.

```
[SwitchB] ospf 2
[SwitchB-ospf-2]import-route direct
[SwitchB-ospf-2]import-route ospf 1
```

Display routing table information on Switch C.

```
[SwitchC] display ip routing-table

Destinations : 28       Routes : 28

Destination/Mask    Proto   Pre Cost        NextHop         Interface
0.0.0.0/32          Direct  0   0           127.0.0.1       InLoop0
1.1.1.0/24          O_ASE2  150 1           3.1.1.1         Vlan300
2.1.2.0/24          O_ASE2  150 1           3.1.1.1         Vlan300
2.1.3.0/24          O_ASE2  150 1           3.1.1.1         Vlan300
2.1.4.0/24          O_ASE2  150 1           3.1.1.1         Vlan300
3.1.1.0/24          Direct  0   0           3.1.1.2         Vlan300
3.1.1.0/32          Direct  0   0           3.1.1.2         Vlan300
3.1.1.2/32          Direct  0   0           127.0.0.1       InLoop0
3.1.1.255/32        Direct  0   0           3.1.1.2         Vlan300
4.1.1.0/24          Direct  0   0           4.1.1.1         Loop101
4.1.1.0/32          Direct  0   0           4.1.1.1         Loop101
4.1.1.1/32          Direct  0   0           127.0.0.1       InLoop0
4.1.1.255/32        Direct  0   0           4.1.1.1         Loop101
4.1.2.0/24          Direct  0   0           4.1.2.1         Loop102
4.1.2.0/32          Direct  0   0           4.1.2.1         Loop102
4.1.2.1/32          Direct  0   0           127.0.0.1       InLoop0
4.1.2.255/32        Direct  0   0           4.1.2.1         Loop102
4.1.3.0/24          Direct  0   0           4.1.3.1         Loop103
4.1.3.0/32          Direct  0   0           4.1.3.1         Loop103
4.1.3.1/32          Direct  0   0           127.0.0.1       InLoop0
4.1.3.255/32        Direct  0   0           4.1.3.1         Loop103
127.0.0.0/8         Direct  0   0           127.0.0.1       InLoop0
127.0.0.0/32        Direct  0   0           127.0.0.1       InLoop0
127.0.0.1/32        Direct  0   0           127.0.0.1       InLoop0
127.255.255.255/32  Direct  0   0           127.0.0.1       InLoop0
```

```
224.0.0.0/4        Direct  0   0           0.0.0.0         NULL0
224.0.0.0/24       Direct  0   0           0.0.0.0         NULL0
255.255.255.255/32 Direct  0   0           127.0.0.1       InLoop0
```

4. Configure OSPF to summarize routes on the ASBR:

Configure OSPF process 2 on Switch B to advertise summary route 2.0.0.0/8.

```
[SwitchB] ospf 2
[SwitchB-ospf-2] asbr-summary 2.0.0.0 8
[SwitchB-ospf-2] quit
```

Display routing table information on Switch C.

```
[SwitchC]display ip routing-table

Destinations : 26       Routes : 26

Destination/Mask   Proto   Pre Cost        NextHop         Interface
0.0.0.0/32         Direct  0   0           127.0.0.1       InLoop0
1.1.1.0/24         O ASE2  150 1           3.1.1.1         Vlan300
2.0.0.0/8          O_ASE2  150 1           3.1.1.1         Vlan300
3.1.1.0/24         Direct  0   0           3.1.1.2         Vlan300
3.1.1.0/32         Direct  0   0           3.1.1.2         Vlan300
3.1.1.2/32         Direct  0   0           127.0.0.1       InLoop0
3.1.1.255/32       Direct  0   0           3.1.1.2         Vlan300
4.1.1.0/24         Direct  0   0           4.1.1.1         Loop101
4.1.1.0/32         Direct  0   0           4.1.1.1         Loop101
4.1.1.1/32         Direct  0   0           127.0.0.1       InLoop0
4.1.1.255/32       Direct  0   0           4.1.1.1         Loop101
4.1.2.0/24         Direct  0   0           4.1.2.1         Loop102
4.1.2.0/32         Direct  0   0           4.1.2.1         Loop102
4.1.2.1/32         Direct  0   0           127.0.0.1       InLoop0
4.1.2.255/32       Direct  0   0           4.1.2.1         Loop102
4.1.3.0/24         Direct  0   0           4.1.3.1         Loop103
4.1.3.0/32         Direct  0   0           4.1.3.1         Loop103
4.1.3.1/32         Direct  0   0           127.0.0.1       InLoop0
4.1.3.255/32       Direct  0   0           4.1.3.1         Loop103
127.0.0.0/8        Direct  0   0           127.0.0.1       InLoop0
127.0.0.0/32       Direct  0   0           127.0.0.1       InLoop0
127.0.0.1/32       Direct  0   0           127.0.0.1       InLoop0
127.255.255.255/32 Direct  0   0           127.0.0.1       InLoop0
224.0.0.0/4        Direct  0   0           0.0.0.0         NULL0
224.0.0.0/24       Direct  0   0           0.0.0.0         NULL0
255.255.255.255/32 Direct  0   0           127.0.0.1       InLoop0
```

Example: Configuring OSPF stub area

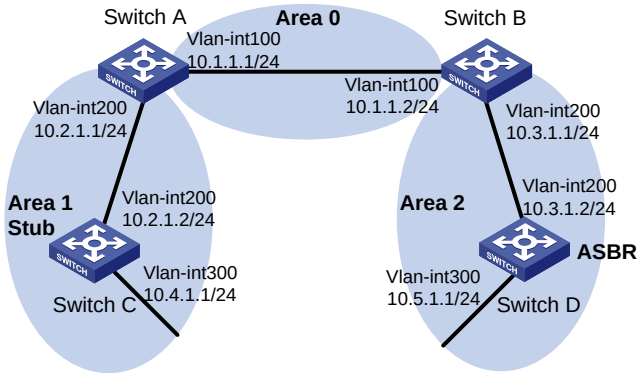
Network configuration

As shown in Figure 11:

- Enable OSPF on all switches, and split the AS into three areas.
- Configure Switch A and Switch B as ABRs to forward routing information between areas.

- Configure Switch D as the ASBR to redistribute static routes.
- Configure Area 1 as a stub area to reduce advertised LSAs without influencing reachability.

Figure 11 Network diagram



Procedure

1. Configure IP addresses for interfaces. (Details not shown.)
2. Enable OSPF (see "Example: Configuring basic OSPF").
3. Configure route redistribution:

   # Configure Switch D to redistribute static routes.

```
<SwitchD> system-view
[SwitchD] ip route-static 3.1.2.1 24 10.5.1.2
[SwitchD] ospf
[SwitchD-ospf-1] import-route static
[SwitchD-ospf-1] quit
```

   # Display ABR/ASBR information on Switch C.

```
<SwitchC> display ospf abr-asbr

          OSPF Process 1 with Router ID 10.4.1.1
                  Routing Table to ABR and ASBR

                Topology base (MTID 0)
 Type        Destination     Area            Cost  Nexthop         RtType
 Intra       10.2.1.1        0.0.0.1         3     10.2.1.1        ABR
 Inter       10.5.1.1        0.0.0.1         7     10.2.1.1        ASBR
```

   # Display OSPF routing table on Switch C.

```
<SwitchC> display ospf routing

          OSPF Process 1 with Router ID 10.4.1.1
                  Routing Table

                Topology base (MTID 0)

 Routing for network
 Destination        Cost     Type    NextHop         AdvRouter       Area
 10.2.1.0/24        3        Transit 0.0.0.0         10.2.1.1        0.0.0.1
 10.3.1.0/24        7        Inter   10.2.1.1        10.2.1.1        0.0.0.1
```

```
10.4.1.0/24        3        Stub    10.4.1.1        10.4.1.1        0.0.0.1
10.5.1.0/24        17       Inter   10.2.1.1        10.2.1.1        0.0.0.1
10.1.1.0/24        5        Inter   10.2.1.1        10.2.1.1        0.0.0.1

Routing for ASEs
Destination        Cost     Type    Tag         NextHop         AdvRouter
3.1.2.0/24         1        Type2   1           10.2.1.1        10.5.1.1

Total nets: 6
Intra area: 2  Inter area: 3  ASE: 1  NSSA: 0
```

The output shows that Switch C's routing table contains an AS external route.

4. Configure Area 1 as a stub area:

Configure Switch A.

```
<SwitchA> system-view
[SwitchA] ospf
[SwitchA-ospf-1] area 1
[SwitchA-ospf-1-area-0.0.0.1] stub
[SwitchA-ospf-1-area-0.0.0.1] quit
[SwitchA-ospf-1] quit
```

Configure Switch C.

```
<SwitchC> system-view
[SwitchC] ospf
[SwitchC-ospf-1] area 1
[SwitchC-ospf-1-area-0.0.0.1] stub
[SwitchC-ospf-1-area-0.0.0.1] quit
[SwitchC-ospf-1] quit
```

Display OSPF routing information on Switch C

```
[SwitchC] display ospf routing

          OSPF Process 1 with Router ID 10.4.1.1
                  Routing Table

                Topology base (MTID 0)

Routing for network
Destination        Cost     Type    NextHop         AdvRouter       Area
0.0.0.0/0          4        Inter   10.2.1.1        10.2.1.1        0.0.0.1
10.2.1.0/24        3        Transit 0.0.0.0         10.2.1.1        0.0.0.1
10.3.1.0/24        7        Inter   10.2.1.1        10.2.1.1        0.0.0.1
10.4.1.0/24        3        Stub    10.4.1.1        10.4.1.1        0.0.0.1
10.5.1.0/24        17       Inter   10.2.1.1        10.2.1.1        0.0.0.1
10.1.1.0/24        5        Inter   10.2.1.1        10.2.1.1        0.0.0.1

Total nets: 6
Intra area: 2  Inter area: 4  ASE: 0  NSSA: 0
```

The output shows that a default route replaces the AS external route.

Configure Area 1 as a totally stub area.

```
[SwitchA] ospf
```

```
[SwitchA-ospf-1] area 1
[SwitchA-ospf-1-area-0.0.0.1] stub no-summary
[SwitchA-ospf-1-area-0.0.0.1] quit
[SwitchA-ospf-1] quit
```

Display OSPF routing information on Switch C.

```
[SwitchC] display ospf routing

          OSPF Process 1 with Router ID 10.4.1.1
                  Routing Table

                Topology base (MTID 0)

 Routing for network
 Destination        Cost     Type    NextHop         AdvRouter       Area
 0.0.0.0/0          4        Inter   10.2.1.1        10.2.1.1        0.0.0.1
 10.2.1.0/24        3        Transit 0.0.0.0         10.4.1.1        0.0.0.1
 10.4.1.0/24        3        Stub    10.4.1.1        10.4.1.1        0.0.0.1

 Total nets: 3
 Intra area: 2  Inter area: 1  ASE: 0  NSSA: 0
```

The output shows that inter-area routes are removed, and only one external route (a default route) exists on Switch C.

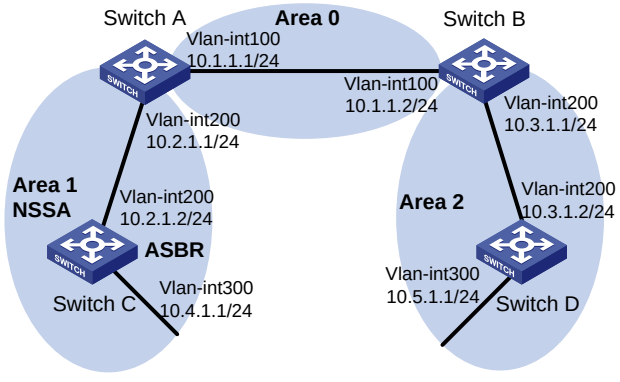
Example: Configuring OSPF NSSA area

Network configuration

As shown in Figure 12:

- Configure OSPF on all switches and split AS into three areas.
- Configure Switch A and Switch B as ABRs to forward routing information between areas.
- Configure Area 1 as an NSSA area and configure Switch C as an ASBR to redistribute static routes into the AS.

Figure 12 Network diagram



Procedure

1. Configure IP addresses for interfaces.
2. Enable OSPF (see "Example: Configuring basic OSPF").

3. Configure Area 1 as an NSSA area:

Configure Switch A.

```
<SwitchA> system-view
[SwitchA] ospf
[SwitchA-ospf-1] area 1
[SwitchA-ospf-1-area-0.0.0.1] nssa
[SwitchA-ospf-1-area-0.0.0.1] quit
[SwitchA-ospf-1] quit
```

Configure Switch C.

```
<SwitchC> system-view
[SwitchC] ospf
[SwitchC-ospf-1] area 1
[SwitchC-ospf-1-area-0.0.0.1] nssa
[SwitchC-ospf-1-area-0.0.0.1] quit
[SwitchC-ospf-1] quit
```

Display OSPF routing information on Switch C.

```
[SwitchC] display ospf routing

          OSPF Process 1 with Router ID 10.4.1.1
                  Routing Table

                Topology base (MTID 0)

 Routing for network
 Destination        Cost     Type    NextHop         AdvRouter       Area
 10.2.1.0/24        3        Transit 10.2.1.2        10.4.1.1        0.0.0.1
 10.3.1.0/24        7        Inter   10.2.1.1        10.2.1.1        0.0.0.1
 10.4.1.0/24        3        Stub    10.4.1.1        10.4.1.1        0.0.0.1
 10.5.1.0/24        17       Inter   10.2.1.1        10.2.1.1        0.0.0.1
 10.1.1.0/24        5        Inter   10.2.1.1        10.2.1.1        0.0.0.1

 Total nets: 5
 Intra area: 2  Inter area: 3  ASE: 0  NSSA: 0
```

4. Configure route redistribution:

Configure Switch C to redistribute static routes.

```
[SwitchC] ip route-static 3.1.3.1 24 10.4.1.2
[SwitchC] ospf
[SwitchC-ospf-1] import-route static
[SwitchC-ospf-1] quit
```

Display OSPF routing information on Switch D.

```
<SwitchD> display ospf routing

          OSPF Process 1 with Router ID 10.5.1.1
                  Routing Table

                Topology base (MTID 0)

 Routing for network
```

```
Destination        Cost     Type    NextHop         AdvRouter       Area
10.2.1.0/24        22       Inter   10.3.1.1        10.3.1.1        0.0.0.2
10.3.1.0/24        10       Transit 10.3.1.2        10.3.1.1        0.0.0.2
10.4.1.0/24        25       Inter   10.3.1.1        10.3.1.1        0.0.0.2
10.5.1.0/24        10       Stub    10.5.1.1        10.5.1.1        0.0.0.2
10.1.1.0/24        12       Inter   10.3.1.1        10.3.1.1        0.0.0.2

Routing for ASEs
Destination        Cost     Type    Tag         NextHop         AdvRouter
3.1.3.0/24         1        Type2   1           10.3.1.1        10.2.1.1

Total nets: 6
Intra area: 2  Inter area: 3  ASE: 1  NSSA: 0
```

The output shows that an external route imported from the NSSA area exists on Switch D.

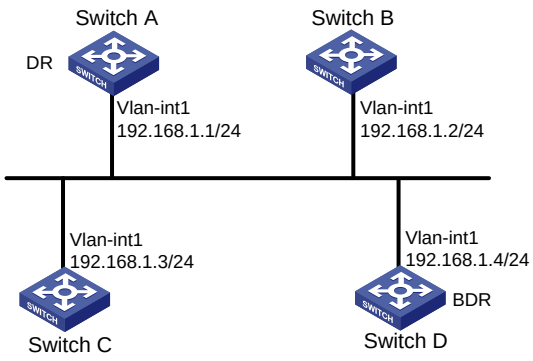
Example: Configuring OSPF DR election

Network configuration

As shown in Figure 13:

- Enable OSPF on Switches A, B, C, and D on the same network.
- Configure Switch D as the DR, and configure Switch C as the BDR.
- Change the router priorities on the interfaces to configure Switch A as the DR and Switch C as the BDR.

Figure 13 Network diagram



Procedure

1. Configure IP addresses for interfaces. (Details not shown.)
2. Configure basic OSPF settings on all switches. (Details not shown.)

   For more information, see "Example: Configuring basic OSPF."
3. Display OSPF neighbor information on Switch A.

```
[SwitchA] display ospf peer verbose

          OSPF Process 1 with Router ID 1.1.1.1
                  Neighbors

 Area 0.0.0.0 interface 192.168.1.1(Vlan-interface1)'s neighbors
 Router ID: 2.2.2.2          Address: 192.168.1.2      GR State: Normal
```

```
  State: 2-Way  Mode: None  Priority: 1
  DR: 192.168.1.4  BDR: 192.168.1.3  MTU: 0
  Options is 0x02 (-|-|-|-|-|-|E|-)
  Dead timer due in 38  sec
  Neighbor is up for 00:01:31
  Authentication Sequence: [ 0 ]
  Neighbor state change count: 6
  BFD status: Disabled

 Router ID: 3.3.3.3          Address: 192.168.1.3      GR State: Normal
  State: Full  Mode: Nbr is master  Priority: 1
  DR: 192.168.1.4  BDR: 192.168.1.3  MTU: 0
  Options is 0x02 (-|-|-|-|-|-|E|-)
  Dead timer due in 31  sec
  Neighbor is up for 00:01:28
  Authentication Sequence: [ 0 ]
  Neighbor state change count: 6
  BFD status: Disabled

 Router ID: 4.4.4.4          Address: 192.168.1.4      GR State: Normal
  State: Full  Mode: Nbr is master  Priority: 1
  DR: 192.168.1.4  BDR: 192.168.1.3  MTU: 0
  Options is 0x02 (-|-|-|-|-|-|E|-)
  Dead timer due in 31  sec
  Neighbor is up for 00:01:28
  Authentication Sequence: [ 0 ]
  Neighbor state change count: 6
  BFD status: Disabled
```

The output shows that Switch D is the DR and Switch C is the BDR.

4. Configure router priorities on interfaces:

Configure Switch A.

```
[SwitchA] interface vlan-interface 1
[SwitchA-Vlan-interface1] ospf dr-priority 100
[SwitchA-Vlan-interface1] quit
```

Configure Switch B.

```
[SwitchB] interface vlan-interface 1
[SwitchB-Vlan-interface1] ospf dr-priority 0
[SwitchB-Vlan-interface1] quit
```

Configure Switch C.

```
[SwitchC] interface vlan-interface 1
[SwitchC-Vlan-interface1] ospf dr-priority 2
[SwitchC-Vlan-interface1] quit
```

Display neighbor information on Switch D.

```
<SwitchD> display ospf peer verbose

          OSPF Process 1 with Router ID 4.4.4.4
                  Neighbors
```

```
 Area 0.0.0.0 interface 192.168.1.4(Vlan-interface1)'s neighbors
 Router ID: 1.1.1.1      Address: 192.168.1.1      GR State: Normal
   State: Full  Mode:Nbr is  slave  Priority: 100
   DR: 192.168.1.4  BDR: 192.168.1.3  MTU: 0
   Options is 0x02 (-|-|-|-|-|-|E|-)
   Dead timer due in 31  sec
   Neighbor is up for 00:11:17
   Authentication Sequence: [ 0 ]
   Neighbor state change count: 6
   BFD status: Disabled

 Router ID: 2.2.2.2      Address: 192.168.1.2      GR State: Normal
   State: Full  Mode:Nbr is  slave  Priority: 0
   DR: 192.168.1.4  BDR: 192.168.1.3  MTU: 0
   Options is 0x02 (-|-|-|-|-|-|E|-)
   Dead timer due in 35  sec
   Neighbor is up for 00:11:19
   Authentication Sequence: [ 0 ]
   Neighbor state change count: 6
   BFD status: Disabled

 Router ID: 3.3.3.3      Address: 192.168.1.3      GR State: Normal
   State: Full  Mode:Nbr is  slave  Priority: 2
   DR: 192.168.1.4  BDR: 192.168.1.3  MTU: 0
   Options is 0x02 (-|-|-|-|-|-|E|-)
   Dead timer due in 33  sec
   Neighbor is up for 00:11:15
   Authentication Sequence: [ 0 ]
   Neighbor state change count: 6
   BFD status: Disabled
```

The output shows that the DR and BDR are not changed, because the priority settings do not take effect immediately.

5. Restart OSPF processes:

Restart the OSPF process of Switch A.

```
<SwitchA> reset ospf 1 process
Reset OSPF process? [Y/N]:y
```

Restart the OSPF process of Switch B.

```
<SwitchB> reset ospf 1 process
Reset OSPF process? [Y/N]:y
```

Restart the OSPF process of Switch C.

```
<SwitchC> reset ospf 1 process
Reset OSPF process? [Y/N]:y
```

Restart the OSPF process of Switch D.

```
<SwitchD> reset ospf 1 process
Reset OSPF process? [Y/N]:y
```

Display neighbor information on Switch D.

```
<SwitchD> display ospf peer verbose
```

```
          OSPF Process 1 with Router ID 4.4.4.4
                  Neighbors

 Area 0.0.0.0 interface 192.168.1.4(Vlan-interface1)'s neighbors
 Router ID: 1.1.1.1          Address: 192.168.1.1      GR State: Normal
   State: Full  Mode: Nbr is slave  Priority: 100
   DR: 192.168.1.1  BDR: 192.168.1.3  MTU: 0
   Options is 0x02 (-|-|-|-|-|-|E|-)
   Dead timer due in 39  sec
   Neighbor is up for 00:01:40
   Authentication Sequence: [ 0 ]
   Neighbor state change count: 6
   BFD status: Disabled

 Router ID: 2.2.2.2          Address: 192.168.1.2      GR State: Normal
   State: 2-Way  Mode: None  Priority: 0
   DR: 192.168.1.1  BDR: 192.168.1.3  MTU: 0
   Options is 0x02 (-|-|-|-|-|-|E|-)
   Dead timer due in 35  sec
   Neighbor is up for 00:01:44
   Authentication Sequence: [ 0 ]
   Neighbor state change count: 6
   BFD status: Disabled

 Router ID: 3.3.3.3          Address: 192.168.1.3      GR State: Normal
   State: Full  Mode: Nbr is slave  Priority: 2
   DR: 192.168.1.1  BDR: 192.168.1.3  MTU: 0
   Options is 0x02 (-|-|-|-|-|-|E|-)
   Dead timer due in 39  sec
   Neighbor is up for 00:01:41
   Authentication Sequence: [ 0 ]
   Neighbor state change count: 6
   BFD status: Disabled
```

The output shows that Switch A becomes the DR and Switch C becomes the BDR.

If the neighbor state is *full,* Switch D has established an adjacency with the neighbor. If the neighbor state is *2-way*, the two switches are not the DR or the BDR, and they do not exchange LSAs.

Display OSPF interface information.

```
<SwitchA> display ospf interface

          OSPF Process 1 with Router ID 1.1.1.1
                  Interfaces

 Area: 0.0.0.0
 IP Address      Type      State   Cost  Pri   DR             BDR
 192.168.1.1     Broadcast DR      1     100   192.168.1.1    192.168.1.3

<SwitchB> display ospf interface
```

```
          OSPF Process 1 with Router ID 2.2.2.2
                  Interfaces

Area: 0.0.0.0
IP Address      Type       State     Cost  Pri   DR            BDR
192.168.1.2     Broadcast  DROther   1     0     192.168.1.1   192.168.1.3
```

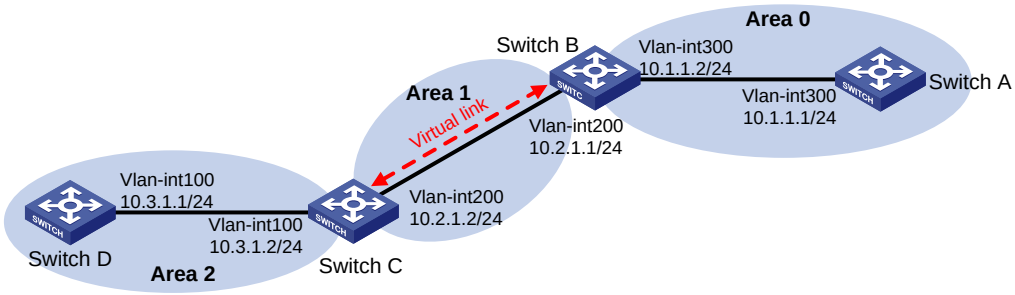
The interface state *DROther* means the interface is not the DR or BDR.

Example: Configuring OSPF virtual link

Network configuration

As shown in Figure 14, configure a virtual link between Switch B and Switch C to connect Area 2 to the backbone area. After configuration, Switch B can learn routes to Area 2.

Figure 14 Network diagram



Procedure

1. Configure IP addresses for interfaces. (Details not shown.)
2. Enable OSPF:

   # Configure Switch A.

```
<SwitchA> system-view
[SwitchA] ospf 1 router-id 1.1.1.1
[SwitchA-ospf-1] area 0
[SwitchA-ospf-1-area-0.0.0.0] network 10.1.1.0 0.0.0.255
[SwitchA-ospf-1-area-0.0.0.0] quit
[SwitchA-ospf-1] quit
```

   # Configure Switch B.

```
<SwitchB> system-view
[SwitchB] ospf 1 router-id 2.2.2.2
[SwitchB-ospf-1] area 0
[SwitchB-ospf-1-area-0.0.0.0] network 10.1.1.0 0.0.0.255
[SwitchB-ospf-1-area-0.0.0.0] quit
[SwitchB-ospf-1] area 1
[SwitchB–ospf-1-area-0.0.0.1] network 10.2.1.0 0.0.0.255
[SwitchB–ospf-1-area-0.0.0.1] quit
[SwitchB-ospf-1] quit
```

   # Configure Switch C.

```
<SwitchC> system-view
```

```
[SwitchC] ospf 1 router-id 3.3.3.3
[SwitchC-ospf-1] area 1
[SwitchC-ospf-1-area-0.0.0.1] network 10.2.1.0 0.0.0.255
[SwitchC-ospf-1-area-0.0.0.1] quit
[SwitchC-ospf-1] area 2
[SwitchC–ospf-1-area-0.0.0.2] network 10.3.1.0 0.0.0.255
[SwitchC–ospf-1-area-0.0.0.2] quit
[SwitchC-ospf-1] quit
```

Configure Switch D.

```
<SwitchD> system-view
[SwitchD] ospf 1 router-id 4.4.4.4
[SwitchD-ospf-1] area 2
[SwitchD-ospf-1-area-0.0.0.2] network 10.3.1.0 0.0.0.255
[SwitchD-ospf-1-area-0.0.0.2] quit
[SwitchD-ospf-1] quit
```

Display the OSPF routing table on Switch B.

```
[SwitchB] display ospf routing

          OSPF Process 1 with Router ID 2.2.2.2
                  Routing Table

                Topology base (MTID 0)

 Routing for network
 Destination        Cost     Type    NextHop         AdvRouter       Area
 10.2.1.0/24        2        Transit 10.2.1.1        3.3.3.3         0.0.0.1
 10.1.1.0/24        2        Transit 10.1.1.2        2.2.2.2         0.0.0.0
 Total nets: 2
 Intra area: 2  Inter area: 0  ASE: 0  NSSA: 0
```

The output shows that Switch B does not have routes to Area 2 because Area 0 is not directly connected to Area 2.

3. Configure a virtual link:

Configure Switch B.

```
[SwitchB] ospf
[SwitchB-ospf-1] area 1
[SwitchB-ospf-1-area-0.0.0.1] vlink-peer 3.3.3.3
[SwitchB-ospf-1-area-0.0.0.1] quit
[SwitchB-ospf-1] quit
```

Configure Switch C.

```
[SwitchC] ospf 1
[SwitchC-ospf-1] area 1
[SwitchC-ospf-1-area-0.0.0.1] vlink-peer 2.2.2.2
[SwitchC-ospf-1-area-0.0.0.1] quit
[SwitchC-ospf-1] quit
```

Display the OSPF routing table on Switch B.

```
[SwitchB] display ospf routing

          OSPF Process 1 with Router ID 2.2.2.2
```

```
                    Routing Table

                 Topology base (MTID 0)

 Routing for network
 Destination        Cost     Type    NextHop         AdvRouter       Area
 10.2.1.0/24        2        Transit 10.2.1.1        3.3.3.3         0.0.0.1
 10.3.1.0/24        5        Inter   10.2.1.2        3.3.3.3         0.0.0.0
 10.1.1.0/24        2        Transit 10.1.1.2        2.2.2.2         0.0.0.0

 Total nets: 3
 Intra area: 2  Inter area: 1  ASE: 0  NSSA: 0
```

The output shows that Switch B has learned the route 10.3.1.0/24 to Area 2.

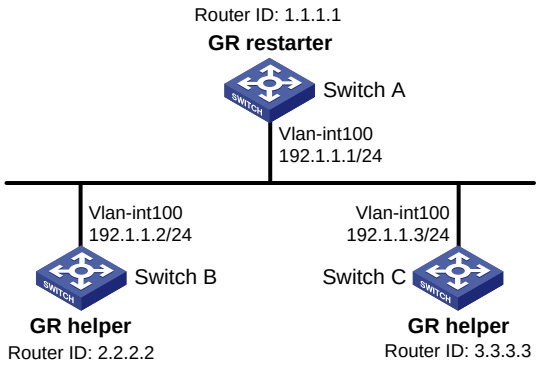
Example: Configuring OSPF GR

Network configuration

As shown in Figure 15:

- Switch A, Switch B, and Switch C that belong to the same AS and the same OSPF routing domain are GR capable.
- Switch A acts as the non-IETF GR restarter. Switch B and Switch C are the GR helpers, and synchronize their LSDBs with Switch A through OOB communication of GR.

Figure 15 Network diagram



Procedure

1. Configure IP addresses for interfaces. (Details not shown.)
2. Enable OSPF:

   # Configure Switch A.

```
SwitchA> system-view
[SwitchA] router id 1.1.1.1
[SwitchA] ospf 100
[SwitchA-ospf-100] area 0
[SwitchA-ospf-100-area-0.0.0.0] network 192.1.1.0 0.0.0.255
[SwitchA-ospf-100-area-0.0.0.0] quit
[SwitchA-ospf-1] quit
```

   # Configure Switch B.

```
<SwitchB> system-view
```

```
[SwitchB] router id 2.2.2.2
[SwitchB] ospf 100
[SwitchB-ospf-100] area 0
[SwitchB-ospf-100-area-0.0.0.0] network 192.1.1.0 0.0.0.255
[SwitchB-ospf-100-area-0.0.0.0] quit
[SwitchB-ospf-1] quit
```

Configure Switch C.

```
<SwitchC> system-view
[SwitchC] router id 3.3.3.3
[SwitchC] ospf 100
[SwitchC-ospf-100] area 0
[SwitchC-ospf-100-area-0.0.0.0] network 192.1.1.0 0.0.0.255
[SwitchC-ospf-100-area-0.0.0.0] quit
[SwitchC-ospf-1] quit
```

3. Configure OSPF GR:

Configure Switch A as the non-IETF OSPF GR restarter: enable the link-local signaling capability, the out-of-band re-synchronization capability, and non-IETF GR capability for OSPF process 100.

```
[SwitchA-ospf-100] enable link-local-signaling
[SwitchA-ospf-100] enable out-of-band-resynchronization
[SwitchA-ospf-100] graceful-restart
[SwitchA-ospf-100] quit
```

Configure Switch B as the GR helper: enable the link-local signaling capability and the out-of-band re-synchronization capability for OSPF process 100.

```
[SwitchB-ospf-100] enable link-local-signaling
[SwitchB-ospf-100] enable out-of-band-resynchronization
```

Configure Switch C as the GR helper: enable the link-local signaling capability and the out-of-band re-synchronization capability for OSPF process 100.

```
[SwitchC-ospf-100] enable link-local-signaling
[SwitchC-ospf-100] enable out-of-band-resynchronization
```

Verifying the configuration

Enable OSPF GR event debugging and restart the OSPF process by using GR on Switch A.

```
<SwitchA> debugging ospf event graceful-restart
<SwitchA> terminal monitor
<SwitchA> terminal logging level 7
<SwitchA> reset ospf 100 process graceful-restart
Reset OSPF process? [Y/N]:y
%Oct 21 15:29:28:727 2011 SwitchA OSPF/5/OSPF_NBR_CHG: OSPF 100 Neighbor
192.1.1.2(Vlan-interface100) from Full to Down.
%Oct 21 15:29:28:729 2011 SwitchA OSPF/5/OSPF_NBR_CHG: OSPF 100 Neighbor
192.1.1.3(Vlan-interface100) from Full to Down.
*Oct 21 15:29:28:735 2011 SwitchA OSPF/7/DEBUG:
OSPF 100 nonstandard GR Started for OSPF Router
*Oct 21 15:29:28:735 2011 SwitchA OSPF/7/DEBUG:
OSPF 100 created GR wait timer,timeout interval is 40(s).
*Oct 21 15:29:28:735 2011 SwitchA OSPF/7/DEBUG:
OSPF 100 created GR Interval timer,timeout interval is 120(s).
*Oct 21 15:29:28:758 2011 SwitchA OSPF/7/DEBUG:
```

```
OSPF 100 created OOB Progress timer for neighbor 192.1.1.3.
*Oct 21 15:29:28:766 2011 SwitchA OSPF/7/DEBUG:
OSPF 100 created OOB Progress timer for neighbor 192.1.1.2.
%Oct 21 15:29:29:902 2011 SwitchA OSPF/5/OSPF_NBR_CHG: OSPF 100 Neighbor
192.1.1.2(Vlan-interface100) from Loading to Full.
*Oct 21 15:29:29:902 2011 SwitchA OSPF/7/DEBUG:
OSPF 100 deleted OOB Progress timer for neighbor 192.1.1.2.
%Oct 21 15:29:30:897 2011 SwitchA OSPF/5/OSPF_NBR_CHG: OSPF 100 Neighbor
192.1.1.3(Vlan-interface100) from Loading to Full.
*Oct 21 15:29:30:897 2011 SwitchA OSPF/7/DEBUG:
OSPF 100 deleted OOB Progress timer for neighbor 192.1.1.3.
*Oct 21 15:29:30:911 2011 SwitchA OSPF/7/DEBUG:
OSPF GR: Process 100 Exit Restart,Reason : DR or BDR change,for neighbor : 192.1.1.3.
*Oct 21 15:29:30:911 2011 SwitchA OSPF/7/DEBUG:
OSPF 100 deleted GR Interval timer.
*Oct 21 15:29:30:912 2011 SwitchA OSPF/7/DEBUG:
OSPF 100 deleted GR wait timer.
%Oct 21 15:29:30:920 2011 SwitchA OSPF/5/OSPF_NBR_CHG: OSPF 100 Neighbor
192.1.1.2(Vlan-interface100) from Full to Down.
%Oct 21 15:29:30:921 2011 SwitchA OSPF/5/OSPF_NBR_CHG: OSPF 100 Neighbor
192.1.1.3(Vlan-interface100) from Full to Down.
%Oct 21 15:29:33:815 2011 SwitchA OSPF/5/OSPF_NBR_CHG: OSPF 100 Neighbor
192.1.1.3(Vlan-interface100) from Loading to Full.
%Oct 21 15:29:35:578 2011 SwitchA OSPF/5/OSPF_NBR_CHG: OSPF 100 Neighbor
192.1.1.2(Vlan-interface100) from Loading to Full.
```

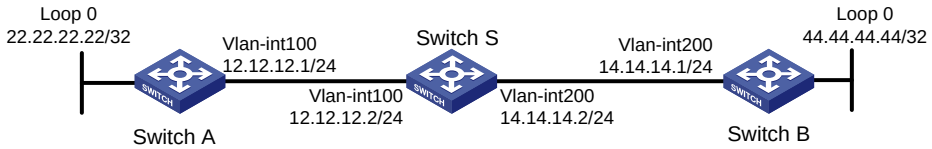
The output shows that Switch A completes GR.

Example: Configuring OSPF NSR

Network configuration

As shown in Figure 16, Switch S, Switch A, and Switch B belong to the same OSPF routing domain. Enable OSPF NSR on Switch S to ensure correct routing when an active/standby switchover occurs on Switch S.

Figure 16 Network diagram



Procedure

1. Configure IP addresses and subnet masks for interfaces on the switches. (Details not shown.)
2. Configure OSPF on the switches to ensure the following: (Details not shown.)
   - Switch S, Switch A, and Switch B can communicate with each other at Layer 3.
   - Dynamic route update can be implemented among them with OSPF.
3. Enable OSPF NSR on Switch S.

```
<SwitchS> system-view
[SwitchS] ospf 100
```

```
[SwitchS-ospf-100] non-stop-routing
[SwitchS-ospf-100] quit
```

Verifying the configuration

Perform an active/standby switchover on Switch S.

```
[SwitchS] placement reoptimize
Predicted changes to the placement
Program                          Current location       New location
-------------------------------------------------------------------
rib                              0/0                    0/0
staticroute                      0/0                    0/0
ospf                             0/0                    1/0
Continue? [y/n]:y
Re-optimization of the placement start. You will be notified on completion.
Re-optimization of the placement complete. Use 'display placement' to view the new
placement.
```

During the switchover period, display OSPF neighbors on Switch A to verify the neighbor relationship between Switch A and Switch S.

```
<SwitchA> display ospf peer

          OSPF Process 1 with Router ID 2.2.2.1
               Neighbor Brief Information

 Area: 0.0.0.0
 Router ID       Address         Pri Dead-Time  State             Interface
 3.3.3.1         12.12.12.2      1   37         Full/BDR          Vlan100
```

Display OSPF routes on Switch A to verify if Switch A has a route to the loopback interface on Switch B.

```
<SwitchA> display ospf routing

          OSPF Process 1 with Router ID 2.2.2.1
                    Routing Table

                Topology base (MTID 0)

 Routing for network
 Destination        Cost     Type    NextHop         AdvRouter       Area
 44.44.44.44/32     2        Stub    12.12.12.2      4.4.4.1         0.0.0.0
 14.14.14.0/24      2        Transit 12.12.12.2      4.4.4.1         0.0.0.0
 22.22.22.22/32     0        Stub    22.22.22.22     2.2.2.1         0.0.0.0
 12.12.12.0/24      1        Transit 12.12.12.1      2.2.2.1         0.0.0.0

 Total nets: 4
 Intra area: 4  Inter area: 0  ASE: 0  NSSA: 0
```

Display OSPF neighbors on Switch B to verify the neighbor relationship between Switch B and Switch S.

```
<SwitchB> display ospf peer

          OSPF Process 1 with Router ID 4.4.4.1
```

```
              Neighbor Brief Information

 Area: 0.0.0.0
 Router ID       Address         Pri Dead-Time  State             Interface
 3.3.3.1         14.14.14.2      1   39         Full/BDR          Vlan200
```

Display OSPF routes on Switch B to verify if Switch B has a route to the loopback interface on Switch A.

```
<SwitchB> display ospf routing

          OSPF Process 1 with Router ID 4.4.4.1
                   Routing Table

                Topology base (MTID 0)

 Routing for network
 Destination        Cost     Type    NextHop         AdvRouter       Area
 44.44.44.44/32     0        Stub    44.44.44.44     4.4.4.1         0.0.0.0
 14.14.14.0/24      1        Transit 14.14.14.1      4.4.4.1         0.0.0.0
 22.22.22.22/32     2        Stub    14.14.14.2      2.2.2.1         0.0.0.0
 12.12.12.0/24      2        Transit 14.14.14.2      2.2.2.1         0.0.0.0

 Total nets: 4
 Intra area: 4  Inter area: 0  ASE: 0  NSSA: 0
```

The output shows the following when an active/standby switchover occurs on Switch S:

- The neighbor relationships and routing information on Switch A and Switch B have not changed.
- The traffic from Switch A to Switch B has not been impacted.

Example: Configuring BFD for OSPF

Network configuration

As shown in Figure 17, run OSPF on Switch A, Switch B, and Switch C so that they are reachable to each other at the network layer.

- When the link over which Switch A and Switch B communicate through a Layer 2 switch fails, BFD can quickly detect the failure and notify OSPF of the failure.
- Switch A and Switch B then communicate through Switch C.

Figure 17 Network diagram

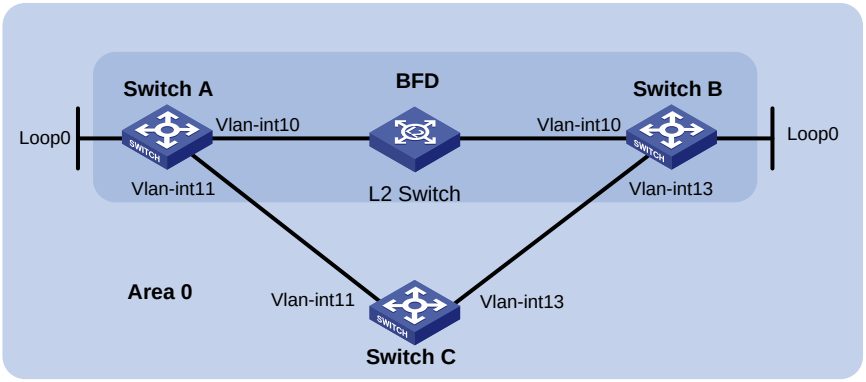


Table 1 Interface and IP address assignment

Device	Interface	IP address
Switch A	Vlan-int10	192.168.0.102/24
Switch A	Vlan-int11	10.1.1.102/24
Switch A	Loop0	121.1.1.1/32
Switch B	Vlan-int10	192.168.0.100/24
Switch B	Vlan-int13	13.1.1.1/24
Switch B	Loop0	120.1.1.1/32
Switch C	Vlan-int11	10.1.1.100/24
Switch C	Vlan-int13	13.1.1.2/24

Procedure

1. Configure IP addresses for interfaces. (Details not shown.)
2. Enable OSPF:

   # Configure Switch A.

```
<SwitchA> system-view
[SwitchA] ospf
[SwitchA-ospf-1] area 0
[SwitchA-ospf-1-area-0.0.0.0] network 192.168.0.0 0.0.0.255
[SwitchA-ospf-1-area-0.0.0.0] network 10.1.1.0 0.0.0.255
[SwitchA-ospf-1-area-0.0.0.0] network 121.1.1.1 0.0.0.0
[SwitchA-ospf-1-area-0.0.0.0] quit
[SwitchA-ospf-1] quit
```

   # Configure Switch B.

```
<SwitchB> system-view
[SwitchB] ospf
[SwitchB-ospf-1] area 0
[SwitchB-ospf-1-area-0.0.0.0] network 192.168.0.0 0.0.0.255
[SwitchB-ospf-1-area-0.0.0.0] network 13.1.1.0 0.0.0.255
[SwitchB-ospf-1-area-0.0.0.0] network 120.1.1.1 0.0.0.0
[SwitchB-ospf-1-area-0.0.0.0] quit
```

```
[SwitchB-ospf-1] quit
```

Configure Switch C.

```
<SwitchC> system-view
[SwitchC] ospf
[SwitchC-ospf-1] area 0
[SwitchC-ospf-1-area-0.0.0.0] network 10.1.1.0 0.0.0.255
[SwitchC-ospf-1-area-0.0.0.0] network 13.1.1.0 0.0.0.255
[SwitchC-ospf-1-area-0.0.0.0] quit
[SwitchC-ospf-1] quit
```

3. Configure BFD:

Enable BFD on Switch A and configure BFD parameters.

```
[SwitchA] bfd session init-mode active
[SwitchA] interface vlan-interface 10
[SwitchA-Vlan-interface10] ospf bfd enable
[SwitchA-Vlan-interface10] bfd min-transmit-interval 500
[SwitchA-Vlan-interface10] bfd min-receive-interval 500
[SwitchA-Vlan-interface10] bfd detect-multiplier 7
[SwitchA-Vlan-interface10] quit
```

Enable BFD on Switch B and configure BFD parameters.

```
[SwitchB] bfd session init-mode active
[SwitchB] interface vlan-interface 10
[SwitchB-Vlan-interface10] ospf bfd enable
[SwitchB-Vlan-interface10] bfd min-transmit-interval 500
[SwitchB-Vlan-interface10] bfd min-receive-interval 500
[SwitchB-Vlan-interface10] bfd detect-multiplier 6
[SwitchB-Vlan-interface10] quit
```

Verifying the configuration

Display the BFD information on Switch A.

```
<SwitchA> display bfd session

 Total Session Num: 1     Up Session Num: 1     Init Mode: Active

 IPv4 session working in control packet mode:

 LD/RD          SourceAddr      DestAddr        State    Holdtime    Interface
 3/1            192.168.0.102   192.168.0.100   Up       1700ms      Vlan10
```

Display routes destined for 120.1.1.1/32 on Switch A.

```
<SwitchA> display ip routing-table 120.1.1.1 verbose

Summary Count : 1

Destination: 120.1.1.1/32
   Protocol: O_INTRA
 Process ID: 1
  SubProtID: 0x1                  Age: 04h20m37s
       Cost: 1              Preference: 10
      IpPre: N/A             QosLocalID: N/A
```

```
        Tag: 0                   State: Active Adv
  OrigTblID: 0x0               OrigVrf: default-vrf
    TableID: 0x2                OrigAs: 0
      NibID: 0x26000002         LastAs: 0
     AttrID: 0xffffffff       Neighbor: 0.0.0.0
      Flags: 0x1008c       OrigNextHop: 192.168.0.100
      Label: NULL          RealNextHop: 192.168.0.100
    BkLabel: NULL            BkNextHop: N/A
    SRLabel: NULL             BkSRLabel: NULL
  Tunnel ID: Invalid         Interface: Vlan-interface10
BkTunnel ID: Invalid       BkInterface: N/A
   FtnIndex: 0x0           TrafficIndex: N/A
  Connector: N/A                 PathID: 0x0
```

The output shows that Switch A communicates with Switch B through VLAN-interface 10. Then the link over VLAN-interface 10 fails.

Display routes destined for 120.1.1.1/32 on Switch A.

```
<SwitchA> display ip routing-table 120.1.1.1 verbose

Summary Count : 1

Destination: 120.1.1.1/32
   Protocol: O_INTRA
 Process ID: 1
  SubProtID: 0x1                  Age: 04h20m37s
       Cost: 2              Preference: 10
      IpPre: N/A             QosLocalID: N/A
        Tag: 0                   State: Active Adv
  OrigTblID: 0x0               OrigVrf: default-vrf
    TableID: 0x2                OrigAs: 0
      NibID: 0x26000002         LastAs: 0
     AttrID: 0xffffffff       Neighbor: 0.0.0.0
      Flags: 0x1008c       OrigNextHop: 10.1.1.100
      Label: NULL          RealNextHop: 10.1.1.100
    BkLabel: NULL            BkNextHop: N/A
    SRLabel: NULL             BkSRLabel: NULL
  Tunnel ID: Invalid         Interface: Vlan-interface11
BkTunnel ID: Invalid       BkInterface: N/A
   FtnIndex: 0x0           TrafficIndex: N/A
  Connector: N/A                 PathID: 0x0
```

The output shows that Switch A communicates with Switch B through VLAN-interface 11.

Example: Configuring OSPF FRR

Network configuration

As shown in Figure 18, Switch A, Switch B, and Switch C reside in the same OSPF domain. Configure OSPF FRR so that when the link between Switch A and Switch B fails, traffic is immediately switched to Link B.

Figure 18 Network diagram

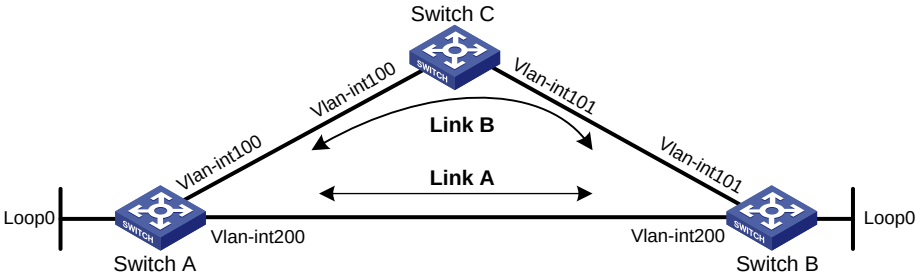


Table 2 Interface and IP address assignment

Device	Interface	IP address
Switch A	Vlan-int100	12.12.12.1/24
Switch A	Vlan-int200	13.13.13.1/24
Switch A	Loop0	1.1.1.1/32
Switch B	Vlan-int101	24.24.24.4/24
Switch B	Vlan-int200	13.13.13.2/24
Switch B	Loop0	4.4.4.4/32
Switch C	Vlan-int100	12.12.12.2/24
Switch C	Vlan-int101	24.24.24.2/24

Procedure

1. Configure IP addresses and subnet masks for interfaces on the switches. (Details not shown.)
2. Configure OSPF on the switches to ensure that Switch A, Switch B, and Switch C can communicate with each other at the network layer. (Details not shown.)
3. Configure OSPF FRR to automatically calculate the backup next hop:

   You can enable OSPF FRR to either calculate a backup next hop by using the LFA algorithm, or specify a backup next hop by using a routing policy.

   - (Method 1.) Enable OSPF FRR to calculate the backup next hop by using the LFA algorithm:

     # Configure Switch A.

     ```
     <SwitchA> system-view
     [SwitchA] ospf 1
     [SwitchA-ospf-1] fast-reroute lfa
     [SwitchA-ospf-1] quit
     ```

     # Configure Switch B.

     ```
     <SwitchB> system-view
     [SwitchB] ospf 1
     [SwitchB-ospf-1] fast-reroute lfa
     [SwitchB-ospf-1] quit
     ```

   - (Method 2.) Enable OSPF FRR to designate a backup next hop by using a routing policy.

     # Configure Switch A.

     ```
     <SwitchA> system-view
     [SwitchA] ip prefix-list abc index 10 permit 4.4.4.4 32
     [SwitchA] route-policy frr permit node 10
     [SwitchA-route-policy-frr-10] if-match ip address prefix-list abc
     ```

```
[SwitchA-route-policy-frr-10] apply fast-reroute backup-interface vlan-interface
100 backup-nexthop 12.12.12.2
[SwitchA-route-policy-frr-10] quit
[SwitchA] ospf 1
[SwitchA-ospf-1] fast-reroute route-policy frr
[SwitchA-ospf-1] quit
```

Configure Switch B.

```
<SwitchB> system-view
[SwitchB] ip prefix-list abc index 10 permit 1.1.1.1 32
[SwitchB] route-policy frr permit node 10
[SwitchB-route-policy-frr-10] if-match ip address prefix-list abc
[SwitchB-route-policy-frr-10] apply fast-reroute backup-interface vlan-interface
101 backup-nexthop 24.24.24.2
[SwitchB-route-policy-frr-10] quit
[SwitchB] ospf 1
[SwitchB-ospf-1] fast-reroute route-policy frr
[SwitchB-ospf-1] quit
```

Verifying the configuration

Display route 4.4.4.4/32 on Switch A to view the backup next hop information.

```
[SwitchA] display ip routing-table 4.4.4.4 verbose

Summary Count : 1

Destination: 4.4.4.4/32
   Protocol: O_INTRA
 Process ID: 1
  SubProtID: 0x1                  Age: 04h20m37s
       Cost: 1              Preference: 10
      IpPre: N/A            QosLocalID: N/A
        Tag: 0                   State: Active Adv
  OrigTblID: 0x0               OrigVrf: default-vrf
    TableID: 0x2                OrigAs: 0
      NibID: 0x26000002         LastAs: 0
     AttrID: 0xffffffff       Neighbor: 0.0.0.0
      Flags: 0x1008c        OrigNextHop: 13.13.13.2
      Label: NULL           RealNextHop: 13.13.13.2
    BkLabel: NULL             BkNextHop: 12.12.12.2
    SRLabel: NULL             BkSRLabel: NULL
  Tunnel ID: Invalid          Interface: Vlan-interface200
BkTunnel ID: Invalid        BkInterface: Vlan-interface100
   FtnIndex: 0x0           TrafficIndex: N/A
  Connector: N/A                 PathID: 0x0
```

Display route 1.1.1.1/32 on Switch B to view the backup next hop information.

```
[SwitchB] display ip routing-table 1.1.1.1 verbose

Summary Count : 1

Destination: 1.1.1.1/32
```

```
   Protocol: O_INTRA
 Process ID: 1
  SubProtID: 0x1                  Age: 04h20m37s
       Cost: 1              Preference: 10
      IpPre: N/A            QosLocalID: N/A
        Tag: 0                   State: Active Adv
  OrigTblID: 0x0               OrigVrf: default-vrf
    TableID: 0x2                OrigAs: 0
      NibID: 0x26000002         LastAs: 0
     AttrID: 0xffffffff       Neighbor: 0.0.0.0
      Flags: 0x1008c        OrigNextHop: 13.13.13.1
      Label: NULL           RealNextHop: 13.13.13.1
    BkLabel: NULL             BkNextHop: 24.24.24.2
    SRLabel: NULL             BkSRLabel: NULL
  Tunnel ID: Invalid          Interface: Vlan-interface200
BkTunnel ID: Invalid        BkInterface: Vlan-interface101
   FtnIndex: 0x0           TrafficIndex: N/A
  Connector: N/A                 PathID: 0x0
```

Troubleshooting OSPF configuration

No OSPF neighbor relationship established

Symptom

No OSPF neighbor relationship can be established.

Analysis

If the physical link and lower layer protocols work correctly, verify OSPF parameters configured on interfaces. Two neighbors must have the same parameters, such as the area ID, network segment, and mask. (A P2P or virtual link can have different network segments and masks.)

Solution

To resolve the problem:

1. Use the **`display ospf peer`** command to verify OSPF neighbor information.
2. Use the **`display ospf interface`** command to verify OSPF interface information.
3. Ping the neighbor router's IP address to verify that the connectivity is normal.
4. Verify OSPF timers. The dead interval on an interface must be a minimum of four times the hello interval.
5. On an NBMA network, use the **`peer ip-address`** command to manually specify the neighbor.
6. A minimum of one interface must have a router priority higher than 0 on an NBMA or a broadcast network.
7. If the problem persists, contact H3C Support.

Incorrect routing information

Symptom

OSPF cannot find routes to other areas.

Analysis

The backbone area must maintain connectivity to all other areas. If a router connects to more than one area, a minimum of one area must be connected to the backbone. The backbone cannot be configured as a stub area.

In a stub area, all routers cannot receive external routes, and all interfaces connected to the stub area must belong to the stub area.

Solution

To resolve the problem:

1. Use the **display ospf peer** command to verify neighbor information.
2. Use the **display ospf interface** command to verify OSPF interface information.
3. Use the **display ospf lsdb** command to verify the LSDB.
4. Use the **display current-configuration configuration ospf** command to verify area configuration. If more than two areas are configured, a minimum of one area is connected to the backbone.
5. In a stub area, all routers attached are configured with the **stub** command. In an NSSA area, all routers attached are configured with the **nssa** command.
6. If a virtual link is configured, use the **display ospf vlink** command to verify the state of the virtual link.
7. If the problem persists, contact H3C Support.

Contents

Configuring PBR

About PBR

Policy-based routing (PBR) uses user-defined policies to route packets. A policy can specify parameters for packets that match specific criteria such as ACLs. The parameters include the next hop.

Packet forwarding process

The device forwards received packets using the following process:

1. The device uses PBR to forward matching packets.
2. If one of the following events occurs, the device searches for a route (except the default route) in the routing table to forward packets:
   - The packets do not match the PBR policy.
   - The PBR-based forwarding fails.
3. If the forwarding fails, the device uses the default route to forward packets.

PBR types

PBR includes the following types:

- **Local PBR**—Guides the forwarding of locally generated packets, such as ICMP packets generated by using the **`ping`** command.
- **Interface PBR**—Guides the forwarding of packets received on an interface.

Policy

A policy includes match criteria and actions to be taken on the matching packets. A policy can have one or multiple nodes as follows:

- Each node is identified by a node number. A smaller node number has a higher priority.
- A node contains **`if-match`** and **`apply`** clauses. An **`if-match`** clause specifies a match criterion, and an **`apply`** clause specifies an action.
- A node has a match mode of **permit** or **deny**.

A policy compares packets with nodes in priority order. If a packet matches the criteria on a node, it is processed by the action on the node. If the packet does not match any criteria on the node, it goes to the next node for a match. If the packet does not match the criteria on any node, the device performs a routing table lookup.

Relationship between if-match clauses

PBR supports only the **`if-match acl`** clause to set an ACL match criterion. On a node, you can specify only one **`if-match`** clause.

Relationship between apply clauses

PBR supports only the **`apply next-hop`** clause to set next hops.

Relationship between the match mode and clauses on the node

Does a packet match all the if-match clauses on the node?	Match mode	
	Permit	**Deny**
Yes.	• If the node contains **`apply`** clauses, PBR executes the **`apply`** clauses on the node. ○ If PBR-based forwarding succeeds, PBR does not compare the packet with the next node. • If the node does not contain **`apply`** clauses, the device performs a routing table lookup for the packet.	The device performs a routing table lookup for the packet.
No.	PBR compares the packet with the next node.	PBR compares the packet with the next node.

NOTE:

A node that has no **`if-match`** clauses matches any packet.

PBR and Track

PBR can work with the Track feature to dynamically adapt the availability status of an **`apply`** clause to the link status of a tracked object. The tracked object can be a next hop.

- When the track entry associated with an object changes to **Negative**, the **`apply`** clause is invalid.
- When the track entry changes to **Positive** or **NotReady**, the **`apply`** clause is valid.

For more information about Track and PBR collaboration, see *High Availability Configuration Guide*.

Restrictions and guidelines: PBR configuration

If the device performs forwarding in software, PBR does not process IP packets destined for the local device.

If the device performs forwarding in hardware and a packet destined for it matches a PBR policy, PBR will execute the apply clauses in the policy, including the clause for forwarding. When you configure a PBR policy, be careful to avoid this situation.

PBR tasks at a glance

To configure PBR, perform the following tasks:

1. Configuring a policy
   a. Creating a node
   b. Setting match criteria for a node
   c. Configuring actions for a node
2. Specifying a policy for PBR

   Choose the following tasks as needed:

Configuring a policy

Creating a node

1. Enter system view.
   system-view
2. Create a node for a policy, and enter its view.
   policy-based-route *policy-name* [**deny** | **permit**] **node** *node-number*
3. (Optional.) Configure a description for the policy node.
   description *text*
   By default, no description is configured for a policy node.

Setting match criteria for a node

Procedure

1. Enter system view.
   system-view
2. Enter policy node view.
   policy-based-route *policy-name* [**deny** | **permit**] **node** *node-number*
3. Set match criteria.
   - Set an ACL match criterion.
     if-match acl { *acl-number* | **name** *acl-name* }
     By default, no ACL match criterion is set.
     The ACL match criterion cannot match Layer 2 information.
     When using the ACL to match packets, PBR ignores the action (**permit** or **deny**) and time range settings in the ACL.

Configuring actions for a node

About apply clauses

You can use the **apply next-hop** clause set next hops for matching packets on a node.

Restrictions and guidelines

If you specify a next hop or default next hop, PBR periodically performs a lookup in the FIB table to determine its availability. Temporary service interruption might occur if PBR does not update the route immediately after its availability status changes.

Configuring actions to direct packet forwarding

1. Enter system view.
   system-view
2. Enter policy node view.
   policy-based-route *policy-name* [**deny** | **permit**] **node** *node-number*
3. Configure actions.

- Set next hops.

  apply next-hop { *ip-address* [**direct**] [**track** *track-entry-number*] }&<1-2>

  By default, no next hop is specified.

  On a node, you can specify a maximum of two next hops for backup in one command line or by executing this command multiple times.

Specifying a policy for PBR

Specifying a policy for local PBR

About local PBR

Perform this task to specify a policy for local PBR to guide the forwarding of locally generated packets.

Restrictions and guidelines

You can specify only one policy for local PBR and must make sure the specified policy already exists. Before you apply a new policy, you must first remove the current policy.

Local PBR might affect local services such as ping and Telnet. When you use local PBR, make sure you fully understand its impact on local services of the device.

Procedure

1. Enter system view.

   system-view

2. Specify a policy for local PBR.

   ip local policy-based-route *policy-name*

   By default, local PBR is not enabled.

Specifying a policy for interface PBR

About interface PBR

Perform this task to apply a policy to an interface to guide the forwarding of packets received on the interface.

Restrictions and guidelines

You can apply only one policy to an interface and must make sure the specified policy already exists. Before you can apply a new interface PBR policy to an interface, you must first remove the current policy from the interface.

You can apply a policy to multiple interfaces.

Procedure

1. Enter system view.

   system-view

2. Enter interface view.

   interface *interface-type interface-number*

3. Specify a policy for interface PBR.

   ip policy-based-route *policy-name*

   By default, no interface policy is applied to an interface.

Display and maintenance commands for PBR

Execute **display** commands in any view and **reset** commands in user view.

Task	Command
Display PBR policy information.	**display ip policy-based-route** [**policy** *policy-name*]
Display interface PBR configuration and statistics.	**display ip policy-based-route interface** *interface-type interface-number* [**slot** *slot-number*]
Display local PBR configuration and statistics.	**display ip policy-based-route local** [**slot** *slot-number*]
Display PBR configuration.	**display ip policy-based-route setup**
Clear PBR statistics.	**reset ip policy-based-route statistics** [**policy** *policy-name*]

PBR configuration examples

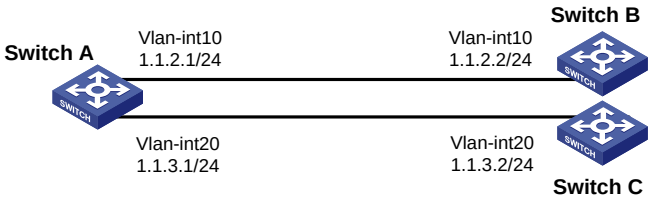
Example: Configuring packet type-based local PBR

Network configuration

As shown in Figure 1, Switch B and Switch C do not have a route to reach each other.

Configure PBR on Switch A to forward all TCP packets to the next hop 1.1.2.2 (Switch B).

Figure 1 Network diagram



Procedure

1. Configure Switch A:

   # Create VLAN 10 and VLAN 20.

```
<SwitchA> system-view
[SwitchA] vlan 10
[SwitchA-vlan10] quit
[SwitchA] vlan 20
[SwitchA-vlan20] quit
```

   # Configure the IP addresses of VLAN-interface 10 and VLAN-interface 20.

```
[SwitchA] interface vlan-interface 10
[SwitchA-Vlan-interface10] ip address 1.1.2.1 24
[SwitchA-Vlan-interface10] quit
[SwitchA] interface vlan-interface 20
[SwitchA-Vlan-interface20] ip address 1.1.3.1 24
[SwitchA-Vlan-interface20] quit
```

   # Configure ACL 3101 to match TCP packets.

```
[SwitchA] acl advanced 3101
[SwitchA-acl-ipv4-adv-3101] rule permit tcp
[SwitchA-acl-ipv4-adv-3101] quit
```

   # Configure Node 5 for the policy **aaa** to forward TCP packets to next hop 1.1.2.2.

```
[SwitchA] policy-based-route aaa permit node 5
[SwitchA-pbr-aaa-5] if-match acl 3101
[SwitchA-pbr-aaa-5] apply next-hop 1.1.2.2
[SwitchA-pbr-aaa-5] quit
```

   # Configure local PBR by applying the policy **aaa** to Switch A.

```
[SwitchA] ip local policy-based-route aaa
```

2. Configure Switch B:

   # Create VLAN 10.

```
<SwitchB> system-view
[SwitchB] vlan 10
[SwitchB-vlan10] quit
```

   # Configure the IP address of VLAN-interface 10.

```
[SwitchB] interface vlan-interface 10
[SwitchB-Vlan-interface10] ip address 1.1.2.2 24
```

3. Configure Switch C:

   # Create VLAN 20.

```
<SwitchC> system-view
[SwitchC] vlan 20
[SwitchC-vlan20] quit
```

   # Configure the IP address of VLAN-interface 20.

```
[SwitchC] interface vlan-interface 20
[SwitchC-Vlan-interface20] ip address 1.1.3.2 24
```

Verifying the configuration

1. Perform telnet operations to verify that local PBR on Switch A operates as configured to forward the matching TCP packets to the next hop 1.1.2.2 (Switch B), as follows:

   # Verify that you can telnet to Switch B from Switch A successfully. (Details not shown.)

Verify that you cannot telnet to Switch C from Switch A. (Details not shown.)

2. Verify that Switch A forwards packets other than TCP packets through VLAN-interface 20. For example, verify that you can ping Switch C from Switch A. (Details not shown.)

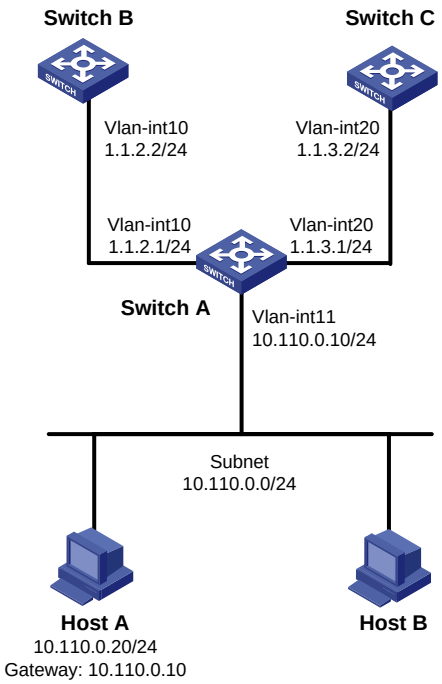
Example: Configuring packet type-based interface PBR

Network configuration

As shown in Figure 2, Switch B and Switch C do not have a route to reach each other.

Configure PBR on Switch A to forward all TCP packets received on VLAN-interface 11 to the next hop 1.1.2.2 (Switch B).

Figure 2 Network diagram



Procedure

1. Make sure Switch B and Switch C can reach Host A. (Details not shown.)
2. Configure Switch A:

   # Create VLAN 10 and VLAN 20.

```
<SwitchA> system-view
[SwitchA] vlan 10
[SwitchA-vlan10] quit
[SwitchA] vlan 20
[SwitchA-vlan20] quit
```

   # Configure the IP addresses of VLAN-interface 10 and VLAN-interface 20.

```
[SwitchA] interface vlan-interface 10
[SwitchA-Vlan-interface10] ip address 1.1.2.1 24
[SwitchA-Vlan-interface10] quit
[SwitchA] interface vlan-interface 20
[SwitchA-Vlan-interface20] ip address 1.1.3.1 24
[SwitchA-Vlan-interface20] quit
```

Configure ACL 3101 to match TCP packets.

```
[SwitchA] acl advanced 3101
[SwitchA-acl-ipv4-adv-3101] rule permit tcp
[SwitchA-acl-ipv4-adv-3101] quit
```

Configure Node 5 for the policy **aaa** to forward TCP packets to next hop 1.1.2.2.

```
[SwitchA] policy-based-route aaa permit node 5
[SwitchA-pbr-aaa-5] if-match acl 3101
[SwitchA-pbr-aaa-5] apply next-hop 1.1.2.2
[SwitchA-pbr-aaa-5] quit
```

Configure interface PBR by applying the policy **aaa** to VLAN-interface 11.

```
[SwitchA] interface vlan-interface 11
[SwitchA-Vlan-interface11] ip address 10.110.0.10 24
[SwitchA-Vlan-interface11] ip policy-based-route aaa
[SwitchA-Vlan-interface11] quit
```

Verifying the configuration

1. Perform telnet operations to verify that interface PBR on Switch A operates as configured to forward the matching TCP packets to the next hop 1.1.2.2 (Switch B), as follows:

   # Verify that you can telnet to Switch B from Host A successfully. (Details not shown.)

   # Verify that you cannot telnet to Switch C from Host A. (Details not shown.)
2. Verify that Switch A forwards packets other than TCP packets through VLAN-interface 20. For example, verify that you can ping Switch C from Host A. (Details not shown.)

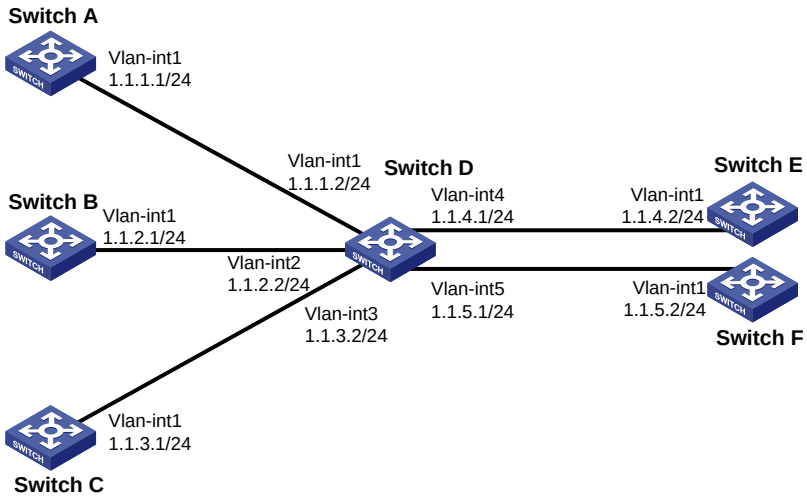
Example: Configuring packet type-based global PBR

Network configuration

As shown in Figure 3, Switch E and Switch F do not have a route to reach each other.

Configure global PBR on Switch D to forward TCP packets to the next hop 1.1.4.2 (Switch E).

Figure 3 Network diagram



Procedure

1. Configure IP addresses for the interfaces. Make sure Switch A, B and C can communicate with Switch E and Switch F, respectively. (Details not shown.)
2. Configure Switch D:

Configure ACL 3101 to match TCP packets sourced from networks 1.1.1.0/24, 1.1.2.0/24, and 1.1.3.0/24.

```
<SwitchD> system-view
[SwitchD] acl advanced 3101
[SwitchD-acl-ipv4-adv-3101] rule permit tcp source 1.1.1.0 0.0.0.255
[SwitchD-acl-ipv4-adv-3101] rule permit tcp source 1.1.2.0 0.0.0.255
[SwitchD-acl-ipv4-adv-3101] rule permit tcp source 1.1.3.0 0.0.0.255
[SwitchD-acl-ipv4-adv-3101] quit
```

Configure node 5 in PBR policy **aaa** to forward TCP packets that match ACL 3101 to next hop 1.1.4.2.

```
[SwitchD] policy-based-route aaa permit node 5
[SwitchD-pbr-aaa-5] if-match acl 3101
[SwitchD-pbr-aaa-5] apply next-hop 1.1.4.2
[SwitchD-pbr-aaa-5] quit
```

Specify PBR policy **aaa** as the global PBR policy.

```
[SwitchD] ip global policy-based-route aaa
```

Verifying the configuration

1. Perform telnet operations to verify that global PBR on Switch D operates as configured to forward the matching TCP packets to the next hop 1.1.4.2 (Switch E), as follows:

   # Verify that you can telnet to Switch E from Switch A, Switch B, and Switch C successfully. (Details not shown.)

   # Verify that you cannot telnet to Switch F from Switch A, Switch B, or Switch C. (Details not shown.)

2. Verify that Switch D forwards packets other than TCP packets as long as a route is available. For example, verify that you can ping Switch F from Switch A, Switch B, and Switch C. (Details not shown.)

Contents

Configuring IPv6 static routing

About IPv6 static routing

Static routes are manually configured and cannot adapt to network topology changes. If a fault or a topological change occurs in the network, the network administrator must modify the static routes manually. IPv6 static routing works well in a simple IPv6 network.

Configuring an IPv6 static route

1. Enter system view.

   system-view

2. Configure an IPv6 static route.

   ipv6 route-static *ipv6-address prefix-length* { *interface-type interface-number* [*next-hop-address*] | *next-hop-address* } [**permanent**] [**preference** *preference*] [**tag** *tag-value*] [**description** *text*]

   By default, no IPv6 static route is configured.

3. (Optional.) Set the default preference for IPv6 static routes.

   ipv6 route-static default-preference *default-preference*

   The default setting is 60.

Deleting IPv6 static routes

About deleting IPv6 static routes

To delete an IPv6 static route, use the **undo ipv6 route-static** command. To delete all IPv6 static routes including the default route, use the **delete ipv6 static-routes all** command.

Procedure

1. Enter system view.

   system-view

2. Delete all IPv6 static routes, including the default route.

   delete ipv6 static-routes all

CAUTION:

This command might interrupt network communication and cause packet forwarding failure. Before executing the command, make sure you fully understand the potential impact on the network.

Configuring BFD for IPv6 static routes

About BFD for IPv6 static routes

BFD provides a general purpose, standard, and medium- and protocol-independent fast failure detection mechanism. It can uniformly and quickly detect the failures of the bidirectional forwarding paths between two routers for protocols, such as routing protocols. BFD for IPv6 static routes tests

the reachability of the next hop for each IPv6 static route. If a next hop is unreachable, BFD deletes the associated IPv6 static route.

For more information about BFD, see *High Availability Configuration Guide*.

Restrictions and guidelines for BFD

When you configure BFD for IPv6 static routes, follow these restrictions and guidelines:

- If you specify a source IPv6 address for BFD packets on the local device, you must specify that IPv6 address as the next hop IPv6 address on the peer device.
- If you specify a non-P2P output interface and a direct next hop, specify the **bfd-source** *ipv6-address* option as a best practice. Make sure the source IPv6 address of BFD packets meets the following requirements:
  - The address is the same as the IPv6 address of the output interface.
  - The address is on the same network segment as the next hop IPv6 address of the same type.

    For example, if the next hop IPv6 address is a link-local address, the source IPv6 address of BFD packets must also be a link-local address.
- Enabling BFD for a flapping route could worsen the situation.

Configuring BFD control packet mode

About BFD control packet mode

This mode uses BFD control packets to detect the status of a link bidirectionally at a millisecond level.

BFD control packet mode can be applied to IPv6 static routes with a direct next hop or with an indirect next hop.

Restrictions and guidelines for BFD control packet mode

If you configure BFD control packet mode at the local end, you must also configure this mode at the peer end.

Configuring BFD control packet mode for an IPv6 static route (direct next hop)

1. Enter system view.

   system-view
2. Configure BFD control packet mode for an IPv6 static route.

   ipv6 route-static *ipv6-address prefix-length interface-type interface-number next-hop-address* **bfd control-packet** [**bfd-source** *ipv6-address*] [**preference** *preference*] [**tag** *tag-value*] [**description** *text*]

   By default, BFD control packet mode for an IPv6 static route is not configured.

Configuring BFD control packet mode for an IPv6 static route (indirect next hop)

1. Enter system view.

   system-view
2. Configure BFD control packet mode for an IPv6 static route.

   ipv6 route-static *ipv6-address prefix-length* { *next-hop-address* **bfd control-packet bfd-source** *ipv6-address* } [**preference** *preference*] [**tag** *tag-value*] [**description** *text*]

   By default, BFD control packet mode for an IPv6 static route is not configured.

Configuring BFD echo packet mode

About single-hop echo packet mode

With BFD echo packet mode enabled for a static route, the output interface sends BFD echo packets to the destination device, which loops the packets back to test the link reachability.

Restrictions and guidelines

You do not need to configure BFD echo packet mode at the peer end.

Do not use BFD for a static route with the output interface in spoofing state.

Procedure

1. Enter system view.

   system-view

2. Configure the source address of echo packets.

   bfd echo-source-ipv6 *ipv6-address*

   By default, the source address of echo packets is not configured.

   The source address of echo packets must be a global unicast address.

   For more information about this command, see *High Availability Command Reference*.

3. Configure BFD echo packet mode for an IPv6 static route.

   ipv6 route-static *ipv6-address prefix-length interface-type interface-number next-hop-address* **bfd echo-packet** [**bfd-source** *ipv6-address*] [**preference** *preference*] [**tag** *tag-value*] [**description** *text*]

   By default, BFD echo packet mode for an IPv6 static route is not configured.

   The next hop IPv6 address must be a global unicast address.

Display and maintenance commands for IPv6 static routing

Execute **display** commands in any view.

Task	Command
Display IPv6 static route next hop information.	**display ipv6 route-static nib** [*nib-id*] [**verbose**]
Display IPv6 static routing table information.	**display ipv6 route-static routing-table** [*ipv6-address prefix-length*]
Display IPv6 static route information.	**display ipv6 routing-table protocol static** [**inactive** | **verbose**]

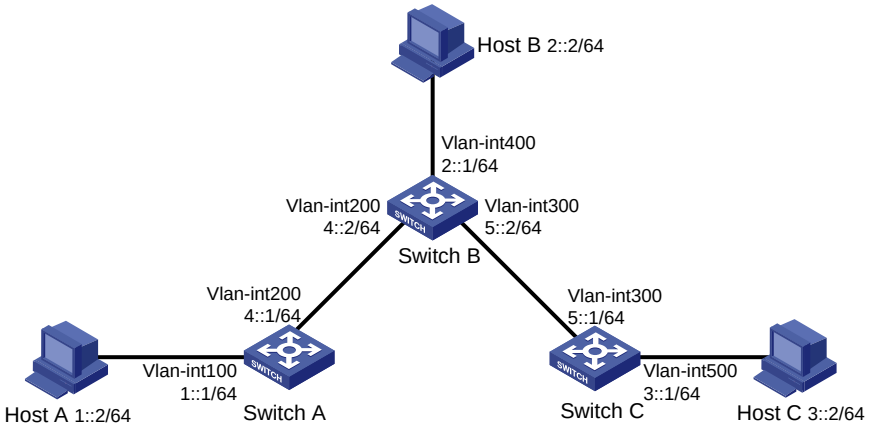
IPv6 static routing configuration examples

Example: Configuring basic IPv6 static route

Network configuration

As shown in Figure 1, configure IPv6 static routes so that hosts can reach one another.

Figure 1 Network diagram



Procedure

1. Configure the IPv6 addresses for all VLAN interfaces. (Details not shown.)
2. Configure IPv6 static routes:

   # Configure a default IPv6 static route on Switch A.

   ```
   <SwitchA> system-view
   [SwitchA] ipv6 route-static :: 0 4::2
   ```

   # Configure two IPv6 static routes on Switch B.

   ```
   <SwitchB> system-view
   [SwitchB] ipv6 route-static 1:: 64 4::1
   [SwitchB] ipv6 route-static 3:: 64 5::1
   ```

   # Configure a default IPv6 static route on Switch C.

   ```
   <SwitchC> system-view
   [SwitchC] ipv6 route-static :: 0 5::2
   ```
3. Configure the IPv6 addresses for all the hosts and configure the default gateway of Host A, Host B, and Host C as 1::1, 2::1, and 3::1.

Verifying the configuration

Display the IPv6 static route information on Switch A.

```
[SwitchA] display ipv6 routing-table protocol static

Summary count : 1

Static Routing table status : <Active>
Summary count : 1

Destination: ::/0                                   Protocol  : Static
NextHop    : 4::2                                   Preference: 60
```

```
Interface  : Vlan200                                  Cost      : 0

Static Routing table status : <Inactive>
Summary count : 0
```

Display the IPv6 static route information on Switch B.

```
[SwitchB] display ipv6 routing-table protocol static

Summary count : 2

Static Routing table status : <Active>
Summary count : 2

Destination: 1::/64                                  Protocol  : Static
NextHop    : 4::1                                    Preference: 60
Interface  : Vlan200                                 Cost      : 0

Destination: 3::/64                                  Protocol  : Static
NextHop    : 5::1                                    Preference: 60
Interface  : Vlan300                                 Cost      : 0

Static Routing table status : <Inactive>
Summary count : 0
```

Use the **ping** command to test the reachability.

```
[SwitchA] ping ipv6 3::1
Ping6(56 data bytes) 4::1 --> 3::1, press CTRL_C to break
56 bytes from 3::1, icmp_seq=0 hlim=62 time=0.700 ms
56 bytes from 3::1, icmp_seq=1 hlim=62 time=0.351 ms
56 bytes from 3::1, icmp_seq=2 hlim=62 time=0.338 ms
56 bytes from 3::1, icmp_seq=3 hlim=62 time=0.373 ms
56 bytes from 3::1, icmp_seq=4 hlim=62 time=0.316 ms

--- Ping6 statistics for 3::1 ---
5 packet(s) transmitted, 5 packet(s) received, 0.0% packet loss
round-trip min/avg/max/std-dev = 0.316/0.416/0.700/0.143 ms
```

Example: Configuring BFD for IPv6 static routes (direct next hop)

Network configuration

As shown in Figure 2:

- Configure an IPv6 static route to subnet 120::/64 on Switch A.
- Configure an IPv6 static route to subnet 121::/64 on Switch B.
- Enable BFD for both routes.
- Configure an IPv6 static route to subnet 120::/64 and an IPv6 static route to subnet 121::/64 on Switch C.

When the link between Switch A and Switch B through the Layer 2 switch fails, BFD can detect the failure immediately, and Switch A and Switch B can communicate through Switch C.

Figure 2 Network diagram

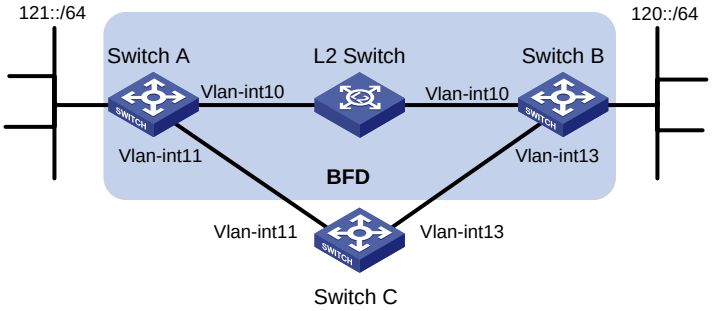


Table 1 Interface and IP address assignment

Device	Interface	IPv6 address
Switch A	Vlan-int10	12::1/64
Switch A	Vlan-int11	10::102/64
Switch B	Vlan-int10	12::2/64
Switch B	Vlan-int13	13::1/64
Switch C	Vlan-int11	10::100/64
Switch C	Vlan-int13	13::2/64

Procedure

1. Configure IPv6 addresses for interfaces. (Details not shown.)
2. Configure IPv6 static routes and BFD:

   # Configure IPv6 static routes on Switch A and enable BFD control packet mode for the static route that traverses the Layer 2 switch.

```
<SwitchA> system-view
[SwitchA] interface vlan-interface 10
[SwitchA-vlan-interface10] bfd min-transmit-interval 500
[SwitchA-vlan-interface10] bfd min-receive-interval 500
[SwitchA-vlan-interface10] bfd detect-multiplier 9
[SwitchA-vlan-interface10] quit
[SwitchA] ipv6 route-static 120:: 64 vlan-interface 10 12::2 bfd control-packet
[SwitchA] ipv6 route-static 120:: 64 10::100 preference 65
[SwitchA] quit
```

   # Configure IPv6 static routes on Switch B and enable BFD control packet mode for the static route that traverses the Layer 2 switch.

```
<SwitchB> system-view
[SwitchB] interface vlan-interface 10
[SwitchB-vlan-interface10] bfd min-transmit-interval 500
[SwitchB-vlan-interface10] bfd min-receive-interval 500
[SwitchB-vlan-interface10] bfd detect-multiplier 9
[SwitchB-vlan-interface10] quit
[SwitchB] ipv6 route-static 121:: 64 vlan-interface 10 12::1 bfd control-packet
[SwitchB] ipv6 route-static 121:: 64 vlan-interface 13 13::2 preference 65
[SwitchB] quit
```

   # Configure IPv6 static routes on Switch C.

```
<SwitchC> system-view
[SwitchC] ipv6 route-static 120:: 64 13::1
[SwitchC] ipv6 route-static 121:: 64 10::102
```

Verifying the configuration

Display the BFD sessions on Switch A.

```
<SwitchA> display bfd session

 Total Session Num: 1     Up Session Num: 1     Init Mode: Active

 IPv6 Session Working Under Ctrl Mode:

       Local Discr: 513                Remote Discr: 33
         Source IP: 12::1
    Destination IP: 12::2
     Session State: Up                      Interface: Vlan10
         Hold Time: 2012ms
```

The output shows that the BFD session has been created.

Display IPv6 static routes on Switch A.

```
<SwitchA> display ipv6 routing-table protocol static

Summary count : 1

Static Routing table status : <Active>
Summary count : 1

Destination: 120::/64                                  Protocol  : Static
NextHop    : 12::2                                     Preference: 60
Interface  : Vlan10                                    Cost      : 0

Direct Routing table status : <Inactive>
Summary count : 0
```

The output shows that Switch A communicates with Switch B through VLAN-interface 10. The link over VLAN-interface 10 fails.

Display IPv6 static routes on Switch A again.

```
<SwitchA> display ipv6 routing-table protocol static

Summary count : 1

Static Routing table status : <Active>
Summary count : 1

Destination: 120::/64                                  Protocol  : Static
NextHop    : 10::100                                   Preference: 65
Interface  : Vlan11                                    Cost      : 0

Static Routing table status : < Inactive>
Summary count : 0
```

The output shows that Switch A communicates with Switch B through VLAN-interface 11.

Example: Configuring BFD for IPv6 static routes (indirect next hop)

Network configuration

As shown in Figure 3:

- Switch A has a route to interface Loopback 1 (2::9/128) on Switch B, and the output interface is VLAN-interface 10.
- Switch B has a route to interface Loopback 1 (1::9/128) on Switch A, and the output interface is VLAN-interface 12.
- Switch D has a route to 1::9/128, and the output interface is VLAN-interface 10. It also has a route to 2::9/128, and the output interface is VLAN-interface 12.

Configure the following:

- Configure an IPv6 static route to subnet 120::/64 on Switch A.
- Configure an IPv6 static route to subnet 121::/64 on Switch B.
- Enable BFD for both routes.
- Configure an IPv6 static route to subnet 120::/64 and an IPv6 static route to subnet 121::/64 on both Switch C and Switch D.

When the link between Switch A and Switch B through Switch D fails, BFD can detect the failure immediately and Switch A and Switch B can communicate through Switch C.

Figure 3 Network diagram

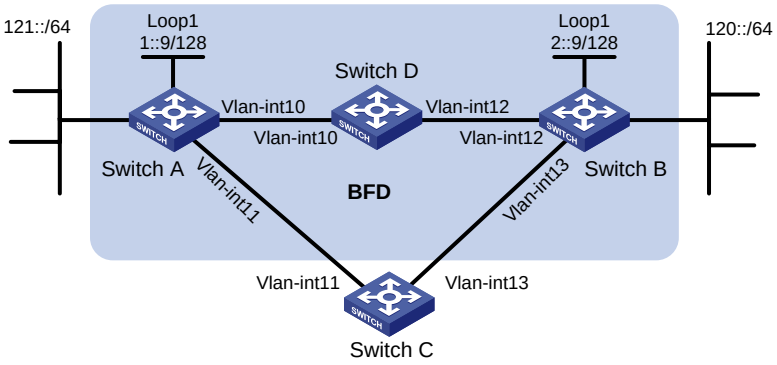


Table 2 Interface and IP address assignment

Device	Interface	IPv6 address
Switch A	Vlan-int10	12::1/64
Switch A	Vlan-int11	10::102/64
Switch A	Loop1	1::9/128
Switch B	Vlan-int12	11::2/64
Switch B	Vlan-int13	13::1/64
Switch B	Loop1	2::9/128
Switch C	Vlan-int11	10::100/64
Switch C	Vlan-int13	13::2/64

Device	Interface	IPv6 address
Switch D	Vlan-int10	12::2/64
Switch D	Vlan-int12	11::1/64

Procedure

1. Configure IPv6 addresses for interfaces. (Details not shown.)
2. Configure IPv6 static routes and BFD:

   # Configure IPv6 static routes on Switch A and enable BFD control packet mode for the IPv6 static route that traverses Switch D.

```
<SwitchA> system-view
[SwitchA] bfd multi-hop min-transmit-interval 500
[SwitchA] bfd multi-hop min-receive-interval 500
[SwitchA] bfd multi-hop detect-multiplier 9
[SwitchA] ipv6 route-static 120:: 64 2::9 bfd control-packet bfd-source 1::9
[SwitchA] ipv6 route-static 120:: 64 10::100 preference 65
[SwitchA] ipv6 route-static 2::9 128 12::2
[SwitchA] quit
```

   # Configure IPv6 static routes on Switch B and enable BFD control packet mode for the static route that traverses Switch D.

```
<SwitchB> system-view
[SwitchB] bfd multi-hop min-transmit-interval 500
[SwitchB] bfd multi-hop min-receive-interval 500
[SwitchB] bfd multi-hop detect-multiplier 9
[SwitchB] ipv6 route-static 121:: 64 1::9 bfd control-packet bfd-source 2::9
[SwitchB] ipv6 route-static 121:: 64 13::2 preference 65
[SwitchB] ipv6 route-static 1::9 128 11::1
[SwitchB] quit
```

   # Configure IPv6 static routes on Switch C.

```
<SwitchC> system-view
[SwitchC] ipv6 route-static 120:: 64 13::1
[SwitchC] ipv6 route-static 121:: 64 10::102
```

   # Configure IPv6 static routes on Switch D.

```
<SwitchD> system-view
[SwitchD] ipv6 route-static 120:: 64 11::2
[SwitchD] ipv6 route-static 121:: 64 12::1
[SwitchD] ipv6 route-static 2::9 128 11::2
[SwitchD] ipv6 route-static 1::9 128 12::1
```

Verifying the configuration

Display the BFD sessions on Switch A.

```
<SwitchA> display bfd session

 Total Session Num: 1     Up Session Num: 1     Init Mode: Active

 IPv6 Session Working Under Ctrl Mode:

       Local Discr: 513                Remote Discr: 33
         Source IP: 1::9
```

```
    Destination IP: 2::9
     Session State: Up                        Interface: N/A
         Hold Time: 2012ms
```

The output shows that the BFD session has been created.

Display the IPv6 static routes on Switch A.

```
<SwitchA> display ipv6 routing-table protocol static

Summary count : 1

Static Routing table status : <Active>
Summary count : 1

Destination: 120::/64                                  Protocol  : Static
NextHop    : 2::9                                      Preference: 60
Interface  : Vlan10                                    Cost      : 0

Static Routing table status : <Inactive>
Summary count : 0
```

The output shows that Switch A communicates Switch B through VLAN-interface 10. The link over VLAN-interface 10 fails.

Display IPv6 static routes on Switch A again.

```
<SwitchA> display ipv6 routing-table protocol static

Summary count : 1

Static Routing table status : <Active>
Summary count : 1

Destination: 120::/64                                  Protocol  : Static
NextHop    : 10::100                                   Preference: 65
Interface  : Vlan11                                    Cost      : 0

Static Routing table status : <Inactive>
Summary count : 0
```

The output shows that Switch A communicates with Switch B through VLAN-interface 11.

Configuring an IPv6 default route

A default IPv6 route is used to forward packets that match no entry in the routing table.

A default IPv6 route can be configured in either of the following ways:

- The network administrator can configure a default route with a destination prefix of **::/0**. For more information, see "Configuring IPv6 static routing."
- Some dynamic routing protocols (such as OSPFv3 and RIPng) can generate a default IPv6 route. For example, an upstream router running OSPFv3 can generate a default IPv6 route and advertise it to other routers. These routers install the default IPv6 route with the next hop being the upstream router. For more information, see the respective chapters on those routing protocols in this configuration guide.

Contents

Configuring RIPng

About RIPng

RIP next generation (RIPng), as an extension of RIP-2 for support of IPv6, is a distance vector routing protocol. It employs UDP to exchange route information through port 521. Most RIP concepts are applicable to RIPng.

RIPng routing metrics

RIPng uses a hop count to measure the distance to a destination. The hop count is the metric or cost. The hop count from a router to a directly connected network is 0. The hop count between two directly connected routers is 1. When the hop count is greater than or equal to 16, the destination network or host is unreachable.

RIPng route entries

RIPng stores route entries in a database. Each route entry contains the following elements:

- **Destination address**—IPv6 address of a destination host or a network.
- **Next hop address**—IPv6 address of the next hop.
- **Egress interface**—Egress interface of the route.
- **Metric**—Cost from the local router to the destination.
- **Route time**—Time elapsed since the most recent update. The time is reset to 0 every time the route entry is updated.
- **Route tag**—Used for route control. For more information, see "Configuring routing policies."

RIPng packets and advertisement

RIPng multicasts request and response packets to exchange routing information. It uses FF02::9 as the destination address and link-local address FE80::/10 as the source address. RIPng exchanges routing information as follows:

1. When RIPng starts or needs to update some route entries, it sends a multicast request packet to neighbors.
2. When a RIPng neighbor receives the request packet, it sends back a response packet that contains the local routing table. RIPng can also advertise route updates in response packets periodically or advertise a triggered update caused by a route change.
3. After RIPng receives the response, it checks the validity of the response before adding routes to its routing table, including the following details:
   - Whether the source IPv6 address is the link-local address.
   - Whether the port number is correct.
4. A response packet that fails the check is discarded.

Protocols and standards

- RFC 2080, *RIPng for IPv6*
- RFC 2081, *RIPng Protocol Applicability Statement*

Restrictions: Hardware compatibility with RIPng

The S5000V3-EI, S5000V5-EI, S5000E-X, S5000X-EI, and WAS6000 switch series do not support RIPng.

RIPng tasks at a glance

To configure RIPng, perform the following tasks:

1. Configuring basic RIPng
2. (Optional.) Configuring RIPng route control
   - Configuring an additional routing metric
   - Configuring RIPng route summarization
   - Advertising a default route
   - Configuring received/redistributed route filtering
   - Setting a preference for RIPng
   - Configuring RIPng route redistribution
3. (Optional.) Tuning and optimizing the RIPng network
   - Setting RIPng timers
   - Configuring split horizon and poison reverse
   - Configuring the RIPng packet sending rate
   - Setting the interval for sending triggered updates
4. (Optional.) Enhancing RIPng availability
   - Configuring RIPng GR
   - Configuring RIPng NSR
   - Configuring RIPng FRR
5. (Optional.) Enhancing RIPng security
   - Configuring zero field check for RIPng packets
   - Applying an IPsec profile

Configuring basic RIPng

1. Enter system view.
   system-view
2. Enable RIPng and enter its view.
   ripng [*process-id*]
   By default, RIPng is disabled.
3. Return to system view.
   quit
4. Enter interface view.
   interface *interface-type interface-number*
5. Enable RIPng on the interface.
   ripng *process-id* **enable**
   By default, RIPng is disabled on the interface.
   If RIPng is not enabled on an interface, the interface does not send or receive any RIPng route.

Configuring RIPng route control

Configuring an additional routing metric

About additional routing metrics

An additional routing metric (hop count) can be added to the metric of an inbound or outbound RIPng route.

- An outbound additional metric is added to the metric of a sent route, and it does not change the route's metric in the routing table.
- An inbound additional metric is added to the metric of a received route before the route is added into the routing table, and the route's metric is changed.

Procedure

1. Enter system view.

   system-view
2. Enter interface view.

   interface *interface-type interface-number*
3. Specify an inbound additional routing metric.

   ripng metricin *value*

   The default additional metric of an inbound route is 0.
4. Specify an outbound additional routing metric.

   ripng metricout *value*

   The default additional metric of an outbound route is 1.

Configuring RIPng route summarization

About RIPng route summarization

RIPng route summarization is interface-based. RIPng advertises a summary route based on the longest match.

RIPng route summarization improves network scalability, reduces routing table size, and increases routing table lookup efficiency.

RIPng advertises a summary route with the smallest metric of all the specific routes.

For example, RIPng has two specific routes to be advertised through an interface: 1:11:11::24 with a metric of a 2 and 1:11:12::34 with a metric of 3. Configure route summarization on the interface, so RIPng advertises a single route 11::0/16 with a metric of 2.

Procedure

1. Enter system view.

   system-view
2. Enter interface view.

   interface *interface-type interface-number*
3. Advertise a summary IPv6 prefix.

   ripng summary-address *ipv6-address prefix-length*

   By default, no summary IPv6 prefix is configured on the interface.

Advertising a default route

About default route advertisement

You can configure RIPng to advertise a default route with the specified cost to its neighbors.

Procedure

1. Enter system view.

   system-view

2. Enter interface view.

   interface *interface-type interface-number*

3. Configure RIPng to advertise a default route.

   ripng default-route { **only** | **originate** } [**cost** *cost-value* | **route-policy** *route-policy-name*] *

   By default, RIPng does not advertise a default route.

   This command advertises a default route on the current interface regardless of whether the default route exists in the local IPv6 routing table.

Configuring received/redistributed route filtering

About received/redistributed route filtering

Perform this task to filter received or redistributed routes by using an IPv6 ACL or IPv6 prefix list. You can also configure RIPng to filter routes redistributed from other routing protocols and routes from a specified neighbor.

Procedure

1. Enter system view.

   system-view

2. Enter RIPng view.

   ripng [*process-id*]

3. Configure a filter policy to filter received routes.

   filter-policy { *ipv6-acl-number* | **prefix-list** *prefix-list-name* } **import**

   By default, RIPng does not filter received routes.

4. Configure a filter policy to filter redistributed routes.

   filter-policy { *ipv6-acl-number* | **prefix-list** *prefix-list-name* } **export** [*protocol* [*process-id*]]

   By default, RIPng does not filter redistributed routes.

Setting a preference for RIPng

About preference for RIPng

Routing protocols each have a preference. When they find routes to the same destination, the route found by the routing protocol with the highest preference is selected as the optimal route. You can manually set a preference for RIPng. The smaller the value, the higher the preference.

Procedure

1. Enter system view.

   system-view

2. Enter RIPng view.
   ripng [*process-id*]
3. Set a preference for RIPng.
   preference { *preference* | **route-policy** *route-policy-name* } *
   By default, the preference of RIPng is 100.

Configuring RIPng route redistribution

1. Enter system view.
   system-view
2. Enter RIPng view.
   ripng [*process-id*]
3. Redistribute routes from other routing protocols.
   - Redistribute direct or static routes.
     import-route { **direct** | **static** } [**cost** *cost-value* | **route-policy** *route-policy-name*] *
   - Redistribute routes from OSPFv3 or other RIPng processes.
     import-route { **ospfv3** | **ripng** } [*process-id*] [**allow-direct** | **cost** *cost-value* | **route-policy** *route-policy-name*] *

   By default, RIPng does not redistribute routes from other routing protocols.
4. (Optional.) Set a default routing metric for redistributed routes.
   default cost *cost-value*
   The default metric of redistributed routes is 0.

Tuning and optimizing the RIPng network

Setting RIPng timers

About RIPng timers

You can adjust RIPng timers to optimize the performance of the RIPng network.

Restrictions and guidelines

When you adjust RIPng timers, consider the network performance, and perform unified configurations on routers running RIPng to avoid unnecessary network traffic or route oscillation.

Procedure

1. Enter system view.
   system-view
2. Enter RIPng view.
   ripng [*process-id*]
3. Set RIPng timers.
   timers { **garbage-collect** *garbage-collect-value* | **suppress** *suppress-value* | **timeout** *timeout-value* | **update** *update-value* } *
   The default settings are as follows:
   - The update timer is 30 seconds.
   - The timeout timer is 180 seconds.

- The suppress timer is 120 seconds.
- The garbage-collect timer is 120 seconds.

Configuring split horizon and poison reverse

Restrictions and guidelines for split horizon and poison reverse

When you configure split horizon and poison reverse, following these restrictions and guidelines:

- If both split horizon and poison reverse are configured, only the poison reverse feature takes effect.
- Split horizon disables RIPng from sending routes through the interface where the routes were learned to prevent routing loops between neighbors. As a best practice, enable split horizon to prevent routing loops in normal cases.
- Poison reverse enables a route learned from an interface to be advertised through the interface. However, the metric of the route is set to 16, which means the route is unreachable.

Configuring split horizon

1. Enter system view.
   `system-view`
2. Enter interface view.
   `interface` *`interface-type interface-number`*
3. Enable split horizon.
   `ripng split-horizon`
   By default, split horizon is enabled.

Configuring poison reverse

1. Enter system view.
   `system-view`
2. Enter interface view.
   `interface` *`interface-type interface-number`*
3. Enable poison reverse.
   `ripng poison-reverse`
   By default, poison reverse is disabled.

Configuring the RIPng packet sending rate

About RIPng packet sending rate configuration

Perform this task to specify the interval for sending RIPng packets and the maximum number of RIPng packets that can be sent at each interval. This feature can avoid excessive RIPng packets from affecting system performance and consuming too much bandwidth.

Procedure

1. Enter system view.
   `system-view`
2. Enter RIPng view.
   `ripng` [*`process-id`*]
3. Configuring the RIPng packet sending rate.
   - Execute the following commands in sequence to configure the RIPng packet sending rate in RIPng view:

ripng [*process-id*]

output-delay *time* **count** *count*

By default, an interface that runs the RIPng process sends a maximum of three RIPng packets every 20 milliseconds.

- Execute the following commands in sequence to configure the RIPng packet sending rate in interface view:

  interface *interface-type interface-number*

  ripng output-delay *time* **count** *count*

  By default, an interface uses the RIPng packet sending rate of the RIPng process that it runs.

Setting the interval for sending triggered updates

About setting the interval for sending triggered updates

Perform this task to avoid network overhead and reduce system resource consumption caused by frequent RIPng triggered updates.

You can use the **timer triggered** command to set the maximum interval, minimum interval, and incremental interval for sending RIPng triggered updates.

For a stable network, the minimum interval is used. If network changes become frequent, the triggered update sending interval is incremented by the incremental interval × 2^{n-2} for each triggered update until the maximum interval is reached. The value *n* is the number of triggered update times.

Procedure

1. Enter system view.

   system-view

2. Enter RIPng view.

   ripng [*process-id*]

3. Set the interval for sending triggered updates.

   timer triggered *maximum-interval* [*minimum-interval* [*incremental-interval*]]

   The default maximum interval is 5 seconds, the default minimum interval is 50 milliseconds, and the default incremental interval is 200 milliseconds.

Configuring RIPng GR

About RIPng GR

GR ensures forwarding continuity when a routing protocol restarts or an active/standby switchover occurs.

Two routers are required to complete a GR process. The following are router roles in a GR process:

- **GR restarter**—Graceful restarting router. It must have GR capability.
- **GR helper**—A neighbor of the GR restarter. It helps the GR restarter to complete the GR process.

After RIPng restarts on a router, the router must learn RIPng routes again and updates its FIB table, which causes network disconnections and route reconvergence.

With the GR feature, the restarting router (known as the GR restarter) can notify the event to its GR capable neighbors. GR capable neighbors (known as GR helpers) maintain their adjacencies with

the router within a configurable GR interval. During this process, the FIB table of the router does not change. After the restart, the router contacts its neighbors to retrieve its FIB.

By default, a RIPng-enabled device acts as the GR helper. Perform this task on the GR restarter.

Restrictions and guidelines

You cannot enable RIPng NSR on a device that acts as GR restarter.

Procedure

1. Enter system view.
   system-view
2. Enable RIPng and enter RIPng view.
   ripng [*process-id*]
3. Enable the GR capability for RIPng.
   graceful-restart
   By default, RIPng GR is disabled.
4. (Optional.) Set the GR interval.
   graceful-restart interval *interval*
   The default GR interval is 60 seconds.

Configuring RIPng NSR

About RIPng NSR

Nonstop routing (NSR) backs up RIPng routing information from the active process to the standby process. After an active/standby switchover, NSR can complete route regeneration without tearing down adjacencies or impacting forwarding services.

NSR does not require the cooperation of neighboring devices to recover routing information, and it is typically used more often than GR.

Restrictions and guidelines

RIPng NSR enabled for a RIPng process takes effect only on that process. If multiple RIPng processes exist, enable RIPng NSR for each process as a best practice.

A device that has RIPng NSR enabled cannot act as GR restarter.

Procedure

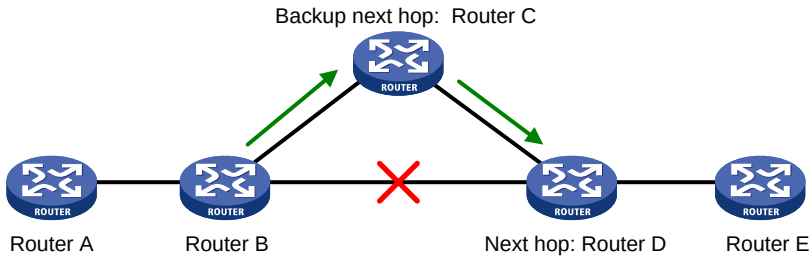
1. Enter system view.
   system-view
2. Enter RIPng view.
   ripng [*process-id*]
3. Enable RIPng NSR.
   non-stop-routing
   By default, RIPng NSR is disabled.

Configuring RIPng FRR

About RIPng FRR

A link or router failure on a path can cause packet loss and even routing loop until RIPng completes routing convergence based on the new network topology. FRR enables fast rerouting to minimize the impact of link or node failures.

Figure 1 Network diagram for RIPng FRR



As shown in Figure 1, configure FRR on Router B by using a routing policy to specify a backup next hop. When the primary link fails, RIPng directs packets to the backup next hop. At the same time, RIPng calculates the shortest path based on the new network topology. Then, the device forwards packets over that path after network convergence.

Restrictions and guidelines for RIPng FRR

RIPng FRR is available only when the state of the primary link (with Layer 3 interfaces staying up) changes from bidirectional to unidirectional or down.

RIPng FRR is only effective for RIPng routes that are learned from directly connected neighbors.

Enabling RIPng FRR

1. Enter system view.
   `system-view`
2. Configure a routing policy.
   You must specify a next hop by using the **`apply ipv6 fast-reroute backup-interface`** command in a routing policy and specify the routing policy for FRR.
   For more information about routing policy configuration, see "Configuring routing policies."
3. Enter RIPng view.
   `ripng` [*`process-id`*]
4. Enable RIPng FRR.
   `fast-reroute route-policy` *`route-policy-name`*
   By default, RIPng FRR is disabled.

Enabling BFD for RIPng FRR

About BFD for RIPng FRR

By default, RIPng FRR does not use BFD to detect primary link failures. For quicker RIPng FRR, use BFD single-hop echo detection on the primary link of redundant links to detect link failure.

Procedure

1. Enter system view.
   system-view
2. Configure the source IP address of BFD echo packets.
   bfd echo-source-ipv6 *ipv6-address*
   By default, the source IP address of BFD echo packets is not configured.
   As a best practice, do not configure the source IP address on the same network segment as any local interfaces.
   For more information about this command, see *High Availability Command Reference*.
3. Enter interface view.
   interface *interface-type interface-number*
4. Enable BFD single-hop echo detection for RIPng FRR.
   ripng primary-path-detect bfd echo
   By default, BFD single-hop echo detection is disabled for RIPng FRR.

Enhancing RIPng security

Configuring zero field check for RIPng packets

About zero field check for RIPng packets

Some fields in the RIPng packet header must be zero. These fields are called zero fields. You can enable zero field check for incoming RIPng packets. If a zero field of a packet contains a non-zero value, RIPng does not process the packets. If you are certain that all packets are trustworthy, disable the zero field check to save CPU resources.

Procedure

1. Enter system view.
   system-view
2. Enter RIPng view.
   ripng [*process-id*]
3. Enable the zero field check for incoming RIPng packets.
   checkzero
   By default, zero field check for incoming RIPng packets is enabled.

Applying an IPsec profile

About IPsec profiles

To protect routing information and prevent attacks, you can configure RIPng to authenticate protocol packets by using an IPsec profile.

An IPsec profile contains inbound and outbound security parameter indexes (SPIs). RIPng compares the inbound SPI defined in the IPsec profile with the outbound SPI in the received packets. Two RIPng devices accept the packets from each other and establish a neighbor relationship only if the SPIs are the same and the relevant IPsec profiles match.

For more information about IPsec profiles, see *Security Configuration Guide*.

Restrictions and guidelines

You can apply an IPsec profile to a RIPng process or to an interface. If an interface and its process each have an IPsec profile, the IPsec profile applied to the interface takes effect.

Applying an IPsec profile to a process

1. Enter system view.
   system-view
2. Enter RIPng view.
   ripng [*process-id*]
3. Apply an IPsec profile to the process.
   enable ipsec-profile *profile-name*
   By default, no IPsec profile is applied.

Applying an IPsec profile to an interface

1. Enter system view.
   system-view
2. Enter interface view.
   interface *interface-type interface-number*
3. Apply an IPsec profile to the interface.
   ripng ipsec-profile *profile-name*
   By default, no IPsec profile is applied.

Display and maintenance commands for RIPng

Execute **display** commands in any view and **reset** commands in user view.

Task	Command
Display configuration information for a RIPng process.	**display ripng** [*process-id*]
Display RIPng GR information.	**display ripng** [*process-id*] **graceful-restart**
Display RIPng NSR information.	**display ripng** [*process-id*] **non-stop-routing**
Display routes in the RIPng database.	**display ripng** *process-id* **database** [*ipv6-address prefix-length*]
Display interface information for a RIPng process.	**display ripng** *process-id* **interface** [*interface-type interface-number*]
Display neighbor information for a RIPng process.	**display ripng** *process-id* **neighbor** [*interface-type interface-number*]
Display the routing information for a RIPng process.	**display ripng** *process-id* **route** [*ipv6-address prefix-length* [**verbose**] | **peer** *ipv6-address* | **statistics**]
Restart a RIPng process.	**reset ripng** *process-id* **process**
Clear statistics for a RIPng process.	**reset ripng** *process-id* **statistics**

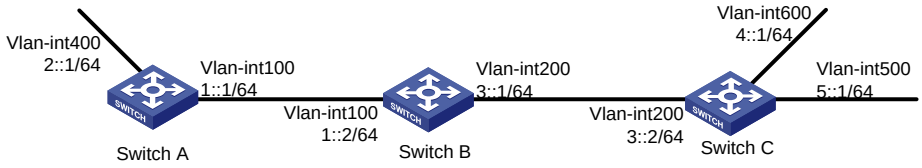
RIPng configuration examples

Example: Configuring basic RIPng

Network configuration

As shown in Figure 2, Switch A, Switch B, and Switch C run RIPng. Configure route filtering on Switch B to accept all received routes except the route 2::/64 and to advertise only the route 4::/64.

Figure 2 Network diagram



Procedure

1. Configure IPv6 addresses for the interfaces. (Details not shown.)
2. Configure basic RIPng settings:

   # Configure Switch A.

```
<SwitchA> system-view
[SwitchA] ripng 1
[SwitchA-ripng-1] quit
[SwitchA] interface vlan-interface 100
[SwitchA-Vlan-interface100] ripng 1 enable
[SwitchA-Vlan-interface100] quit
[SwitchA] interface vlan-interface 400
[SwitchA-Vlan-interface400] ripng 1 enable
[SwitchA-Vlan-interface400] quit
```

   # Configure Switch B.

```
<SwitchB> system-view
[SwitchB] ripng 1
[SwitchB-ripng-1] quit
[SwitchB] interface vlan-interface 100
[SwitchB-Vlan-interface100] ripng 1 enable
[SwitchB-Vlan-interface100] quit
[SwitchB] interface vlan-interface 400
[SwitchB-Vlan-interface400] ripng 1 enable
[SwitchB-Vlan-interface400] quit
```

   # Configure Switch C.

```
<SwitchC> system-view
[SwitchC] ripng 1
[SwitchC-ripng-1] quit
[SwitchC] interface vlan-interface 200
[SwitchC-Vlan-interface200] ripng 1 enable
[SwitchC-Vlan-interface200] quit
[SwitchC] interface vlan-interface 500
[SwitchC-Vlan-interface500] ripng 1 enable
```

```
[SwitchC-Vlan-interface500] quit
[SwitchC] interface vlan-interface 600
[SwitchC-Vlan-interface600] ripng 1 enable
[SwitchC-Vlan-interface600] quit
```

Display the RIPng routing table on Switch B.

```
[SwitchB] display ripng 1 route
   Route Flags: A - Aging, S - Suppressed, G - Garbage-collect, D – Direct
                O - Optimal, F - Flush to RIB
 ----------------------------------------------------------------

 Peer FE80::20F:E2FF:FE23:82F5 on Vlan-interface100
 Destination 2::/64,
     via FE80::20F:E2FF:FE23:82F5, cost 1, tag 0, AOF, 6 secs
 Peer FE80::20F:E2FF:FE00:100  on Vlan-interface200
 Destination 4::/64,
     via FE80::20F:E2FF:FE00:100, cost 1, tag 0, AOF, 11 secs
 Destination 5::/64,
     via FE80::20F:E2FF:FE00:100, cost 1, tag 0, AOF, 11
 Local route
 Destination 1::/64,
     via ::, cost 0, tag 0, DOF
 Destination 3::/64,
     via ::, cost 0, tag 0, DOF
```

Display the RIPng routing table on Switch A.

```
[SwitchA] display ripng 1 route
   Route Flags: A - Aging, S - Suppressed, G - Garbage-collect, D – Direct
                O - Optimal, F - Flush to RIB
 ----------------------------------------------------------------

 Peer FE80::200:2FF:FE64:8904 on Vlan-interface100
 Destination 3::/64,
     via FE80::200:2FF:FE64:8904, cost 1, tag 0, AOF, 31 secs
 Destination 4::/64,
     via FE80::200:2FF:FE64:8904, cost 2, tag 0, AOF, 31 secs
 Destination 5::/64,
     via FE80::200:2FF:FE64:8904, cost 2, tag 0, AOF, 31 secs
 Local route
 Destination 2::/64,
     via ::, cost 0, tag 0, DOF
 Destination 1::/64,
     via ::, cost 0, tag 0, DOF
```

3. Configure route filtering:

Use IPv6 prefix lists on Switch B to filter received and redistributed routes.

```
[SwitchB] ipv6 prefix-list aaa permit 4:: 64
[SwitchB] ipv6 prefix-list bbb deny 2:: 64
[SwitchB] ipv6 prefix-list bbb permit :: 0 less-equal 128
[SwitchB] ripng 1
[SwitchB-ripng-1] filter-policy prefix-list aaa export
```

```
[SwitchB-ripng-1] filter-policy prefix-list bbb import
[SwitchB-ripng-1] quit
```

Display RIPng routing tables on Switch B and Switch A.

```
[SwitchB] display ripng 1 route
   Route Flags: A - Aging, S - Suppressed, G - Garbage-collect, D – Direct
                O - Optimal, F - Flush to RIB
 ------------------------------------------------------------

 Peer FE80::1:100 on Vlan-interface100

 Peer FE80::3:200 on Vlan-interface200
 Destination 4::/64,
     via FE80::2:200, cost 1, tag 0, AOF, 11 secs
 Destination 5::/64,
     via FE80::2:200, cost 1, tag 0, AOF, 11 secs
 Local route
 Destination 1::/64,
     via ::, cost 0, tag 0, DOF
 Destination 3::/64,
     via ::, cost 0, tag 0, DOF
[SwitchA] display ripng 1 route
   Route Flags: A - Aging, S - Suppressed, G - Garbage-collect, D – Direct
                O - Optimal, F - Flush to RIB
 ------------------------------------------------------------

 Peer FE80::2:100 on Vlan-interface100
 Destination 4::/64,
     via FE80::1:100, cost 2, tag 0, AOF, 2 secs
 Local route
 Destination 1::/64,
     via ::, cost 0, tag 0, DOF
 Destination 2::/64,
     via ::, cost 0, tag 0, DOF
```

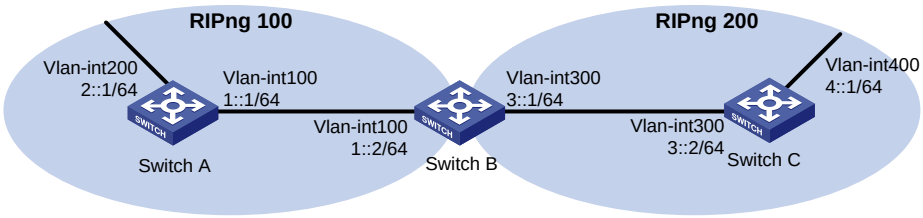
Example: Configuring RIPng route redistribution

Network configuration

As shown in Figure 3, Switch B communicates with Switch A through RIPng 100 and with Switch C through RIPng 200.

Configure route redistribution on Switch B, so the two RIPng processes can redistribute routes from each other.

Figure 3 Network diagram



Procedure

1. Configure IPv6 addresses for the interfaces. (Details not shown.)
2. Configure basic RIPng settings:

   # Enable RIPng 100 on Switch A.

```
<SwitchA> system-view
[SwitchA] ripng 100
[SwitchA-ripng-100] quit
[SwitchA] interface vlan-interface 100
[SwitchA-Vlan-interface100] ripng 100 enable
[SwitchA-Vlan-interface100] quit
[SwitchA] interface vlan-interface 200
[SwitchA-Vlan-interface200] ripng 100 enable
[SwitchA-Vlan-interface200] quit
```

   # Enable RIPng 100 and RIPng 200 on Switch B.

```
<SwitchB> system-view
[SwitchB] ripng 100
[SwitchB-ripng-100] quit
[SwitchB] interface vlan-interface 100
[SwitchB-Vlan-interface100] ripng 100 enable
[SwitchB-Vlan-interface100] quit
[SwitchB] ripng 200
[SwitchB-ripng-200] quit
[SwitchB] interface vlan-interface 300
[SwitchB-Vlan-interface300] ripng 200 enable
[SwitchB-Vlan-interface300] quit
```

   # Enable RIPng 200 on Switch C.

```
<SwitchC> system-view
[SwitchC] ripng 200
[SwitchC] interface vlan-interface 300
[SwitchC-Vlan-interface300] ripng 200 enable
[SwitchC-Vlan-interface300] quit
[SwitchC] interface vlan-interface 400
[SwitchC-Vlan-interface400] ripng 200 enable
[SwitchC-Vlan-interface400] quit
```

   # Display the routing table on Switch A.

```
[SwitchA] display ipv6 routing-table

Destinations : 7 Routes : 7
```

```
Destination: ::1/128                                    Protocol  : Direct
NextHop    : ::1                                        Preference: 0
Interface  : InLoop0                                    Cost      : 0

Destination: 1::/64                                     Protocol  : Direct
NextHop    : ::                                         Preference: 0
Interface  : Vlan100                                    Cost      : 0

Destination: 1::1/128                                   Protocol  : Direct
NextHop    : ::1                                        Preference: 0
Interface  : InLoop0                                    Cost      : 0

Destination: 2::/64                                     Protocol  : Direct
NextHop    : ::                                         Preference: 0
Interface  : Vlan200                                    Cost      : 0

Destination: 2::1/128                                   Protocol  : Direct
NextHop    : ::1                                        Preference: 0
Interface  : InLoop0                                    Cost      : 0

Destination: FE80::/10                                  Protocol  : Direct
NextHop    : ::                                         Preference: 0
Interface  : NULL0                                      Cost      : 0

Destination: FF00::/8                                   Protocol  : Direct
NextHop    : ::                                         Preference: 0
Interface  : NULL0                                      Cost      : 0
```

3. Configure RIPng route redistribution:

Configure route redistribution between the two RIPng processes on Switch B.

```
[SwitchB] ripng 100
[SwitchB-ripng-100] import-route ripng 200
[SwitchB-ripng-100] quit
[SwitchB] ripng 200
[SwitchB-ripng-200] import-route ripng 100
[SwitchB-ripng-200] quit
```

Display the routing table on Switch A.

```
[SwitchA] display ipv6 routing-table

Destinations : 8 Routes : 8

Destination: ::1/128                                    Protocol  : Direct
NextHop    : ::1                                        Preference: 0
Interface  : InLoop0                                    Cost      : 0

Destination: 1::/64                                     Protocol  : Direct
NextHop    : ::                                         Preference: 0
Interface  : Vlan100                                    Cost      : 0
```

```
Destination: 1::1/128                                   Protocol  : Direct
NextHop    : ::1                                        Preference: 0
Interface  : InLoop0                                    Cost      : 0

Destination: 2::/64                                     Protocol  : Direct
NextHop    : ::                                         Preference: 0
Interface  : Vlan200                                    Cost      : 0

Destination: 2::1/128                                   Protocol  : Direct
NextHop    : ::1                                        Preference: 0
Interface  : InLoop0                                    Cost      : 0

Destination: 4::/64                                     Protocol  : RIPng
NextHop    : FE80::200:BFF:FE01:1C02                    Preference: 100
Interface  : Vlan100                                    Cost      : 1

Destination: FE80::/10                                  Protocol  : Direct
NextHop    : ::                                         Preference: 0
Interface  : NULL0                                      Cost      : 0

Destination: FF00::/8                                   Protocol  : Direct
NextHop    : ::                                         Preference: 0
Interface  : NULL0                                      Cost      : 0
```

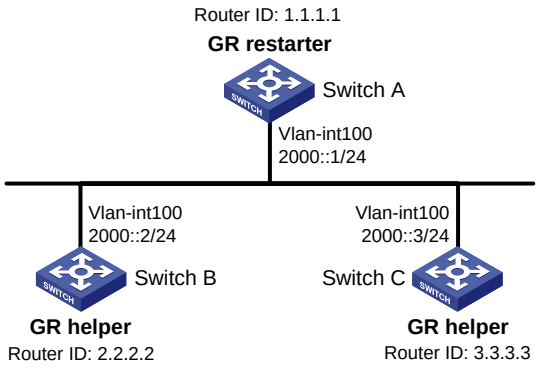
Example: Configuring RIPng GR

Network configuration

As shown in Figure 4, Switch A, Switch B, and Switch C learn IPv6 routing information through RIPng.

Configure Switch A as the GR restarter. Configure Switch B and Switch C as the GR helpers to synchronize their routing tables with Switch A by using GR.

Figure 4 Network diagram



Procedure

1. Configure IPv6 addresses for the interfaces. (Details not shown.)
2. Configure RIPng on the switches to ensure the following: (Details not shown.)
   - Switch A, Switch B, and Switch C can communicate with each other at Layer 3.

- Dynamic route update can be implemented among them with RIPng.

3. Enable RIPng GR on Switch A.

```
<SwitchA> system-view
[SwitchA] ripng 1
[SwitchA-ripng-1] graceful-restart
```

Verifying the configuration

Restart RIPng or trigger an active/standby switchover, and then display GR status on Switch A.

```
<SwitchA> display ripng 1 graceful-restart
RIPng process: 1
 Graceful Restart capability     : Enabled
 Current GR state                : Normal
 Graceful Restart period         : 60  seconds
 Graceful Restart remaining time: 0   seconds
```

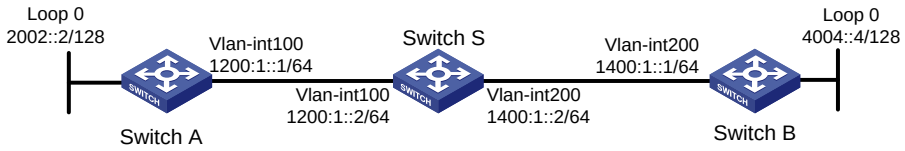
Example: Configuring RIPng NSR

Network configuration

As shown in Figure 5, Switch S, Switch A, and Switch B learn IPv6 routing information through RIPng.

Enable RIPng NSR on Switch S to ensure correct routing when an active/standby switchover occurs on Switch S.

Figure 5 Network diagram



Procedure

1. Configure IPv6 addresses for the interfaces. (Details not shown.)
2. Configure RIPng on the switches to ensure the following: (Details not shown.)
   - Switch S, Switch A, and Switch B can communicate with each other at Layer 3.
   - Dynamic route update can be implemented among them with RIPng.
3. Enable RIPng NSR on Switch S.

```
<SwitchS> system-view
[SwitchS] ripng 1
[SwitchS-ripng-1] non-stop-routing
[SwitchS-ripng-1] quit
```

Verifying the configuration

Perform an active/standby switchover on Switch S.

```
[SwitchS] placement reoptimize
Predicted changes to the placement
Program                          Current location       New location
-------------------------------------------------------------------
lb                               0/0                    0/0
lsm                              0/0                    0/0
```

```
slsp                              0/0                   0/0
rib6                              0/0                   0/0
routepolicy                       0/0                   0/0
rib                               0/0                   0/0
staticroute6                      0/0                   0/0
staticroute                       0/0                   0/0
ripng                             0/0                   1/0
Continue? [y/n]:y
Re-optimization of the placement start. You will be notified on completion
Re-optimization of the placement complete. Use 'display placement' to view the new
placement
```

During the switchover period, display RIPng neighbors on Switch A to verify the neighbor relationship between Switch A and Switch S.

```
[SwitchA] display ripng 1 neighbor
 Neighbor Address: FE80::AE45:5CE7:422E:2867
     Interface  : Vlan-interface100
     Version    : RIPng version 1     Last update: 00h00m23s
     Bad packets: 0                   Bad routes : 0
```

Display RIPng routes on Switch A to verify if Switch A has a route to the loopback interface on Switch B.

```
[SwitchA] display ripng 1 route
   Route Flags: A - Aging, S - Suppressed, G - Garbage-collect, D - Direct
                O - Optimal, F - Flush to RIB
 ------------------------------------------------------------------
 Peer FE80::AE45:5CE7:422E:2867 on Vlan-interface100
 Destination 1400:1::/64,
     via FE80::AE45:5CE7:422E:2867, cost 1, tag 0, AOF, 1 secs
 Destination 4004::4/128,
     via FE80::AE45:5CE7:422E:2867, cost 2, tag 0, AOF, 1 secs
 Local route
 Destination 2002::2/128,
     via ::, cost 0, tag 0, DOF
 Destination 1200:1::/64,
     via ::, cost 0, tag 0, DOF
```

Display RIPng neighbors on Switch B to verify the neighbor relationship between Switch B and Switch S.

```
[SwitchB] display ripng 1 neighbor
 Neighbor Address: FE80::20C:29FF:FECE:6277
     Interface  : Vlan-interface200
     Version    : RIPng version 1     Last update: 00h00m18s
     Bad packets: 0                   Bad routes : 0
```

Display RIPng routes on Switch B to verify if Switch B has a route to the loopback interface on Switch A.

```
[SwitchB] display ripng 1 route
   Route Flags: A - Aging, S - Suppressed, G - Garbage-collect, D - Direct
                O - Optimal, F - Flush to RIB
 ------------------------------------------------------------------
 Peer FE80::20C:29FF:FECE:6277 on Vlan-interface200
```

```
Destination 2002::2/128,
    via FE80::20C:29FF:FECE:6277, cost 2, tag 0, AOF, 24 secs
Destination 1200:1::/64,
    via FE80::20C:29FF:FECE:6277, cost 1, tag 0, AOF, 24 secs
Local route
Destination 4004::4/128,
    via ::, cost 0, tag 0, DOF
Destination 1400:1::/64,
    via ::, cost 0, tag 0, DOF
```

The output shows the following when an active/standby switchover occurs on Switch S:

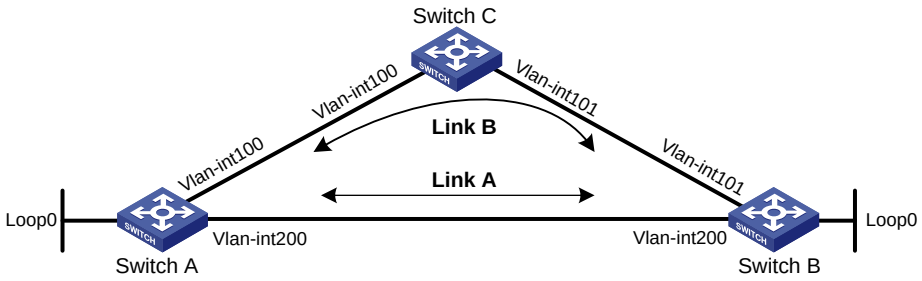
- The neighbor relationships and routing information on Switch A and Switch B have not changed.
- The traffic from Switch A to Switch B has not been impacted.

Example: Configuring RIPng FRR

Network configuration

As shown in Figure 6, Switch A, Switch B, and Switch C run RIPng. Configure RIPng FRR so that when Link A becomes unidirectional, traffic can be switched to Link B immediately.

Figure 6 Network diagram



Device	Interface	IP address
Switch A	VLAN-interface 100	1::1/64
Switch A	VLAN-interface 200	2::1/64
Switch A	Loopback 0	10::1/128
Switch B	VLAN-interface 101	3::1/64
Switch B	VLAN-interface 200	2::2/64
Switch B	Loopback 0	20::1/128
Switch C	VLAN-interface 100	1::2/64
Switch C	VLAN-interface 101	3::2/64

Procedure

1. Configure IPv6 addresses for the interfaces on the switches. (Details not shown.)
2. Configure RIPng on the switches to make sure Switch A, Switch B, and Switch C can communicate with each other at Layer 3. (Details not shown.)
3. Configure RIPng FRR:

   # Configure Switch A.

```
<SwitchA> system-view
[SwitchA] ipv6 prefix-list abc index 10 permit 20::1 128
[SwitchA] route-policy frr permit node 10
[SwitchA-route-policy-frr-10] if-match ipv6 address prefix-list abc
[SwitchA-route-policy-frr-10] apply ipv6 fast-reroute backup-interface
vlan-interface 100 backup-nexthop 1::2
[SwitchA-route-policy-frr-10] quit
[SwitchA] ripng 1
[SwitchA-ripng-1] fast-reroute route-policy frr
[SwitchA-ripng-1] quit
```

Configure Switch B.

```
<SwitchB> system-view
[SwitchB] ipv6 prefix-list abc index 10 permit 10::1 128
[SwitchB] route-policy frr permit node 10
[SwitchB-route-policy-frr-10] if-match ipv6 address prefix-list abc
[SwitchB-route-policy-frr-10] apply ipv6 fast-reroute backup-interface
vlan-interface 101 backup-nexthop 3::2
[SwitchB-route-policy-frr-10] quit
[SwitchB] ripng 1
[SwitchB-ripng-1] fast-reroute route-policy frr
[SwitchB-ripng-1] quit
```

Verifying the configuration

Display the route 20::1/128 on Switch A to view the backup next hop information.

```
[SwitchA] display ipv6 routing-table 20::1 128 verbose

Summary count : 1

Destination: 20::1/128
   Protocol: RIPng
 Process ID: 1
  SubProtID: 0x0                  Age: 00h17m42s
       Cost: 1              Preference: 100
      IpPre: N/A            QosLocalID: N/A
        Tag: 0                   State: Inactive Adv
  OrigTblID: 0x0               OrigVrf: default-vrf
    TableID: 0xa                OrigAs: 0
      NibID: 0x22000003         LastAs: 0
     AttrID: 0xffffffff       Neighbor: FE80::34CD:9FF:FE2F:D02
      Flags: 0x41           OrigNextHop: FE80::34CD:9FF:FE2F:D02
      Label: NULL           RealNextHop: FE80::34CD:9FF:FE2F:D02
    BkLabel: NULL             BkNextHop: FE80::7685:45FF:FEAD:102
    SRLabel: NULL             BkSRLabel: NULL
  Tunnel ID: Invalid          Interface: Vlan-interface200
BkTunnel ID: Invalid        BkInterface: Vlan-interface100
   FtnIndex: 0x0           TrafficIndex: N/A
  Connector: N/A                 PathID: 0x0
```

Display the route 10::1/128 on Switch B to view the backup next hop information.

```
[SwitchB] display ipv6 routing-table 10::1 128 verbose
```

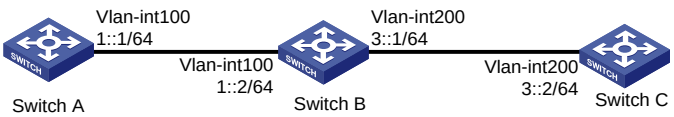
```
Summary count : 1

Destination: 10::1/128
   Protocol: RIPng
 Process ID: 1
  SubProtID: 0x0                  Age: 00h22m34s
       Cost: 1              Preference: 100
      IpPre: N/A            QosLocalID: N/A
        Tag: 0                   State: Inactive Adv
  OrigTblID: 0x0               OrigVrf: default-vrf
    TableID: 0xa                OrigAs: 0
      NibID: 0x22000001         LastAs: 0
     AttrID: 0xffffffff       Neighbor: FE80::34CC:E8FF:FE5B:C02
      Flags: 0x41           OrigNextHop: FE80::34CC:E8FF:FE5B:C02
      Label: NULL           RealNextHop: FE80::34CC:E8FF:FE5B:C02
    BkLabel: NULL             BkNextHop: FE80::7685:45FF:FEAD:102
    SRLabel: NULL             BkSRLabel: NULL
  Tunnel ID: Invalid          Interface: Vlan-interface200
BkTunnel ID: Invalid        BkInterface: Vlan-interface101
   FtnIndex: 0x0            TrafficIndex: N/A
  Connector: N/A                 PathID: 0x0
```

Example: Configuring RIPng IPsec profile

Network configuration

As shown in Figure 7, configure RIPng on the switches, and configure IPsec profiles on the switches to authenticate and encrypt protocol packets.

Figure 7 Network diagram



Procedure

1. Configure IPv6 addresses for the interfaces. (Details not shown.)
2. Configure basic RIPng settings:

   # Configure Switch A.

   ```
   <SwitchA> system-view
   [SwitchA] ripng 1
   [SwitchA-ripng-1] quit
   [SwitchA] interface vlan-interface 100
   [SwitchA-Vlan-interface100] ripng 1 enable
   [SwitchA-Vlan-interface100] quit
   ```

   # Configure Switch B.

   ```
   <SwitchB> system-view
   [SwitchB] ripng 1
   [SwitchB-ripng-1] quit
   ```

```
[SwitchB] interface vlan-interface 200
[SwitchB-Vlan-interface200] ripng 1 enable
[SwitchB-Vlan-interface200] quit
[SwitchB] interface vlan-interface 100
[SwitchB-Vlan-interface100] ripng 1 enable
[SwitchB-Vlan-interface100] quit
```

Configure Switch C.

```
<SwitchC> system-view
[SwitchC] ripng 1
[SwitchC-ripng-1] quit
[SwitchC] interface vlan-interface 200
[SwitchC-Vlan-interface200] ripng 1 enable
[SwitchC-Vlan-interface200] quit
```

3. Configure RIPng IPsec profiles:

- On Switch A:

  # Create an IPsec transform set named **protrf1**.

  ```
  [SwitchA] ipsec transform-set protrf1
  ```

  # Specify the ESP encryption and authentication algorithms.

  ```
  [SwitchA-ipsec-transform-set-protrf1] esp encryption-algorithm 3des-cbc
  [SwitchA-ipsec-transform-set-protrf1] esp authentication-algorithm md5
  ```

  # Specify transport mode for encapsulation.

  ```
  [SwitchA-ipsec-transform-set-protrf1] encapsulation-mode transport
  [SwitchA-ipsec-transform-set-protrf1] quit
  ```

  # Create a manual IPsec profile named **profile001**.

  ```
  [SwitchA] ipsec profile profile001 manual
  ```

  # Reference IPsec transform set **protrf1**.

  ```
  [SwitchA-ipsec-profile-profile001-manual] transform-set protrf1
  ```

  # Configure the inbound and outbound SPIs for ESP.

  ```
  [SwitchA-ipsec-profile-profile001-manual] sa spi inbound esp 256
  [SwitchA-ipsec-profile-profile001-manual] sa spi outbound esp 256
  ```

  # Configure the inbound and outbound SA keys for ESP.

  ```
  [SwitchA-ipsec-profile-profile001-manual] sa string-key inbound esp simple abc
  [SwitchA-ipsec-profile-profile001-manual] sa string-key outbound esp simple abc
  [SwitchA-ipsec-profile-profile001-manual] quit
  ```

- On Switch B:

  # Create an IPsec transform set named **protrf1**.

  ```
  [SwitchB] ipsec transform-set protrf1
  ```

  # Specify the ESP encryption and authentication algorithms.

  ```
  [SwitchB-ipsec-transform-set-protrf1] esp encryption-algorithm 3des-cbc
  [SwitchB-ipsec-transform-set-protrf1] esp authentication-algorithm md5
  ```

  # Specify transport mode for encapsulation.

  ```
  [SwitchB-ipsec-transform-set-protrf1] encapsulation-mode transport
  [SwitchB-ipsec-transform-set-protrf1] quit
  ```

  # Create a manual IPsec profile named **profile001**.

  ```
  [SwitchB] ipsec profile profile001 manual
  ```

  # Reference IPsec transform set **protrf1**.

  ```
  [SwitchB-ipsec-profile-profile001-manual] transform-set protrf1
  ```

Configure the inbound and outbound SPIs for ESP.

```
[SwitchB-ipsec-profile-profile001-manual] sa spi inbound esp 256
[SwitchB-ipsec-profile-profile001-manual] sa spi outbound esp 256
```

Configure the inbound and outbound SA keys for ESP.

```
[SwitchB-ipsec-profile-profile001-manual] sa string-key inbound esp simple abc
[SwitchB-ipsec-profile-profile001-manual] sa string-key outbound esp simple abc
[SwitchB-ipsec-profile-profile001-manual] quit
```

- On Switch C:

  # Create an IPsec transform set named **protrf1**.

  ```
  [SwitchC] ipsec transform-set protrf1
  ```

  # Specify the ESP encryption and authentication algorithms.

  ```
  [SwitchC-ipsec-transform-set-protrf1] esp encryption-algorithm 3des-cbc
  [SwitchC-ipsec-transform-set-protrf1] esp authentication-algorithm md5
  ```

  # Specify transport mode for encapsulation.

  ```
  [SwitchC-ipsec-transform-set-protrf1] encapsulation-mode transport
  [SwitchC-ipsec-transform-set-protrf1] quit
  ```

  # Create a manual IPsec profile named **profile001**.

  ```
  [SwitchC] ipsec profile profile001 manual
  ```

  # Reference IPsec transform set **protrf1**.

  ```
  [SwitchC-ipsec-profile-profile001-manual] transform-set protrf1
  ```

  # Configure the inbound and outbound SPIs for ESP.

  ```
  [SwitchC-ipsec-profile-profile001-manual] sa spi inbound esp 256
  [SwitchC-ipsec-profile-profile001-manual] sa spi outbound esp 256
  ```

  # Configure the inbound and outbound SA keys for ESP.

  ```
  [SwitchC-ipsec-profile-profile001-manual] sa string-key inbound esp simple abc
  [SwitchC-ipsec-profile-profile001-manual] sa string-key outbound esp simple abc
  [SwitchC-ipsec-profile-profile001-manual] quit
  ```

4. Apply the IPsec profiles to the RIPng process on each device:
   - On Switch A:

     ```
     [SwitchA] ripng 1
     [SwitchA-ripng-1] enable ipsec-profile profile001
     [SwitchA-ripng-1] quit
     ```

   - On Switch B:

     ```
     [SwitchB] ripng 1
     [SwitchB-ripng-1] enable ipsec-profile profile001
     [SwitchB-ripng-1] quit
     ```

   - On Switch C:

     ```
     [SwitchC] ripng 1
     [SwitchC-ripng-1] enable ipsec-profile profile001
     [SwitchC-ripng-1] quit
     ```

Verifying the configuration

Verify that the RIPng packets between Switches A, B and C are protected by IPsec. (Details not shown.)

Contents

Configuring OSPFv3

About OSPFv3

This chapter describes how to configure RFC 2740-compliant Open Shortest Path First version 3 (OSPFv3) for an IPv6 network.

Comparison of OSPFv3 with OSPFv2

OSPFv3 and OSPFv2 have the following in common:

- 32-bit router ID and area ID.
- Hello, Database Description (DD), Link State Request (LSR), Link State Update (LSU), Link State Acknowledgment (LSAck).
- Mechanisms for finding neighbors and establishing adjacencies.
- Mechanisms for advertising and aging LSAs.

OSPFv3 and OSPFv2 have the following differences:

- OSPFv3 runs on a per-link basis. OSPFv2 runs on a per-IP-subnet basis.
- OSPFv3 supports running multiple processes on an interface, but OSPFv2 does not support.
- OSPFv3 identifies neighbors by router ID. OSPFv2 identifies neighbors by IP address.

For more information about OSPFv2, see "Configuring OSPF."

OSPFv3 packets

OSPFv3 uses the following packet types:

- **Hello**—Periodically sent to find and maintain neighbors, containing timer values, information about the DR, BDR, and known neighbors.
- **DD**—Describes the digest of each LSA in the LSDB, exchanged between two routers for data synchronization.
- **LSR**—Requests needed LSAs from the neighbor. After exchanging the DD packets, the two routers know which LSAs of the neighbor are missing from their LSDBs. They then send an LSR packet to each other, requesting the missing LSAs. The LSA packet contains the digest of the missing LSAs.
- **LSU**—Transmits the requested LSAs to the neighbor.
- **LSAck**—Acknowledges received LSU packets.

OSPFv3 LSA types

OSPFv3 sends routing information in LSAs. The following LSAs are commonly used:

- **Router LSA**—Type-1 LSA, originated by all routers. This LSA describes the collected states of the router's interfaces to an area, and is flooded throughout a single area only.
- **Network LSA**—Type-2 LSA, originated for broadcast and NBMA networks by the DR. This LSA contains the list of routers connected to the network, and is flooded throughout a single area only.
- **Inter-Area-Prefix LSA**—Type-3 LSA, originated by ABRs and flooded throughout the LSA's associated area. Each Inter-Area-Prefix LSA describes a route with IPv6 address prefix to a destination outside the area, yet still inside the AS.

- **Inter-Area-Router LSA**—Type-4 LSA, originated by ABRs and flooded throughout the LSA's associated area. Each Inter-Area-Router LSA describes a route to ASBR.
- **AS External LSA**—Type-5 LSA, originated by ASBRs, and flooded throughout the AS, except stub areas and Not-So-Stubby Areas (NSSAs). Each AS External LSA describes a route to another AS. A default route can be described by an AS External LSA.
- **NSSA LSA**—Type-7 LSA, originated by ASBRs in NSSAs and flooded throughout a single NSSA. NSSA LSAs describe routes to other ASs.
- **Link LSA**—Type-8 LSA. A router originates a separate Link LSA for each attached link. Link LSAs have link-local flooding scope. Each Link LSA describes the IPv6 address prefix of the link and Link-local address of the router.
- **Intra-Area-Prefix LSA**—Type-9 LSA. Each Intra-Area-Prefix LSA contains IPv6 prefix information on a router, stub area, or transit area information, and has area flooding scope. It was introduced because Router LSAs and Network LSAs contain no address information.
- **Grace LSA**—Type-11 LSA, generated by a GR restarter at reboot and transmitted on the local link. The GR restarter describes the cause and interval of the reboot in the Grace LSA to notify its neighbors that it performs a GR operation.

Protocols and standards

- RFC 2328, *OSPF Version 2*
- RFC 3101, *OSPF Not-So-Stubby Area (NSSA) Option*
- RFC 4552, *Authentication/Confidentiality for OSPFv3*
- RFC 5187, *OSPFv3 Graceful Restart*
- RFC 5286, *Basic Specification for IP Fast Reroute: Loop-Free Alternates*
- RFC 5329, *Traffic Engineering Extensions to OSPF Version 3*
- RFC 5340, *OSPF for IPv6*
- RFC 5643, *Management Information Base for OSPFv3*
- RFC 6506, *Supporting Authentication Trailer for OSPFv3*
- RFC 6969, *OSPFv3 Instance ID Registry Update*
- RFC 7166, *Supporting Authentication Trailer for OSPFv3*

Restrictions: Hardware compatibility with OSPFv3

The S5110V2-SI, S5000V3-EI, S5000V5-EI, S5000E-X, S5000X-EI, and WAS6000 switch series do not support OSPFv3.

OSPFv3 tasks at a glance

To configure OSPFv3, perform the following tasks:

1. Enabling OSPFv3
2. (Optional.) Configuring OSPFv3 area parameters
   - Configuring a stub area
   - Configuring an NSSA area
   - Configuring an OSPFv3 virtual link

     Perform this task on an ABR to create a virtual link when connectivity cannot be maintained between a non-backbone area and the backbone, or within the backbone.
3. (Optional.) Configuring OSPFv3 network types

- Setting the broadcast network type for an OSPFv3 interface
- Setting the NBMA network type for an OSPFv3 interface
- Setting the P2MP network type for an OSPFv3 interface
- Setting the P2P network type for an OSPFv3 interface

4. (Optional.) Configuring OSPFv3 route control
   - Configuring OSPFv3 inter-area route summarization
   - Configuring OSPFv3 received route filtering
   - Configuring Inter-Area-Prefix LSA filtering
   - Setting an OSPFv3 cost for an interface
   - Setting a preference for OSPFv3
   - Configuring OSPFv3 route redistribution
5. (Optional.) Setting OSPFv3 timers
   - Setting OSPFv3 packet timers
   - Setting LSA transmission delay
   - Setting SPF calculation interval
   - Setting the LSA generation interval
   - Setting the LSU transmit rate
6. (Optional.) Setting a DR priority for an interface
7. (Optional.) Configuring OSPFv3 packet parameters
   - Ignoring MTU check for DD packets
   - Disabling interfaces from receiving and sending OSPFv3 packets
8. (Optional.) Configuring prefix suppression
9. (Optional.) Configuring a stub router
10. (Optional.) Enhancing OSPFv3 availability
    - Configuring OSPFv3 GR
    - Configuring OSPFv3 NSR
    - Configuring BFD for OSPFv3
    - Configuring OSPFv3 FRR
11. (Optional.) Enhancing OSPFv3 security
    - Configuring OSPFv3 authentication
    - Applying an IPsec profile for authenticating OSPFv3 packets
12. (Optional.) Configuring OSPFv3 logging and SNMP notifications
    - Enabling logging for neighbor state changes
    - Setting the maximum number of OSPFv3 logs
    - Configuring OSPFv3 network management

Enabling OSPFv3

About enabling OSPFv3

To enable an OSPFv3 process on a router:

1. Enable the OSPFv3 process globally.
2. Assign the OSPFv3 process a router ID.
3. Enable the OSPFv3 process on related interfaces.

An OSPFv3 process ID has only local significance. Process 1 on a router can exchange packets with process 2 on another router.

OSPFv3 requires you to manually specify a router ID for each router in an AS. Make sure all assigned router IDs in the AS are unique.

Restrictions and guideline

If a router runs multiple OSPFv3 processes, you must specify a unique router ID for each process.

Procedure

1. Enter system view.
   system-view
2. Enable an OSPFv3 process and enter its view.
   ospfv3 [*process-id*]
   By default, no OSPFv3 processes are enabled.
3. Specify a router ID.
   router-id *router-id*
   By default, no router ID is configured.
4. Enter interface view.
   interface *interface-type interface-number*
5. Enable an OSPFv3 process on the interface.
   ospfv3 *process-id* **area** *area-id* [**instance** *instance-id*]
   By default, no OSPFv3 processes are enabled on an interface.

Configuring OSPFv3 area parameters

About OSPFv3 areas

OSPFv3 has the same stub area, NSSA area, and virtual link features as OSPFv2.

After you split an OSPFv3 AS into multiple areas, the LSA number is reduced and OSPFv3 applications are extended. To further reduce the size of routing tables and the number of LSAs, configure the non-backbone areas at an AS edge as stub areas.

A stub area cannot import external routes, but an NSSA area can import external routes into the OSPFv3 routing domain while retaining other stub area characteristics.

Non-backbone areas exchange routing information through the backbone area, so the backbone and non-backbone areas (including the backbone itself) must be fully meshed. If no connectivity can be achieved, configure virtual links.

Configuring a stub area

Restrictions and guidelines

To configure a stub area, you must perform this task on all routers attached to the area.

Procedure

1. Enter system view.
   system-view
2. Enter OSPFv3 view.
   ospfv3 [*process-id*]

3. Enter OSPFv3 area view.

   area *area-id*

4. Configure the area as a stub area.

   stub [**default-route-advertise-always** | **no-summary**] *

   By default, no area is configured as a stub area.

   The **no-summary** keyword is only available on the ABR of a stub area. If you specify the **no-summary** keyword, the ABR only advertises a default route in an Inter-Area-Prefix LSA into the stub area.

5. (Optional.) Set a cost for the default route advertised to the stub area.

   default-cost *cost-value*

   By default, the cost for the default route advertised to the stub area is 1.

Configuring an NSSA area

Restrictions and guidelines

To configure an NSSA area, you must perform this task on all routers attached to the area.

Procedure

1. Enter system view.

   system-view

2. Enter OSPFv3 view.

   ospfv3 [*process-id*]

3. Enter OSPFv3 area view.

   area *area-id*

4. Configure the area as an NSSA area.

   nssa [**default-route-advertise** [**cost** *cost-value* | **nssa-only** | **route-policy** *route-policy-name* | **tag** *tag* | **type** *type*] * | **no-import-route** | **no-summary** | [**translate-always** | **translate-never**] | **suppress-fa** | **translator-stability-interval** *value*] *

   By default, no area is configured as an NSSA area.

   To configure a totally NSSA area, execute the **nssa no-summary** command on the ABR. The ABR of a totally NSSA area does not advertise inter-area routes into the area.

5. (Optional.) Set a cost for the default route advertised to the NSSA area.

   default-cost *cost-value*

   By default, the cost for the default route advertised to the NSSA area is 1.

   This command takes effect only on the ABR/ASBR of an NSSA or totally NSSA area.

Configuring an OSPFv3 virtual link

About OSPFv3 virtual links

You can configure a virtual link to maintain connectivity between a non-backbone area and the backbone, or in the backbone itself.

Restrictions and guidelines

Both ends of a virtual link are ABRs that must be configured with the **vlink-peer** command.

Procedure

1. Enter system view.
   system-view
2. Enter OSPFv3 view.
   ospfv3 [*process-id*]
3. Enter OSPFv3 area view.
   area *area-id*
4. Configure a virtual link.
   vlink-peer *router-id* [**dead** *seconds* | **hello** *seconds* | **instance** *instance-id* | **ipsec-profile** *profile-name* | **retransmit** *seconds* | **trans-delay** *seconds*] *

Configuring OSPFv3 network types

Restrictions and guidelines for OSPFv3 network type configuration

Based on the link layer protocol, OSPFv3 classifies networks into different types, including broadcast, NBMA, P2MP, and P2P.

- If any routers in a broadcast network do not support multicasting, you can change the network type to NBMA.
- If only two routers running OSPFv3 exist on a network segment, you can change the network type to P2P to save costs.

Setting the broadcast network type for an OSPFv3 interface

1. Enter system view.
   system-view
2. Enter interface view.
   interface *interface-type interface-number*
3. Set the network type to broadcast for the OSPFv3 interface.
   ospfv3 network-type broadcast [**instance** *instance-id*]
   By default, the network type of an interface is broadcast.

Setting the NBMA network type for an OSPFv3 interface

Restrictions and guidelines

For NBMA interfaces, you must specify the link-local IP addresses and DR priorities for their neighbors because these interfaces cannot find neighbors by broadcasting hello packets.

Procedure

1. Enter system view.
   system-view
2. Enter interface view.
   interface *interface-type interface-number*
3. Set the network type to NBMA for the OSPFv3 interface.

ospfv3 network-type nbma [**instance** *instance-id*]

By default, the network type of an interface is broadcast.

4. (Optional.) Set the router priority for the interface

   ospfv3 dr-priority *priority*

   By default, an interface has a router priority of 1.

   An interface's router priority determines its privilege in DR/BDR selection.

5. Specify an NBMA neighbor.

   ospfv3 peer *ipv6-address* [**cost** *cost-value* | **dr-priority** *priority*] [**instance** *instance-id*]

   By default, no link-local address is specified for the neighbor interface.

Setting the P2MP network type for an OSPFv3 interface

Restrictions and guidelines

For P2MP interfaces (only when in unicast mode), you must specify the link-local IP addresses of their neighbors because these interfaces cannot find neighbors by broadcasting hello packets.

Procedure

1. Enter system view.

   system-view

2. Enter interface view.

   interface *interface-type interface-number*

3. Set the network type to P2MP for the OSPFv3 interface.

   ospfv3 network-type p2mp [**unicast**] [**instance** *instance-id*]

   By default, the network type of an interface is broadcast.

4. Specify a P2MP unicast neighbor.

   ospfv3 peer *ipv6-address* [**cost** *cost-value* | **dr-priority** *priority*] [**instance** *instance-id*]

   By default, no link-local address is specified for the neighbor interface.

Setting the P2P network type for an OSPFv3 interface

1. Enter system view.

   system-view

2. Enter interface view.

   interface *interface-type interface-number*

3. Set the network type to P2P for the OSPFv3 interface.

   ospfv3 network-type p2p [**instance** *instance-id*]

   By default, the network type of an interface is broadcast.

Configuring OSPFv3 route control

Configuring OSPFv3 inter-area route summarization

About OSPFv3 inter-area route summarization

If contiguous network segments exist in an area, you can summarize them into one network segment on the ABR. The ABR will advertise only the summary route. Any LSA on the specified network segment will not be advertised, reducing the LSDB size in other areas.

Procedure

1. Enter system view.
   system-view
2. Enter OSPFv3 view.
   ospfv3 [*process-id*]
3. Enter OSPFv3 area view.
   area *area-id*
4. Configure route summarization on the ABR.
   abr-summary *ipv6-address prefix-length* [**not-advertise**] [**cost** *cost-value*]
   By default, route summarization is not configured on an ABR.

Configuring redistributed route summarization

About redistributed route summarization

Perform this task to enable an ASBR to summarize external routes within the specified address range into a single route.

An ASBR can summarize routes in the following LSAs:

- Type-5 LSAs.
- Type-7 LSAs in an NSSA area.
- Type-5 LSAs translated from Type-7 LSAs in an NSSA area if the ASBR (also an ABR) is a translator. If the ASBR is not a translator, it cannot summarize routes in Type-5 LSAs translated from Type-7 LSAs.

Procedure

1. Enter system view.
   system-view
2. Enter OSPFv3 view.
   ospfv3 [*process-id*]
3. Configure route summarization on an ASBR.
   asbr-summary *ipv6-address prefix-length* [**cost** *cost-value* | **not-advertise** | **nssa-only** | **tag** *tag*] *
   By default, route summarization is not configured on an ASBR.

Configuring OSPFv3 received route filtering

About OSPFv3 received route filtering

This task allows you to filter routes calculated by using received LSAs.

Procedure

1. Enter system view.

   system-view

2. Enter OSPFv3 view.

   ospfv3 [*process-id*]

3. Configure OSPFv3 to filter routes calculated by using received LSAs.

   filter-policy { *ipv6-acl-number* [**gateway** *prefix-list-name*] | **prefix-list** *prefix-list-name* [**gateway** *prefix-list-name*] | **gateway** *prefix-list-name* | **route-policy** *route-policy-name* } **import**

   By default, OSPFv3 accepts all routes calculated by using received LSAs.

   This command can only filter routes computed by OSPFv3. Only routes not filtered out can be added into the local routing table.

Configuring Inter-Area-Prefix LSA filtering

Restrictions and guidelines

The **filter** command takes effect only on ABRs.

Procedure

1. Enter system view.

   system-view

2. Enter OSPFv3 view.

   ospfv3 [*process-id*]

3. Enter OSPFv3 area view.

   area *area-id*

4. Configure OSPFv3 to filter Inter-Area-Prefix LSAs.

   filter { *ipv6-acl-number* | **prefix-list** *prefix-list-name* | **route-policy** *route-policy-name* } { **export** | **import** }

   By default, OSPFv3 accepts all Inter-Area-Prefix LSAs.

Setting an OSPFv3 cost for an interface

About setting an OSPFv3 cost for an interface

You can set an OSPFv3 cost for an interface with one of the following methods:

- Set the cost value in interface view.
- Set a bandwidth reference value for the interface, and OSPFv3 computes the cost automatically based on the bandwidth reference value by using the following formula:

  Interface OSPFv3 cost = Bandwidth reference value (100 Mbps) / Interface bandwidth (Mbps)

  - If the calculated cost is greater than 65535, the value of 65535 is used.
  - If the calculated cost is smaller than 1, the value of 1 is used.
- If no cost is set for an interface, OSPFv3 automatically computes the cost for the interface.

Setting a cost in interface view

1. Enter system view.
   system-view
2. Enter interface view.
   interface *interface-type interface-number*
3. Set an OSPFv3 cost for the interface.
   ospfv3 cost *cost-value* [**instance** *instance-id*]
   By default, the OSPFv3 cost is 1 for a VLAN interface, is 0 for a loopback interface. The OSPFv3 cost is automatically computed according to the interface bandwidth for other interfaces.

Setting a bandwidth reference value

1. Enter system view.
   system-view
2. Enter OSPFv3 view.
   ospfv3 [*process-id*]
3. Set a bandwidth reference value.
   bandwidth-reference *value*
   The default bandwidth reference value is 100 Mbps.

Setting a preference for OSPFv3

About routing protocol preference

A router can run multiple routing protocols. The system assigns a priority for each protocol. When these routing protocols find the same route, the route found by the protocol with the highest priority is selected.

Procedure

1. Enter system view.
   system-view
2. Enter OSPFv3 view.
   ospfv3 [*process-id*]
3. Set a preference for OSPFv3.
   preference [**ase**] { *preference* | **route-policy** *route-policy-name* } *
   By default, the preference of OSPFv3 internal routes is 10, and the preference of OSPFv3 external routes is 150.

Configuring OSPFv3 route redistribution

Restrictions and guidelines

Because OSPFv3 is a link state routing protocol, it cannot directly filter LSAs to be advertised. OSPFv3 filters only redistributed routes. Only routes that are not filtered out can be advertised in LSAs.

Procedure

1. Enter system view.
   system-view

2. Enter OSPFv3 view.

   ospfv3 [*process-id*]

3. Configure OSPFv3 to redistribute routes from other routing protocols.

   import-route { **direct** | **static** } [**cost** *cost-value* | **nssa-only** | **route-policy** *route-policy-name* | **tag** *tag* | **type** *type*] *

   import-route { **ospfv3** | **ripng** } [*process-id* | **all-processes**] [**allow-direct** | **cost** *cost-value* | **nssa-only** | **route-policy** *route-policy-name* | **tag** *tag* | **type** *type*] *

   By default, route redistribution is disabled.

4. (Optional.) Configure OSPFv3 to filter redistributed routes.

   filter-policy { *ipv6-acl-number* | **prefix-list** *prefix-list-name* } **export** [**direct** | { **ospfv3** | **ripng** } [*process-id*] | **static**]

   By default, OSPFv3 accepts all redistributed routes.

   This command filters only routes redistributed by the **import-route** command. If no routes are redistributed by the **import-route** command, this command does not take effect.

5. Set a tag for redistributed routes.

   default tag *tag*

   By default, the tag of redistributed routes is 1.

Configuring default route redistribution

About default route redistribution

The **import-route** command cannot redistribute a default external route. To redistribute a default route, perform this task.

Procedure

1. Enter system view.

   system-view

2. Enter OSPFv3 view.

   ospfv3 [*process-id*]

3. Redistribute a default route.

   default-route-advertise [[**always** | **permit-calculate-other**] | **cost** *cost-value* | **route-policy** *route-policy-name* | **tag** *tag* | **type** *type*] *

   By default, no default route is redistributed.

4. Set a tag for redistributed routes.

   default tag *tag*

   By default, the tag of redistributed routes is 1.

Setting OSPFv3 timers

Setting OSPFv3 packet timers

1. Enter system view.

   system-view

2. Enter interface view.

   interface *interface-type interface-number*

3. Set the hello interval.

   ospfv3 timer hello *seconds* [**instance** *instance-id*]

   The default hello interval on P2P and broadcast interfaces is 10 seconds. The default hello interval on P2MP and NBMA interfaces is 30 seconds.

4. Set the dead interval.

   ospfv3 timer dead *seconds* [**instance** *instance-id*]

   The default dead interval on P2P and broadcast interfaces is 40 seconds. The default dead interval on P2MP and NBMA interfaces is 120 seconds.

   The dead interval set on neighboring interfaces cannot be too short. If the interval is too short, a neighbor is easily down.

5. Set the poll interval.

   ospfv3 timer poll *seconds* [**instance** *instance-id*]

   By default, the poll interval is 120 seconds.

6. Set the LSA retransmission interval.

   ospfv3 timer retransmit *interval* [**instance** *instance-id*]

   The default LSA retransmission interval is 5 seconds.

   The LSA retransmission interval cannot be too short. If the interval is too short, unnecessary retransmissions will occur.

Setting LSA transmission delay

About setting LSA transmission delay

Each LSA in the LSDB has an age that is incremented by 1 every second, but the age does not change during transmission. Therefore, it is necessary to add a transmission delay into the age time, especially for low-speed links.

Procedure

1. Enter system view.

   system-view

2. Enter interface view.

   interface *interface-type interface-number*

3. Set the LSA transmission delay.

   ospfv3 trans-delay *seconds* [**instance** *instance-id*]

   By default, the LSA transmission delay is 1 second.

Setting SPF calculation interval

About setting SPF calculation interval

LSDB changes result in SPF calculations. When the topology changes frequently, a large amount of network and router resources are occupied by SPF calculation. You can adjust the SPF calculation interval to reduce the impact.

For a stable network, the minimum interval is used. If network changes become frequent, the SPF calculation interval is incremented by the incremental interval × 2^{n-2} for each calculation until the maximum interval is reached. The value *n* is the number of calculation times.

Procedure

1. Enter system view.

   system-view

2. Enter OSPFv3 view.

   ospfv3 [*process-id*]

3. Set the SPF calculation interval.

   spf-schedule-interval *maximum-interval* [*minimum-interval* [*incremental-interval*]]

   By default, the maximum interval is 5 seconds, the minimum interval is 50 milliseconds, and the incremental interval is 200 milliseconds.

Setting the LSA generation interval

About setting the LSA generation interval

You can adjust the LSA generation interval to protect network resources and routers from being over consumed by frequent network changes.

For a stable network, the minimum interval is used. If network changes become frequent, the LSA generation interval is incremented by the incremental interval × 2^{n-2} for each generation until the maximum interval is reached. The value *n* is the number of generation times.

Procedure

1. Enter system view.

   system-view

2. Enter OSPFv3 view.

   ospfv3 [*process-id*]

3. Set the LSA generation interval.

   lsa-generation-interval *maximum-interval* [*minimum-interval* [*incremental-interval*]]

   By default, the maximum interval is 5 seconds, the minimum interval is 0 milliseconds, and the incremental interval is 0 milliseconds.

Setting the LSU transmit rate

About setting the LSU transmit rate

Sending large numbers of LSU packets affects router performance and consumes a large amount of network bandwidth. You can configure the router to send LSU packets at an interval and to limit the maximum number of LSU packets sent out of an OSPFv3 interface at each interval.

Procedure

1. Enter system view.

   system-view

2. Enter OSPFv3 view.

   ospfv3 [*process-id*]

3. Set the LSU transmit rate.

   transmit-pacing interval *interval* **count** *count*

   By default, an OSPFv3 interface sends a maximum of three LSU packets every 20 milliseconds.

Setting a DR priority for an interface

About DR priority

The router priority is used for DR election. Interfaces having the priority 0 cannot become a DR or BDR.

Procedure

1. Enter system view.
   system-view
2. Enter interface view.
   interface *interface-type interface-number*
3. Set a router priority.
   ospfv3 dr-priority *priority* [**instance** *instance-id*]
   The default router priority is 1.

Configuring OSPFv3 packet parameters

Ignoring MTU check for DD packets

About ignoring MTU check for DD packets

When LSAs are few in DD packets, it is unnecessary to check the MTU in DD packets to improve efficiency.

Restrictions and guidelines

A neighbor relationship can be established only if the interface's MTU is the same as that of the peer.

Procedure

1. Enter system view.
   system-view
2. Enter interface view.
   interface *interface-type interface-number*
3. Ignore MTU check for DD packets.
   ospfv3 mtu-ignore [**instance** *instance-id*]
   By default, OSPFv3 does not ignore MTU check for DD packets.

Disabling interfaces from receiving and sending OSPFv3 packets

About disabling interfaces from receiving and sending OSPFv3 packets

After an OSPFv3 interface is set to **silent**, direct routes of the interface can still be advertised in Intra-Area-Prefix LSAs through other interfaces, but other OSPFv3 packets cannot be advertised. No neighboring relationship can be established on the interface. This feature can enhance the adaptability of OSPFv3 networking.

Procedure

1. Enter system view.
   system-view

2. Enter OSPFv3 view.

   ospfv3 [*process-id*]

3. Disable interfaces from receiving and sending OSPFv3 packets.

   silent-interface { *interface-type interface-number* | **all** }

   By default, the interfaces can receive and send OSPFv3 packets.

   This command disables only the interfaces that run the current process. However, multiple OSPFv3 processes can disable the same interface from receiving and sending OSPFv3 packets.

Configuring prefix suppression

About prefix suppression

By default, an OSPFv3 interface advertises all of its prefixes in LSAs. To speed up OSPFv3 convergence, you can suppress interfaces from advertising all of their prefixes. This feature helps improve network security by preventing IP routing to the suppressed networks.

When prefix suppression is enabled:

- OSPFv3 does not advertise the prefixes of suppressed interfaces in Type-8 LSAs.
- On broadcast and NBMA networks, the DR does not advertise the prefixes of suppressed interfaces in Type-9 LSAs that reference Type-2 LSAs.
- On P2P and P2MP networks, OSPFv3 does not advertise the prefixes of suppressed interfaces in Type-9 LSAs that reference Type-1 LSAs.

Restrictions and guidelines for prefix suppression

As a best practice, configure prefix suppression on all OSPFv3 routers if you want to use prefix suppression.

Configuring prefix suppression for an OSPFv3 process

1. Enter system view.

   system-view

2. Enter OSPFv3 view.

   ospfv3 [*process-id*]

3. Enable prefix suppression for the OSPFv3 process.

   prefix-suppression

   By default, prefix suppression is disabled for an OSPFv3 process.

   Enabling prefix suppression for an OSPFv3 process does not suppress the prefixes of loopback interfaces and passive interfaces.

Configuring prefix suppression for an interface

1. Enter system view.

   system-view

2. Enter interface view.

   interface *interface-type interface-number*

3. Enable prefix suppression for the interface.

ospfv3 prefix-suppression [**disable**] [**instance** *instance-id*]

By default, prefix suppression is disabled for an interface.

Configuring a stub router

About stub routers

A stub router is used for traffic control. It reports its status as a stub router to neighboring OSPFv3 routers. The neighboring routers can have a route to the stub router, but they do not use the stub router to forward data.

Use either of the following methods to configure a router as a stub router:

- Clear the R-bit of the Option field in Type-1 LSAs. When the R-bit is clear, the OSPFv3 router can participate in OSPFv3 topology distribution without forwarding traffic.
- Use the OSPFv3 max-metric router LSA feature. This feature enables OSPFv3 to advertise its locally generated Type-1 LSAs with a maximum cost of 65535. Neighbors do not send packets to the stub router as long as they have a route with a smaller cost.

Procedure

1. Enter system view.

   system-view
2. Enter OSPFv3 view.

   ospfv3 [*process-id*]
3. Configure the router as a stub router.
   - Configure the router as a stub router and clear the R-bit of the Option field in Type-1 LSAs.

     stub-router r-bit [**include-stub** | **on-startup** *seconds*] *
   - Configure the router as a stub router and advertise the locally generated Type-1 LSAs with the maximum cost of 65535.

     stub-router max-metric [**external-lsa** [*max-metric-value*] | **summary-lsa** [*max-metric-value*] | **include-stub** | **on-startup** *seconds*] *

   By default, the router is not configured as a stub router.

   A stub router is not related to a stub area.

Configuring OSPFv3 GR

About OSPFv3 GR

GR ensures forwarding continuity when a routing protocol restarts or an active/standby switchover occurs.

Two routers are required to complete a GR process. The following are router roles in a GR process:

- **GR restarter**—Graceful restarting router. It must be Graceful Restart capable.
- **GR helper**—The neighbor of the GR restarter. It helps the GR restarter to complete the GR process.

To prevent service interruption after a master/backup switchover, a GR restarter running OSPFv3 must perform the following tasks:

- Keep the GR restarter forwarding entries stable during reboot.
- Establish all adjacencies and obtain complete topology information after reboot.

After the active/standby switchover, the GR restarter sends a Grace LSA to tell its neighbors that it performs a GR. Upon receiving the Grace LSA, the neighbors with the GR helper capability enter the helper mode (and are called GR helpers). Then, the GR restarter retrieves its adjacencies and LSDB with the help of the GR helpers.

Restrictions and guidelines for OSPFv3 GR

You cannot enable OSPFv3 NSR on a device that acts as GR restarter.

Configuring GR restarter

1. Enter system view.
   system-view
2. Enter OSPFv3 view.
   ospfv3 [*process-id*]
3. Enable the GR capability.
   graceful-restart enable [**global** | **planned-only**] *
   By default, OSPFv3 GR restarter capability is disabled.
4. (Optional.) Set the GR interval.
   graceful-restart interval *interval*
   By default, the GR interval is 120 seconds.

Configuring GR helper

1. Enter system view.
   system-view
2. Enter OSPFv3 view.
   ospfv3 [*process-id*]
3. Enable the GR helper capability.
   graceful-restart helper enable [**planned-only**]
   By default, the GR helper capability is enabled.
4. Enable strict LSA checking.
   graceful-restart helper strict-lsa-checking
   By default, strict LSA checking is disabled.

Triggering OSPFv3 GR

About triggering OSPFv3 GR

OSPFv3 GR is triggered by an active/standby switchover or when this task is performed.

Procedure

To trigger OSPFv3 GR, execute the **reset ospfv3** [*process-id*] **process graceful-restart** command in user view.

Configuring OSPFv3 NSR

About OSPFv3 NSR

Nonstop routing (NSR) backs up OSPFv3 link state information from the active process to the standby process. After an active/standby switchover, NSR can complete link state recovery and route regeneration without tearing down adjacencies or impacting forwarding services.

NSR does not require the cooperation of neighboring devices to recover routing information, and it is typically used more often than GR.

Restrictions and guidelines

A device that has OSPFv3 NSR enabled cannot act as GR restarter.

Procedure

1. Enter system view.
   system-view
2. Enter OSPFv3 view.
   ospfv3 [*process-id*]
3. Enable OSPFv3 NSR.
   non-stop-routing

   By default, OSPFv3 NSR is disabled.

   This command takes effect only for the current process. As a best practice, enable OSPFv3 NSR for each process if multiple OSPFv3 processes exist.

Configuring BFD for OSPFv3

About BFD for OSPFv3

Bidirectional forwarding detection (BFD) provides a mechanism to quickly detect the connectivity of links between OSPFv3 neighbors, improving the convergence speed of OSPFv3. For more information about BFD, see *High Availability Configuration Guide*.

After discovering neighbors by sending hello packets, OSPFv3 notifies BFD of the neighbor addresses, and BFD uses these addresses to establish sessions. Before a BFD session is established, it is in the down state. In this state, BFD control packets are sent at an interval of no less than 1 second to reduce BFD control packet traffic. After the BFD session is established, BFD control packets are sent at the negotiated interval, thereby implementing fast fault detection.

To configure BFD for OSPFv3, you need to configure OSPFv3 first.

Procedure

1. Enter system view.
   system-view
2. Enter OSPFv3 view.
   ospfv3 [*process-id*]
3. Specify a router ID.
   router-id *router-id*
4. Quit the OSPFv3 view.
   quit
5. Enter interface view.
   interface *interface-type interface-number*

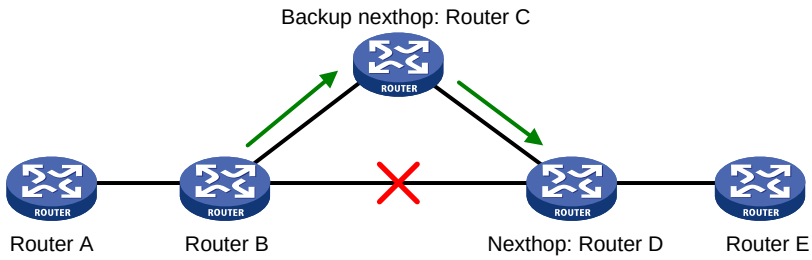
6. Enable an OSPFv3 process on the interface.
   ospfv3 *process-id* **area** *area-id* [**instance** *instance-id*]
7. Enable BFD on the interface.
   ospfv3 bfd enable [**instance** *instance-id*]
   By default, BFD is disabled on the OSPFv3 interface.

Configuring OSPFv3 FRR

About OSPFv3 FRR

A primary link failure can cause packet loss and even a routing loop until OSPFv3 completes routing convergence based on the new network topology. OSPFv3 FRR enables fast rerouting to minimize the failover time.

Figure 1 Network diagram for OSPFv3 FRR



As shown in Figure 1, configure FRR on Router B. OSPFv3 FRR automatically calculates a backup next hop or specifies a backup next hop by using a routing policy. When the primary link fails, OSPFv3 directs packets to the backup next hop. At the same time, OSPFv3 calculates the shortest path based on the new network topology. It forwards packets over the path after network convergence.

You can configure OSPFv3 FRR to calculate a backup next hop by using the loop free alternate (LFA) algorithm, or specify a backup next hop by using a routing policy.

Configuring OSPFv3 FRR to use the LFA algorithm to calculate a backup next hop

Restrictions and guidelines

Do not use the **fast-reroute lfa** command together with the **vlink-peer** command.

Procedure

1. Enter system view.
   system-view
2. Enter interface view.
   interface *interface-type interface-number*
3. (Optional.) Disable LFA on an interface.
   ospfv3 fast-reroute lfa-backup exclude
   By default, the interface on which LFA is enabled can be selected as a backup interface.
4. Return to system view.
   quit

5. Enter OSPFv3 view.
   ospfv3 [*process-id*]
6. Enable OSPFv3 FRR to use the LFA algorithm to calculate a backup next hop.
   fast-reroute lfa [**abr-only**]
   By default, OSPFv3 FRR is disabled.
   If **abr-only** is specified, the route to the ABR is selected as the backup path.

Configuring OSPFv3 FRR to use a backup next hop in a routing policy

About configuring a backup next hop in a routing policy

Before you perform this task, use the **apply ipv6 fast-reroute backup-interface** command to specify a backup next hop in the routing policy to be used. For more information about the **apply ipv6 fast-reroute backup-interface** command and routing policy configuration, see "Configuring routing policies."

Procedure

1. Enter system view.
   system-view
2. Enter interface view.
   interface *interface-type interface-number*
3. (Optional.) Disable LFA on an interface.
   ospfv3 fast-reroute lfa-backup exclude
   By default, the interface is enabled with LFA and it can be selected as a backup interface.
4. Return to system view.
   quit
5. Enter OSPFv3 view.
   ospfv3 [*process-id*]
6. Configure OSPFv3 FRR to use a backup next hop in a routing policy.
   fast-reroute route-policy *route-policy-name*
   By default, OSPFv3 FRR is disabled.

Configuring BFD control packet mode for OSPFv3 FRR

About BFD control packet mode for OSPFv3 FRR

By default, OSPFv3 FRR does not use BFD to detect primary link failures. To speed up OSPFv3 convergence, enable BFD control packet mode for OSPFv3 FRR to detect primary link failures. This mode requires BFD configuration on both OSPFv3 routers on the link.

Procedure

1. Enter system view.
   system-view
2. Enter interface view.
   interface *interface-type interface-number*
3. Enable BFD control packet mode for OSPFv3 FRR.
   ospfv3 primary-path-detect bfd ctrl [**instance** *instance-id*]

By default, BFD control packet mode is disabled for OSPFv3 FRR.

Configuring BFD echo packet mode for OSPFv3 FRR

About BFD echo packet mode for OSPFv3 FRR

By default, OSPFv3 FRR does not use BFD to detect primary link failures. To speed up OSPFv3 convergence, enable BFD echo packet mode for OSPFv3 FRR to detect primary link failures. This mode requires BFD configuration on one OSPFv3 router on the link.

Procedure

1. Enter system view.
   system-view
2. Configure the source IPv6 address of BFD echo packets.
   bfd echo-source-ipv6 *ipv6-address*
   By default, the source IPv6 address of BFD echo packets is not configured.
   The source IPv6 address cannot be on the same network segment as any local interface's IP address.
   For more information about this command, see *High Availability Command Reference*.
3. Enter interface view.
   interface *interface-type interface-number*
4. Enable BFD echo packet mode for OSPFv3 FRR.
   ospfv3 primary-path-detect bfd echo [**instance** *instance-id*]
   By default, BFD echo packet mode is disabled for OSPFv3 FRR.

Enhancing OSPFv3 security

Configuring OSPFv3 authentication

About OSPFv3 authentication

OSPFv3 uses keychain authentication to prevent routing information from being leaked and routers from being attacked.

OSPFv3 adds the Authentication Trailer option into outgoing packets, and uses the authentication information in the option to authenticate incoming packets. Only packets that pass the authentication can be received. If a packet fails the authentication, the OSPFv3 neighbor relationship cannot be established.

Restrictions and guidelines

The authentication mode specified for an OSPFv3 interface has a higher priority than the mode specified for an OSPFv3 area.

OSPFv3 supports only the HMAC-SHA-256 and HMAC-SM3 authentication algorithms.

The ID of keys used for authentication can only be in the range of 0 to 65535.

Configuring OSPFv3 area authentication

1. Enter system view.
   system-view
2. Enter OSPFv3 view.
   ospfv3 [*process-id*]

3. Enter OSPFv3 area view.

   area *area-id*

4. Specify an authentication mode for the area.

   authentication-mode keychain *keychain-name*

   By default, no authentication is performed for the area.

   For more information about keychains, see *Security Configuration Guide*.

Configuring OSPFv3 interface authentication

1. Enter system view.

   system-view

2. Enter interface view.

   interface *interface-type interface-number*

3. Specify an authentication mode for the interface.

   ospfv3 authentication-mode keychain *keychain-name* [**instance** *instance-id*]

   By default, no authentication is performed for the interface.

   For more information about keychains, see *Security Configuration Guide*.

Applying an IPsec profile for authenticating OSPFv3 packets

About IPsec profile for authenticating OSPFv3 packets

To protect routing information and prevent attacks, OSPFv3 can authenticate protocol packets by using an IPsec profile. For more information about IPsec profiles, see *Security Configuration Guide*.

Outbound OSPFv3 packets carry the Security Parameter Index (SPI) defined in the relevant IPsec profile. A device compares the SPI carried in a received packet with the configured IPsec profile. If they match, the device accepts the packet. Otherwise, the device discards the packet and will not establish a neighbor relationship with the sending device.

Restrictions and guidelines for applying an IPsec profile

You can configure an IPsec profile for an area, an interface, or a virtual link.

- To implement area-based IPsec protection, configure the same IPsec profile on the routers in the target area.
- To implement interface-based IPsec protection, configure the same IPsec profile on the interfaces between two neighboring routers.
- To implement virtual link-based IPsec protection, configure the same IPsec profile on the two routers connected over the virtual link.
- If an interface and its area each have an IPsec profile configured, the interface uses its own IPsec profile.
- If a virtual link and area 0 each have an IPsec profile configured, the virtual link uses its own IPsec profile.

Applying an IPsec profile to an area

1. Enter system view.

   system-view

2. Enter OSPFv3 view.

   ospfv3 [*process-id*]

3. Enter OSPFv3 area view.

   area *area-id*

4. Apply an IPsec profile to the area.
   enable ipsec-profile *profile-name*
   By default, no IPsec profile is applied.

Applying an IPsec profile to an interface

1. Enter system view.
   system-view
2. Enter interface view.
   interface *interface-type interface-number*
3. Apply an IPsec profile to the interface.
   ospfv3 ipsec-profile *profile-name* [**instance** *instance-id*]
   By default, no IPsec profile is applied.

Applying an IPsec profile to a virtual link

1. Enter system view.
   system-view
2. Enter OSPFv3 view.
   ospfv3 [*process-id*]
3. Enter OSPFv3 area view.
   area *area-id*
4. Apply an IPsec profile to a virtual link.
   vlink-peer *router-id* [**dead** *seconds* | **hello** *seconds* | **instance** *instance-id* | **ipsec-profile** *profile-name* | **retransmit** *seconds* | **trans-delay** *seconds*] *
   By default, no IPsec profile is applied.

Configuring OSPFv3 logging and SNMP notifications

Enabling logging for neighbor state changes

About neighbor state change logging

With this feature enabled, the router delivers logs about neighbor state changes to its information center. The information center processes logs according to user-defined output rules (whether to output logs and where to output). For more information about the information center, see *Network Management and Monitoring Configuration Guide*.

Procedure

1. Enter system view.
   system-view
2. Enter OSPFv3 view.
   ospfv3 [*process-id*]
3. Enable logging for neighbor state changes.
   log-peer-change
   By default, this feature is enabled.

Setting the maximum number of OSPFv3 logs

About OSPFv3 logs

OSPFv3 logs include route calculation logs, neighbor logs, and LSA aging logs.

Procedure

1. Enter system view.

   system-view

2. Enter OSPFv3 view.

   ospfv3 [*process-id*]

3. Set the maximum number of OSPFv3 logs.

   event-log { **lsa-flush** | **peer** | **spf** } **size** *count*

   By default, the maximum number of LSA aging logs, neighbor logs, or route calculation logs is 10.

Configuring OSPFv3 network management

About OSPFv3 network management

This task involves the following configurations:

- Bind an OSPFv3 process to MIB so that you can use network management software to manage the specified OSPFv3 process.
- Enable SNMP notifications for OSPFv3 to report important events.
- Set the SNMP notification output interval and the maximum number of SNMP notifications that can be output at each interval.

To report critical OSPFv3 events to an NMS, enable SNMP notifications for OSPFv3. For SNMP notifications to be sent correctly, you must also configure SNMP on the device. For more information about SNMP configuration, see the network management and monitoring configuration guide for the device.

The standard OSPFv3 MIB provides only single-instance MIB objects. To identify multiple OSPFv3 processes in the standard OSPFv3 MIB, you must assign a unique context name to each OSPFv3 process.

Context is a method introduced to SNMPv3 for multiple-instance management. For SNMPv1/v2c, you must specify a community name as a context name for protocol identification.

Procedure

1. Enter system view.

   system-view

2. Bind MIB to an OSPFv3 process.

   ospfv3 mib-binding *process-id*

   By default, MIB is bound to the process with the smallest process ID.

3. Enable SNMP notifications for OSPFv3.

   snmp-agent trap enable ospfv3 [**grrestarter-status-change** | **grhelper-status-change** | **if-state-change** | **if-cfg-error** | **if-bad-pkt** | **neighbor-state-change** | **nssatranslator-status-change** | **virtif-bad-pkt** | **virtif-cfg-error** | **virtif-state-change** | **virtgrhelper-status-change** | **virtneighbor-state-change**]*

   By default, SNMP notifications for OSPFv3 are enabled.

4. Enter OSPFv3 view.

ospfv3 [*process-id*]

5. Configure an SNMP context for the OSPFv3 process.

   snmp context-name *context-name*

   By default, no SNMP context is configured for the OSPFv3 process.

6. (Optional.) Set the SNMP notification output interval and the maximum number of SNMP notifications that can be output at each interval.

   snmp trap rate-limit interval *trap-interval* **count** *trap-number*

   By default, OSPFv3 outputs a maximum of seven SNMP notifications within 10 seconds.

Display and maintenance commands for OSPFv3

Execute **display** commands in any view and **reset** commands in user view.

Task	Command
Display summary route information on the OSPFv3 ABR.	**display ospfv3** [*process-id*] [**area** *area-id*] **abr-summary** [*ipv6-address prefix-length*] [**verbose**]
Display OSPFv3 neighbor information.	**display ospfv3** [*process-id*] [**area** *area-id*] **peer** [[*interface-type interface-number*] [**verbose**] | *peer-router-id* | **statistics**]
Display OSPFv3 request list information.	**display ospfv3** [*process-id*] [**area** *area-id*] **request-queue** [*interface-type interface-number*] [*neighbor-id*]
Display OSPFv3 retransmission list information.	**display ospfv3** [*process-id*] [**area** *area-id*] **retrans-queue** [*interface-type interface-number*] [*neighbor-id*]
Display OSPFv3 topology information.	**display ospfv3** [*process-id*] [**area** *area-id*] **spf-tree** [**verbose**]
Display OSPFv3 process information.	**display ospfv3** [*process-id*] [**verbose**]
Display information about the routes to OSPFv3 ABR and ASBR.	**display ospfv3** [*process-id*] **abr-asbr**
Display summary route information on the OSPFv3 ASBR.	**display ospfv3** [*process-id*] **asbr-summary** [*ipv6-address prefix-length*] [**verbose**]
Display OSPFv3 log information.	**display ospfv3** [*process-id*] **event-log** { **lsa-flush** | **peer** | **spf** }
Display OSPFv3 GR information.	**display ospfv3** [*process-id*] **graceful-restart** [**verbose**]
Display OSPFv3 interface information.	**display ospfv3** [*process-id*] **interface** [*interface-type interface-number* | **verbose**]
Display OSPFv3 LSDB information.	**display ospfv3** [*process-id*] **lsdb** [{ **external** | **grace** | **inter-prefix** | **inter-router** | **intra-prefix** | **link** | **network** | **nssa** | **router** | **unknown** [*type*] } [*link-state-id*] [**originate-router** *router-id* | **self-originate**] | **statistics** | **total** | **verbose**]

Task	Command
Display OSPFv3 next hop information.	**display ospfv3** [*process-id*] **nexthop**
Display OSPFv3 NSR information.	**display ospfv3** [*process-id*] **non-stop-routing**
Display OSPFv3 routing information.	**display ospfv3** [*process-id*] **routing** [*ipv6-address prefix-length*]
Display OSPFv3 statistics.	**display ospfv3** [*process-id*] **statistics** [**error**]
Display OSPFv3 virtual link information.	**display ospfv3** [*process-id*] **vlink**
Clear OSPFv3 log information.	**reset ospfv3** [*process-id*] **event-log** [**lsa-flush** | **peer** | **spf**]
Restart an OSPFv3 process.	**reset ospfv3** [*process-id*] **process** [**graceful-restart**]
Restart OSPFv3 route redistribution.	**reset ospfv3** [*process-id*] **redistribution**
Clear OSPFv3 statistics.	**reset ospfv3** [*process-id*] **statistics**

OSPFv3 configuration examples

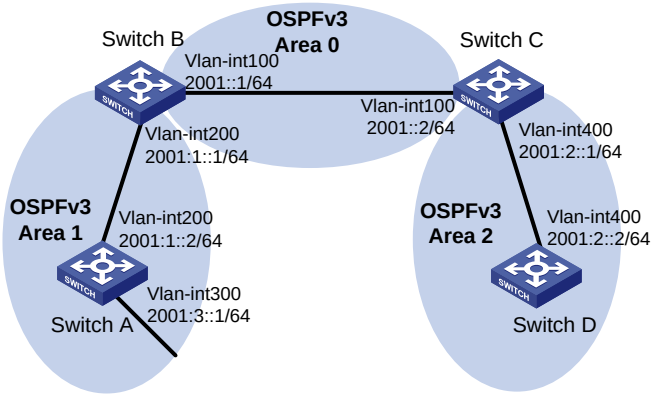
Example: Configuring OSPFv3 stub area

Network configuration

As shown in Figure 2:

- Enable OSPFv3 on all switches.
- Split the AS into three areas.
- Configure Switch B and Switch C as ABRs to forward routing information between areas.
- Configure Area 2 as a stub area to reduce LSAs in the area without affecting route reachability.

Figure 2 Network diagram



Procedure

1. Configure IPv6 addresses for interfaces. (Details not shown.)

2. Configure basic OSPFv3:

On Switch A, enable OSPFv3 and specify the router ID as 1.1.1.1.

```
<SwitchA> system-view
[SwitchA] ospfv3
[SwitchA-ospfv3-1] router-id 1.1.1.1
[SwitchA-ospfv3-1] quit
[SwitchA] interface vlan-interface 300
[SwitchA-Vlan-interface300] ospfv3 1 area 1
[SwitchA-Vlan-interface300] quit
[SwitchA] interface vlan-interface 200
[SwitchA-Vlan-interface200] ospfv3 1 area 1
[SwitchA-Vlan-interface200] quit
```

On Switch B, enable OSPFv3 and specify the router ID as 2.2.2.2.

```
<SwitchB> system-view
[SwitchB] ospfv3
[SwitchB-ospfv3-1] router-id 2.2.2.2
[SwitchB-ospfv3-1] quit
[SwitchB] interface vlan-interface 100
[SwitchB-Vlan-interface100] ospfv3 1 area 0
[SwitchB-Vlan-interface100] quit
[SwitchB] interface vlan-interface 200
[SwitchB-Vlan-interface200] ospfv3 1 area 1
[SwitchB-Vlan-interface200] quit
```

On Switch C, enable OSPFv3 and specify the router ID as 3.3.3.3.

```
<SwitchC> system-view
[SwitchC] ospfv3
[SwitchC-ospfv3-1] router-id 3.3.3.3
[SwitchC-ospfv3-1] quit
[SwitchC] interface vlan-interface 100
[SwitchC-Vlan-interface100] ospfv3 1 area 0
[SwitchC-Vlan-interface100] quit
[SwitchC] interface vlan-interface 400
[SwitchC-Vlan-interface400] ospfv3 1 area 2
[SwitchC-Vlan-interface400] quit
```

On Switch D, enable OSPFv3 and specify the router ID as 4.4.4.4.

```
<SwitchD> system-view
[SwitchD] ospfv3
[SwitchD-ospfv3-1] router-id 4.4.4.4
[SwitchD-ospfv3-1] quit
[SwitchD] interface vlan-interface 400
[SwitchD-Vlan-interface400] ospfv3 1 area 2
[SwitchD-Vlan-interface400] quit
```

Display OSPFv3 neighbors on Switch B.

```
[SwitchB] display ospfv3 peer

              OSPFv3 Process 1 with Router ID 2.2.2.2

 Area: 0.0.0.0
```

```
 Router ID       Pri State            Dead-Time InstID Interface
 3.3.3.3         1   Full/BDR         00:00:40  0      Vlan100

 Area: 0.0.0.1
 Router ID       Pri State            Dead-Time InstID Interface
 1.1.1.1         1   Full/DR          00:00:40  0      Vlan200
```

Display OSPFv3 neighbors on Switch C.

```
[SwitchC] display ospfv3 peer

              OSPFv3 Process 1 with Router ID 3.3.3.3

 Area: 0.0.0.0
 Router ID       Pri State            Dead-Time InstID Interface
 2.2.2.2         1   Full/DR          00:00:40  0      Vlan100

 Area: 0.0.0.2
 Router ID       Pri State            Dead-Time InstID Interface
 4.4.4.4         1   Full/BDR         00:00:40  0      Vlan400
```

Display OSPFv3 routing table information on Switch D.

```
[SwitchD] display ospfv3 routing

              OSPFv3 Process 1 with Router ID 4.4.4.4
 I  - Intra area route,  E1 - Type 1 external route,  N1 - Type 1 NSSA route
 IA - Inter area route,  E2 - Type 2 external route,  N2 - Type 2 NSSA route
 *  - Selected route

*Destination: 2001::/64
  Type       : IA                       Area       : 0.0.0.2
  AdvRouter  : 3.3.3.3                  Preference : 10
  NibID      : 0x23000004               Cost       : 2
  Interface  : Vlan400                  BkInterface: N/A
  Nexthop    : FE80::48C0:26FF:FEDA:305
  BkNexthop  : N/A

 *Destination: 2001:1::/64
  Type       : IA                       Area       : 0.0.0.2
  AdvRouter  : 3.3.3.3                  Preference : 10
  NibID      : 0x23000004               Cost       : 3
  Interface  : Vlan400                  BkInterface: N/A
  Nexthop    : FE80::48C0:26FF:FEDA:305
  BkNexthop  : N/A

 *Destination: 2001:2::/64
```

```
  Type       : I                          Area       : 0.0.0.2
  AdvRouter  : 4.4.4.4                    Preference : 10
  NibID      : 0x23000002                 Cost       : 1
  Interface  : Vlan400                    BkInterface: N/A
  Nexthop    : ::
  BkNexthop  : N/A

 *Destination: 2001:3::1/128
  Type       : IA                         Area       : 0.0.0.2
  AdvRouter  : 3.3.3.3                    Preference : 10
  NibID      : 0x23000004                 Cost       : 3
  Interface  : Vlan400                    BkInterface: N/A
  Nexthop    : FE80::48C0:26FF:FEDA:305
  BkNexthop  : N/A

 Total: 4
 Intra area: 1         Inter area: 3         ASE: 0         NSSA: 0
```

3. Configure Area 2 as a stub area:

Configure Switch D.

```
[SwitchD] ospfv3
[SwitchD-ospfv3-1] area 2
[SwitchD-ospfv3-1-area-0.0.0.2] stub
```

Configure Switch C, and specify the cost of the default route sent to the stub area as 10.

```
[SwitchC] ospfv3
[SwitchC-ospfv3-1] area 2
[SwitchC-ospfv3-1-area-0.0.0.2] stub
[SwitchC-ospfv3-1-area-0.0.0.2] default-cost 10
```

Display OSPFv3 routing table information on Switch D.

```
[SwitchD] display ospfv3 routing

              OSPFv3 Process 1 with Router ID 4.4.4.4
------------------------------------------------------------------------
 I  - Intra area route,  E1 - Type 1 external route,  N1 - Type 1 NSSA route
 IA - Inter area route,  E2 - Type 2 external route,  N2 - Type 2 NSSA route
 *  - Selected route

*Destination: ::/0
  Type       : IA                         Area       : 0.0.0.2
  AdvRouter  : 3.3.3.3                    Preference : 10
  NibID      : 0x23000003                 Cost       : 11
  Interface  : Vlan400                    BkInterface: N/A
  Nexthop    : FE80::48C0:26FF:FEDA:305
  BkNexthop  : N/A

 *Destination: 2001::/64
  Type       : IA                         Area       : 0.0.0.2
  AdvRouter  : 3.3.3.3                    Preference : 10
  NibID      : 0x23000003                 Cost       : 2
```

```
 Interface  : Vlan400                    BkInterface: N/A
 Nexthop    : FE80::48C0:26FF:FEDA:305
 BkNexthop  : N/A

*Destination: 2001:1::/64
 Type       : IA                         Area       : 0.0.0.2
 AdvRouter  : 3.3.3.3                    Preference : 10
 NibID      : 0x23000003                 Cost       : 3
 Interface  : Vlan400                    BkInterface: N/A
 Nexthop    : FE80::48C0:26FF:FEDA:305
 BkNexthop  : N/A

*Destination: 2001:2::/64
 Type       : I                          Area       : 0.0.0.2
 AdvRouter  : 4.4.4.4                    Preference : 10
 NibID      : 0x23000001                 Cost       : 1
 Interface  : Vlan400                    BkInterface: N/A
 Nexthop    : ::
 BkNexthop  : N/A

*Destination: 2001:3::1/128
 Type       : IA                         Area       : 0.0.0.2
 AdvRouter  : 3.3.3.3                    Preference : 10
 NibID      : 0x23000003                 Cost       : 3
 Interface  : Vlan400                    BkInterface: N/A
 Nexthop    : FE80::48C0:26FF:FEDA:305
 BkNexthop  : N/A

Total: 5
Intra area: 1         Inter area: 4         ASE: 0         NSSA: 0
```

The output shows that a default route is added, and its cost is the cost of a direct route plus the configured cost.

4. Configure Area 2 as a totally stub area:

Configure Area 2 as a totally stub area on Switch C.

```
[SwitchC-ospfv3-1-area-0.0.0.2] stub no-summary
```

Display OSPFv3 routing table information on Switch D.

```
[SwitchD] display ospfv3 routing

              OSPFv3 Process 1 with Router ID 4.4.4.4
------------------------------------------------------------------------
 I  - Intra area route,  E1 - Type 1 external route,  N1 - Type 1 NSSA route
 IA - Inter area route,  E2 - Type 2 external route,  N2 - Type 2 NSSA route
 *  - Selected route

*Destination: ::/0
 Type       : IA                         Area       : 0.0.0.2
 AdvRouter  : 3.3.3.3                    Preference : 10
 NibID      : 0x23000003                 Cost       : 11
```

```
 Interface   : Vlan400                    BkInterface: N/A
 Nexthop     : FE80::48C0:26FF:FEDA:305
 BkNexthop   : N/A

*Destination: 2001:2::/64
 Type        : I                         Area       : 0.0.0.2
 AdvRouter   : 4.4.4.4                   Preference : 10
 NibID       : 0x23000001                Cost       : 1
 Interface   : Vlan400                   BkInterface: N/A
 Nexthop     : ::
 BkNexthop   : N/A

Total: 2
Intra area: 1         Inter area: 1         ASE: 0         NSSA: 0
```

The output shows that route entries are reduced. All indirect routes are removed, except the default route.

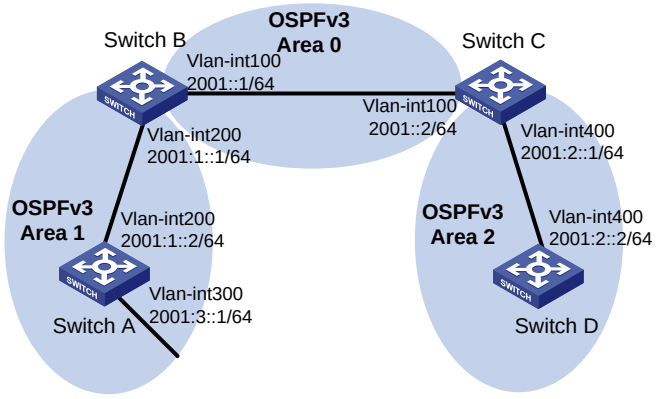
Example: Configuring OSPFv3 NSSA area

Network configuration

As shown in Figure 3:

- Configure OSPFv3 on all switches and split the AS into three areas.
- Configure Switch B and Switch C as ABRs to forward routing information between areas.
- Configure Area 1 as an NSSA area and configure Switch A as an ASBR to redistribute static routes into the AS.

Figure 3 Network diagram



Procedure

1. Configure IPv6 addresses for interfaces. (Details not shown.)
2. Configure basic OSPFv3 (see "Example: Configuring OSPFv3 stub area").
3. Configure Area 1 as an NSSA area:

   # Configure Switch A.

```
[SwitchA] ospfv3
[SwitchA-ospfv3-1] area 1
[SwitchA-ospfv3-1-area-0.0.0.1] nssa
[SwitchA-ospfv3-1-area-0.0.0.1] quit
```

```
[SwitchA-ospfv3-1] quit
```

Configure Switch B.

```
[SwitchB] ospfv3
[SwitchB-ospfv3-1] area 1
[SwitchB-ospfv3-1-area-0.0.0.1] nssa
[SwitchB-ospfv3-1-area-0.0.0.1] quit
[SwitchB-ospfv3-1] quit
```

Display OSPFv3 routing information on Switch D.

```
[SwitchD] display ospfv3 1 routing

              OSPFv3 Process 1 with Router ID 4.4.4.4
------------------------------------------------------------------------
 I  - Intra area route,  E1 - Type 1 external route,  N1 - Type 1 NSSA route
 IA - Inter area route,  E2 - Type 2 external route,  N2 - Type 2 NSSA route
 *  - Selected route

*Destination: 2001::/64
  Type       : IA                        Area       : 0.0.0.2
  AdvRouter  : 3.3.3.3                   Preference : 10
  NibID      : 0x23000003                Cost       : 2
  Interface  : Vlan200                   BkInterface: N/A
  Nexthop    : FE80::48C0:26FF:FEDA:305
  BkNexthop  : N/A

 *Destination: 2001:1::/64
  Type       : IA                        Area       : 0.0.0.2
  AdvRouter  : 3.3.3.3                   Preference : 10
  NibID      : 0x23000003                Cost       : 3
  Interface  : Vlan200                   BkInterface: N/A
  Nexthop    : FE80::48C0:26FF:FEDA:305
  BkNexthop  : N/A

 *Destination: 2001:2::/64
  Type       : I                         Area       : 0.0.0.2
  AdvRouter  : 4.4.4.4                   Preference : 10
  NibID      : 0x23000001                Cost       : 1
  Interface  : Vlan200                   BkInterface: N/A
  Nexthop    : ::
  BkNexthop  : N/A

 *Destination: 2001:3::/64
  Type       : IA                        Area       : 0.0.0.2
  AdvRouter  : 3.3.3.3                   Preference : 10
  NibID      : 0x23000003                Cost       : 4
  Interface  : Vlan200                   BkInterface: N/A
  Nexthop    : FE80::48C0:26FF:FEDA:305
  BkNexthop  : N/A
```

```
 Total: 4
 Intra area: 1         Inter area: 3         ASE: 0         NSSA: 0
```

4. Configure route redistribution:

Configure an IPv6 static route, and configure OSPFv3 to redistribute the static route on Switch A.

```
[SwitchA] ipv6 route-static 1234:: 64 null 0
[SwitchA] ospfv3 1
[SwitchA-ospfv3-1] import-route static
[SwitchA-ospfv3-1] quit
```

Display OSPFv3 routing information on Switch D.

```
[SwitchD] display ospfv3 1 routing

               OSPFv3 Process 1 with Router ID 4.4.4.4
------------------------------------------------------------------------
 I  - Intra area route,  E1 - Type 1 external route,  N1 - Type 1 NSSA route
 IA - Inter area route,  E2 - Type 2 external route,  N2 - Type 2 NSSA route
 *  - Selected route

*Destination: 2001::/64
  Type       : IA                        Area       : 0.0.0.2
  AdvRouter  : 3.3.3.3                   Preference : 10
  NibID      : 0x23000002                Cost       : 2
  Interface  : Vlan400                   BkInterface: N/A
  Nexthop    : FE80::48C0:26FF:FEDA:305
  BkNexthop  : N/A

 *Destination: 2001:1::/64
  Type       : IA                        Area       : 0.0.0.2
  AdvRouter  : 3.3.3.3                   Preference : 10
  NibID      : 0x23000002                Cost       : 3
  Interface  : Vlan400                   BkInterface: N/A
  Nexthop    : FE80::48C0:26FF:FEDA:305
  BkNexthop  : N/A

 *Destination: 2001:2::/64
  Type       : I                         Area       : 0.0.0.2
  AdvRouter  : 4.4.4.4                   Preference : 10
  NibID      : 0x23000004                Cost       : 1
  Interface  : Vlan400                   BkInterface: N/A
  Nexthop    : ::
  BkNexthop  : N/A

 *Destination: 2001:3::/64
  Type       : IA                        Area       : 0.0.0.2
  AdvRouter  : 3.3.3.3                   Preference : 10
  NibID      : 0x23000002                Cost       : 4
  Interface  : Vlan400                   BkInterface: N/A
  Nexthop    : FE80::48C0:26FF:FEDA:305
```

```
 BkNexthop  : N/A

*Destination: 1234::/64
 Type       : E2                         Tag        : 1
 AdvRouter  : 2.2.2.2                    Preference : 150
 NibID      : 0x23000001                 Cost       : 1
 Interface  : Vlan400                    BkInterface: N/A
 Nexthop    : FE80::48C0:26FF:FEDA:305
 BkNexthop  : N/A

Total: 5
Intra area: 1         Inter area: 3         ASE: 1         NSSA: 0
```

The output shows an AS external route imported from the NSSA area exists on Switch D.

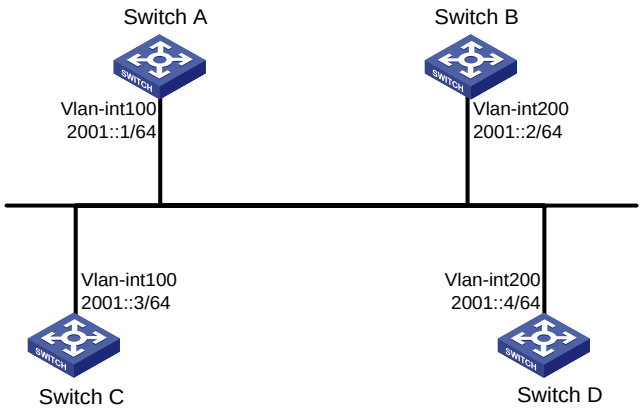
Example: Configuring OSPFv3 DR election

Network configuration

As shown in Figure 4:

- Configure router priority 100 for Switch A, the highest priority on the network, so it will become the DR.
- Configure router priority 2 for Switch C, the second highest priority on the network, so it will become the BDR.
- Configure router priority 0 for Switch B, so it cannot become a DR or BDR.
- Switch D uses the default router priority 1.

Figure 4 Network diagram



Procedure

1. Configure IPv6 addresses for interfaces. (Details not shown.)
2. Configure basic OSPFv3:

   # On Switch A, enable OSPFv3 and specify the router ID as 1.1.1.1.

```
<SwitchA> system-view
[SwitchA] ospfv3
[SwitchA-ospfv3-1] router-id 1.1.1.1
[SwitchA-ospfv3-1] quit
[SwitchA] interface vlan-interface 100
```

```
[SwitchA-Vlan-interface100] ospfv3 1 area 0
[SwitchA-Vlan-interface100] quit
```

On Switch B, enable OSPFv3 and specify the router ID as 2.2.2.2.

```
<SwitchB> system-view
[SwitchB] ospfv3
[SwitchB-ospfv3-1] router-id 2.2.2.2
[SwitchB-ospfv3-1] quit
[SwitchB] interface vlan-interface 200
[SwitchB-Vlan-interface200] ospfv3 1 area 0
[SwitchB-Vlan-interface200] quit
```

On Switch C, enable OSPFv3 and specify the router ID as 3.3.3.3.

```
<SwitchC> system-view
[SwitchC] ospfv3
[SwitchC-ospfv3-1] router-id 3.3.3.3
[SwitchC-ospfv3-1] quit
[SwitchC] interface vlan-interface 100
[SwitchC-Vlan-interface100] ospfv3 1 area 0
[SwitchC-Vlan-interface100] quit
```

On Switch D, enable OSPFv3 and specify the router ID as 4.4.4.4.

```
<SwitchD> system-view
[SwitchD] ospfv3
[SwitchD-ospfv3-1] router-id 4.4.4.4
[SwitchD-ospfv3-1] quit
[SwitchD] interface vlan-interface 200
[SwitchD-Vlan-interface200] ospfv3 1 area 0
[SwitchD-Vlan-interface200] quit
```

Display neighbor information on Switch A. The switches have the same default DR priority 1, so Switch D (the switch with the highest router ID) is elected as the DR, and Switch C is the BDR.

```
[SwitchA] display ospfv3 peer

              OSPFv3 Process 1 with Router ID 1.1.1.1

 Area: 0.0.0.0
--------------------------------------------------------------------------
 Router ID       Pri State             Dead-Time InstID Interface
 2.2.2.2         1   2-Way/DROther     00:00:36  0      Vlan200
 3.3.3.3         1   Full/BDR          00:00:35  0      Vlan100
 4.4.4.4         1   Full/DR           00:00:33  0      Vlan200
```

Display neighbor information on Switch D. The neighbor states are all full.

```
[SwitchD] display ospfv3 peer

              OSPFv3 Process 1 with Router ID 4.4.4.4

 Area: 0.0.0.0
--------------------------------------------------------------------------
 Router ID       Pri State             Dead-Time InstID Interface
 1.1.1.1         1   Full/DROther      00:00:30  0      Vlan100
```

```
 2.2.2.2         1   Full/DROther      00:00:37  0      Vlan200
 3.3.3.3         1   Full/BDR          00:00:31  0      Vlan100
```

3. Configure router priorities for interfaces:

Set the router priority of VLAN-interface 100 to 100 on Switch A.

```
[SwitchA] interface Vlan-interface 100
[SwitchA-Vlan-interface100] ospfv3 dr-priority 100
[SwitchA-Vlan-interface100] quit
```

Set the router priority of VLAN-interface 200 to 0 on Switch B.

```
[SwitchB] interface vlan-interface 200
[SwitchB-Vlan-interface200] ospfv3 dr-priority 0
[SwitchB-Vlan-interface200] quit
```

Set the router priority of VLAN-interface 100 to 2 on Switch C.

```
[SwitchC] interface Vlan-interface 100
[SwitchC-Vlan-interface100] ospfv3 dr-priority 2
[SwitchC-Vlan-interface100] quit
```

Display neighbor information on Switch A. Router priorities have been updated, but the DR and BDR are not changed.

```
[SwitchA] display ospfv3 peer

              OSPFv3 Process 1 with Router ID 1.1.1.1

 Area: 0.0.0.0
--------------------------------------------------------------------------
 Router ID       Pri State             Dead-Time InstID Interface
 2.2.2.2         0   2-Way/DROther     00:00:36  0      Vlan200
 3.3.3.3         2   Full/BDR          00:00:35  0      Vlan200
 4.4.4.4         1   Full/DR           00:00:33  0      Vlan200
```

Display neighbor information on Switch D. Switch D is still the DR.

```
[SwitchD] display ospfv3 peer

              OSPFv3 Process 1 with Router ID 4.4.4.4

 Area: 0.0.0.0
--------------------------------------------------------------------------
 Router ID       Pri State             Dead-Time InstID Interface
 1.1.1.1         100 Full/DROther      00:00:30  0      Vlan100
 2.2.2.2         0   Full/DROther      00:00:37  0      Vlan200
 3.3.3.3         2   Full/BDR          00:00:31  0      Vlan100
```

4. Restart DR and BDR election:

Use the **shutdown** and **undo shutdown** commands on interfaces to restart DR and BDR election. (Details not shown.)

Display neighbor information on Switch A. The output shows that Switch C becomes the BDR.

```
[SwitchA] display ospfv3 peer

              OSPFv3 Process 1 with Router ID 1.1.1.1

 Area: 0.0.0.0
--------------------------------------------------------------------------
```

```
 Router ID       Pri State            Dead-Time InstID Interface
 2.2.2.2         0   Full/DROther     00:00:36  0      Vlan200
 3.3.3.3         2   Full/BDR         00:00:35  0      Vlan100
 4.4.4.4         1   Full/DROther     00:00:33  0      Vlan200
```

Display neighbor information on Switch D.

```
[SwitchD] display ospfv3 peer

             OSPFv3 Process 1 with Router ID 4.4.4.4

 Area: 0.0.0.0
----------------------------------------------------------------------------
 Router ID       Pri State            Dead-Time InstID Interface
 1.1.1.1         100 Full/DR          00:00:30  0      Vlan100
 2.2.2.2         0   2-Way/DROther    00:00:37  0      Vlan200
 3.3.3.3         2   Full/BDR         00:00:31  0      Vlan100
```

The output shows that Switch A becomes the DR.

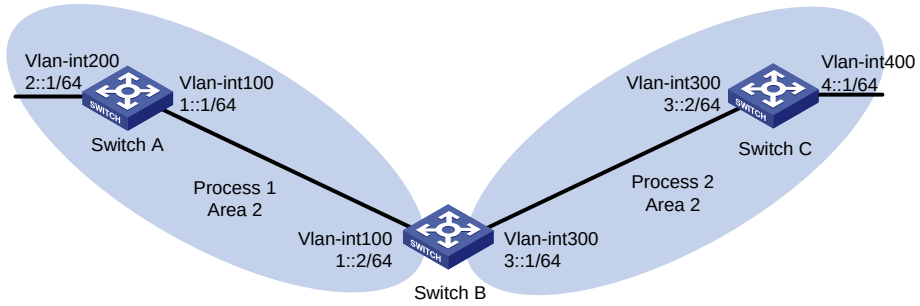
Example: Configuring OSPFv3 route redistribution

Network configuration

As shown in Figure 5:

- Switch A, Switch B, and Switch C are in Area 2.
- OSPFv3 process 1 and OSPFv3 process 2 run on Switch B. Switch B communicates with Switch A and Switch C through OSPFv3 process 1 and OSPFv3 process 2.
- Configure OSPFv3 process 2 to redistribute direct routes and the routes from OSPFv3 process 1 on Switch B, and set the metric for redistributed routes to 3. Switch C can then learn the routes destined for 1::0/64 and 2::0/64, and Switch A cannot learn the routes destined for 3::0/64 or 4::0/64.

Figure 5 Network diagram



Procedure

1. Configure IPv6 addresses for interfaces. (Details not shown.)
2. Configure basic OSPFv3:

   # Enable OSPFv3 process 1 on Switch A.

```
<SwitchA> system-view
[SwitchA] ospfv3 1
[SwitchA-ospfv3-1] router-id 1.1.1.1
[SwitchA-ospfv3-1] quit
[SwitchA] interface vlan-interface 100
```

```
[SwitchA-Vlan-interface100] ospfv3 1 area 2
[SwitchA-Vlan-interface100] quit
[SwitchA] interface vlan-interface 200
[SwitchA-Vlan-interface200] ospfv3 1 area 2
[SwitchA-Vlan-interface200] quit
```

Enable OSPFv3 process 1 and OSPFv3 process 2 on Switch B.

```
<SwitchB> system-view
[SwitchB] ospfv3 1
[SwitchB-ospfv3-1] router-id 2.2.2.2
[SwitchB-ospfv3-1] quit
[SwitchB] interface vlan-interface 100
[SwitchB-Vlan-interface100] ospfv3 1 area 2
[SwitchB-Vlan-interface100] quit
[SwitchB] ospfv3 2
[SwitchB-ospfv3-2] router-id 3.3.3.3
[SwitchB-ospfv3-2] quit
[SwitchB] interface vlan-interface 300
[SwitchB-Vlan-interface300] ospfv3 2 area 2
[SwitchB-Vlan-interface300] quit
```

Enable OSPFv3 process 2 on Switch C.

```
<SwitchC> system-view
[SwitchC] ospfv3 2
[SwitchC-ospfv3-2] router-id 4.4.4.4
[SwitchC-ospfv3-2] quit
[SwitchC] interface vlan-interface 300
[SwitchC-Vlan-interface300] ospfv3 2 area 2
[SwitchC-Vlan-interface300] quit
[SwitchC] interface vlan-interface 400
[SwitchC-Vlan-interface400] ospfv3 2 area 2
[SwitchC-Vlan-interface400] quit
```

Display the routing table on Switch C.

```
[SwitchC] display ipv6 routing-table

Destinations : 7 Routes : 7

Destination: ::1/128                                Protocol  : Direct
NextHop    : ::1                                    Preference: 0
Interface  : InLoop0                                Cost      : 0

Destination: 3::/64                                 Protocol  : Direct
NextHop    : ::                                     Preference: 0
Interface  : Vlan300                                Cost      : 0

Destination: 3::2/128                               Protocol  : Direct
NextHop    : ::1                                    Preference: 0
Interface  : InLoop0                                Cost      : 0

Destination: 4::/64                                 Protocol  : Direct
```

```
NextHop    : ::                                    Preference: 0
Interface  : Vlan400                               Cost      : 0

Destination: 4::1/128                              Protocol  : Direct
NextHop    : ::1                                   Preference: 0
Interface  : InLoop0                               Cost      : 0

Destination: FE80::/10                             Protocol  : Direct
NextHop    : ::                                    Preference: 0
Interface  : NULL0                                 Cost      : 0

Destination: FF00::/8                              Protocol  : Direct
NextHop    : ::                                    Preference: 0
Interface  : NULL0                                 Cost      : 0
```

3. Configure OSPFv3 route redistribution:

Configure OSPFv3 process 2 to redistribute direct routes and the routes from OSPFv3 process 1 on Switch B, and set the metric for redistributed routes to 3.

```
[SwitchB] ospfv3 2
[SwitchB-ospfv3-2] import-route ospfv3 1 cost 3
[SwitchB-ospfv3-2] import-route direct cost 3
[SwitchB-ospfv3-2] quit
```

Display the routing table on Switch C.

```
[SwitchC] display ipv6 routing-table

Destinations : 9 Routes : 9

Destination: ::1/128                               Protocol  : Direct
NextHop    : ::1                                   Preference: 0
Interface  : InLoop0                               Cost      : 0

Destination: 1::/64                                Protocol  : O_ASE2
NextHop    : FE80::200:CFF:FE01:1C03               Preference: 150
Interface  : Vlan300                               Cost      : 3

Destination: 2::/64                                Protocol  : O_ASE2
NextHop    : FE80::200:CFF:FE01:1C03               Preference: 150
Interface  : Vlan300                               Cost      : 3

Destination: 3::/64                                Protocol  : Direct
NextHop    : ::                                    Preference: 0
Interface  : Vlan300                               Cost      : 0

Destination: 3::2/128                              Protocol  : Direct
NextHop    : ::1                                   Preference: 0
Interface  : InLoop0                               Cost      : 0

Destination: 4::/64                                Protocol  : Direct
NextHop    : ::                                    Preference: 0
```

```
Interface  : Vlan400                                Cost      : 0

Destination: 4::1/128                               Protocol  : Direct
NextHop    : ::1                                    Preference: 0
Interface  : InLoop0                                Cost      : 0

Destination: FE80::/10                              Protocol  : Direct
NextHop    : ::                                     Preference: 0
Interface  : NULL0                                  Cost      : 0

Destination: FF00::/8                               Protocol  : Direct
NextHop    : ::                                     Preference: 0
Interface  : NULL0                                  Cost      : 0
```

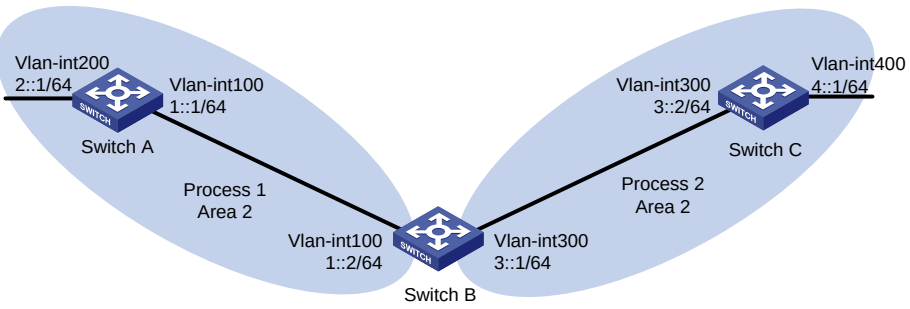
Example: Configuring OSPFv3 route summarization

Network configuration

As shown in Figure 6:

- Switch A, Switch B, and Switch C are in Area 2.
- OSPFv3 process 1 and OSPFv3 process 2 run on Switch B. Switch B communicates with Switch A and Switch C through OSPFv3 process 1 and OSPFv3 process 2, respectively.
- On Switch A, configure IPv6 addresses 2:1:1::1/64, 2:1:2::1/64, and 2:1:3::1/64 for VLAN-interface 200.
- On Switch B, configure OSPFv3 process 2 to redistribute direct routes and the routes from OSPFv3 process 1. Switch C can then learn the routes destined for 2::/64, 2:1:1::/64, 2:1:2::/64, and 2:1:3::/64.
- On Switch B, configure route summarization to advertise only summary route 2::/16 to Switch C.

Figure 6 Network diagram



Procedure

1. Configure IPv6 addresses for interfaces. (Details not shown.)
2. Configure OSPFv3:

   # Enable OSPFv3 process 1 on Switch A.

```
<SwitchA> system-view
[SwitchA] ospfv3 1
[SwitchA-ospfv3-1] router-id 1.1.1.1
[SwitchA-ospfv3-1] quit
[SwitchA] interface vlan-interface 100
```

```
[SwitchA-Vlan-interface100] ospfv3 1 area 2
[SwitchA-Vlan-interface100] quit
[SwitchA] interface vlan-interface 200
[SwitchA-Vlan-interface200] ipv6 address 2:1:1::1 64
[SwitchA-Vlan-interface200] ipv6 address 2:1:2::1 64
[SwitchA-Vlan-interface200] ipv6 address 2:1:3::1 64
[SwitchA-Vlan-interface200] ospfv3 1 area 2
[SwitchA-Vlan-interface200] quit
```

Enable OSPFv3 process 1 and OSPFv3 process 2 on Switch B.

```
<SwitchB> system-view
[SwitchB] ospfv3 1
[SwitchB-ospfv3-1] router-id 2.2.2.2
[SwitchB-ospfv3-1] quit
[SwitchB] interface vlan-interface 100
[SwitchB-Vlan-interface100] ospfv3 1 area 2
[SwitchB-Vlan-interface100] quit
[SwitchB] ospfv3 2
[SwitchB-ospfv3-2] router-id 3.3.3.3
[SwitchB-ospfv3-2] quit
[SwitchB] interface vlan-interface 300
[SwitchB-Vlan-interface300] ospfv3 2 area 2
[SwitchB-Vlan-interface300] quit
```

Enable OSPFv3 process 2 on Switch C.

```
<SwitchC> system-view
[SwitchC] ospfv3 2
[SwitchC-ospfv3-2] router-id 4.4.4.4
[SwitchC-ospfv3-2] quit
[SwitchC] interface vlan-interface 300
[SwitchC-Vlan-interface300] ospfv3 2 area 2
[SwitchC-Vlan-interface300] quit
[SwitchC] interface vlan-interface 400
[SwitchC-Vlan-interface400] ospfv3 2 area 2
[SwitchC-Vlan-interface400] quit
```

3. Configure OSPFv3 route redistribution:

Configure OSPFv3 process 2 to redistribute direct routes and the routes from OSPFv3 process 1 on Switch B.

```
[SwitchB] ospfv3 2
[SwitchB-ospfv3-2] import-route ospfv3 1
[SwitchB-ospfv3-2] import-route direct
[SwitchB-ospfv3-2] quit
```

Display the routing table on Switch C.

```
[SwitchC] display ipv6 routing-table

Destinations : 12 Routes : 12

Destination: ::1/128                                Protocol  : Direct
NextHop    : ::1                                    Preference: 0
Interface  : InLoop0                                Cost      : 0
```

```
Destination: 1::/64                                   Protocol  : O_ASE2
NextHop    : FE80::200:CFF:FE01:1C03                  Preference: 150
Interface  : Vlan300                                  Cost      : 1

Destination: 2::/64                                   Protocol  : O_ASE2
NextHop    : FE80::200:CFF:FE01:1C03                  Preference: 150
Interface  : Vlan300                                  Cost      : 1

Destination: 2:1:1::/64                               Protocol  : O_ASE2
NextHop    : FE80::200:CFF:FE01:1C03                  Preference: 150
Interface  : Vlan300                                  Cost      : 1

Destination: 2:1:2::/64                               Protocol  : O_ASE2
NextHop    : FE80::200:CFF:FE01:1C03                  Preference: 150
Interface  : Vlan300                                  Cost      : 1

Destination: 2:1:3::/64                               Protocol  : O_ASE2
NextHop    : FE80::200:CFF:FE01:1C03                  Preference: 150
Interface  : Vlan300                                  Cost      : 1

Destination: 3::/64                                   Protocol  : Direct
NextHop    : 3::2                                     Preference: 0
Interface  : Vlan300                                  Cost      : 0

Destination: 3::2/128                                 Protocol  : Direct
NextHop    : ::1                                      Preference: 0
Interface  : InLoop0                                  Cost      : 0

Destination: 4::/64                                   Protocol  : Direct
NextHop    : 4::1                                     Preference: 0
Interface  : Vlan400                                  Cost      : 0

Destination: 4::1/128                                 Protocol  : Direct
NextHop    : ::1                                      Preference: 0
Interface  : InLoop0                                  Cost      : 0

Destination: FE80::/10                                Protocol  : Direct
NextHop    : ::                                       Preference: 0
Interface  : NULL0                                    Cost      : 0

Destination: FF00::/8                                 Protocol  : Direct
NextHop    : ::                                       Preference: 0
Interface  : NULL0                                    Cost      : 0
```

4. Configure ASBR route summarization:

On Switch B, configure OSPFv3 process 2 to advertise a single route 2::/16.

```
[SwitchB] ospfv3 2
[SwitchB-ospfv3-2] asbr-summary 2:: 16
```

```
[SwitchB-ospfv3-2] quit
```

Display the routing table on Switch C.

```
[SwitchC] display ipv6 routing-table

Destinations : 9 Routes : 9

Destination: ::1/128                                Protocol  : Direct
NextHop    : ::1                                    Preference: 0
Interface  : InLoop0                                Cost      : 0

Destination: 1::/64                                 Protocol  : O_ASE2
NextHop    : FE80::200:CFF:FE01:1C03                Preference: 150
Interface  : Vlan300                                Cost      : 1

Destination: 2::/16                                 Protocol  : O_ASE2
NextHop    : FE80::200:CFF:FE01:1C03                Preference: 150
Interface  : Vlan300                                Cost      : 1

Destination: 3::/64                                 Protocol  : Direct
NextHop    : 3::2                                   Preference: 0
Interface  : Vlan300                                Cost      : 0

Destination: 3::2/128                               Protocol  : Direct
NextHop    : ::1                                    Preference: 0
Interface  : InLoop0                                Cost      : 0

Destination: 4::/64                                 Protocol  : Direct
NextHop    : 4::1                                   Preference: 0
Interface  : Vlan400                                Cost      : 0

Destination: 4::1/128                               Protocol  : Direct
NextHop    : ::1                                    Preference: 0
Interface  : InLoop0                                Cost      : 0

Destination: FE80::/10                              Protocol  : Direct
NextHop    : ::                                     Preference: 0
Interface  : NULL0                                  Cost      : 0

Destination: FF00::/8                               Protocol  : Direct
NextHop    : ::                                     Preference: 0
Interface  : NULL0                                  Cost      : 0
```

Example: Configuring OSPFv3 GR

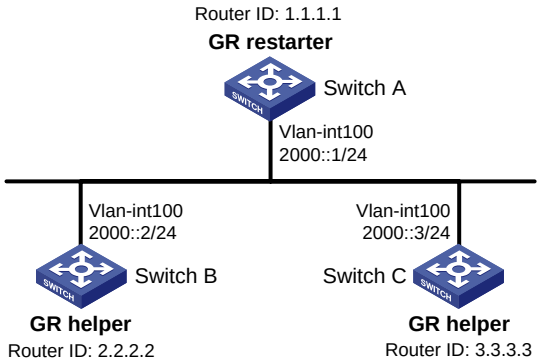
Network configuration

As shown in Figure 7:

- Switch A, Switch B, and Switch C that reside in the same AS and the same OSPFv3 routing domain are GR capable.

- Switch A acts as the GR restarter. Switch B and Switch C act as the GR helpers, and synchronize their LSDBs with Switch A through GR.

Figure 7 Network diagram



Procedure

1. Configure IPv6 addresses for interfaces. (Details not shown.)
2. Configure basic OSPFv3:

   # On Switch A, enable OSPFv3 process 1, enable GR, and set the router ID to 1.1.1.1.

   ```
   <SwitchA> system-view
   [SwitchA] ospfv3 1
   [SwitchA-ospfv3-1] router-id 1.1.1.1
   [SwitchA-ospfv3-1] graceful-restart enable
   [SwitchA-ospfv3-1] quit
   [SwitchA] interface vlan-interface 100
   [SwitchA-Vlan-interface100] ospfv3 1 area 1
   [SwitchA-Vlan-interface100] quit
   ```

   # On Switch B, enable OSPFv3 and set the router ID to 2.2.2.2. (By default, GR helper is enabled on Switch B.)

   ```
   <SwitchB> system-view
   [SwitchB] ospfv3 1
   [SwitchB-ospfv3-1] router-id 2.2.2.2
   [SwitchB-ospfv3-1] quit
   [SwitchB] interface vlan-interface 100
   [SwitchB-Vlan-interface100] ospfv3 1 area 1
   [SwitchB-Vlan-interface100] quit
   ```

   # On Switch C, enable OSPFv3 and set the router ID to 3.3.3.3. (By default, GR helper is enabled on Switch C.)

   ```
   <SwitchC> system-view
   [SwitchC] ospfv3 1
   [SwitchC-ospfv3-1] router-id 3.3.3.3
   [SwitchC-ospfv3-1] quit
   [SwitchC] interface vlan-interface 100
   [SwitchC-Vlan-interface100] ospfv3 1 area 1
   [SwitchC-Vlan-interface100] quit
   ```

Verifying the configuration

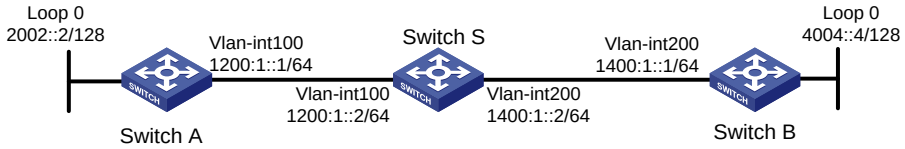
Perform a master/backup switchover on Switch A to trigger an OSPFv3 GR operation. (Details not shown.)

Example: Configuring OSPFv3 NSR

Network configuration

As shown in Figure 8, Switch S, Switch A, and Switch B belong to the same OSPFv3 routing domain. Enable OSPFv3 NSR on Switch S to ensure correct routing when an active/standby switchover occurs on Switch S.

Figure 8 Network diagram



Procedure

1. Configure IP addresses and subnet masks for interfaces on the switches. (Details not shown.)
2. Configure OSPFv3 on the switches to ensure that Switch S, Switch A, and Switch B can communicate with each other at Layer 3. (Details not shown.)
3. Configure OSPFv3:

   # On Switch A, enable OSPFv3, and set the router ID to 1.1.1.1.

```
<SwitchA> system-view
[SwitchA] ospfv3 1
[SwitchA-ospfv3-1] router-id 1.1.1.1
[SwitchA-ospfv3-1] quit
[SwitchA] interface vlan-interface 100
[SwitchA-Vlan-interface100] ospfv3 1 area 1
[SwitchA-Vlan-interface100] quit
```

   # On Switch B, enable OSPFv3, and set the router ID to 2.2.2.2.

```
<SwitchB> system-view
[SwitchB] ospfv3 1
[SwitchB-ospfv3-1] router-id 2.2.2.2
[SwitchB-ospfv3-1] quit
[SwitchB] interface vlan-interface 200
[SwitchB-Vlan-interface200] ospfv3 1 area 1
[SwitchB-Vlan-interface200] quit
```

   # On Switch S, enable OSPFv3, set the router ID to 3.3.3.3, and enable NSR.

```
<SwitchS> system-view
[SwitchS] ospfv3 1
[SwitchS-ospfv3-1] router-id 3.3.3.3
[SwitchS-ospfv3-1] non-stop-routing
[SwitchS-ospfv3-1] quit
[SwitchS] interface vlan-interface 100
[SwitchS-Vlan-interface100] ospfv3 1 area 1
[SwitchS-Vlan-interface100] quit
[SwitchS] interface vlan-interface 200
[SwitchS-Vlan-interface200] ospfv3 1 area 1
[SwitchS-Vlan-interface200] quit
```

Verifying the configuration

Verify the following:

- When an active/standby switchover occurs on Switch S, the neighbor relationships and routing information on Switch A and Switch B have not changed. (Details not shown.)
- The traffic from Switch A to Switch B has not been impacted. (Details not shown.)

Example: Configuring BFD for OSPFv3

Network configuration

As shown in Figure 9:

- Configure OSPFv3 on Switch A, Switch B and Switch C and configure BFD over the link Switch A<—>L2 Switch<—>Switch B.
- After the link Switch A<—>L2 Switch<—>Switch B fails, BFD can quickly detect the failure and notify OSPFv3 of the failure. Then Switch A and Switch B communicate through Switch C.

Figure 9 Network diagram

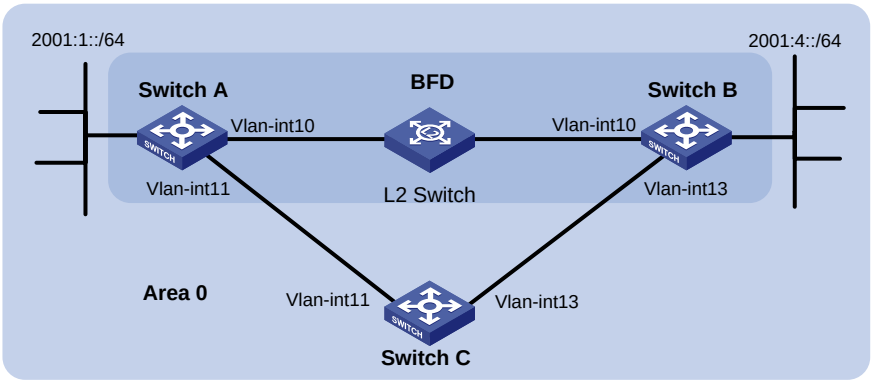


Table 1 Interface and IP address assignment

Device	Interface	IPv6 address
Switch A	Vlan-int10	2001::1/64
Switch A	Vlan-int11	2001:2::1/64
Switch B	Vlan-int10	2001::2/64
Switch B	Vlan-int13	2001:3::2/64
Switch C	Vlan-int11	2001:2::2/64
Switch C	Vlan-int13	2001:3::1/64

Procedure

1. Configure IPv6 addresses for the interfaces. (Details not shown.)
2. Configure basic OSPFv3:

   # On Switch A, enable OSPFv3 and specify the router ID as 1.1.1.1.

```
<SwitchA> system-view
[SwitchA] ospfv3
[SwitchA-ospfv3-1] router-id 1.1.1.1
[SwitchA-ospfv3-1] quit
[SwitchA] interface vlan-interface 10
```

```
[SwitchA-Vlan-interface10] ospfv3 1 area 0
[SwitchA-Vlan-interface10] quit
[SwitchA] interface vlan-interface 11
[SwitchA-Vlan-interface11] ospfv3 1 area 0
[SwitchA-Vlan-interface11] quit
```

On Switch B, enable OSPFv3 and specify the router ID as 2.2.2.2.

```
<SwitchB> system-view
[SwitchB] ospfv3
[SwitchB-ospfv3-1] router-id 2.2.2.2
[SwitchB-ospfv3-1] quit
[SwitchB] interface vlan-interface 10
[SwitchB-Vlan-interface10] ospfv3 1 area 0
[SwitchB-Vlan-interface10] quit
[SwitchB] interface vlan-interface 13
[SwitchB-Vlan-interface13] ospfv3 1 area 0
[SwitchB-Vlan-interface13] quit
```

On Switch C, enable OSPFv3 and specify the router ID as 3.3.3.3.

```
<SwitchC> system-view
[SwitchC] ospfv3
[SwitchC-ospfv3-1] router-id 3.3.3.3
[SwitchC-ospfv3-1] quit
[SwitchC] interface vlan-interface 11
[SwitchC-Vlan-interface11] ospfv3 1 area 0
[SwitchC-Vlan-interface11] quit
[SwitchC] interface vlan-interface 13
[SwitchC-Vlan-interface13] ospfv3 1 area 0
[SwitchC-Vlan-interface13] quit
```

3. Configure BFD:

Enable BFD and configure BFD parameters on Switch A.

```
[SwitchA] bfd session init-mode active
[SwitchA] interface vlan-interface 10
[SwitchA-Vlan-interface10] ospfv3 bfd enable
[SwitchA-Vlan-interface10] bfd min-transmit-interval 500
[SwitchA-Vlan-interface10] bfd min-receive-interval 500
[SwitchA-Vlan-interface10] bfd detect-multiplier 7
[SwitchA-Vlan-interface10] return
```

Enable BFD and configure BFD parameters on Switch B.

```
[SwitchB] bfd session init-mode active
[SwitchB] interface vlan-interface 10
[SwitchB-Vlan-interface10] ospfv3 bfd enable
[SwitchB-Vlan-interface10] bfd min-transmit-interval 500
[SwitchB-Vlan-interface10] bfd min-receive-interval 500
[SwitchB-Vlan-interface10] bfd detect-multiplier 6
```

Verifying the configuration

Display the BFD information on Switch A.

```
<SwitchA> display bfd session
```

```
 Total Session Num: 1           Init Mode: Active

 IPv6 session working in control packet mode:

     Local Discr: 1441               Remote Discr: 1450
       Source IP: FE80::20F:FF:FE00:1202 (link-local address of VLAN-interface 10 on
Switch A)
  Destination IP: FE80::20F:FF:FE00:1200 (link-local address of VLAN-interface 10 on
Switch B)
   Session State: Up                     Interface: Vlan10
       Hold Time: 2319ms
```

Display routes destined for 2001:4::0/64 on Switch A.

```
<SwitchA> display ipv6 routing-table 2001:4::0 64

Summary Count : 1

Destination: 2001:4::/64                              Protocol  : O_INTRA
NextHop    : FE80::20F:FF:FE00:1200                   Preference: 10
Interface  : Vlan10                                   Cost      : 1
```

The output information shows that Switch A communicates with Switch B through VLAN-interface 10. The link over VLAN-interface 10 fails.

Display routes to 2001:4::0/64 on Switch A.

```
<SwitchA> display ipv6 routing-table 2001:4::0 64

Summary Count : 1

Destination: 2001:4::/64                              Protocol  : O_INTRA
NextHop    : FE80::BAAF:67FF:FE27:DCD0                Preference: 10
Interface  : Vlan11                                   Cost      : 2
```

The output shows that Switch A communicates with Switch B through VLAN-interface 11.

Example: Configuring OSPFv3 FRR

Network configuration

As shown in Figure 10, Switch A, Switch B, and Switch C reside in the same OSPFv3 domain. Configure OSPFv3 FRR so that when Link A fails, traffic is immediately switched to Link B.

Figure 10 Network diagram

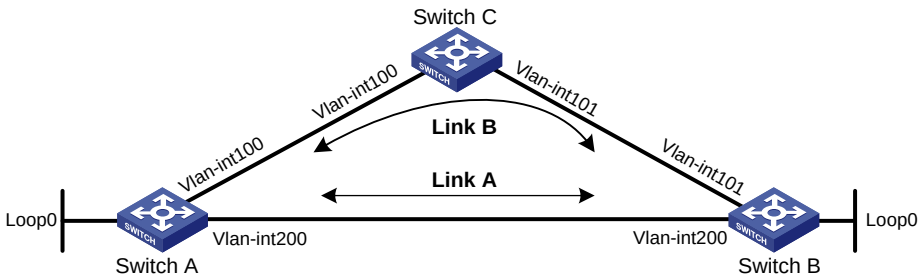


Table 2 Interface and IP address assignment

Device	Interface	IP address	Device	Interface	IP address
Switch A	Vlan-int100	1::1/64	Switch B	Vlan-int101	3::1/64
	Vlan-int200	2::1/64		Vlan-int200	2::2/64
	Loop0	10::1/128		Loop0	20::1/128
Switch C	Vlan-int100	1::2/64			
	Vlan-int101	3::2/64			

Procedure

1. Configure IPv6 addresses and subnet masks for interfaces on the switches. (Details not shown.)
2. Configure OSPFv3 on the switches to ensure that Switch A, Switch B, and Switch C can communicate with each other at the network layer. (Details not shown.)
3. Configure OSPFv3 FRR to automatically calculate the backup next hop:

   You can enable OSPFv3 FRR to either calculate a backup next hop by using the LFA algorithm, or specify a backup next hop by using a routing policy.

   - (Method 1.) Enable OSPFv3 FRR to calculate the backup next hop by using the LFA algorithm:

     # Configure Switch A.

     ```
     <SwitchA> system-view
     [SwitchA] ospfv3 1
     [SwitchA-ospfv3-1] fast-reroute lfa
     [SwitchA-ospfv3-1] quit
     ```

     # Configure Switch B.

     ```
     <SwitchB> system-view
     [SwitchB] ospfv3 1
     [SwitchB-ospfv3-1] fast-reroute lfa
     [SwitchB-ospfv3-1] quit
     ```

   - (Method 2.) Enable OSPFv3 FRR to designate a backup next hop by using a routing policy:

     # Configure Switch A.

     ```
     <SwitchA> system-view
     [SwitchA] ipv6 prefix-list abc index 10 permit 20::1 128
     [SwitchA] route-policy frr permit node 10
     [SwitchA-route-policy-frr-10] if-match ipv6 address prefix-list abc
     [SwitchA-route-policy-frr-10] apply ipv6 fast-reroute backup-interface
     vlan-interface 100 backup-nexthop 1::2
     [SwitchA-route-policy-frr-10] quit
     [SwitchA] ospfv3 1
     [SwitchA-ospfv3-1] fast-reroute route-policy frr
     [SwitchA-ospfv3-1] quit
     ```

     # Configure Switch B.

     ```
     <SwitchB> system-view
     [SwitchB] ipv6 prefix-list abc index 10 permit 10::1 128
     [SwitchB] route-policy frr permit node 10
     [SwitchB-route-policy-frr-10] if-match ipv6 address prefix-list abc
     ```

```
[SwitchB-route-policy-frr-10] apply ipv6 fast-reroute backup-interface
vlan-interface 101 backup-nexthop 3::2
[SwitchB-route-policy-frr-10] quit
[SwitchB] ospfv3 1
[SwitchB-ospfv3-1] fast-reroute route-policy frr
[SwitchB-ospfv3-1] quit
```

Verifying the configuration

Display the route 20::1/128 on Switch A to view the backup next hop information.

```
[SwitchA] display ipv6 routing-table 20::1 128 verbose

Summary count : 1

Destination: 20::1/128
   Protocol: O_INTRA
 Process ID: 1
  SubProtID: 0x1                  Age: 00h03m45s
       Cost: 6              Preference: 10
      IpPre: N/A            QosLocalID: N/A
        Tag: 0                 State: Active Adv
  OrigTblID: 0x0              OrigVrf: default-vrf
    TableID: 0xa               OrigAs: 0
      NibID: 0x23000005        LastAs: 0
     AttrID: 0xffffffff       Neighbor: ::
      Flags: 0x10041       OrigNextHop: FE80::7685:45FF:FEAD:102
      Label: NULL          RealNextHop: FE80::7685:45FF:FEAD:102
    BkLabel: NULL            BkNextHop: FE80::34CD:9FF:FE2F:D02
    SRLabel: NULL            BkSRLabel: NULL
  Tunnel ID: Invalid         Interface: Vlan-interface200
BkTunnel ID: Invalid       BkInterface: Vlan-interface100
   FtnIndex: 0x0           TrafficIndex: N/A
  Connector: N/A                PathID: 0x0
```

Display the route 10::1/128 on Switch B to view the backup next hop information.

```
[SwitchB] display ipv6 routing-table 10::1 128 verbose

Summary count : 1

Destination: 10::1/128
   Protocol: O_INTRA
 Process ID: 1
  SubProtID: 0x1                  Age: 00h03m10s
       Cost: 1              Preference: 10
      IpPre: N/A            QosLocalID: N/A
        Tag: 0                 State: Active Adv
  OrigTblID: 0x0              OrigVrf: default-vrf
    TableID: 0xa               OrigAs: 0
      NibID: 0x23000006        LastAs: 0
     AttrID: 0xffffffff       Neighbor: ::
      Flags: 0x10041       OrigNextHop: FE80::34CC:E8FF:FE5B:C02
```

```
      Label: NULL             RealNextHop: FE80::34CC:E8FF:FE5B:C02
    BkLabel: NULL               BkNextHop: FE80::7685:45FF:FEAD:102
    SRLabel: NULL               BkSRLabel: NULL
  Tunnel ID: Invalid            Interface: Vlan-interface200
BkTunnel ID: Invalid          BkInterface: Vlan-interface101
   FtnIndex: 0x0             TrafficIndex: N/A
  Connector: N/A                   PathID: 0x0
```

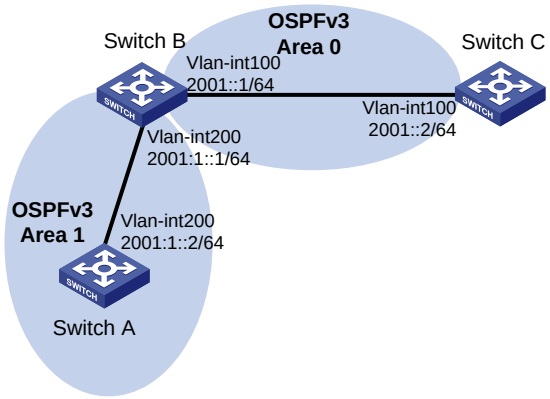
Example: Configuring OSPFv3 IPsec profile

Network configuration

As shown in Figure 11, all switches run OSPFv3, and the AS is divided into two areas.

Configure IPsec profiles on the switches to authenticate and encrypt protocol packets.

Figure 11 Network diagram



Procedure

1. Configure IPv6 addresses for interfaces. (Details not shown.)
2. Configure OSPFv3 basic features:

   # On Switch A, enable OSPFv3 and specify the router ID as 1.1.1.1.

```
<SwitchA> system-view
[SwitchA] ospfv3 1
[SwitchA-ospfv3-1] router-id 1.1.1.1
[SwitchA-ospfv3-1] quit
[SwitchA] interface vlan-interface 200
[SwitchA-Vlan-interface200] ospfv3 1 area 1
[SwitchA-Vlan-interface200] quit
```

   # On Switch B, enable OSPFv3 and specify the router ID as 2.2.2.2.

```
<SwitchB> system-view
[SwitchB] ospfv3 1
[SwitchB-ospfv3-1] router-id 2.2.2.2
[SwitchB-ospfv3-1] quit
[SwitchB] interface vlan-interface 100
[SwitchB-Vlan-interface100] ospfv3 1 area 0
[SwitchB-Vlan-interface100] quit
[SwitchB] interface vlan-interface 200
[SwitchB-Vlan-interface200] ospfv3 1 area 1
```

```
[SwitchB-Vlan-interface200] quit
```

On Switch C, enable OSPFv3 and specify the router ID as 3.3.3.3.

```
<SwitchC> system-view
[SwitchC] ospfv3 1
[SwitchC-ospfv3-1] router-id 3.3.3.3
[SwitchC-ospfv3-1] quit
[SwitchC] interface vlan-interface 100
[SwitchC-Vlan-interface100] ospfv3 1 area 0
[SwitchC-Vlan-interface100] quit
```

3. Configure OSPFv3 IPsec profiles:

- On Switch A:

  # Create an IPsec transform set named **trans**.

  ```
  [SwitchA] ipsec transform-set trans
  ```

  # Specify the encapsulation mode as **transport**.

  ```
  [SwitchA-ipsec-transform-set-trans] encapsulation-mode transport
  ```

  # Specify the ESP encryption and authentication algorithms.

  ```
  [SwitchA-ipsec-transform-set-trans] protocol esp
  [SwitchA-ipsec-transform-set-trans] esp encryption-algorithm aes-cbc-128
  [SwitchA-ipsec-transform-set-trans] esp authentication-algorithm sha1
  [SwitchA-ipsec-transform-set-trans] quit
  ```

  # Create a manual IPsec profile named **profile001**.

  ```
  [SwitchA] ipsec profile profile001 manual
  ```

  # Use IPsec transform set **trans**.

  ```
  [SwitchA-ipsec-profile-manual-profile001] transform-set trans
  ```

  # Configure the inbound and outbound SPIs for ESP.

  ```
  [SwitchA-ipsec-profile-manual-profile001] sa spi outbound esp 123456
  [SwitchA-ipsec-profile-manual-profile001] sa spi inbound esp 123456
  ```

  # Configure the inbound and outbound SA keys for ESP.

  ```
  [SwitchA-ipsec-profile-manual-profile001] sa string-key outbound esp simple
  abcdefg
  [SwitchA-ipsec-profile-manual-profile001] sa string-key inbound esp simple
  abcdefg
  [SwitchA-ipsec-profile-manual-profile001] quit
  ```

- On Switch B:

  # Create an IPsec transform set named **trans**.

  ```
  [SwitchB] ipsec transform-set trans
  ```

  # Specify the encapsulation mode as **transport**.

  ```
  [SwitchB-ipsec-transform-set-trans] encapsulation-mode transport
  ```

  # Specify the ESP encryption and authentication algorithms.

  ```
  [SwitchB-ipsec-transform-set-trans] protocol esp
  [SwitchB-ipsec-transform-set-trans] esp encryption-algorithm aes-cbc-128
  [SwitchB-ipsec-transform-set-trans] esp authentication-algorithm sha1
  [SwitchB-ipsec-transform-set-trans] quit
  ```

  # Create a manual IPsec profile named **profile001**.

  ```
  [SwitchB] ipsec profile profile001 manual
  ```

  # Use IPsec transform set **trans**.

  ```
  [SwitchB-ipsec-profile-manual-profile001] transform-set trans
  ```

Configure the inbound and outbound SPIs for ESP.

```
[SwitchB-ipsec-profile-manual-profile001] sa spi outbound esp 123456
[SwitchB-ipsec-profile-manual-profile001] sa spi inbound esp 123456
```

Configure the inbound and outbound SA keys for ESP.

```
[SwitchB-ipsec-profile-manual-profile001] sa string-key outbound esp simple
abcdefg
[SwitchB-ipsec-profile-manual-profile001] sa string-key inbound esp simple
abcdefg
[SwitchB-ipsec-profile-manual-profile001] quit
```

Create a manual IPsec profile named **profile002**.

```
[SwitchB] ipsec profile profile002 manual
```

Use IPsec transform set **trans**.

```
[SwitchB-ipsec-profile-manual-profile002] transform-set trans
```

Configure the inbound and outbound SPIs for ESP.

```
[SwitchB-ipsec-profile-manual-profile002] sa spi outbound esp 256
[SwitchB-ipsec-profile-manual-profile002] sa spi inbound esp 256
```

Configure the inbound and outbound SA keys for ESP.

```
[SwitchB-ipsec-profile-manual-profile002] sa string-key outbound esp simple
byebye
[SwitchB-ipsec-profile-manual-profile001] sa string-key inbound esp simple byebye
[SwitchB-ipsec-profile-manual-profile001] quit
```

- On Switch C:

  # Create an IPsec transform set named **trans**.

  ```
  [SwitchC] ipsec transform-set trans
  ```

  # Specify the encapsulation mode as **transport**.

  ```
  [SwitchC-ipsec-transform-set-trans] encapsulation-mode transport
  ```

  # Specify the ESP encryption and authentication algorithms.

  ```
  [SwitchC-ipsec-transform-set-trans] protocol esp
  [SwitchC-ipsec-transform-set-trans] esp encryption-algorithm aes-cbc-128
  [SwitchC-ipsec-transform-set-trans] esp authentication-algorithm sha1
  [SwitchC-ipsec-transform-set-trans] quit
  ```

  # Create a manual IPsec profile named **profile002**.

  ```
  [SwitchC] ipsec profile profile002 manual
  ```

  # Use IPsec transform set **trans**.

  ```
  [SwitchC-ipsec-profile-manual-profile002] transform-set trans
  ```

  # Configure the inbound and outbound SPIs for ESP.

  ```
  [SwitchC-ipsec-profile-manual-profile002] sa spi outbound esp 256
  [SwitchC-ipsec-profile-manual-profile002] sa spi inbound esp 256
  ```

  # Configure the inbound and outbound SA keys for ESP.

  ```
  [SwitchC-ipsec-profile-manual-profile002] sa string-key outbound esp simple
  byebye
  [SwitchC-ipsec-profile-manual-profile001] sa string-key inbound esp simple byebye
  [SwitchC-ipsec-profile-manual-profile001] quit
  ```

4. Apply the IPsec profiles to areas:

Configure Switch A.

```
[SwitchA] ospfv3 1
[SwitchA-ospfv3-1] area 1
```

```
[SwitchA-ospfv3-1-area-0.0.0.1] enable ipsec-profile profile001
[SwitchA-ospfv3-1-area-0.0.0.1] quit
[SwitchA-ospfv3-1] quit
```

Configure Switch B.

```
[SwitchB] ospfv3 1
[SwitchB-ospfv3-1] area 0
[SwitchB-ospfv3-1-area-0.0.0.0] enable ipsec-profile profile002
[SwitchB-ospfv3-1-area-0.0.0.0] quit
[SwitchB-ospfv3-1] area 1
[SwitchB-ospfv3-1-area-0.0.0.1] enable ipsec-profile profile001
[SwitchB-ospfv3-1-area-0.0.0.1] quit
[SwitchB-ospfv3-1] quit
```

Configure Switch C.

```
[SwitchC] ospfv3 1
[SwitchC-ospfv3-1] area 0
[SwitchC-ospfv3-1-area-0.0.0.0] enable ipsec-profile profile002
[SwitchC-ospfv3-1-area-0.0.0.0] quit
[SwitchC-ospfv3-1] quit
```

Verifying the configuration

Verify that OSPFv3 packets between Switches A, B, and C are protected by IPsec. (Details not shown.)

Contents

Configuring IPv6 PBR

About IPv6 PBR

IPv6 policy-based routing (PBR) uses user-defined policies to route IPv6 packets. A policy can specify parameters for packets that match specific criteria such as ACLs. The parameters include the next hop.

IPv6 packet forwarding process

A device forwards received IPv6 packets using the following process:

1. The device uses PBR to forward matching packets.
2. If one of the following events occurs, the device searches for a route (except the default route) in the routing table to forward packets:
   - The packets do not match the PBR policy.
   - The PBR-based forwarding fails.
3. If the forwarding fails, the device uses the default route to forward packets.

IPv6 PBR types

IPv6 PBR includes the following types:

- **Local PBR**—Guides the forwarding of locally generated packets, such as the ICMP packets generated by using the **`ping`** command.
- **Interface PBR**—Guides the forwarding of packets received on an interface only.

Policy

An IPv6 policy includes match criteria and actions to be taken on the matching packets. A policy can have one or multiple nodes as follows:

- Each node is identified by a node number. A smaller node number has a higher priority.
- A node contains **`if-match`** and **`apply`** clauses. An **`if-match`** clause specifies a match criterion, and an **`apply`** clause specifies an action.
- A node has a match mode of **permit** or **deny**.

An IPv6 policy compares packets with nodes in priority order. If a packet matches the criteria on a node, it is processed by the action on the node. If the packet does not match any criteria on the node, it goes to the next node for a match. If the packet does not match the criteria on any node, the device performs a routing table lookup for the packet.

Relationship between if-match clauses

IPv6 PBR supports only the **`if-match acl`** clause to set an ACL match criterion. On a node, you can specify only one **`if-match`** clause.

Relationship between apply clauses

IPv6 PBR supports only the **`apply next-hop`** clause to set next hops.

Relationship between the match mode and clauses on the node

Does a packet match all the if-match clauses on the node?	Match mode	
	In permit mode	**In deny mode**
Yes	• If the node contains **apply** clauses, IPv6 PBR executes the **apply** clauses on the node. ○ If IPv6 PBR-based forwarding succeeds, IPv6 PBR does not compare the packet with the next node. • If the node does not contain **apply** clauses, the device performs a routing table lookup for the packet.	The device performs a routing table lookup for the packet.
No	IPv6 PBR compares the packet with the next node.	IPv6 PBR compares the packet with the next node.

NOTE:

A node that has no **if-match** clauses matches any packet.

IPv6 PBR and Track

IPv6 PBR can work with the Track feature to dynamically adapt the availability status of an **apply** clause to the link status of a tracked object. The tracked object can be a next hop.

- When the track entry associated with an object changes to **Negative**, the **apply** clause is invalid.
- When the track entry changes to **Positive** or **NotReady**, the **apply** clause is valid.

For more information about Track and IPv6 PBR collaboration, see *High Availability Configuration Guide*.

Restrictions and guidelines: IPv6 PBR configuration

If the device performs forwarding in software, IPv6 PBR does not process IP packets destined for the local device.

If the device performs forwarding in hardware and a packet destined for it matches an IPv6 PBR policy, IPv6 PBR will execute the apply clauses in the policy, including the clause for forwarding. When you configure an IPv6 PBR policy, be careful to avoid this situation.

IPv6 PBR tasks at a glance

To configure IPv6 PBR, perform the following tasks:

1. Configuring an IPv6 policy
   a. Creating an IPv6 node
   b. Setting match criteria for an IPv6 node

c. Configuring actions for an IPv6 node

2. Specifying a policy for IPv6 PBR

   Choose the following tasks as needed:

   - Specifying an IPv6 policy for IPv6 local PBR
   - Specifying an IPv6 policy for IPv6 interface PBR

Configuring an IPv6 policy

Creating an IPv6 node

1. Enter system view.

   system-view

2. Create an IPv6 policy or policy node and enter its view.

   ipv6 policy-based-route *policy-name* [**deny** | **permit**] **node** *node-number*

3. (Optional.) Configure a description for the IPv6 policy node.

   description *text*

   By default, no description is configured for an IPv6 policy node.

Setting match criteria for an IPv6 node

1. Enter system view.

   system-view

2. Enter IPv6 policy node view.

   ipv6 policy-based-route *policy-name* [**deny** | **permit**] **node** *node-number*

3. Set match criteria.

   - Set an ACL match criterion.

     if-match acl { *ipv6-acl-number* | **name** *ipv6-acl-name* }

     By default, no ACL match criterion is set.

     The ACL match criterion cannot match Layer 2 information.

     When using the ACL to match packets, IPv6 PBR ignores the action (**permit** or **deny**) and time range settings in the ACL.

Configuring actions for an IPv6 node

About apply clauses

IPv6 PBR supports only the **apply next-hop** clause to set next hops for matching packets.

Restrictions and guidelines for action configuration

If you specify a next hop or default next hop, IPv6 PBR periodically performs a lookup in the FIB table to determine its availability. Temporary service interruption might occur if IPv6 PBR does not update the route immediately after its availability status changes.

Configuring actions for a node

1. Enter system view.

   system-view

2. Enter IPv6 policy node view.

ipv6 policy-based-route *policy-name* [**deny** | **permit**] **node** *node-number*

3. Configure actions for a node.
   - Set next hops for permitted IPv6 packets.

     apply next-hop { *ipv6-address* [**direct**] [**track** *track-entry-number*] } &<1-2>

     By default, no next hops are specified.

     You can specify multiple next hops for backup in one command line or by executing this command multiple times. You can specify a maximum of two next hops for a node.

Specifying a policy for IPv6 PBR

Specifying an IPv6 policy for IPv6 local PBR

About IPv6 local PBR

Perform this task to specify an IPv6 policy for IPv6 local PBR to guide the forwarding of locally generated packets.

Restrictions and guidelines

You can specify only one policy for IPv6 local PBR and must make sure the specified policy already exists. Before you apply a new policy, you must first remove the current policy.

IPv6 local PBR might affect local services, such as ping and Telnet. When you use IPv6 local PBR, make sure you fully understand its impact on local services of the device.

Procedure

1. Enter system view.

   system-view

2. Specify an IPv6 policy for IPv6 local PBR.

   ipv6 local policy-based-route *policy-name*

   By default, IPv6 local PBR is not enabled.

Specifying an IPv6 policy for IPv6 interface PBR

About interface PBR

Perform this task to apply an IPv6 policy to an interface to guide the forwarding of packets received on the interface only.

Restrictions and guidelines

You can apply only one policy to an interface and must make sure the specified policy already exists. Before you apply a new policy, you must first remove the current policy from the interface.

You can apply a policy to multiple interfaces.

Procedure

1. Enter system view.

   system-view

2. Enter interface view.

   interface *interface-type interface-number*

3. Specify an IPv6 policy for IPv6 interface PBR.

   ipv6 policy-based-route *policy-name*

By default, no IPv6 policy is applied to the interface.

Display and maintenance commands for IPv6 PBR

Execute **display** commands in any view and **reset** commands in user view.

Task	Command
Display IPv6 PBR policy information.	**display ipv6 policy-based-route** [**policy** *policy-name*]
Display IPv6 interface PBR configuration and statistics.	**display ipv6 policy-based-route interface** *interface-type interface-number* [**slot** *slot-number*]
Display IPv6 local PBR configuration and statistics.	**display ipv6 policy-based-route local** [**slot** *slot-number*]
Display IPv6 PBR configuration.	**display ipv6 policy-based-route setup**
Clear IPv6 PBR statistics.	**reset ipv6 policy-based-route statistics** [**policy** *policy-name*]

IPv6 PBR configuration examples

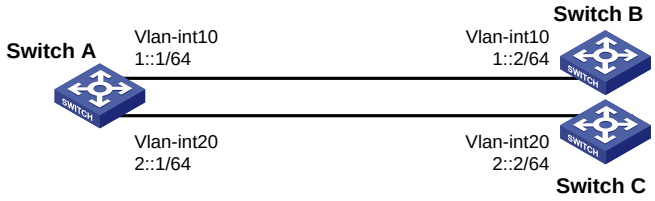
Example: Configuring packet type-based IPv6 local PBR

Network configuration

As shown in Figure 1, Switch B and Switch C are connected through Switch A. Switch B and Switch C do not have a route to reach each other.

Configure IPv6 PBR on Switch A to forward all TCP packets to the next hop 1::2 (Switch B).

Figure 1 Network diagram



Procedure

1. Configure Switch A:

Create VLAN 10 and VLAN 20.

```
<SwitchA> system-view
[SwitchA] vlan 10
[SwitchA-vlan10] quit
[SwitchA] vlan 20
[SwitchA-vlan20] quit
```

Configure the IPv6 addresses of VLAN-interface 10 and VLAN-interface 20.

```
[SwitchA] interface vlan-interface 10
[SwitchA-Vlan-interface10] ipv6 address 1::1 64
[SwitchA-Vlan-interface10] quit
[SwitchA] interface vlan-interface 20
[SwitchA-Vlan-interface20] ipv6 address 2::1 64
[SwitchA-Vlan-interface20] quit
```

Configure ACL 3001 to match TCP packets.

```
[SwitchA] acl ipv6 advanced 3001
[SwitchA-acl-ipv6-adv-3001] rule permit tcp
[SwitchA-acl-ipv6-adv-3001] quit
```

Configure Node 5 for policy **aaa** to forward TCP packets to next hop 1::2.

```
[SwitchA] ipv6 policy-based-route aaa permit node 5
[SwitchA-pbr6-aaa-5] if-match acl 3001
[SwitchA-pbr6-aaa-5] apply next-hop 1::2
[SwitchA-pbr6-aaa-5] quit
```

Configure IPv6 local PBR by applying policy **aaa** to Switch A.

```
[SwitchA] ipv6 local policy-based-route aaa
```

2. Configure Switch B:

Create VLAN 10.

```
<SwitchB> system-view
[SwitchB] vlan 10
[SwitchB-vlan10] quit
```

Configure the IPv6 address of VLAN-interface 10.

```
[SwitchB] interface vlan-interface 10
[SwitchB-Vlan-interface10] ipv6 address 1::2 64
```

3. Configure Switch C:

Create VLAN 20.

```
<SwitchC> system-view
[SwitchC] vlan 20
[SwitchC-vlan20] quit
```

Configure the IPv6 address of VLAN-interface 20.

```
[SwitchC] interface vlan-interface 20
[SwitchC-Vlan-interface20] ipv6 address 2::2 64
```

Verifying the configuration

1. Perform telnet operations to verify that IPv6 local PBR on Switch A operates as configured to forward the matching TCP packets to the next hop 1::2 (Switch B), as follows:

   # Verify that you can telnet to Switch B from Switch A successfully. (Details not shown.)

   # Verify that you cannot telnet to Switch C from Switch A. (Details not shown.)
2. Verify that Switch A forwards packets other than TCP packets through VLAN-interface 20. For example, verify that you can ping Switch C from Switch A. (Details not shown.)

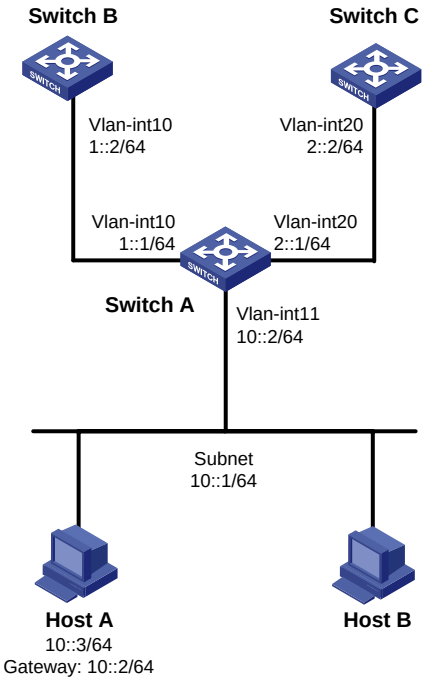
Example: Configuring packet type-based IPv6 interface PBR

Network configuration

As shown in Figure 2, Switch B and Switch C do not have a route to reach each other.

Configure IPv6 PBR on Switch A to forward all TCP packets received on VLAN-interface 11 to the next hop 1::2 (Switch B).

Figure 2 Network diagram



Procedure

1. Configure Switch A:

   # Create VLAN 10 and VLAN 20.

   ```
   <SwitchA> system-view
   [SwitchA] vlan 10
   [SwitchA-vlan10] quit
   [SwitchA] vlan 20
   [SwitchA-vlan20] quit
   ```

   # Configure RIPng.

```
[SwitchA] ripng 1
[SwitchA-ripng-1] quit
[SwitchA] interface vlan-interface 10
[SwitchA-Vlan-interface10] ipv6 address 1::1 64
[SwitchA-Vlan-interface10] ripng 1 enable
[SwitchA-Vlan-interface10] quit
[SwitchA] interface vlan-interface 20
[SwitchA-Vlan-interface20] ipv6 address 2::1 64
[SwitchA-Vlan-interface20] ripng 1 enable
[SwitchA-Vlan-interface20] quit
```

Configure ACL 3001 to match TCP packets.

```
[SwitchA] acl ipv6 advanced 3001
[SwitchA-acl-ipv6-adv-3001] rule permit tcp
[SwitchA-acl-ipv6-adv-3001] quit
```

Configure Node 5 for policy **aaa** to forward TCP packets to next hop 1::2.

```
[SwitchA] ipv6 policy-based-route aaa permit node 5
[SwitchA-pbr6-aaa-5] if-match acl 3001
[SwitchA-pbr6-aaa-5] apply next-hop 1::2
[SwitchA-pbr6-aaa-5] quit
```

Configure IPv6 interface PBR by applying policy **aaa** to VLAN-interface 11.

```
[SwitchA] interface vlan-interface 11
[SwitchA-Vlan-interface11] ipv6 address 10::2 64
[SwitchA-Vlan-interface11] undo ipv6 nd ra halt
[SwitchA-Vlan-interface11] ripng 1 enable
[SwitchA-Vlan-interface11] ipv6 policy-based-route aaa
```

2. Configure Switch B:

Create VLAN 10.

```
<SwitchB> system-view
[SwitchB] vlan 10
[SwitchB-vlan10] quit
```

Configure RIPng.

```
[SwitchB] ripng 1
[SwitchB-ripng-1] quit
[SwitchB] interface vlan-interface 10
[SwitchB-Vlan-interface10] ipv6 address 1::2 64
[SwitchB-Vlan-interface10] ripng 1 enable
[SwitchB-Vlan-interface10] quit
```

3. Configure Switch C:

Create VLAN 20.

```
<SwitchC> system-view
[SwitchC] vlan 20
[SwitchC-vlan20] quit
```

Configure RIPng.

```
[SwitchC] ripng 1
[SwitchC-ripng-1] quit
[SwitchC] interface vlan-interface 20
[SwitchC-Vlan-interface20] ipv6 address 2::2 64
```

```
[SwitchC-Vlan-interface20] ripng 1 enable
[SwitchC-Vlan-interface20] quit
```

Verifying the configuration

1. Enable IPv6 and configure the IPv6 address 10::3 for Host A.

```
C:\>ipv6 install
Installing...
Succeeded.
C:\>ipv6 adu 4/10::3
```

2. Perform telnet operations to verify that IPv6 interface PBR on Switch A operates as configured to forward the matching TCP packets to the next hop 1::2 (Switch B), as follows:

   # Verify that you can telnet to Switch B from Host A successfully. (Details not shown.)

   # Verify that you cannot telnet to Switch C from Host A. (Details not shown.)

3. Verify that Switch A forwards packets other than TCP packets through VLAN-interface 20. For example, verify that you can ping Switch C from Host A. (Details not shown.)

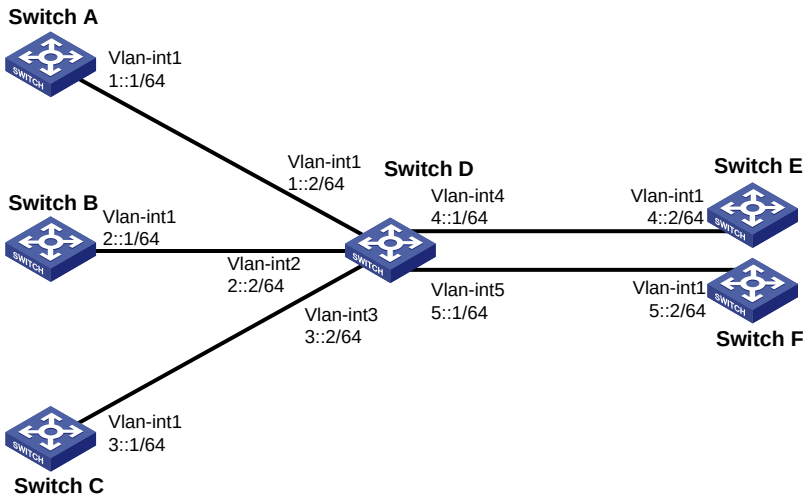
Example: Configuring packet type-based IPv6 global PBR

Network configuration

As shown in Figure 3, Switch E and Switch F do not have a route to reach each other.

Configure IPv6 global PBR on Switch D to forward TCP packets to the next hop 4::2 (Switch E).

Figure 3 Network diagram



Procedure

1. Configure IPv6 addresses for the interfaces. Make sure Switch A, B and C can communicate with Switch E and Switch F, respectively. (Details not shown.)
2. Configure Switch D:

   # Configure IPv6 ACL 3101 to match TCP packets sourced from networks 1::0/64, 2::0/64, and 3::0/64.

```
<SwitchD> system-view
[SwitchD] acl ipv6 advanced 3101
[SwitchD-acl-ipv6-adv-3101] rule permit tcp source 1::0 64
[SwitchD-acl-ipv4-adv-3101] rule permit tcp source 2::0 64
[SwitchD-acl-ipv4-adv-3101] rule permit tcp source 3::0 64
```

```
[SwitchD-acl-ipv4-adv-3101] quit
```

Configure node 5 in IPv6 PBR policy **aaa** to forward TCP packets that match ACL 3101 to next hop 4::2.

```
[SwitchD] ipv6 policy-based-route aaa permit node 5
[SwitchD-pbr6-aaa-5] if-match acl 3101
[SwitchD-pbr6-aaa-5] apply next-hop 4::2
[SwitchD-pbr6-aaa-5] quit
```

Specify IPv6 PBR policy **aaa** as the IPv6 global PBR policy.

```
[SwitchD] ipv6 global policy-based-route aaa
```

Verifying the configuration

1. Perform telnet operations to verify that IPv6 global PBR on Switch D operates as configured to forward the matching TCP packets to the next hop 4::2 (Switch E), as follows:

   # Verify that you can telnet to Switch E from Switch A, Switch B, and Switch C successfully. (Details not shown.)

   # Verify that you cannot telnet to Switch F from Switch A, Switch B, or Switch C. (Details not shown.)

2. Verify that Switch D forwards packets other than TCP packets as long as a route is available. For example, verify that you can ping Switch F from Switch A, Switch B, and Switch C. (Details not shown.)

Contents

Configuring routing policies

About routing policies

Routing policies control routing paths by filtering and modifying routing information.

Routing policies can filter advertised, received, and redistributed routes, and modify attributes for specific routes.

Implementation of a routing policy

To configure a routing policy:

1. Configure filters based on route attributes.
2. Create a routing policy and apply filters to the routing policy.

Filters

Routing policies can use the following filters to match routes.

ACL

An ACL can match the destination or next hop of routes.

For more information about ACLs, see *ACL and QoS Configuration Guide*.

IP prefix list

An IP prefix list matches the destination address of routes.

An IP prefix list can contain multiple items that specify prefix ranges. Each destination IP address prefix of a route is compared with these items in ascending order of their index numbers. A prefix matches the IP prefix list if it matches one item in the list.

Routing policy

A routing policy can contain multiple nodes, which are in a logical OR relationship. A node with a smaller number is matched first. A route matches the routing policy if it matches one node (except the node configured with the **continue** clause) in the routing policy.

Each node has a match mode of **permit** or **deny**.

- **permit**—Specifies the **permit** match mode for a routing policy node. If a route meets all the **if-match** clauses of the node, it is handled by the **apply** clauses of the node. The route is not compared with the next node unless the **continue** clause is configured. If a route does not meet all the **if-match** clauses of the node, it is compared with the next node.
- **deny**—Specifies the **deny** match mode for a routing policy node. The **apply** and **continue** clauses of a deny node are never executed. If a route meets all the **if-match** clauses of the node, it is denied without being compared with the next node. If a route does not meet all the **if-match** clauses of the node, it is compared with the next node.

A node can contain a set of **if-match**, **apply**, and **continue** clauses.

- **if-match** clauses—Specify the match criteria that match the attributes of routes. The **if-match** clauses are in a logical AND relationship. A route must meet all the **if-match** clauses to match the node.
- **apply** clauses—Specify the actions to be taken on permitted routes, such as modifying a route attribute.

- **continue** clause—Specifies the next node. A route that matches the current node (permit node) must match the specified next node in the same routing policy. The **continue** clause combines the **if-match** and **apply** clauses of the two nodes to improve flexibility of the routing policy. After you configure a **continue** clause, a route can pass the routing policy even if it does not match the specified next node. To reject such a route, add a **deny** node without clauses.

Follow these guidelines when you configure **if-match**, **apply**, and **continue** clauses:

- If you only want to filter routes, do not configure **apply** clauses.
- If you do not configure any **if-match** clauses for a permit node, the node will permit all routes.
- Configure a permit node containing no **if-match** or **apply** clauses following multiple deny nodes to allow unmatched routes to pass.

Routing policy tasks at a glance

To configure a routing policy, perform the following tasks:

1. (Optional.) Configure filters:
   - Configuring an IPv4 prefix list
   - Configuring an IPv6 prefix list
2. Configuring a routing policy:
   a. Creating a routing policy
   b. Configuring if-match clauses
   c. Configuring apply clauses
   d. Configuring the continue clause

Configuring an IPv4 prefix list

Restrictions and guidelines

If all the items are set to **deny** mode, no routes can pass the IPv4 prefix list. To permit unmatched IPv4 routes, you must configure the **permit** 0.0.0.0 0 **less-equal** 32 item following multiple **deny** items.

Procedure

1. Enter system view.

   system-view

2. Configure an IPv4 prefix list.

   ip prefix-list *prefix-list-name* [**index** *index-number*] { **deny** | **permit** } *ip-address mask-length* [**greater-equal** *min-mask-length*] [**less-equal** *max-mask-length*]

Configuring an IPv6 prefix list

Restrictions and guidelines

If all items are set to **deny** mode, no routes can pass the IPv6 prefix list. To permit unmatched IPv6 routes, you must configure the **permit** :: 0 **less-equal** 128 item following multiple **deny** items.

Procedure

1. Enter system view.

   system-view

2. Configure an IPv6 prefix list.

   ipv6 prefix-list *prefix-list-name* [**index** *index-number*] { **deny** | **permit** } *ipv6-address* { **inverse** *inverse-prefix-length* | *prefix-length* [**greater-equal** *min-prefix-length*] [**less-equal** *max-prefix-length*] }

Configuring a routing policy

Creating a routing policy

About creating a routing policy

A routing policy must have a minimum of one permit node. If all the nodes are in **deny** mode, no routes can pass the routing policy.

Procedure

1. Enter system view.

   system-view

2. Create a routing policy and a node, and enter routing policy node view.

   route-policy *route-policy-name* { **deny** | **permit** } **node** *node-number*

Configuring if-match clauses

About if-match clause configuration

You can either specify no **if-match** clauses or multiple **if-match** clauses for a routing policy node. If no **if-match** clause is specified for a permit node, all routes can pass the node. If no **if-match** clause is specified for a deny node, no routes can pass the node.

Restrictions and guidelines

When you configure **if-match** clauses, follow these restrictions and guidelines:

- The **if-match** clauses of a routing policy node have a logical AND relationship. A route must meet all **if-match** clauses before it can be executed by the **apply** clauses of the node. If an **if-match** command exceeds the maximum length, multiple **if-match** clauses of the same type are generated. These clauses have a logical OR relationship. A route only needs to meet one of them.
- All IPv4 routes match a node if the **if-match** clauses of the node use only IPv6 ACLs. All IPv6 routes match a node if the **if-match** clauses of the node use only IPv4 ACLs.
- If the ACL used by an **if-match** clause does not exist, the clause is always matched. If no rules of the specified ACL are matched or the match rules are inactive, the clause is not matched.
- If the prefix list, community list, or extended community list used by an **if-match** clause does not exist, the clause is always matched. If no rules of the specified prefix list, community list, or extended community list are matched, the clause is not matched.

Procedure

1. Enter system view.

   system-view

2. Enter routing policy node view.

   route-policy *route-policy-name* { **deny** | **permit** } **node** *node-number*

3. Match routes whose destination, next hop, or source address matches an ACL or prefix list.

   IPv4:

if-match ip { **address** | **next-hop** | **route-source** } { **acl** *ipv4-acl-number* | **prefix-list** *prefix-list-name* }

IPv6:

if-match ipv6 { **address** | **next-hop** | **route-source** } { **acl** *ipv6-acl-number* | **prefix-list** *prefix-list-name* }

By default, no ACL or prefix list match criterion is configured.

4. Configure route match criteria.
   - Match routes having the specified cost.
     if-match cost *cost-value*
   - Match routes having the specified output interface.
     if-match interface { *interface-type interface-number* }&<1-16>
   - Match routes having the specified route type.
     if-match route-type { **external-type1** | **external-type1or2** | **external-type2** | **internal** | **nssa-external-type1** | **nssa-external-type1or2** | **nssa-external-type2** } *
   - Match IGP routes having the specified tag value.
     if-match tag *tag-value*

   By default, no route match criteria are configured.

Configuring apply clauses

1. Enter system view.
   system-view
2. Enter routing policy node view.
   route-policy *route-policy-name* { **deny** | **permit** } **node** *node-number*
3. Configure the route cost and cost type.
   - Set a cost for routes.
     apply cost [**+** | **-**] *cost-value*
     By default, no cost is set for routes.
   - Set a cost type for routes.
     apply cost-type { **type-1** | **type-2** }
     By default, no cost type is set for routes.
4. Set the next hop for routes.
   IPv4:
   apply ip-address next-hop *ip-address* [**public**]
   IPv6:
   apply ipv6 next-hop *ipv6-address*
   By default, no next hop is set for routes.
   The configuration does not apply to redistributed routes.
5. Configure route priorities.
   - Set an IP precedence for matching routes.
     apply ip-precedence { *value* | **clear** }
     By default, no IP precedence is set.
   - Set a preference.
     apply preference *preference*

By default, no preference is set.

- Set a prefix priority.

  apply prefix-priority { **critical** | **high** | **medium** }

  By default, the prefix priority is low.

6. Set a tag value for IGP routes.

   apply tag *tag-value*

   By default, no tag value is set for IGP routes.

7. Set a backup link for fast reroute (FRR).

   IPv4:

   apply fast-reroute { **backup-interface** *interface-type interface-number* [**backup-nexthop** *ip-address*] | **backup-nexthop** *ip-address* }

   IPv6:

   apply ipv6 fast-reroute { **backup-interface** *interface-type interface-number* [**backup-nexthop** *ipv6-address*] | **backup-nexthop** *ipv6-address* }

   By default, no backup link is set for FRR.

Configuring the continue clause

Restrictions and guidelines

When you configure the **continue** clause to combine multiple nodes, follow these restrictions and guidelines:

- If you configure an **apply** clause that sets different attribute values on all the nodes, the **apply** clause of the node configured most recently takes effect.
- If you configure the following **apply** clauses on all the nodes, the **apply** clause of each node takes effect:
  - **apply as-path** without the **replace** keyword.
  - **apply cost** with the **+** or **–** keyword.
  - **apply community** with the **additive** keyword.
  - **apply extcommunity** with the **additive** keyword.
- The **apply comm-list delete** clause configured on the current node cannot delete the community attributes set by the **apply community** clauses of the preceding nodes.

Procedure

1. Enter system view.

   system-view

2. Enter routing policy node view.

   route-policy *route-policy-name* { **deny** | **permit** } **node** *node-number*

3. Specify the next node to be matched.

   continue [*node-number*]

   By default, no continue clause is configured.

   The specified next node must have a larger number than the current node.

Configuring the routing policy change delay timer

About the routing policy change delay timer

This feature makes a routing policy take effect after a delayed time interval, which prevents incomplete routing policy configuration from being issued to cause incorrect route advertisement. The system automatically starts the timer when a routing policy changes. The changes will not take effect on the policy until the change delay timer expires.

A routing policy changes when one of the following events occurs:

- A routing policy is created.
- A routing policy node, **if-match** clause, or **apply** clause is added, modified, or deleted for a routing policy.
- An IPv4 prefix list, IPv6 prefix list, AS path list, community list, extended community list, or MAC list is added, modified, or deleted.
- The ACL used by an **if-match** clause changes.

Procedure

1. Enter system view.

   system-view

2. Set the routing policy change delay timer.

   route-policy-change delay-time { *time-value* | **unlimited** }

   By default, routing policy changes immediately take effect, but the routing protocol waits five seconds before processing routes from the new routing policy.

   When the delay timer expires, the routing protocol waits five seconds before processing routes from the new routing policy.

Display and maintenance commands for routing policies

Execute **display** commands in any view and **reset** commands in user view.

Task	Command
Display IPv4 prefix list statistics.	**display ip prefix-list** [**name** *prefix-list-name*]
Display IPv6 prefix list statistics.	**display ipv6 prefix-list** [**name** *prefix-list-name*]
Display routing policy information.	**display route-policy** [**name** *route-policy-name*]
Clear IPv4 prefix list statistics.	**reset ip prefix-list** [*prefix-list-name*]
Clear IPv6 prefix list statistics.	**reset ipv6 prefix-list** [*prefix-list-name*]

Routing policy configuration examples

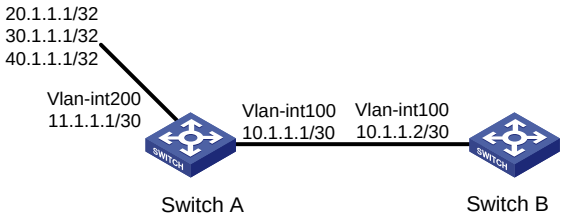
Example: Configuring a routing policy for redistributing static routes to RIP

Network configuration

As shown in Figure 1, Switch A exchanges routing information with Switch B by using RIP.

On Switch A, configure three static routes. Use a routing policy to configure Switch B to redistribute networks 20.1.1.1/32 and 40.1.1.1/32 and block network 30.1.1.1/32.

Figure 1 Network diagram



Procedure

1. Configure Switch A:

   # Configure IP addresses for interfaces VLAN-interface 100 and VLAN-interface 200.

   ```
   <SwitchA> system-view
   [SwitchA] interface vlan-interface 100
   [SwitchA-vlan-interface100] ip address 10.1.1.1 30
   [SwitchA-vlan-interface100] quit
   [SwitchA] interface vlan-interface 200
   [SwitchA-vlan-interface200] ip address 11.1.1.1 30
   [SwitchA-vlan-interface200] quit
   ```

   # Enable RIP on interface VLAN-interface 100.

   ```
   [SwitchA] interface vlan-interface 100
   [SwitchA-vlan-interface100] rip 1 enable
   [SwitchA-vlan-interface100] quit
   ```

   # Configure three static routes and set the next hop of the three routes to 11.1.1.2.

   ```
   [SwitchA] ip route-static 20.1.1.1 32 11.1.1.2
   [SwitchA] ip route-static 30.1.1.1 32 11.1.1.2
   [SwitchA] ip route-static 40.1.1.1 32 11.1.1.2
   ```

   # Configure a routing policy.

   ```
   [SwitchA] ip prefix-list a index 10 permit 30.1.1.1 32
   [SwitchA] route-policy static2rip deny node 0
   [SwitchA-route-policy-static2rip-0] if-match ip address prefix-list a
   [SwitchA-route-policy-static2rip-0] quit
   [SwitchA] route-policy static2rip permit node 10
   [SwitchA-route-policy-static2rip-10] quit
   ```

   # Enable RIP and apply routing policy **static2rip** to filter redistributed static routes.

   ```
   [SwitchA] rip
   [SwitchA-rip-1] import-route static route-policy static2rip
   ```

2. Configure Switch B:

   # Configure an IP address for interface VLAN-interface 100.

```
<SwitchB> system-view
[SwitchB] interface vlan-interface 100
[SwitchB-vlan-interface100] ip address 10.1.1.2 30
```

   # Enable RIP.

```
[SwitchB] rip
[SwitchB-rip-1] quit
```

   # Enable RIP on the interface.

```
[SwitchB] interface vlan-interface 100
[SwitchB-vlan-interface100] rip 1 enable
[SwitchB-vlan-interface100] quit
```

Verifying the configuration

Display the routing table information on Switch B.

```
<SwitchB> display ip routing-table

Destinations : 14       Routes : 14

Destination/Mask   Proto   Pre Cost        NextHop         Interface
0.0.0.0/32         Direct  0   0           127.0.0.1       InLoop0
10.1.1.0/30        Direct  0   0           10.1.1.2        Vlan100
10.1.1.0/32        Direct  0   0           10.1.1.2        Vlan100
10.1.1.2/32        Direct  0   0           127.0.0.1       InLoop0
10.1.1.3/32        Direct  0   0           10.1.1.2        Vlan100
20.0.0.0/8         RIP     100 1           10.1.1.1        Vlan100
40.0.0.0/8         RIP     100 1           10.1.1.1        Vlan100
127.0.0.0/8        Direct  0   0           127.0.0.1       InLoop0
127.0.0.0/32       Direct  0   0           127.0.0.1       InLoop0
127.0.0.1/32       Direct  0   0           127.0.0.1       InLoop0
127.255.255.255/32 Direct  0   0           127.0.0.1       InLoop0
224.0.0.0/4        Direct  0   0           0.0.0.0         NULL0
224.0.0.0/24       Direct  0   0           0.0.0.0         NULL0
255.255.255.255/32 Direct  0   0           127.0.0.1       InLoop
```

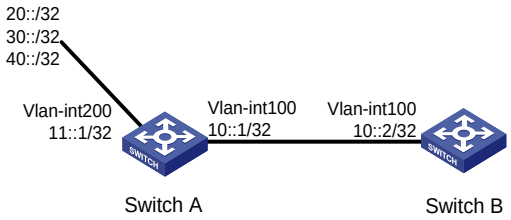
Example: Configuring a routing policy for IPv6 route redistribution

Network configuration

As shown in Figure 2:

- Run RIPng on Switch A and Switch B.
- Configure three static routes on Switch A.
- On Switch A, apply a routing policy to redistribute static routes 20::/32 and 40::/32 and deny route 30::/32.

Figure 2 Network diagram



Procedure

1. Configure Switch A:

Configure IPv6 addresses for VLAN-interface 100 and VLAN-interface 200.

```
<SwitchA> system-view
[SwitchA] interface vlan-interface 100
[SwitchA-Vlan-interface100] ipv6 address 10::1 32
[SwitchA-Vlan-interface100] quit
[SwitchA] interface vlan-interface 200
[SwitchA-Vlan-interface200] ipv6 address 11::1 32
[SwitchA-Vlan-interface200] quit
```

Enable RIPng on VLAN-interface 100.

```
[SwitchA] interface vlan-interface 100
[SwitchA-Vlan-interface100] ripng 1 enable
[SwitchA-Vlan-interface100] quit
```

Configure three static routes with next hop 11::2, and make sure the static routes are active.

```
[SwitchA] ipv6 route-static 20:: 32 11::2
[SwitchA] ipv6 route-static 30:: 32 11::2
[SwitchA] ipv6 route-static 40:: 32 11::2
```

Configure a routing policy.

```
[SwitchA] ipv6 prefix-list a index 10 permit 30:: 32
[SwitchA] route-policy static2ripng deny node 0
[SwitchA-route-policy-static2ripng-0] if-match ipv6 address prefix-list a
[SwitchA-route-policy-static2ripng-0] quit
[SwitchA] route-policy static2ripng permit node 10
[SwitchA-route-policy-static2ripng-10] quit
```

Enable RIPng and apply the routing policy to static route redistribution.

```
[SwitchA] ripng
[SwitchA-ripng-1] import-route static route-policy static2ripng
```

2. Configure Switch B:

Configure the IPv6 address for VLAN-interface 100.

```
<SwitchB> system-view
[SwitchB] interface vlan-interface 100
[SwitchB-Vlan-interface100] ipv6 address 10::2 32
```

Enable RIPng.

```
[SwitchB] ripng
[SwitchB-ripng-1] quit
```

Enable RIPng on VLAN-interface 100.

```
[SwitchB] interface vlan-interface 100
[SwitchB-Vlan-interface100] ripng 1 enable
```

```
    [SwitchB-Vlan-interface100] quit
```

Verifying the configuration

Display the RIPng routing table on Switch B.

```
[SwitchB] display ripng 1 route
   Route Flags: A - Aging, S - Suppressed, G - Garbage-collect
 ----------------------------------------------------------------

 Peer FE80::7D58:0:CA03:1 on Vlan-interface 100
 Destination 20::/32,
     via FE80::7D58:0:CA03:1, cost 1, tag 0, A, 8 secs
 Destination 40::/32,
     via FE80::7D58:0:CA03:1, cost 1, tag 0, A, 3 secs
 Local route
 Destination 10::/32,
     via ::, cost 0, tag 0, DOF
```

IP Multicast Configuration Guide

This command reference is applicable to the following switches and software versions:

H3C S5120V2-LI switch series (Release 6308P01 and later)
H3C S3100V3-SI switch series (Release 6309P01 and later)
H3C S5110V2 switch series (Release 6310 and later)
H3C S5110V2-SI switch series (Release 6310 and later)
H3C S5000V3-EI switch series (Release 6310 and later)
H3C S5000V5-EI switch series (Release 6319P01 and later)
H3C S5000E-X switch series (Release 6310 and later)
H3C S5130S-LI switch series (Release 6310 and later)
H3C MS4320V2 switch series (Release 6308P01 and later)
H3C MS4320 switch series (Release 6308P01 and later)
H3C MS4300V2 switch series (Release 6308P01 and later)
H3C MS4200 switch series (Release 6310 and later)
H3C WS5810-WiNet switch series (Release 6308P01 and later)
H3C WS5820-WiNet switch series (Release 6308P01 and later)
H3C WAS6000 switch series (Release 6308P01 and later)
H3C S5000X-EI switch series (Release 6329 and later)
H3C MS4320V3 switch series (Release 6329 and later)
H3C S5120V3-SI switch series (Release 6329 and later)
H3C S5120V3-LI switch series (Release 6329 and later)

New H3C Technologies Co., Ltd.
http://www.h3c.com

Software version: Release 63xx
Document version: 6W105-20230524

Preface

This configuration guide describes IP multicast fundamentals and configuration procedures. It covers the IPv4 multicast configuration and IPv6 multicast configuration. With multicast, you can implement efficient point-to-multipoint data transmission in your network.

This preface includes the following topics about the documentation:

Audience

This documentation is intended for:

- Network planners.
- Field technical support and servicing engineers.
- Network administrators.

Conventions

The following information describes the conventions used in the documentation.

Command conventions

Convention	Description
Boldface	**Bold** text represents commands and keywords that you enter literally as shown.
Italic	*Italic* text represents arguments that you replace with actual values.
[ ]	Square brackets enclose syntax choices (keywords or arguments) that are optional.
{ x | y | ... }	Braces enclose a set of required syntax choices separated by vertical bars, from which you select one.
[x | y | ...]	Square brackets enclose a set of optional syntax choices separated by vertical bars, from which you select one or none.
{ x | y | ... } *	Asterisk marked braces enclose a set of required syntax choices separated by vertical bars, from which you select a minimum of one.
[x | y | ...] *	Asterisk marked square brackets enclose optional syntax choices separated by vertical bars, from which you select one choice, multiple choices, or none.
&<1-n>	The argument or keyword and argument combination before the ampersand (&) sign can be entered 1 to n times.
#	A line that starts with a pound (#) sign is comments.

GUI conventions

Convention	Description
Boldface	Window names, button names, field names, and menu items are in Boldface. For example, the **New User** window opens; click **OK**.
>	Multi-level menus are separated by angle brackets. For example, **File** > **Create** >

Convention	Description
	Folder.

Symbols

Convention	Description
⚠ **WARNING!**	An alert that calls attention to important information that if not understood or followed can result in personal injury.
△ **CAUTION:**	An alert that calls attention to important information that if not understood or followed can result in data loss, data corruption, or damage to hardware or software.
ⓘ **IMPORTANT:**	An alert that calls attention to essential information.
NOTE:	An alert that contains additional or supplementary information.
TIP:	An alert that provides helpful information.

Network topology icons

Convention	Description
	Represents a generic network device, such as a router, switch, or firewall.
	Represents a routing-capable device, such as a router or Layer 3 switch.
	Represents a generic switch, such as a Layer 2 or Layer 3 switch, or a router that supports Layer 2 forwarding and other Layer 2 features.
	Represents an access controller, a unified wired-WLAN module, or the access controller engine on a unified wired-WLAN switch.
	Represents an access point.
	Represents a wireless terminator unit.
	Represents a wireless terminator.
	Represents a mesh access point.
	Represents omnidirectional signals.
	Represents directional signals.
	Represents a security product, such as a firewall, UTM, multiservice security gateway, or load balancing device.
	Represents a security module, such as a firewall, load balancing, NetStream, SSL VPN, IPS, or ACG module.

Examples provided in this document

Examples in this document might use devices that differ from your device in hardware model, configuration, or software version. It is normal that the port numbers, sample output, screenshots, and other information in the examples differ from what you have on your device.

Documentation feedback

You can e-mail your comments about product documentation to info@h3c.com.

We appreciate your comments.

Contents

Multicast overview

Introduction to multicast

As a technique that coexists with unicast and broadcast, the multicast technique effectively addresses the issue of point-to-multipoint data transmission. By enabling high-efficiency point-to-multipoint data transmission over a network, multicast greatly saves network bandwidth and reduces network load.

By using multicast technology, a network operator can easily provide bandwidth-critical and time-critical information services. These services include live webcasting, Web TV, distance learning, telemedicine, Web radio, and real-time video conferencing.

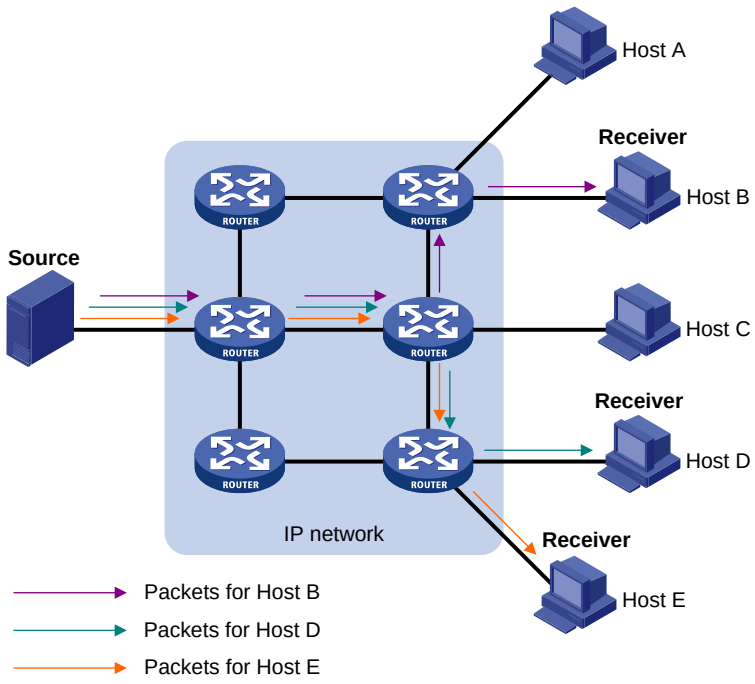
Information transmission techniques

The information transmission techniques include unicast, broadcast, and multicast.

Unicast

In unicast transmission, the information source must send a separate copy of information to each host that needs the information.

Figure 1 Unicast transmission



In Figure 1, Host B, Host D, and Host E need the information. A separate transmission channel must be established from the information source to each of these hosts.

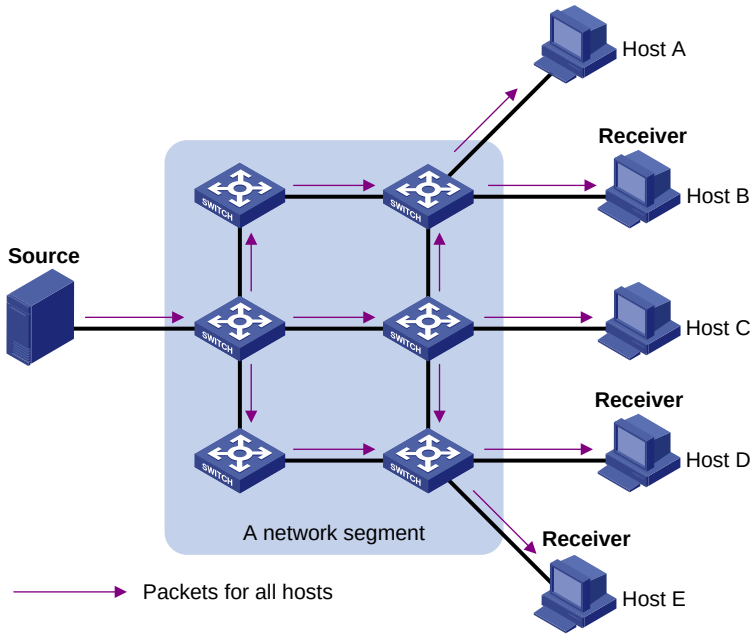
In unicast transmission, the traffic transmitted over the network is proportional to the number of hosts that need the information. If a large number of hosts need the information, the information source must send a separate copy of the same information to each of these hosts. Sending many copies can place a tremendous pressure on the information source and the network bandwidth.

Unicast is not suitable for batch transmission of information.

Broadcast

In broadcast transmission, the information source sends information to all hosts on the subnet, even if some hosts do not need the information.

Figure 2 Broadcast transmission



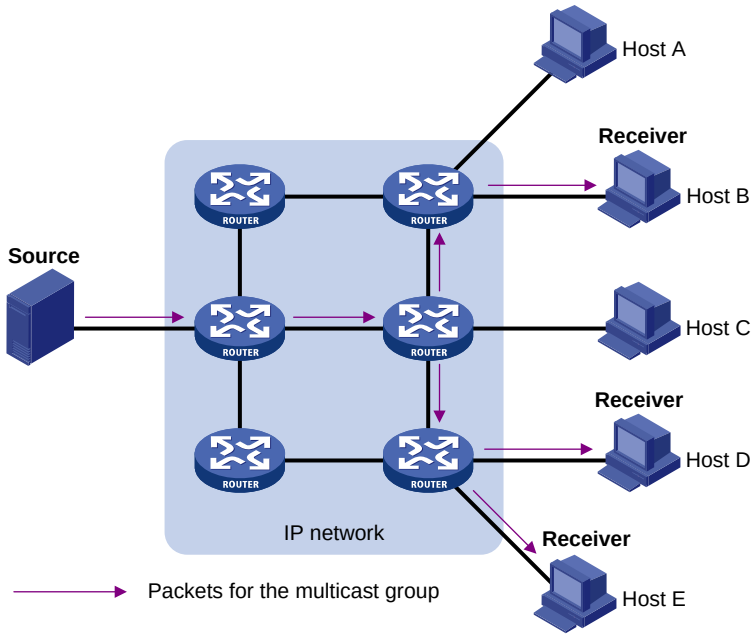
In Figure 2, only Host B, Host D, and Host E need the information. If the information is broadcast to the subnet, Host A and Host C also receive it. In addition to information security issues, broadcasting to hosts that do not need the information also causes traffic flooding on the same subnet.

Broadcast is disadvantageous in transmitting data to specific hosts. Moreover, broadcast transmission is a significant waste of network resources.

Multicast

Multicast provides point-to-multipoint data transmissions with the minimum network consumption. When some hosts on the network need multicast information, the information sender, or multicast source, sends only one copy of the information. Multicast distribution trees are built through multicast routing protocols, and the packets are replicated only on nodes where the trees branch.

Figure 3 Multicast transmission



In Figure 3, the multicast source sends only one copy of the information to a multicast group. Host B, Host D, and Host E, which are information receivers, must join the multicast group. The routers on the network duplicate and forward the information based on the distribution of the group members. Finally, the information is correctly delivered to Host B, Host D, and Host E.

To summarize, multicast has the following advantages:

- **Advantages over unicast**—Multicast data is replicated and distributed until it flows to the farthest-possible node from the source. The increase of receiver hosts will not remarkably increase the load of the source or the usage of network resources.
- **Advantages over broadcast**—Multicast data is sent only to the receivers that need it. This saves network bandwidth and enhances network security. In addition, multicast data is not confined to the same subnet.

Multicast features

- A multicast group is a multicast receiver set identified by an IP multicast address. Hosts must join a multicast group to become members of the multicast group before they receive the multicast data addressed to that multicast group. Typically, a multicast source does not need to join a multicast group.
- A multicast source is an information sender. It can send data to multiple multicast groups at the same time. Multiple multicast sources can send data to the same multicast group at the same time.
- The group memberships are dynamic. Hosts can join or leave multicast groups at any time. Multicast groups are not subject to geographic restrictions.
- Multicast routers or Layer 3 multicast devices are routers or Layer 3 switches that support Layer 3 multicast. They provide multicast routing and manage multicast group memberships on stub subnets with attached group members. A multicast router itself can be a multicast group member.

For a better understanding of the multicast concept, you can compare multicast transmission to the transmission of TV programs.

Table 1 Comparing TV program transmission and multicast transmission

TV program transmission	Multicast transmission
A TV station transmits a TV program through a channel.	A multicast source sends multicast data to a multicast group.
A user tunes the TV set to the channel.	A receiver joins the multicast group.
The user starts to watch the TV program transmitted by the TV station on the channel.	The receiver starts to receive the multicast data sent by the source to the multicast group.
The user turns off the TV set or tunes to another channel.	The receiver leaves the multicast group or joins another group.

Multicast benefits and applications

Multicast benefits

- **Enhanced efficiency**—Reduces the processor load of information source servers and network devices.
- **Optimal performance**—Reduces redundant traffic.
- **Distributed application**—Enables point-to-multipoint applications at the price of minimum network resources.

Multicast applications

- Multimedia and streaming applications, such as Web TV, Web radio, and real-time video/audio conferencing
- Communication for training and cooperative operations, such as distance learning and telemedicine
- Data warehouse and financial applications (stock quotes)
- Any other point-to-multipoint application for data distribution

Multicast models

Based on how the receivers treat the multicast sources, the multicast models include any-source multicast (ASM), source-filtered multicast (SFM), and source-specific multicast (SSM).

ASM model

In the ASM model, any multicast sources can send information to a multicast group. Receivers can join a multicast group and get multicast information addressed to that multicast group from any multicast sources. In this model, receivers do not know the positions of the multicast sources in advance.

SFM model

The SFM model is derived from the ASM model. To a multicast source, the two models appear to have the same multicast membership architecture.

The SFM model functionally extends the ASM model. The upper-layer software checks the source address of received multicast packets and permits or denies multicast traffic from specific sources.

The receivers obtain the multicast data from only part of the multicast sources. To a receiver, multicast sources are not all valid, but are filtered.

SSM model

The SSM model provides a transmission service that enables multicast receivers to specify the multicast sources in which they are interested.

In the SSM model, receivers have already determined the locations of the multicast sources. This is the main difference between the SSM model and the ASM model. In addition, the SSM model uses a different multicast address range than the ASM/SFM model. Dedicated multicast forwarding paths are established between receivers and the specified multicast sources.

Multicast addresses

IP multicast addresses

IPv4 multicast addresses

IANA assigned the Class D address block (224.0.0.0 to 239.255.255.255) to IPv4 multicast.

Table 2 Class D IP address blocks and description

Address block	Description
224.0.0.0 to 224.0.0.255	Reserved permanent group addresses. The IP address 224.0.0.0 is reserved. Other IP addresses can be used by routing protocols and for topology searching, protocol maintenance, and so on. Table 3 lists common permanent group addresses. A packet destined for an address in this block will not be forwarded beyond the local subnet regardless of the TTL value in the IP header.
224.0.1.0 to 238.255.255.255	Globally scoped group addresses. This block includes the following types of designated group addresses: • **232.0.0.0/8**—SSM group addresses. • **233.0.0.0/8**—Glop group addresses.
239.0.0.0 to 239.255.255.255	Administratively scoped multicast addresses. These addresses are considered locally unique rather than globally unique. You can reuse them in domains administered by different organizations without causing conflicts. For more information, see RFC 2365.

NOTE:

Glop is a mechanism for assigning multicast addresses between different ASs. By filling an AS number into the middle two bytes of 233.0.0.0, you get 255 multicast addresses for that AS. For more information, see RFC 2770.

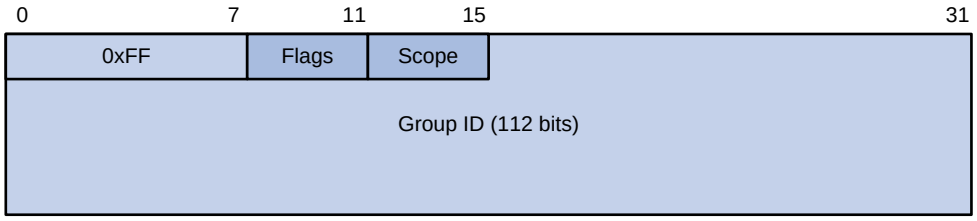
Table 3 Common permanent multicast group addresses

Address	Description
224.0.0.1	All systems on this subnet, including hosts and routers.
224.0.0.2	All multicast routers on this subnet.
224.0.0.3	Unassigned.
224.0.0.4	DVMRP routers.
224.0.0.5	OSPF routers.

Address	Description
224.0.0.6	OSPF designated routers and backup designated routers.
224.0.0.7	Shared Tree (ST) routers.
224.0.0.8	ST hosts.
224.0.0.9	RIPv2 routers.
224.0.0.11	Mobile agents.
224.0.0.12	DHCP server/relay agent.
224.0.0.13	All Protocol Independent Multicast (PIM) routers.
224.0.0.14	RSVP encapsulation.
224.0.0.15	All Core-Based Tree (CBT) routers.
224.0.0.16	Designated SBM.
224.0.0.17	All SBMs.
224.0.0.18	VRRP.

IPv6 multicast addresses

Figure 4 IPv6 multicast format



The following describes the fields of an IPv6 multicast address:

- **0xFF**—The most significant eight bits are 11111111.
- **Flags**—The Flags field contains four bits.

  Figure 5 Flags field format

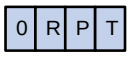
  

  Table 4 Flags field description

Bit	Description
0	Reserved, set to 0.
R	• When set to 0, this address is an IPv6 multicast address without an embedded RP address. • When set to 1, this address is an IPv6 multicast address with an embedded RP address. (The P and T bits must also be set to 1.)
P	• When set to 0, this address is an IPv6 multicast address not based on a unicast prefix. • When set to 1, this address is an IPv6 multicast address based on a unicast prefix. (The T bit must also be set to 1.)

Bit	Description
T	• When set to 0, this address is an IPv6 multicast address permanently-assigned by IANA. • When set to 1, this address is a transient or dynamically assigned IPv6 multicast address.

- **Scope**—The Scope field contains four bits, which represent the scope of the IPv6 internetwork for which the multicast traffic is intended.

  Table 5 Values of the Scope field

Value	Meaning
0, F	Reserved.
1	Interface-local scope.
2	Link-local scope.
3	Subnet-local scope.
4	Admin-local scope.
5	Site-local scope.
6, 7, 9 through D	Unassigned.
8	Organization-local scope.
E	Global scope.

- **Group ID**—The Group ID field contains 112 bits. It uniquely identifies an IPv6 multicast group in the scope that the Scope field defines.

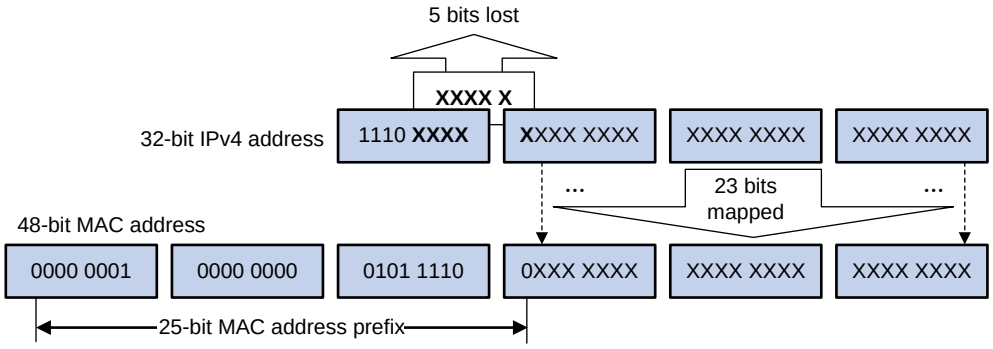
Ethernet multicast MAC addresses

An Ethernet multicast MAC address identifies receivers that belong to the same multicast group at the data link layer.

IPv4 multicast MAC addresses

As defined by IANA, the most significant 24 bits of an IPv4 multicast MAC address are 0x01005E. Bit 25 is 0, and the other 23 bits are the least significant 23 bits of an IPv4 multicast address.

Figure 6 IPv4-to-MAC address mapping

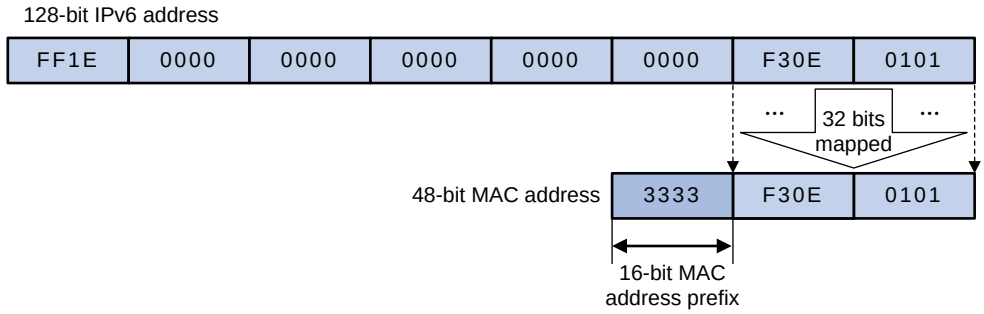


The most significant four bits of an IPv4 multicast address are fixed at 1110. In an IPv4-to-MAC address mapping, five bits of the IPv4 multicast address are lost. As a result, 32 IPv4 multicast addresses are mapped to the same IPv4 multicast MAC address. A device might receive unwanted multicast data at Layer 2 processing, which needs to be filtered by the upper layer.

IPv6 multicast MAC addresses

As defined by IANA, the most significant 16 bits of an IPv6 multicast MAC address are 0x3333. The least significant 32 bits are mapped from the least significant 32 bits of an IPv6 multicast address. Therefore, the problem of duplicate IPv6-to-MAC address mapping also arises like IPv4-to-MAC address mapping.

Figure 7 IPv6-to-MAC address mapping



Multicast protocols

Multicast protocols include the following categories:

- Layer 3 and Layer 2 multicast protocols:
  - Layer 3 multicast refers to IP multicast operating at the network layer.

    Layer 3 multicast protocols—IGMP, MLD, PIM, IPv6 PIM, MSDP, MBGP, and IPv6 MBGP.
  - Layer 2 multicast refers to IP multicast operating at the data link layer.

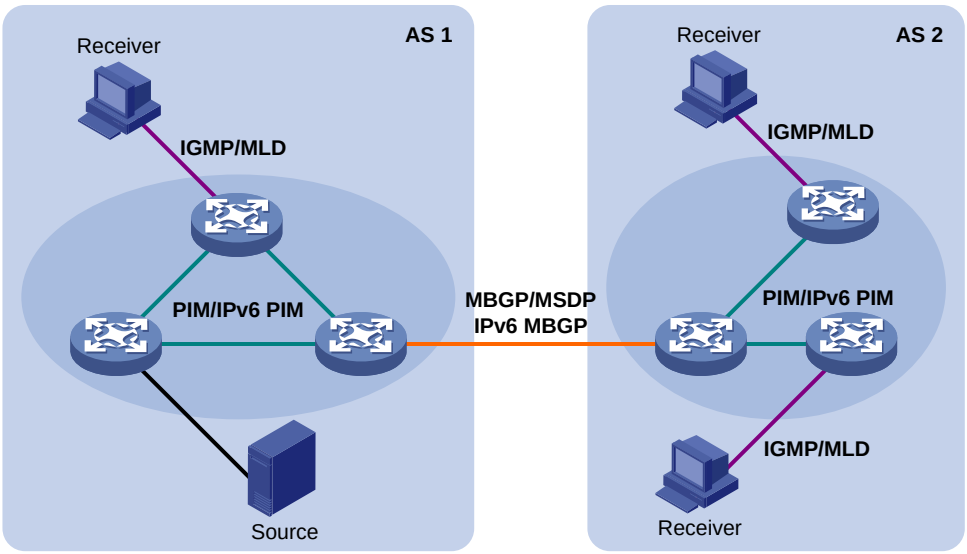
    Layer 2 multicast protocols—IGMP snooping, MLD snooping, PIM snooping, IPv6 PIM snooping, multicast VLAN, and IPv6 multicast VLAN.
- IPv4 and IPv6 multicast protocols:
  - **For IPv4 networks**—IGMP snooping, PIM snooping, multicast VLAN, IGMP, PIM, MSDP, and MBGP.
  - **For IPv6 networks**—MLD snooping, IPv6 PIM snooping, IPv6 multicast VLAN, MLD, IPv6 PIM, and IPv6 MBGP.

This section provides only general descriptions about applications and functions of the Layer 2 and Layer 3 multicast protocols in a network. For more information about these protocols, see the related chapters.

Layer 3 multicast protocols

In Figure 8, Layer 3 multicast protocols include multicast group management protocols and multicast routing protocols.

Figure 8 Positions of Layer 3 multicast protocols



- Multicast group management protocols:

  Internet Group Management Protocol (IGMP) and Multicast Listener Discovery (MLD) protocol are multicast group management protocols. Typically, they run between hosts and Layer 3 multicast devices that directly connect to the hosts to establish and maintain multicast group memberships.

- Multicast routing protocols:

  A multicast routing protocol runs on Layer 3 multicast devices to establish and maintain multicast routes and correctly and efficiently forward multicast packets. Multicast routes constitute loop-free data transmission paths (also known as multicast distribution trees) from a data source to multiple receivers.

  In the ASM model, multicast routes include intra-domain routes and inter-domain routes.

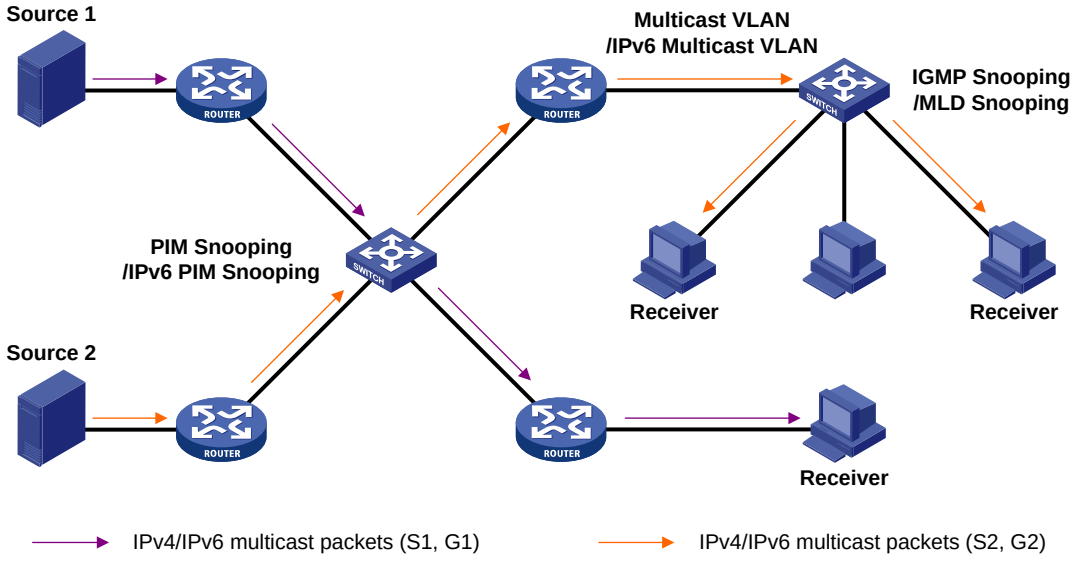
  - An intra-domain multicast routing protocol discovers multicast sources and builds multicast distribution trees within an AS to deliver multicast data to receivers. Among a variety of mature intra-domain multicast routing protocols, PIM is most widely used. Based on the forwarding mechanism, PIM has dense mode (often referred to as PIM-DM) and sparse mode (often referred to as PIM-SM).
  - An inter-domain multicast routing protocol is used for delivering multicast information between two ASs. So far, mature solutions include Multicast Source Discovery Protocol (MSDP) and MBGP. MSDP propagates multicast source information among different ASs. MBGP is an extension of the MP-BGP for exchanging multicast routing information among different ASs.

  For the SSM model, multicast routes are not divided into intra-domain routes and inter-domain routes. Because receivers know the positions of the multicast sources, channels established through PIM-SM are sufficient for the transport of multicast information.

Layer 2 multicast protocols

In Figure 9, Layer 2 multicast protocols include IGMP snooping, MLD snooping, PIM snooping, IPv6 PIM snooping, multicast VLAN, and IPv6 multicast VLAN.

Figure 9 Positions of Layer 2 multicast protocols



- IGMP snooping and MLD snooping:

  IGMP snooping and MLD snooping are multicast constraining mechanisms that run on Layer 2 devices. They manage and control multicast groups by monitoring and analyzing IGMP or MLD messages exchanged between the hosts and Layer 3 multicast devices. This effectively controls the flooding of multicast data in Layer 2 networks.

- PIM snooping and IPv6 PIM snooping:

  PIM snooping and IPv6 PIM snooping run on Layer 2 devices. They work with IGMP snooping or MLD snooping to analyze received PIM messages. Then, they add the ports that are interested in specific multicast data to a PIM snooping routing entry or IPv6 PIM snooping routing entry. In this way, multicast data can be forwarded to only the ports that are interested in the data.

- Multicast VLAN and IPv6 multicast VLAN:

  Multicast VLAN or IPv6 multicast VLAN runs on a Layer 2 device in a multicast network where multicast receivers for the same group exist in different VLANs. With these protocols, the Layer 3 multicast device sends only one copy of multicast to the multicast VLAN or IPv6 multicast VLAN on the Layer 2 device. This method avoids waste of network bandwidth and extra burden on the Layer 3 device.

Multicast packet forwarding mechanism

In a multicast model, receiver hosts of a multicast group are usually located at different areas on the network. They are identified by the same multicast group address. To deliver multicast packets to these receivers, a multicast source encapsulates the multicast data in an IP packet with the multicast group address as the destination address. Multicast routers on the forwarding paths forward multicast packets that an incoming interface receives through multiple outgoing interfaces. Compared to a unicast model, a multicast model is more complex in the following aspects:

- To ensure multicast packet transmission on the network, different routing tables are used to guide multicast forwarding. These routing tables include unicast routing tables, routing tables for multicast (for example, the MBGP routing table), and static multicast routing tables.
- To process the same multicast information from different peers received on different interfaces, the multicast device performs an RPF check on each multicast packet. The RPF check result determines whether the packet will be forwarded or discarded. The RPF check mechanism is the basis for most multicast routing protocols to implement multicast forwarding.

For more information about the RPF mechanism, see "Configuring multicast routing and forwarding" and "Configuring IPv6 multicast routing and forwarding."

IP multicast architecture

IP multicast addresses the following issues:

- Where should the multicast source transmit information to? (Multicast addressing.)
- What receivers exist on the network? (Host registration.)
- Where is the multicast source that will provide data to the receivers? (Multicast source discovery.)
- How is the information transmitted to the receivers? (Multicast routing.)

IP multicast is an end-to-end service. The multicast architecture involves the following parts:

- **Addressing mechanism**—A multicast source sends information to a group of receivers through a multicast address.
- **Host registration**—Receiver hosts can join and leave multicast groups dynamically. This mechanism is the basis for management of group memberships.
- **Multicast routing**—A multicast distribution tree (a forwarding path tree for multicast data on the network) is constructed for delivering multicast data from a multicast source to receivers.
- **Multicast applications**—A software system that supports multicast applications, such as video conferencing, must be installed on multicast sources and receiver hosts. The TCP/IP stack must support reception and transmission of multicast data.

Common notations in multicast

The following notations are commonly used in multicast transmission:

- **(*, G)**—Rendezvous point tree (RPT), or a multicast packet that any multicast source sends to multicast group G. The asterisk (*) represents any multicast source, and "G" represents a specific multicast group.
- **(S, G)**—Shortest path tree (SPT), or a multicast packet that multicast source "S" sends to multicast group "G." "S" represents a specific multicast source, and "G" represents a specific multicast group.

Contents

Configuring IGMP snooping

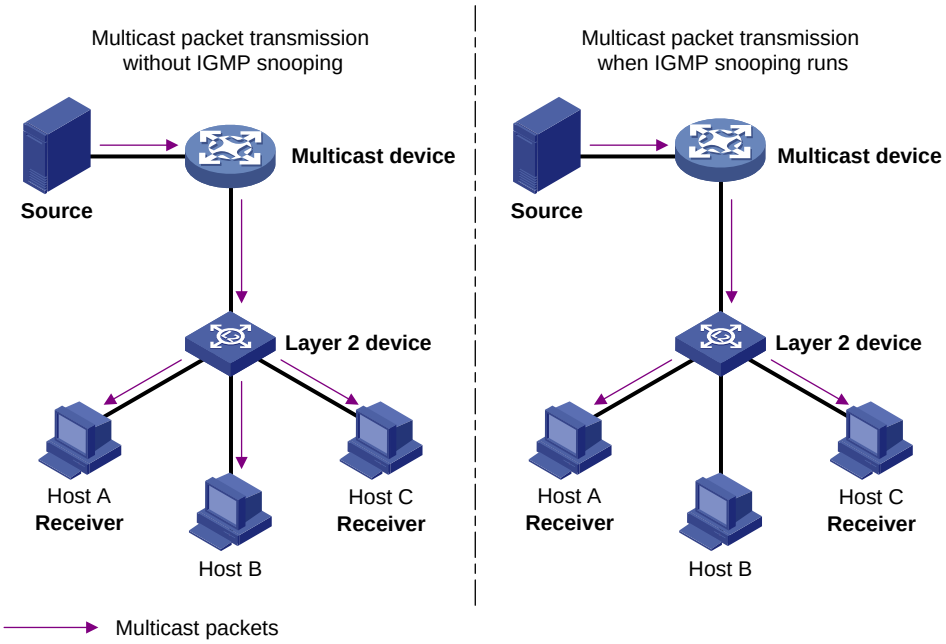
About IGMP snooping

IGMP snooping runs on a Layer 2 device as a multicast constraining mechanism to improve multicast forwarding efficiency. It creates Layer 2 multicast forwarding entries from IGMP packets that are exchanged between the hosts and the Layer 3 device.

Fundamentals of IGMP snooping

As shown in Figure 1, when IGMP snooping is not enabled, the Layer 2 switch floods multicast packets to all hosts in a VLAN. When IGMP snooping is enabled, the Layer 2 switch forwards multicast packets of known multicast groups to only the receivers.

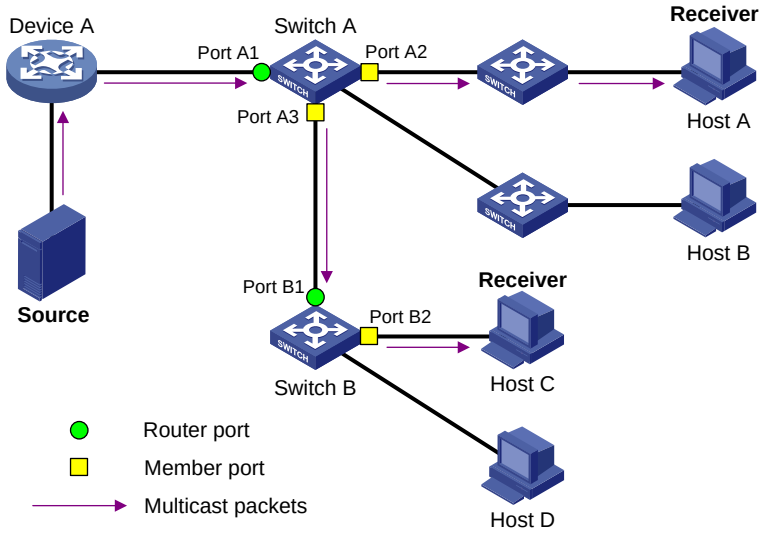
Figure 1 Multicast packet transmission without and with IGMP snooping



IGMP snooping ports

As shown in Figure 2, IGMP snooping runs on Switch A and Switch B, and Host A and Host C are receivers in a multicast group. IGMP snooping ports are divided into member ports and router ports.

Figure 2 IGMP snooping ports



Router ports

On an IGMP snooping Layer 2 device, the ports toward Layer 3 multicast devices are called router ports. In Figure 2, Port A1 of Switch A and Port B1 of Switch B are router ports.

Router ports contain the following types:

- **Dynamic router port**—When a port receives an IGMP general query whose source address is not 0.0.0.0 or receives a PIM hello message, the port is added into the dynamic router port list. At the same time, an aging timer is started for the port. If the port receives either of the messages before the timer expires, the timer is reset. If the port does not receive either of the messages when the timer expires, the port is removed from the dynamic router port list.
- **Static router port**—When a port is statically configured as a router port, it is added into the static router port list. The static router port does not age out, and it can be deleted only manually.

Do not confuse the "router port" in IGMP snooping with the "routed interface" commonly known as the "Layer 3 interface." The router port in IGMP snooping is a Layer 2 interface.

Member ports

On an IGMP snooping Layer 2 device, the ports toward receiver hosts are called member ports. In Figure 2, Port A2 and Port A3 of Switch A and Port B2 of Switch B are member ports.

Member ports contain the following types:

- **Dynamic member port**—When a port receives an IGMP report, it is added to the associated dynamic IGMP snooping forwarding entry as an outgoing interface. At the same time, an aging timer is started for the port. If the port receives an IGMP report before the timer expires, the timer is reset. If the port does not receive an IGMP report when the timer expires, the port is removed from the associated dynamic forwarding entry.
- **Static member port**—When a port is statically configured as a member port, it is added to the associated static IGMP snooping forwarding entry as an outgoing interface. The static member port does not age out, and it can be deleted only manually.

Unless otherwise specified, router ports and member ports in this document include both static and dynamic router ports and member ports.

How IGMP snooping works

The ports in this section are dynamic ports. For information about how to configure and remove static ports, see "Configuring a static member port" and "Configuring a static router port."

IGMP messages types include general query, IGMP report, and leave message. An IGMP snooping-enabled Layer 2 device performs differently depending on the message types.

General query

The IGMP querier periodically sends IGMP general queries to all hosts and devices on the local subnet to check for the existence of multicast group members.

After receiving an IGMP general query, the Layer 2 device forwards the query to all ports in the VLAN except the receiving port. The Layer 2 device also performs one of the following actions:

- If the receiving port is a dynamic router port in the dynamic router port list, the Layer 2 device restarts the aging timer for the port.
- If the receiving port does not exist in the dynamic router port list, the Layer 2 device adds the port to the dynamic router port list. It also starts an aging timer for the port.

IGMP report

A host sends an IGMP report to the IGMP querier for the following purposes:

- Responds to queries if the host is a multicast group member.
- Applies for a multicast group membership.

After receiving an IGMP report from a host, the Layer 2 device forwards the report through all the router ports in the VLAN. It also resolves the address of the reported multicast group, and looks up the forwarding table for a matching entry as follows:

- If no match is found, the Layer 2 device creates a forwarding entry with the receiving port as an outgoing interface. It also marks the receiving port as a dynamic member port and starts an aging timer for the port.
- If a match is found but the matching forwarding entry does not contain the receiving port, the Layer 2 device adds the receiving port to the outgoing interface list. It also marks the receiving port as a dynamic member port and starts an aging timer for the port.
- If a match is found and the matching forwarding entry contains the receiving port, the Layer 2 device restarts the aging timer for the port.

NOTE:

A Layer 2 device does not forward an IGMP report through a non-router port because of the host IGMP report suppression mechanism. If a non-router port has member host attached, the member hosts suppress their IGMP reports upon receiving IGMP reports forwarded by the non-router port. The Layer 2 device cannot know the existence of the member hosts attached to the non-router port.

Leave message

An IGMPv1 receiver host does not send any leave messages when it leaves a multicast group. The Layer 2 device cannot immediately update the status of the port that connects to the receiver host. The Layer 2 device does not remove the port from the outgoing interface list in the associated forwarding entry until the aging time for the group expires.

An IGMPv2 or IGMPv3 host sends an IGMP leave message when it leaves a multicast group.

When the Layer 2 device receives an IGMP leave message on a dynamic member port, the Layer 2 device first examines whether a forwarding entry matches the group address in the message.

- If no match is found, the Layer 2 device discards the IGMP leave message.
- If a match is found but the receiving port is not an outgoing interface in the forwarding entry, the Layer 2 device discards the IGMP leave message.

- If a match is found and the receiving port is not the only outgoing interface in the forwarding entry, the Layer 2 device performs the following actions:
  - Discards the IGMP leave message.
  - Sends an IGMP group-specific query to identify whether the group has active receivers attached to the receiving port.
  - Sets the aging timer for the receiving port to twice the IGMP last member query interval.
- If a match is found and the receiving port is the only outgoing interface in the forwarding entry, the Layer 2 device performs the following actions:
  - Forwards the IGMP leave message to all router ports in the VLAN.
  - Sends an IGMP group-specific query to identify whether the group has active receivers attached to the receiving port.
  - Sets the aging timer for the receiving port to twice the IGMP last member query interval.

After receiving the IGMP leave message on a port, the IGMP querier resolves the multicast group address in the message. Then, it sends an IGMP group-specific query to the multicast group through the receiving port.

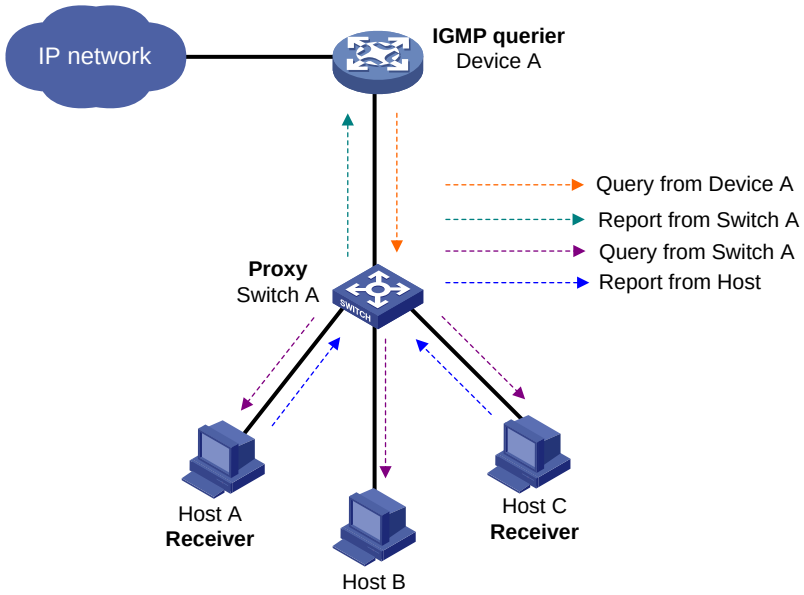
After receiving the IGMP group-specific query, the Layer 2 device forwards the query through all router ports and member ports of the group in the VLAN. Then, it waits for the responding IGMP report from the directly connected hosts. For the dynamic member port that received the leave message, the Layer 2 device also performs one of the following actions:

- If the port receives an IGMP report before the aging timer expires, the Layer 2 device resets the aging timer.
- If the port does not receive an IGMP report when the aging timer expires, the Layer 2 device removes the port from the forwarding entry for the multicast group.

IGMP snooping proxying

As shown in Figure 3, to reduce the number of IGMP report and leave messages received by the upstream device, you can enable IGMP snooping proxying on the edge device. With IGMP snooping proxying enabled, the edge device acts as a host for the upstream IGMP snooping querier to send IGMP report and leave messages to Device A. The host IGMP report suppression mechanism on the edge device does not take effect.

Figure 3 IGMP snooping proxying



The IGMP snooping proxy device processes different IGMP messages as follows:

- General query.

  After receiving an IGMP general query, the device forwards the query to all ports in the VLAN except the receiving port. The device also generates an IGMP report based on the local membership information and sends the report to all router ports.

- Group-specific query or group-and-source-specific query.

  After receiving an IGMP group-specific query or group-and-source-specific query, the device forwards the query to all ports in the VLAN except the receiving port. If the forwarding entry has a member port, the device sends a report to all router ports in the VLAN.

- Report.

  After receiving an IGMP report from a host, the device looks up the forwarding table for a matching entry as follows:

  - If a match is found and the matching forwarding entry contains the receiving port, the device resets the aging timer for the port.
  - If a match is found but the matching forwarding entry does not contain the receiving port, the device adds the receiving port to the outgoing interface list. It also marks the receiving port as a dynamic member port and starts an aging timer for the port.
  - If no match is found, the device creates a forwarding entry with the receiving port as an outgoing interface. It also marks the receiving port as a dynamic member port and starts an aging timer for the port. Then it sends the report to all router ports.

- Leave message.

  After receiving the IGMP leave message on a port, the device sends an IGMP group-specific query through the receiving port. The device sends the IGMP leave message to all router ports only when the last member port is removed from the forwarding entry.

Protocols and standards

RFC 4541, *Considerations for Internet Group Management Protocol (IGMP) and Multicast Listener Discovery (MLD) Snooping Switches*

Restrictions and guidelines: IGMP snooping configuration

For IGMP reports received from secondary VLANs, the associated IGMP snooping forwarding entries are maintained by the primary VLAN. Therefore, you need to enable IGMP snooping only for the primary VLAN. The IGMP snooping configuration made in secondary VLANs does not take effect. For more information about primary VLANs and secondary VLANs, see *Layer 2—LAN Switching Configuration Guide*.

The IGMP snooping configurations made on Layer 2 aggregate interfaces do not interfere with the configurations made on member ports. In addition, the configurations made on Layer 2 aggregate interfaces do not take part in aggregation calculations. The configuration made on a member port of the aggregate group takes effect after the port leaves the aggregate group.

Some features can be configured for a VLAN in VLAN view or for multiple VLANs in IGMP-snooping view. The configuration made in VLAN view and the configuration made in IGMP-snooping view have the same priority, and the most recent configuration takes effect.

Some features can be configured for a VLAN in VLAN view or globally for all VLANs in IGMP-snooping view. The VLAN-specific configuration takes priority over the global configuration.

Some features can be configured for an interface in interface view or for all interfaces of the specified VLANs in IGMP-snooping view. The interface-specific configuration takes priority over the configuration made in IGMP-snooping view.

VLAN-based IGMP snooping tasks at a glance

To configure IGMP snooping for VLANs, perform the following tasks:

1. Enabling the IGMP snooping feature
2. Enabling IGMP snooping

   Choose the following tasks as needed:
   - Enabling IGMP snooping globally
   - Enabling IGMP snooping for VLANs
3. (Optional.) Configuring basic IGMP snooping features
   - Specifying an IGMP snooping version
   - Setting the maximum number of IGMP snooping forwarding entries
   - Configuring static multicast MAC address entries
   - Setting the IGMP last member query interval
4. (Optional.) Configuring IGMP snooping port features
   - Setting aging timers for dynamic ports
   - Configuring a static member port
   - Configuring a static router port
   - Configuring a port as a simulated member host
   - Enabling fast-leave processing
   - Disabling a port from becoming a dynamic router port
5. (Optional.) Configuring the IGMP snooping querier
   - Enabling the IGMP snooping querier
   - Enabling IGMP snooping querier election
   - Configuring parameters for IGMP general queries and responses
6. (Optional.) Enabling IGMP snooping proxying
7. (Optional.) Configuring parameters for IGMP messages
   - Configuring source IP addresses for IGMP messages
   - Setting the 802.1p priority for IGMP messages
8. (Optional.) Configuring IGMP snooping policies
   - Configuring a multicast group policy
   - Enabling multicast source port filtering
   - Enabling dropping unknown multicast data
   - Enabling IGMP report suppression
   - Setting the maximum number of multicast groups on a port
   - Enabling multicast group replacement
   - Enabling host tracking
   - Configuring an IGMP snooping access control policy
9. (Optional.) Setting the DSCP value for outgoing IGMP protocol packets

Enabling the IGMP snooping feature

About enabling the IGMP snooping feature

You must enable the IGMP snooping feature before you configure other IGMP snooping features.

Procedure

1. Enter system view.
   `system-view`
2. Enable the IGMP snooping feature and enter IGMP-snooping view.
   `igmp-snooping`
   By default, the IGMP snooping feature is disabled.

Enabling IGMP snooping

Enabling IGMP snooping globally

About enabling IGMP snooping globally

After you enable IGMP snooping globally, IGMP snooping is enabled for all VLANs. You can disable IGMP snooping for a VLAN when IGMP snooping is globally enabled.

Restrictions and guidelines

To configure other IGMP snooping features for VLANs, you must enable IGMP snooping for the specific VLANs even though IGMP snooping is enabled globally.

The VLAN-specific IGMP snooping configuration takes priority over the global IGMP snooping configuration. For example, if you enable IGMP snooping globally and then use the **`igmp-snooping disable`** command to disable IGMP snooping for a VLAN, IGMP snooping is disabled in the VLAN.

Procedure

1. Enter system view.
   `system-view`
2. Enter IGMP-snooping view.
   `igmp-snooping`
3. Enable IGMP snooping globally.
   `global-enable`
   By default, IGMP snooping is disabled globally.
4. (Optional.) Disable IGMP snooping for a VLAN.
   a. Return to system view.
      `quit`
   b. Enter VLAN view.
      `vlan` *`vlan-id`*
   c. Disable IGMP snooping for the VLAN.
      `igmp-snooping disable`
      By default, the IGMP snooping status in a VLAN is consistent with the global IGMP snooping status.

Enabling IGMP snooping for VLANs

Restrictions and guidelines

You can enable IGMP snooping for multiple VLANs by using the **enable vlan** command in IGMP-snooping view or for a VLAN by using the **igmp-snooping enable** command in VLAN view. The configuration in VLAN view has the same priority as the configuration in IGMP-snooping view.

IGMP snooping configuration in a VLAN takes effect only on the member ports in the VLAN.

Enabling IGMP snooping for multiple VLANs

1. Enter system view.
   system-view
2. Enter IGMP-snooping view.
   igmp-snooping
3. Enable IGMP snooping for the specified VLANs.
   enable vlan *vlan-list*
   By default, the IGMP snooping status in a VLAN is consistent with the global IGMP snooping status.

Enabling IGMP snooping for a VLAN

1. Enter system view.
   system-view
2. Enter VLAN view.
   vlan *vlan-id*
3. Enable IGMP snooping for the VLAN.
   igmp-snooping enable
   By default, the IGMP snooping status in a VLAN is consistent with the global IGMP snooping status.

Configuring basic IGMP snooping features

Specifying an IGMP snooping version

About IGMP snooping versions

Different IGMP snooping versions process different versions of IGMP messages.

- IGMPv2 snooping processes IGMPv1 messages, IGMPv2 messages, and IGMPv3 queries, but it floods IGMPv3 reports in the VLAN instead of processing them.
- IGMPv3 snooping processes IGMPv1, IGMPv2, and IGMPv3 messages.

Restrictions and guidelines

If you change the IGMP snooping version from 2 to 3, the device performs the following actions:

- Clears all IGMP snooping forwarding entries that are dynamically created.
- Keeps static IGMPv3 snooping forwarding entries (*, G).
- Clears static IGMPv3 snooping forwarding entries (S, G), which will be restored when the IGMP snooping version is switched back to 3.

For more information about static IGMP snooping forwarding entries, see "Configuring a static member port."

Specifying an IGMP snooping version for multiple VLANs

1. Enter system view.
   system-view
2. Enter IGMP-snooping view.
   igmp-snooping
3. Specify an IGMP snooping version for multiple VLANs.
   version *version-number* **vlan** *vlan-list*
   By default, the IGMP snooping version for a VLAN is 2.

Specifying an IGMP snooping version for a VLAN

1. Enter system view.
   system-view
2. Enter VLAN view.
   vlan *vlan-id*
3. Specify an IGMP snooping version for the VLAN.
   igmp-snooping version *version-number*
   By default, the IGMP snooping version for a VLAN is 2.

Setting the maximum number of IGMP snooping forwarding entries

About setting the maximum number of IGMP snooping forwarding entries

You can modify the maximum number of IGMP snooping forwarding entries, including dynamic entries and static entries. When the number of forwarding entries on the device reaches the upper limit, the device does not automatically remove any existing entries. To allow new entries to be created, remove some entries manually.

Procedure

1. Enter system view.
   system-view
2. Enter IGMP-snooping view.
   igmp-snooping
3. Set the maximum number of IGMP snooping forwarding entries.
   entry-limit *limit*
   By default, the maximum number of IGMP snooping forwarding entries is 4294967295.

Configuring static multicast MAC address entries

About static multicast MAC address entries

In Layer 2 multicast, multicast MAC address entries can be dynamically created through Layer 2 multicast protocols (such as IGMP snooping). You can also manually configure static multicast MAC address entries by binding multicast MAC addresses and ports to control the destination ports of the multicast data.

Restrictions and guidelines

You must specify an unused multicast MAC address when configuring a static multicast MAC address entry. A multicast MAC address is the MAC address in which the least significant bit of the most significant octet is 1.

Configuring a static multicast MAC address entry in system view

1. Enter system view.
   system-view
2. Configure a static multicast MAC address entry.
   mac-address multicast *mac-address* **interface** *interface-list* **vlan** *vlan-id*

Configuring a static multicast MAC address entry in interface view

1. Enter system view.
   system-view
2. Enter Layer 2 interface view.
   - Enter Layer 2 Ethernet interface view.
     interface *interface-type interface-number*
   - Enter Layer 2 aggregate interface view.
     interface bridge-aggregation *interface-number*
3. Configure a static multicast MAC address entry.
   mac-address multicast *mac-address* **vlan** *vlan-id*

Setting the IGMP last member query interval

About the IGMP last member query interval

A receiver host starts a report delay timer for a multicast group when it receives an IGMP group-specific query for the group. This timer is set to a random value in the range of 0 to the maximum response time advertised in the query. When the timer value decreases to 0, the host sends an IGMP report to the group.

The IGMP last member query interval defines the maximum response time advertised in IGMP group-specific queries. Set an appropriate value for the IGMP last member query interval to speed up hosts' responses to IGMP group-specific queries and avoid IGMP report traffic bursts.

Setting the IGMP last member query interval globally

1. Enter system view.
   system-view
2. Enter IGMP-snooping view.
   igmp-snooping
3. Set the IGMP last member query interval globally.
   last-member-query-interval *interval*

   By default, the global IGMP last member query interval is 1 second.

Setting the IGMP last member query interval for a VLAN

1. Enter system view.
   system-view
2. Enter VLAN view.
   vlan *vlan-id*

3. Set the IGMP last member query interval for the VLAN.

   igmp-snooping last-member-query-interval *interval*

   By default, the IGMP last member query interval is 1 second for a VLAN.

Configuring IGMP snooping port features

Setting aging timers for dynamic ports

About aging timers for dynamic ports

A dynamic router port is removed from the dynamic router port list if it does not receive an IGMP general query or PIM hello message when its aging timer expires.

A dynamic member port is removed from the dynamic member port if it does not receive an IGMP report when its aging timer expires.

Restrictions and guidelines

Set an appropriate value for the aging timers of dynamic ports. For example, if the memberships of multicast groups frequently change, set a relatively small value for the aging timer of the dynamic member ports. If the memberships of multicast groups rarely change, set a relatively large value.

If a dynamic router port receives a PIMv2 hello message, the aging timer for the port is specified by the hello message. In this case, the **router-aging-time** or **igmp-snooping router-aging-time** command does not take effect on the port.

IGMP group-specific queries originated by the Layer 2 device trigger the adjustment of aging timers for dynamic member ports. If a dynamic member port receives such a query, its aging timer is set to twice the IGMP last member query interval. For more information about setting the IGMP last member query interval on the Layer 2 device, see "Setting the IGMP last member query interval."

Setting the aging timers for dynamic ports globally

1. Enter system view.

   system-view

2. Enter IGMP-snooping view.

   igmp-snooping

3. Set the aging timer for dynamic router ports globally.

   router-aging-time *seconds*

   By default, the aging timer for dynamic router ports is 260 seconds.

4. Set the global aging timer for dynamic member ports globally.

   host-aging-time *seconds*

   By default, the aging timer for dynamic member ports is 260 seconds.

Setting the aging timers for dynamic ports in a VLAN

1. Enter system view.

   system-view

2. Enter VLAN view.

   vlan *vlan-id*

3. Set the aging timer for dynamic router ports in the VLAN.

   igmp-snooping router-aging-time *seconds*

   By default, the aging timer for dynamic router ports is 260 seconds.

4. Set the aging timer for dynamic member ports in the VLAN.

igmp-snooping host-aging-time *seconds*

By default, the aging timer for dynamic member ports is 260 seconds.

Configuring a static member port

About static member ports

You can configure a port as a static member port for a multicast group so that hosts attached to the port can always receive multicast for the group. The static member port does not respond to IGMP queries. When you complete or cancel this configuration on a port, the port does not send an unsolicited IGMP report or leave message.

Procedure

1. Enter system view.

   system-view
2. Enter Layer 2 interface view.
   - Enter Layer 2 Ethernet interface view.

     interface *interface-type interface-number*
   - Enter Layer 2 aggregate interface view.

     interface bridge-aggregation *interface-number*
3. Configure the port as a static member port.

   igmp-snooping static-group *group-address* [**source-ip** *source-address*] **vlan** *vlan-id*

   By default, a port is not a static member port.

Configuring a static router port

About static router ports

You can configure a port as a static router port for a multicast group so that all multicast data for the group received on the port will be forwarded.

Procedure

1. Enter system view.

   system-view
2. Enter Layer 2 interface view.
   - Enter Layer 2 Ethernet interface view.

     interface *interface-type interface-number*
   - Enter Layer 2 aggregate interface view.

     interface bridge-aggregation *interface-number*
3. Configure the port as a static router port.

   igmp-snooping static-router-port vlan *vlan-id*

   By default, a port is not a static router port.

Configuring a port as a simulated member host

About simulated member hosts

When a port is configured as a simulated member host, it is equivalent to an independent host in the following ways:

- It sends an unsolicited IGMP report when you complete the configuration.
- It responds to IGMP general queries with IGMP reports.
- It sends an IGMP leave message when you cancel the configuration.

The version of IGMP running on the simulated member host is the same as the version of IGMP snooping running on the port. The port ages out in the same way as a dynamic member port.

Procedure

1. Enter system view.
   system-view
2. Enter Layer 2 interface view.
   - Enter Layer 2 Ethernet interface view.
     interface *interface-type interface-number*
   - Enter Layer 2 aggregate interface view.
     interface bridge-aggregation *interface-number*
3. Configure the port as a simulated member host.
   igmp-snooping host-join *group-address* [**source-ip** *source-address*] **vlan** *vlan-id*

   By default, the port is not a simulated member host.

Enabling fast-leave processing

About fast-leave processing

This feature enables the Layer 2 device to immediately remove a port from the forwarding entry for a multicast group when the port receives a leave massage. The Layer 2 device no longer sends or forwards IGMP group-specific queries for the group to the port.

Restrictions and guidelines

Do not enable fast-leave processing on a port that has multiple receiver hosts in a VLAN. If you do so, the remaining receivers cannot receive multicast data for a group after a receiver leaves the group.

Enabling fast-leave processing globally

1. Enter system view.
   system-view
2. Enter IGMP-snooping view.
   igmp-snooping
3. Enable fast-leave processing globally.
   fast-leave [**vlan** *vlan-list*]

   By default, fast-leave processing is disabled globally.

Enabling fast-leave processing on a port

1. Enter system view.
   system-view
2. Enter Layer 2 interface view.
   - Enter Layer 2 Ethernet interface view.
     interface *interface-type interface-number*
   - Enter Layer 2 aggregate interface view.
     interface bridge-aggregation *interface-number*

3. Enable fast-leave processing on the port.
   igmp-snooping fast-leave [**vlan** *vlan-list*]
   By default, fast-leave processing is disabled on a port.

Disabling a port from becoming a dynamic router port

About disabling a port from becoming a dynamic router port

A receiver host might send IGMP general queries or PIM hello messages for testing purposes. On the Layer 2 device, the port that receives either of the messages becomes a dynamic router port. Before the aging timer for the port expires, the following problems might occur:

- All multicast data for the VLAN to which the port belongs flows to the port. Then, the port forwards the data to attached receiver hosts. The receiver hosts will receive multicast data that it does not want to receive.
- The port forwards the IGMP general queries or PIM hello messages to its upstream Layer 3 devices. These messages might affect the multicast routing protocol state (such as the IGMP querier or DR election) on the Layer 3 devices. This might further cause network interruption.

To solve these problems, you can disable a port from becoming a dynamic router port. This also improves network security and the control over receiver hosts.

Restrictions and guidelines

This configuration and the static router port configuration do not interfere with each other.

Procedure

1. Enter system view.
   system-view
2. Enter Layer 2 interface view.
   - Enter Layer 2 Ethernet interface view.
     interface *interface-type interface-number*
   - Enter Layer 2 aggregate interface view.
     interface bridge-aggregation *interface-number*
3. Disable the port from becoming a dynamic router port.
   igmp-snooping router-port-deny [**vlan** *vlan-list*]
   By default, a port is allowed to become a dynamic router port.

Configuring the IGMP snooping querier

Enabling the IGMP snooping querier

About the IGMP snooping querier

This feature enables the Layer 2 device to periodically send IGMP general queries to establish and maintain multicast forwarding entries at the data link Layer. You can configure an IGMP snooping querier on a network without Layer 3 multicast devices.

Restrictions and guidelines

Do not enable the IGMP snooping querier on a multicast network that runs IGMP. An IGMP snooping querier does not take part in IGMP querier elections. However, it might affect IGMP querier elections if it sends IGMP general queries with a low source IP address.

Enabling the IGMP snooping querier for a VLAN

1. Enter system view.
   system-view
2. Enter VLAN view.
   vlan *vlan-id*
3. Enable the IGMP snooping querier for the VLAN.
   igmp-snooping querier
   By default, the IGMP snooping querier is disabled for a VLAN.

Enabling IGMP snooping querier election

About IGMP snooping querier election

To avoid traffic interruption caused by the failure of a single querier in a VLAN, configure multiple queriers in the VLAN and enable querier election. When the elected querier fails, the device starts a new querier election to ensure multicast forwarding. The mechanism for IGMP snooping querier election is the same as that for IGMP querier election.

Prerequisites for enabling IGMP snooping querier election

Before you enable IGMP snooping querier election, you must complete the following tasks:

- Enable the IGMP snooping querier for a VLAN. For more information about enabling the IGMP snooping querier, see "Enabling the IGMP snooping querier."
- Configure the source IP address for IGMP general queries as an IP address different from 0.0.0.0 and the local querier IP address. An IGMP snooping querier performs querier election only if the source IP address of a received IGMP general query is not 0.0.0.0 or its own IP address.
- Make sure the candidate IGMP snooping queriers run the same IGMP snooping version. To specify the IGMP snooping version, use the **igmp-snooping version** command.

Enabling IGMP snooping querier election for a VLAN

1. Enter system view.
   system-view
2. Enter VLAN view.
   vlan *vlan-id*
3. Enable IGMP snooping querier election for the VLAN.
   igmp-snooping querier-election
   By default, IGMP snooping querier election is disabled for a VLAN.

Configuring parameters for IGMP general queries and responses

About parameters for IGMP general queries and responses

You can modify the IGMP general query interval based on the actual condition of the network.

A receiver host starts a report delay timer for each multicast group that it has joined when it receives an IGMP general query. This timer is set to a random value in the range of 0 to the maximum response time advertised in the query. When the timer value decreases to 0, the host sends an IGMP report to the corresponding multicast group.

Set an appropriate value for the maximum response time for IGMP general queries to speed up hosts' responses to IGMP general queries and avoid IGMP report traffic bursts.

Restrictions and guidelines

To avoid mistakenly deleting multicast group members, make sure the IGMP general query interval is greater than the maximum response time for IGMP general queries.

Configuring parameters for IGMP general queries and responses globally

1. Enter system view.
   system-view
2. Enter IGMP-snooping view.
   igmp-snooping
3. Set the maximum response time for IGMP general queries.
   max-response-time *seconds*
   By default, the maximum response time for IGMP general queries is 10 seconds.

Configuring parameters for IGMP general queries and responses in a VLAN

1. Enter system view.
   system-view
2. Enter VLAN view.
   vlan *vlan-id*
3. Set the IGMP general query interval in the VLAN.
   igmp-snooping query-interval *interval*
   By default, the IGMP general query interval is 125 seconds for a VLAN.
4. Set the maximum response time for IGMP general queries in the VLAN.
   igmp-snooping max-response-time *seconds*
   By default, the maximum response time for IGMP general queries is 10 seconds for a VLAN.

Enabling IGMP snooping proxying

About enabling IGMP snooping proxying

The device enabled with IGMP snooping proxying is called an IGMP snooping proxy. The IGMP snooping proxy acts as a host to the upstream device. Enabled with IGMP snooping querier, the IGMP snooping proxy acts as the router to downstream devices and receives report and leave messages on behalf of the upstream device. As a best practice, enable IGMP snooping proxy on the edge device to alleviate the effect caused by excessive packets.

Restrictions and guidelines for enabling IGMP snooping proxying

Before you enable IGMP snooping proxying for a VLAN, you must first enable IGMP snooping globally and enable IGMP snooping for the VLAN. IGMP snooping proxying does not take effect on sub VLANs of a multicast VLAN.

Use this feature with IGMP snooping querier. For more information about enabling IGMP snooping querier, see "Enabling the IGMP snooping querier."

Enabling IGMP snooping proxying for a VLAN

1. Enter system view.

system-view

2. Enter VLAN view.

   vlan *vlan-id*

3. Enable IGMP snooping proxying for the VLAN.

   igmp-snooping proxy enable

   By default, IGMP snooping proxying is disabled for a VLAN.

Configuring parameters for IGMP messages

Configuring source IP addresses for IGMP messages

About configuring source IP addresses for IGMP messages

The IGMP snooping querier might send IGMP general queries with the source IP address 0.0.0.0. The port that receives such queries will not be maintained as a dynamic router port. This might prevent the associated dynamic IGMP snooping forwarding entry from being correctly created at the data link layer and eventually cause multicast traffic forwarding failures. To avoid this problem, you can configure a non-all-zero IP address as the source IP address of the IGMP queries on the IGMP snooping querier. This configuration might affect the IGMP querier election within the subnet.

You can also change the source IP address of IGMP reports or leave messages sent by a simulated member host or an IGMP snooping proxy.

Configuring the source IP addresses for IGMP messages in a VLAN

1. Enter system view.

   system-view

2. Enter VLAN view.

   vlan *vlan-id*

3. Configure the source IP address for IGMP general queries.

   igmp-snooping general-query source-ip *ip-address*

   By default, the source IP address of IGMP general queries is the IP address of the current VLAN interface. If the current VLAN interface does not have an IP address, the source IP address is 0.0.0.0.

4. Configure the source IP address for IGMP group-specific queries.

   igmp-snooping special-query source-ip *ip-address*

   By default, the source IP address of IGMP group-specific queries is one of the following:

   - The source address of IGMP group-specific queries if the IGMP snooping querier of the VLAN has received IGMP general queries.
   - The IP address of the current VLAN interface if the IGMP snooping querier does not receive an IGMP general query.
   - 0.0.0.0 if the IGMP snooping querier does not receive an IGMP general query and the current VLAN interface does not have an IP address.

5. Configure the source IP address for IGMP reports.

   igmp-snooping report source-ip *ip-address*

   By default, the source IP address of IGMP reports is the IP address of the current VLAN interface. If the current VLAN interface does not have an IP address, the source IP address is 0.0.0.0.

6. Configure the source IP address for IGMP leave messages.

   igmp-snooping leave source-ip *ip-address*

By default, the source IP address of IGMP leave messages is the IP address of the current VLAN interface. If the current VLAN interface does not have an IP address, the source IP address is 0.0.0.0.

Setting the 802.1p priority for IGMP messages

About the 802.1p priority for IGMP messages

When congestion occurs on outgoing ports of the Layer 2 device, it forwards IGMP messages in their 802.1p priority order, from highest to lowest. You can assign a higher 802.1p priority to IGMP messages that are created or forwarded by the device.

Setting the 802.1p priority for IGMP messages globally

1. Enter system view.
   system-view
2. Enter IGMP-snooping view.
   igmp-snooping
3. Set the 802.1p priority for IGMP messages.
   dot1p-priority *priority*
   By default, the global 802.1p priority is 6 for IGMP messages.

Setting the 802.1p priority for IGMP messages in a VLAN

1. Enter system view.
   system-view
2. Enter VLAN view.
   vlan *vlan-id*
3. Set the 802.1p priority for IGMP messages in the VLAN.
   igmp-snooping dot1p-priority *priority*
   By default, the 802.1p priority is 6 for IGMP messages in a VLAN.

Configuring IGMP snooping policies

Configuring a multicast group policy

About multicast group policies

This feature enables the Layer 2 device to filter IGMP reports by using an ACL that specifies the multicast groups and the optional sources. It is used to control the multicast groups that hosts can join. This configuration takes effect only on the multicast groups that ports join dynamically.

In a multicast application, a host sends an unsolicited IGMP report when a user requests a multicast program. The Layer 2 device uses the multicast group policy to filter the IGMP report. The host can join the multicast group only if the IGMP report is permitted by the multicast group policy.

Configuring a multicast group policy globally

1. Enter system view.
   system-view
2. Enter IGMP-snooping view.
   igmp-snooping
3. Configure a multicast group policy globally.

group-policy *ipv4-acl-number* [**vlan** *vlan-list*]

By default, no multicast group policies are configured, and hosts can join any multicast groups.

Configuring a multicast group policy on a port

1. Enter system view.
   system-view
2. Enter Layer 2 interface view.
   - Enter Layer 2 Ethernet interface view.
     interface *interface-type interface-number*
   - Enter Layer 2 aggregate interface view.
     interface bridge-aggregation *interface-number*
3. Configure a multicast group policy on the port.
   igmp-snooping group-policy *ipv4-acl-number* [**vlan** *vlan-list*]

   By default, no multicast group policies are configured on a port, and hosts attached to the port can join any multicast groups.

Enabling multicast source port filtering

About multicast source port filtering

This feature enables the Layer 2 device to discard all multicast data packets and to accept multicast protocol packets. You can enable this feature on ports that connect only to multicast receivers.

Restrictions and guidelines

When multicast source port filtering is enabled, the system automatically enables multicast source port filtering.

The configuration made for multiple interfaces in IGMP-snooping view has the same priority as the interface-specific configuration, and the most recent configuration takes effect.

Enabling multicast source port filtering in IGMP-snooping view

1. Enter system view.
   system-view
2. Enter IGMP-snooping view.
   igmp-snooping
3. Enable multicast source port filtering.
   source-deny port *interface-list*

   By default, multicast source port filtering is disabled.

Enabling multicast source port filtering in interface view

1. Enter system view.
   system-view
2. Enter Layer 2 Ethernet interface view.
   interface *interface-type interface-number*
3. Enable multicast source port filtering.
   igmp-snooping source-deny

   By default, multicast source port filtering is disabled.

Enabling dropping unknown multicast data

About dropping unknown multicast data

Unknown multicast data refers to multicast data for which no forwarding entries exist in the IGMP snooping forwarding table. This feature enables the device to forward unknown multicast data only to the router port. If the device does not have a router port, unknown multicast data will be dropped.

If you do not enable this feature, the unknown multicast data is flooded in the VLAN to which the data belongs.

Restrictions and guidelines

When dropping unknown IPv4 multicast data is enabled, the device also drops unknown IPv6 multicast data.

When this feature is enabled in a VLAN, the device still forwards unknown multicast data out of router ports except the receiving router port in this VLAN.

Enabling dropping unknown multicast data for a VLAN

1. Enter system view.

   system-view
2. Enter VLAN view.

   vlan *vlan-id*
3. Enable dropping unknown multicast data for the VLAN.

   igmp-snooping drop-unknown

   By default, dropping unknown multicast data is disabled for a VLAN. Unknown multicast data is flooded in the VLAN.

Enabling IGMP report suppression

About IGMP report suppression

This feature enables the Layer 2 device to forward only the first IGMP report for a multicast group to its directly connected Layer 3 device. Other reports for the same group in the same query interval are discarded. Use this feature to reduce multicast traffic.

Procedure

1. Enter system view.

   system-view
2. Enter IGMP-snooping view.

   igmp-snooping
3. Enable IGMP report suppression.

   report-aggregation

   By default, IGMP report suppression is enabled.

Setting the maximum number of multicast groups on a port

About setting the maximum number of multicast groups on a port

You can set the maximum number of multicast groups on a port to regulate the port traffic. This feature takes effect only on the multicast groups that a port joins dynamically.

If the number of multicast groups on a port exceeds the limit, the system removes all the forwarding entries associated with the port. The receiver hosts attached to that port can join multicast groups

again before the number of multicast groups on the port reaches the limit. When the number of multicast groups on the port reaches the limit, the port automatically drops IGMP reports for new groups.

Procedure

1. Enter system view.
   system-view
2. Enter Layer 2 interface view.
   - Enter Layer 2 Ethernet interface view.
     interface *interface-type interface-number*
   - Enter Layer 2 aggregate interface view.
     interface bridge-aggregation *interface-number*
3. Set the maximum number of multicast groups on the port.
   igmp-snooping group-limit *limit* [**vlan** *vlan-list*]
   By default, no limit is placed on the maximum number of multicast groups on a port.

Enabling multicast group replacement

About multicast group replacement

When multicast group replacement is enabled, the port does not drop IGMP reports for new groups if the number of multicast groups on the port reaches the upper limit. Instead, the port leaves the multicast group that has the lowest IP address and joins the new group contained in the IGMP report. The multicast group replacement feature is typically used in the channel switching application.

Restrictions and guidelines

This feature takes effect only on the multicast groups that a port joins dynamically.

This feature does not take effect if the following conditions exist:

- The number of the IGMP snooping forwarding entries on the device reaches the upper limit.
- The multicast group that the port newly joins is not included in the multicast group list maintained by the device.

Enabling multicast group replacement globally

1. Enter system view.
   system-view
2. Enter IGMP-snooping view.
   igmp-snooping
3. Enable multicast group replacement globally.
   overflow-replace [**vlan** *vlan-list*]
   By default, multicast group replacement is disabled globally.

Enabling multicast group replacement on a port

1. Enter system view.
   system-view
2. Enter Layer 2 interface view.
   - Enter Layer 2 Ethernet interface view.
     interface *interface-type interface-number*
   - Enter Layer 2 aggregate interface view.
     interface bridge-aggregation *interface-number*

3. Enable multicast group replacement on the port.

   igmp-snooping overflow-replace [**vlan** *vlan-list*]

   By default, multicast group replacement is disabled on a port.

Enabling host tracking

About host tracking

This feature enables the Layer 2 device to record information about member hosts that are receiving multicast data. The information includes IP addresses of the hosts, length of time elapsed since the hosts joined multicast groups, and remaining timeout time for the hosts. This feature facilitates monitoring and managing member hosts.

Enabling host tracking globally

1. Enter system view.

   system-view

2. Enter IGMP-snooping view.

   igmp-snooping

3. Enable host tracking globally.

   host-tracking

   By default, host tracking is disabled globally.

Enabling host tracking for a VLAN

1. Enter system view.

   system-view

2. Enter VLAN view.

   vlan *vlan-id*

3. Enable host tracking for the VLAN.

   igmp-snooping host-tracking

   By default, host tracking is disabled for a VLAN.

Configuring an IGMP snooping access control policy

About IGMP snooping access control policies

This feature enables the device to use ACLs to filter IGMP reports and leave messages from multicast users. Multicast users can join or leave only multicast groups permitted by the IGMP snooping access control policies.

Procedure

1. Enter system view.

   system-view

2. Enter user profile view.

   user-profile *profile-name*

   For more information about this command, see user profile commands in *Security Command Reference*.

3. Configure an IGMP snooping access control policy.

   igmp-snooping access-policy *ipv4-acl-number*

   By default, no IGMP snooping access control policies are configured. Multicast users can join or leave any multicast groups.

Setting the DSCP value for outgoing IGMP protocol packets

About the DSCP value for outgoing IGMP protocol packets

The DSCP value determines the packet transmission priority. A greater DSCP value represents a higher priority.

Procedure

1. Enter system view.
   system-view
2. Enter IGMP snooping view.
   igmp-snooping
3. Set the DSCP value for outgoing IGMP protocol packets.
   dscp *dscp-value*
   By default, the DSCP value is 48 for outgoing IGMP protocol packets.

Display and maintenance commands for IGMP snooping

Execute **display** commands in any view and **reset** commands in user view.

Task	Command
Display IGMP snooping status.	**display igmp-snooping** [**global** | **vlan** *vlan-id*]
Display dynamic IGMP snooping group entries.	**display igmp-snooping group** [*group-address* | *source-address*] * [**vlan** *vlan-id*] [**interface** *interface-type interface-number* | [**verbose**] [**slot** *slot-number*]]
Display host tracking information.	**display igmp-snooping host-tracking vlan** *vlan-id* **group** *group-address* [**source** *source-address*] [**slot** *slot-number*]
Display dynamic router port information.	**display igmp-snooping router-port** [**vlan** *vlan-id* [**verbose**] [**slot** *slot-number*]
Display static IGMP snooping group entries.	**display igmp-snooping static-group** [*group-address* | *source-address*] * [**vlan** *vlan-id*] [**verbose**] [**slot** *slot-number*]
Display static router port information.	**display igmp-snooping static-router-port** [**vlan** *vlan-id*] [**verbose**] [**slot** *slot-number*]
Display statistics for the IGMP messages and PIMv2 hello messages learned by IGMP snooping.	**display igmp-snooping statistics**
Display Layer 2 multicast fast forwarding entries.	**display l2-multicast fast-forwarding cache** [**vlan** *vlan-id*] [*source-address* |

Task	Command
	group-address] * [**slot** *slot-number*]
Display information about Layer 2 IP multicast groups.	**display l2-multicast ip** [**group** *group-address* | **source** *source-address*] * [**vlan** *vlan-id*] [**slot** *slot-number*]
Display Layer 2 IP multicast group entries.	**display l2-multicast ip forwarding** [**group** *group-address* | **source** *source-address*] * [**vlan** *vlan-id*] [**slot** *slot-number*]
Display information about Layer 2 MAC multicast groups.	**display l2-multicast mac** [*mac-address*] [**vlan** *vlan-id*] [**slot** *slot-number*]
Display Layer 2 MAC multicast group entries.	**display l2-multicast mac forwarding** [*mac-address*] [**vlan** *vlan-id*] [**slot** *slot-number*]
Display static multicast MAC address entries.	**display mac-address** [*mac-address* [**vlan** *vlan-id*] | [**multicast**] [**vlan** *vlan-id*] [**count**]]
Clear dynamic IGMP snooping group entries.	**reset igmp-snooping group** { *group-address* [*source-address*] | **all** } [**vlan** *vlan-id*]
Clear dynamic router port information.	**reset igmp-snooping router-port** { **all** | **vlan** *vlan-id* }
Clear statistics for IGMP messages and PIMv2 hello messages learned through IGMP snooping.	**reset igmp-snooping statistics**
Clear Layer 2 multicast fast forwarding entries.	**reset l2-multicast fast-forwarding cache** [**vlan** *vlan-id*] { { *source-address* | *group-address* } * | **all** } [**slot** *slot-number*]

IGMP snooping configuration examples

Example: Configuring VLAN-based IGMP snooping group polices and simulated joining

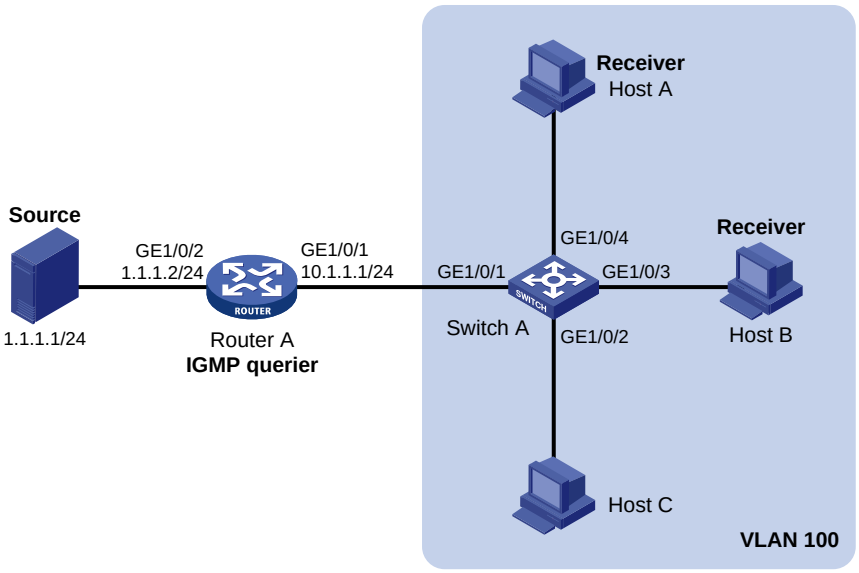
Network configuration

As shown in Figure 4, Router A runs IGMPv2 and acts as the IGMP querier. Switch A runs IGMPv2 snooping.

Configure a multicast group policy and simulated joining to meet the following requirements:

- Host A and Host B receive only the multicast data addressed to multicast group 224.1.1.1. Multicast data can be forwarded through GigabitEthernet 1/0/3 and GigabitEthernet 1/0/4 of Switch A uninterruptedly, even though Host A and Host B fail to receive the multicast data.
- Switch A will drop unknown multicast data instead of flooding it in VLAN 100.

Figure 4 Network diagram



Procedure

1. Assign an IP address and subnet mask to each interface, as shown in Figure 4. (Details not shown.)
2. Configure Router A:

   # Enable IP multicast routing.

   ```
   <RouterA> system-view
   [RouterA] multicast routing
   [RouterA-mrib] quit
   ```

   # Enable IGMP on GigabitEthernet 1/0/1.

   ```
   [RouterA] interface gigabitethernet 1/0/1
   [RouterA-GigabitEthernet1/0/1] igmp enable
   [RouterA-GigabitEthernet1/0/1] quit
   ```

   # Enable PIM-DM on GigabitEthernet 1/0/2.

   ```
   [RouterA] interface gigabitethernet 1/0/2
   [RouterA-GigabitEthernet1/0/2] pim dm
   [RouterA-GigabitEthernet1/0/2] quit
   ```

3. Configure Switch A:

   # Enable the IGMP snooping feature.

   ```
   <SwitchA> system-view
   [SwitchA] igmp-snooping
   [SwitchA-igmp-snooping] quit
   ```

   # Create VLAN 100, and assign GigabitEthernet 1/0/1 through GigabitEthernet 1/0/4 to the VLAN.

   ```
   [SwitchA] vlan 100
   [SwitchA-vlan100] port gigabitethernet 1/0/1 to gigabitethernet 1/0/4
   ```

   # Enable IGMP snooping, and enable dropping unknown multicast data for VLAN 100.

   ```
   [SwitchA-vlan100] igmp-snooping enable
   [SwitchA-vlan100] igmp-snooping drop-unknown
   [SwitchA-vlan100] quit
   ```

Configure a multicast group policy so that hosts in VLAN 100 can join only multicast group 224.1.1.1.

```
[SwitchA] acl basic 2001
[SwitchA-acl-ipv4-basic-2001] rule permit source 224.1.1.1 0
[SwitchA-acl-ipv4-basic-2001] quit
[SwitchA] igmp-snooping
[SwitchA-igmp-snooping] group-policy 2001 vlan 100
[SwitchA-igmp-snooping] quit
```

Configure GigabitEthernet 1/0/3 and GigabitEthernet 1/0/4 as simulated member hosts of multicast group 224.1.1.1.

```
[SwitchA] interface gigabitethernet 1/0/3
[SwitchA-GigabitEthernet1/0/3] igmp-snooping host-join 224.1.1.1 vlan 100
[SwitchA-GigabitEthernet1/0/3] quit
[SwitchA] interface gigabitethernet 1/0/4
[SwitchA-GigabitEthernet1/0/4] igmp-snooping host-join 224.1.1.1 vlan 100
[SwitchA-GigabitEthernet1/0/4] quit
```

Verifying the configuration

Send IGMP reports from Host A and Host B to join multicast groups 224.1.1.1 and 224.2.2.2. (Details not shown.)

Display dynamic IGMP snooping group entries for VLAN 100 on Switch A.

```
[SwitchA] display igmp-snooping group vlan 100
Total 1 entries.

VLAN 100: Total 1 entries.
  (0.0.0.0, 224.1.1.1)
    Host ports (2 in total):
      GE1/0/3                          (00:03:23)
      GE1/0/4                          (00:04:10)
```

The output shows the following information:

- Host A and Host B have joined multicast group 224.1.1.1 through the member ports GigabitEthernet 1/0/4 and GigabitEthernet 1/0/3 on Switch A, respectively.
- Host A and Host B have failed to join multicast group 224.2.2.2.

Example: Configuring VLAN-based IGMP snooping static ports

Network configuration

As shown in Figure 5:

- Router A runs IGMPv2 and acts as the IGMP querier. Switch A, Switch B, and Switch C run IGMPv2 snooping.
- Host A and host C are permanent receivers of multicast group 224.1.1.1.

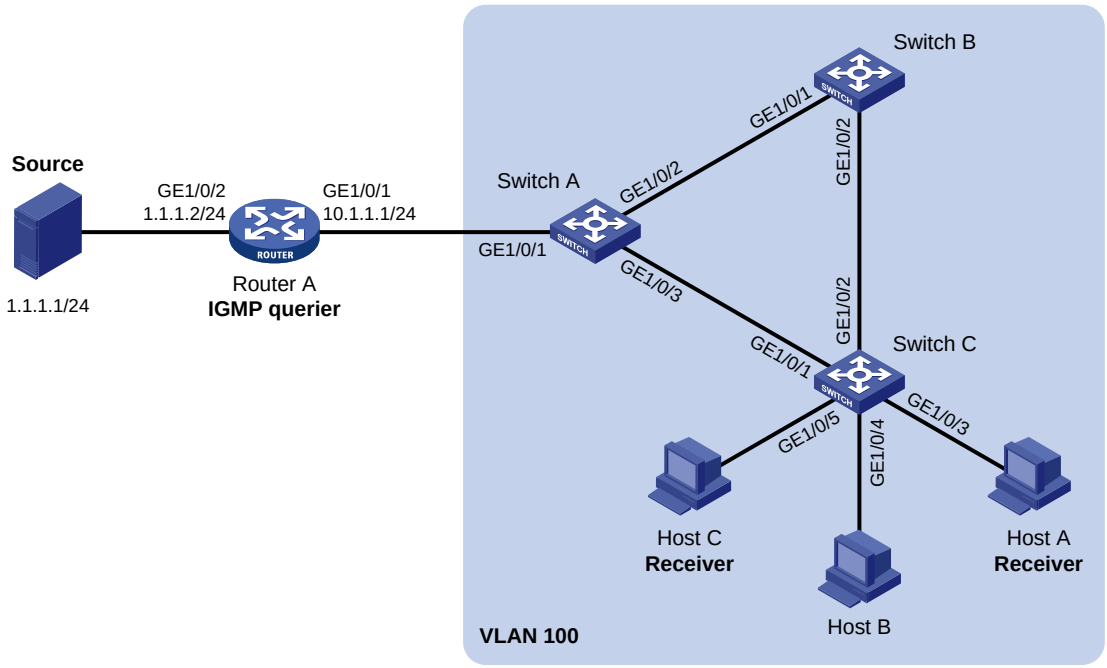
Configure static ports to meet the following requirements:

- To enhance the reliability of multicast traffic transmission, configure GigabitEthernet 1/0/3 and GigabitEthernet 1/0/5 on Switch C as static member ports for multicast group 224.1.1.1.
- Suppose the STP runs on the network. To avoid data loops, the forwarding path from Switch A to Switch C is blocked. Multicast data flows to the receivers attached to Switch C only along the path of Switch A—Switch B—Switch C. When this path is blocked, a minimum of one IGMP

query-response cycle must be completed before multicast data flows to the receivers along the path of Switch A—Switch C. In this case, the multicast delivery is interrupted during the process. For more information about the STP, see *Layer 2—LAN Switching Configuration Guide*.

Configure GigabitEthernet 1/0/3 on Switch A as a static router port. Then, multicast data can flow to the receivers nearly uninterruptedly along the path of Switch A—Switch C when the path of Switch A—Switch B—Switch C is blocked.

Figure 5 Network diagram



Procedure

1. Assign an IP address and subnet mask to each interface, as shown in Figure 5. (Details not shown.)
2. Configure Router A:

   # Enable IP multicast routing.

   ```
   <RouterA> system-view
   [RouterA] multicast routing
   [RouterA-mrib] quit
   ```

   # Enable IGMP on GigabitEthernet 1/0/1.

   ```
   [RouterA] interface gigabitethernet 1/0/1
   [RouterA-GigabitEthernet1/0/1] igmp enable
   [RouterA-GigabitEthernet1/0/1] quit
   ```

   # Enable PIM-DM on GigabitEthernet 1/0/2.

   ```
   [RouterA] interface gigabitethernet 1/0/2
   [RouterA-GigabitEthernet1/0/2] pim dm
   [RouterA-GigabitEthernet1/0/2] quit
   ```

3. Configure Switch A:

   # Enable the IGMP snooping feature.

   ```
   <SwitchA> system-view
   [SwitchA] igmp-snooping
   [SwitchA-igmp-snooping] quit
   ```

Create VLAN 100, and assign GigabitEthernet 1/0/1 through GigabitEthernet 1/0/3 to the VLAN.

```
[SwitchA] vlan 100
[SwitchA-vlan100] port gigabitethernet 1/0/1 to gigabitethernet 1/0/3
```

Enable IGMP snooping for VLAN 100.

```
[SwitchA-vlan100] igmp-snooping enable
[SwitchA-vlan100] quit
```

Configure GigabitEthernet 1/0/3 as a static router port.

```
[SwitchA] interface gigabitethernet 1/0/3
[SwitchA-GigabitEthernet1/0/3] igmp-snooping static-router-port vlan 100
[SwitchA-GigabitEthernet1/0/3] quit
```

4. Configure Switch B:

Enable the IGMP snooping feature.

```
<SwitchB> system-view
[SwitchB] igmp-snooping
[SwitchB-igmp-snooping] quit
```

Create VLAN 100, and assign GigabitEthernet 1/0/1 and GigabitEthernet 1/0/2 to the VLAN.

```
[SwitchB] vlan 100
[SwitchB-vlan100] port gigabitethernet 1/0/1 gigabitethernet 1/0/2
```

Enable IGMP snooping for VLAN 100.

```
[SwitchB-vlan100] igmp-snooping enable
[SwitchB-vlan100] quit
```

5. Configure Switch C:

Enable the IGMP snooping feature.

```
<SwitchC> system-view
[SwitchC] igmp-snooping
[SwitchC-igmp-snooping] quit
```

Create VLAN 100, and assign GigabitEthernet 1/0/1 through GigabitEthernet 1/0/5 to the VLAN.

```
[SwitchC] vlan 100
[SwitchC-vlan100] port gigabitethernet 1/0/1 to gigabitethernet 1/0/5
```

Enable IGMP snooping for VLAN 100.

```
[SwitchC-vlan100] igmp-snooping enable
[SwitchC-vlan100] quit
```

Configure GigabitEthernet 1/0/3 and GigabitEthernet 1/0/5 as static member ports for multicast group 224.1.1.1.

```
[SwitchC] interface gigabitethernet 1/0/3
[SwitchC-GigabitEthernet1/0/3] igmp-snooping static-group 224.1.1.1 vlan 100
[SwitchC-GigabitEthernet1/0/3] quit
[SwitchC] interface gigabitethernet 1/0/5
[SwitchC-GigabitEthernet1/0/5] igmp-snooping static-group 224.1.1.1 vlan 100
[SwitchC-GigabitEthernet1/0/5] quit
```

Verifying the configuration

Display static router port information for VLAN 100 on Switch A.

```
[SwitchA] display igmp-snooping static-router-port vlan 100
VLAN 100:
  Router ports (1 in total):
```

```
    GE1/0/3
```

The output shows that GigabitEthernet 1/0/3 on Switch A has become a static router port.

Display static IGMP snooping group entries for VLAN 100 on Switch C.

```
[SwitchC] display igmp-snooping static-group vlan 100
Total 1 entries.

VLAN 100: Total 1 entries.
  (0.0.0.0, 224.1.1.1)
    Host ports (2 in total):
      GE1/0/3
      GE1/0/5
```

The output shows that GigabitEthernet 1/0/3 and GigabitEthernet 1/0/5 on Switch C have become static member ports of multicast group 224.1.1.1.

Example: Configuring the VLAN-based IGMP snooping querier

Network configuration

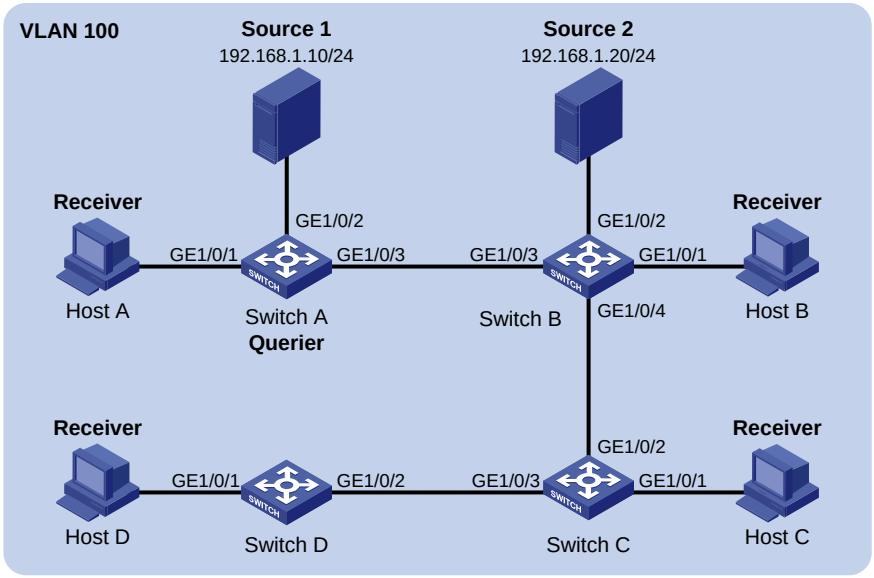
As shown in Figure 6:

- The network is a Layer 2-only network.
- Source 1 and Source 2 send multicast data to multicast groups 224.1.1.1 and 225.1.1.1, respectively.
- Host A and Host C are receivers of multicast group 224.1.1.1, and Host B and Host D are receivers of multicast group 225.1.1.1.
- All host receivers run IGMPv2, and all switches run IGMPv2 snooping. Switch A (which is close to the multicast sources) acts as the IGMP snooping querier.

Configure the switches to meet the following requirements:

- To prevent the switches from flooding unknown data in the VLAN, enable all the switches to drop unknown multicast data.
- A switch does not mark a port that receives an IGMP query with source IP address 0.0.0.0 as a dynamic router port. This adversely affects the establishment of Layer 2 forwarding entries and multicast traffic forwarding. To avoid this, configure the source IP address of IGMP queries as a non-zero IP address.

Figure 6 Network diagram



Procedure

1. Configure Switch A:

   # Enable the IGMP snooping feature.

   ```
   <SwitchA> system-view
   [SwitchA] igmp-snooping
   [SwitchA-igmp-snooping] quit
   ```

   # Create VLAN 100, and assign GigabitEthernet 1/0/1 through GigabitEthernet 1/0/3 to the VLAN.

   ```
   [SwitchA] vlan 100
   [SwitchA-vlan100] port gigabitethernet 1/0/1 to gigabitethernet 1/0/3
   ```

   # Enable IGMP snooping, and enable dropping unknown multicast data for VLAN 100.

   ```
   [SwitchA-vlan100] igmp-snooping enable
   [SwitchA-vlan100] igmp-snooping drop-unknown
   ```

   # Configure Switch A as the IGMP snooping querier.

   ```
   [SwitchA-vlan100] igmp-snooping querier
   [SwitchA-vlan100] quit
   ```

   # In VLAN 100, specify 192.168.1.1 as the source IP address of IGMP general queries.

   ```
   [SwitchA-vlan100] igmp-snooping general-query source-ip 192.168.1.1
   ```

   # In VLAN 100, specify 192.168.1.1 as the source IP address of IGMP group-specific queries.

   ```
   [SwitchA-vlan100] igmp-snooping special-query source-ip 192.168.1.1
   [SwitchA-vlan100] quit
   ```

2. Configure Switch B:

   # Enable the IGMP snooping feature.

   ```
   <SwitchB> system-view
   [SwitchB] igmp-snooping
   [SwitchB-igmp-snooping] quit
   ```

   # Create VLAN 100, and assign GigabitEthernet 1/0/1 through GigabitEthernet 1/0/4 to the VLAN.

   ```
   [SwitchB] vlan 100
   ```

```
[SwitchB-vlan100] port gigabitethernet 1/0/1 to gigabitethernet 1/0/4
```

Enable IGMP snooping, and enable dropping unknown multicast data for VLAN 100.

```
[SwitchB-vlan100] igmp-snooping enable
[SwitchB-vlan100] igmp-snooping drop-unknown
[SwitchB-vlan100] quit
```

3. Configure Switch C:

Enable the IGMP snooping feature.

```
<SwitchC> system-view
[SwitchC] igmp-snooping
[SwitchC-igmp-snooping] quit
```

Create VLAN 100, and assign GigabitEthernet 1/0/1 through GigabitEthernet 1/0/3 to the VLAN.

```
[SwitchC] vlan 100
[SwitchC-vlan100] port gigabitethernet 1/0/1 to gigabitethernet 1/0/3
```

Enable IGMP snooping, and enable dropping unknown multicast data for VLAN 100.

```
[SwitchC-vlan100] igmp-snooping enable
[SwitchC-vlan100] igmp-snooping drop-unknown
[SwitchC-vlan100] quit
```

4. Configure Switch D:

Enable the IGMP snooping feature.

```
<SwitchD> system-view
[SwitchD] igmp-snooping
[SwitchD-igmp-snooping] quit
```

Create VLAN 100, and assign GigabitEthernet 1/0/1 and GigabitEthernet 1/0/2 to the VLAN.

```
[SwitchD] vlan 100
[SwitchD-vlan100] port gigabitethernet 1/0/1 to gigabitethernet 1/0/2
```

Enable IGMP snooping, and enable dropping unknown multicast data for VLAN 100.

```
[SwitchD-vlan100] igmp-snooping enable
[SwitchD-vlan100] igmp-snooping drop-unknown
[SwitchD-vlan100] quit
```

Verifying the configuration

Display statistics for IGMP messages and PIMv2 hello messages learned through IGMP snooping on Switch B.

```
[SwitchB] display igmp-snooping statistics
Received IGMP general queries:  3
Received IGMPv1 reports:  0
Received IGMPv2 reports:  12
Received IGMP leaves:  0
Received IGMPv2 specific queries:  0
Sent     IGMPv2 specific queries:  0
Received IGMPv3 reports:  0
Received IGMPv3 reports with right and wrong records:  0
Received IGMPv3 specific queries:  0
Received IGMPv3 specific sg queries:  0
Sent     IGMPv3 specific queries:  0
Sent     IGMPv3 specific sg queries:  0
Received PIMv2 hello:  0
```

```
Received error IGMP messages:  0
```

The output shows that all switches except Switch A can receive the IGMP general queries after Switch A acts as the IGMP snooping querier.

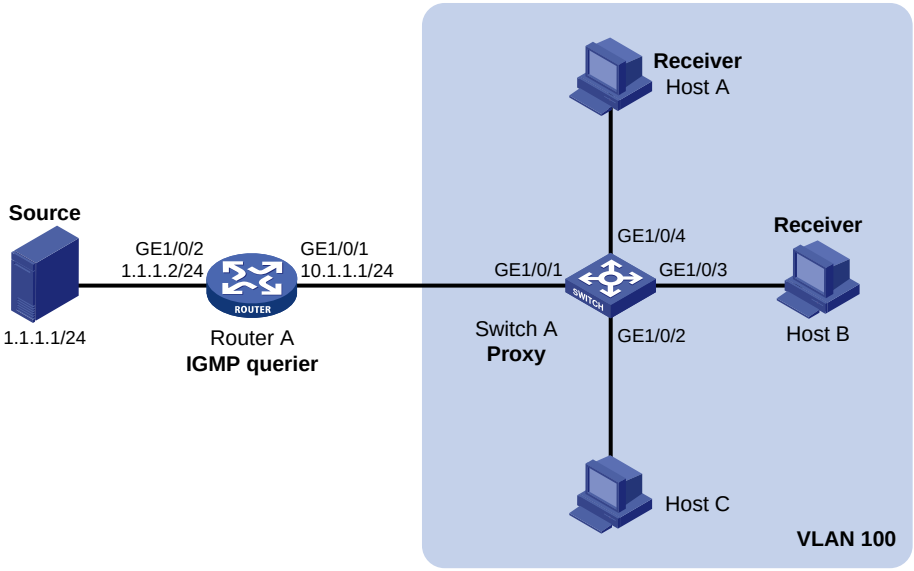
Example: Configuring VLAN-based IGMP snooping proxying

Network configuration

As shown in Figure 7, Router A runs IGMPv2 and acts as the IGMP querier. Switch A runs IGMPv2 snooping. Configure IGMP snooping proxying so that Switch A can perform the following actions:

- Forward IGMP report and leave messages to Router A.
- Respond to IGMP queries sent by Router A and forward the queries to downstream hosts.

Figure 7 Network diagram



Procedure

1. Assign an IP address and subnet mask to each interface, as shown in Figure 7. (Details not shown.)
2. Configure Router A:

   # Enable IP multicast routing.

   ```
   <RouterA> system-view
   [RouterA] multicast routing
   [RouterA-mrib] quit
   ```

   # Enable IGMP and PIM-DM on GigabitEthernet 1/0/1.

   ```
   [RouterA] interface gigabitethernet 1/0/1
   [RouterA-GigabitEthernet1/0/1] igmp enable
   [RouterA-GigabitEthernet1/0/1] pim dm
   [RouterA-GigabitEthernet1/0/1] quit
   ```

   # Enable PIM-DM on GigabitEthernet 1/0/2.

   ```
   [RouterA] interface gigabitethernet 1/0/2
   [RouterA-GigabitEthernet1/0/2] pim dm
   [RouterA-GigabitEthernet1/0/2] quit
   ```
3. Configure Switch A:

Enable the IGMP snooping feature.

```
<SwitchA> system-view
[SwitchA] igmp-snooping
[SwitchA-igmp-snooping] quit
```

Create VLAN 100, and assign GigabitEthernet 1/0/1 through GigabitEthernet 1/0/4 to the VLAN.

```
[SwitchA] vlan 100
[SwitchA-vlan100] port gigabitethernet 1/0/1 to gigabitethernet 1/0/4
```

Enable IGMP snooping and IGMP snooping proxying for the VLAN.

```
[SwitchA-vlan100] igmp-snooping enable
[SwitchA-vlan100] igmp-snooping proxy enable
[SwitchA-vlan100] quit
```

Verifying the configuration

Send IGMP reports from Host A and Host B to join multicast groups 224.1.1.1 and 224.1.1.1. (Details not shown.)

Display brief information about IGMP snooping group entries on Switch A.

```
[SwitchA] display igmp-snooping group
 Total 1 entries.

VLAN 100: Total 1 entries.
  (0.0.0.0, 224.1.1.1)
    Host ports (2 in total):
      GE1/0/3                                  (00:04:00)
      GE1/0/4                                  (00:04:04)
```

The output shows that GigabitEthernet 1/0/3 and GigabitEthernet 1/0/4 are member ports of multicast group 224.1.1.1. Host A and Host B become receivers of the group.

Display IGMP group membership information on Router A.

```
[RouterA] display igmp group
IGMP groups in total: 1
 GigabitEthernet1/0/1(10.1.1.1):
  IGMP groups reported in total: 1
   Group address   Last reporter   Uptime      Expires
   224.1.1.1       0.0.0.0         00:00:31    00:02:03
```

Send an IGMP leave message from Host A to leave multicast group 224.1.1.1. (Details not shown.)

Display brief information about IGMP snooping group entries on Switch A.

```
[SwitchA] display igmp-snooping group
Total 1 entries.

VLAN 100: Total 1 entries.
  (0.0.0.0, 224.1.1.1)
    Host ports (1 in total):
      GE1/0/3                                  ( 00:01:23 )
```

The output shows that GigabitEthernet 1/0/3 is the only member port of multicast group 224.1.1.1. Only Host B remains as the receiver of the group.

Troubleshooting IGMP snooping

Layer 2 multicast forwarding cannot function

Symptom

Layer 2 multicast forwarding cannot function on the Layer 2 device.

Solution

To resolve the problem:

1. Use the **display igmp-snooping** command to display IGMP snooping status.
2. If IGMP snooping is not enabled, use the **igmp-snooping** command in system view to enable the IGMP snooping feature. Then, use the **igmp-snooping enable** command in VLAN view to enable IGMP snooping for the VLAN.
3. If IGMP snooping is enabled globally but not enabled for the VLAN, use the **igmp-snooping enable** command in VLAN view to enable IGMP snooping for the VLAN.
4. If the problem persists, contact H3C Support.

Multicast group policy does not work

Symptom

Hosts can receive multicast data for multicast groups that are not permitted by the multicast group policy.

Solution

To resolve the problem:

1. Use the **display acl** command to verify that the configured ACL meets the multicast group policy requirements.
2. Use the **display this** command in IGMP-snooping view or in a corresponding interface view to verify that the correct multicast group policy has been applied. If the applied policy is not correct, use the **group-policy** or **igmp-snooping group-policy** command to apply the correct multicast group policy.
3. Use the **display igmp-snooping** command to verify that dropping unknown multicast data is enabled. If it is not, use the **igmp-snooping drop-unknown** command to enable dropping unknown multicast data.
4. If the problem persists, contact H3C Support.

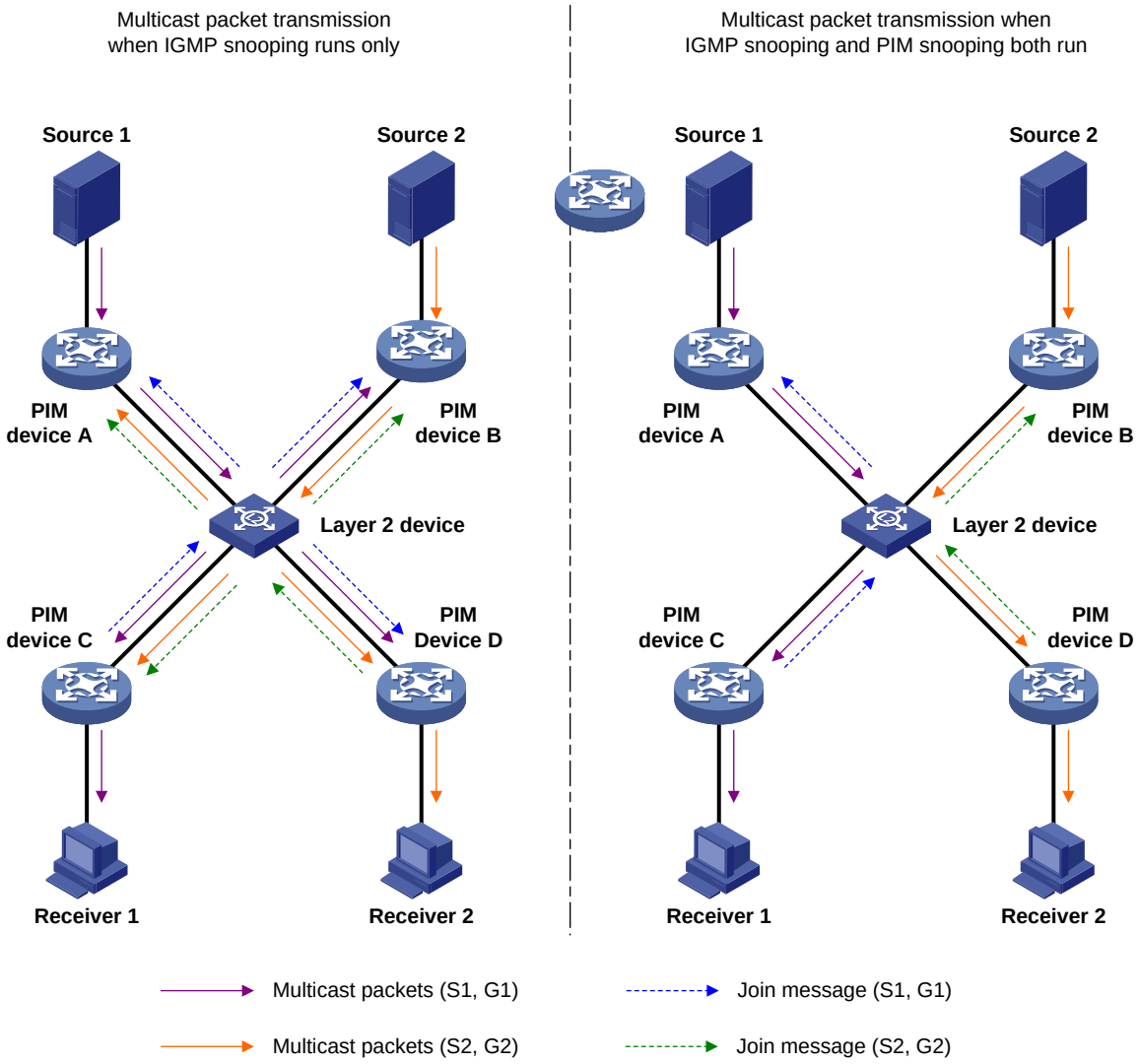
Contents

Configuring PIM snooping

About PIM snooping

PIM snooping runs on Layer 2 devices. It works with IGMP snooping to analyze received PIM messages, and adds the ports that are interested in specific multicast data to a PIM snooping routing entry. In this way, the multicast data can be forwarded to only the ports that are interested in the data.

Figure 1 Multicast packet transmission without or with PIM snooping



As shown in Figure 1, Source 1 sends multicast data to multicast group G1, and Source 2 sends multicast data to multicast group G2. Receiver 1 belongs to G1, and Receiver 2 belongs to G2. The Layer 2 switch's interfaces that connect to the PIM routers are in the same VLAN.

- When the Layer 2 switch runs only IGMP snooping, it performs the following actions:
  - **a.** Maintains the router ports according to the received PIM hello messages that PIM routers send.
  - **b.** Floods all other types of received PIM messages except PIM hello messages in the VLAN.
  - **c.** Forwards all multicast data to all router ports in the VLAN.

Each PIM router in the VLAN, whether interested in the multicast data or not, can receive all multicast data and all PIM messages except PIM hello messages.

- When the Layer 2 switch runs both IGMP snooping and PIM snooping, it performs the following actions:
  a. Examines whether a PIM router is interested in the multicast data addressed to a multicast group according to the received PIM messages that the router sends.
  b. Adds only the ports that connect to the router and are interested in the data to a PIM snooping routing entry.
  c. Forwards PIM messages and multicast data to only the routers that are interested in the data, which saves network bandwidth.

For more information about IGMP snooping and the router port, see "Configuring IGMP snooping."

Restrictions and guidelines: PIM snooping configuration

PIM snooping does not take effect on secondary VLANs. As a best practice, do not configure PIM snooping for secondary VLANs. For more information about secondary VLANs, see *Layer 2—LAN Switching Configuration Guide*.

After you configure PIM snooping for a VLAN, PIM snooping takes effect only on ports that belong to the VLAN.

PIM snooping tasks at a glance

To configure PIM snooping, perform the following tasks:

1. Enabling PIM snooping
2. (Optional.) Setting the aging time for global ports after a master/subordinate switchover
   - Setting the aging time for global neighbor ports
   - Setting the aging time for global downstream ports and global router ports

Enabling PIM snooping

1. Enter system view.
   `system-view`
2. Enable the IGMP snooping feature and enter IGMP-snooping view.
   `igmp-snooping`
   By default, IGMP snooping is disabled.
   For more information about this command, see IGMP snooping commands in *IP Multicast Command Reference*.
3. Return to system view.
   `quit`
4. Enter VLAN view.
   `vlan` *`vlan-id`*
5. Enable IGMP snooping for the VLAN.
   `igmp-snooping enable`
   By default, IGMP snooping is disabled in a VLAN.

For more information about this command, see *IP Multicast Command Reference*.

6. Enable PIM snooping for the VLAN.

   pim-snooping enable

   By default, PIM snooping is disabled in a VLAN.

Setting the aging time for global ports after a master/subordinate switchover

About global ports

A global port is a virtual port on the master device, such as a Layer 2 aggregate interface. A global port that acts as a neighbor port, downstream port, or router port is called a global neighbor port, global downstream port, and global router port, respectively.

Perform this task to decrease Layer 2 multicast data interruption caused by the aging of PIM snooping entries after a master/subordinate switchover.

Restrictions and guidelines

For a global neighbor port, the set aging time does not take effect when the port receives a PIM hello message after a master/subordinate switchover. The aging time for the port is determined by the aging time in the PIM hello message.

For a global router port or global downstream port, the set aging time does not take effect when the port receives a PIM join message after a master/subordinate switchover. The aging time for the port is determined by the aging time in the PIM join message.

Setting the aging time for global neighbor ports

1. Enter system view.

   system-view

2. Enter VLAN view.

   vlan *vlan-id*

3. Set the aging time for global neighbor ports after a master/subordinate switchover.

   pim-snooping graceful-restart neighbor-aging-time *seconds*

   By default, the aging time for global neighbor ports after a master/subordinate switchover is 105 seconds.

Setting the aging time for global downstream ports and global router ports

1. Enter system view.

   system-view

2. Enter VLAN view.

   vlan *vlan-id*

3. Set the aging time for global downstream ports and global router ports after a master/subordinate switchover.

   pim-snooping graceful-restart join-aging-time *seconds*

By default, the aging time for downstream ports and global router ports after a master/subordinate switchover is 210 seconds.

Display and maintenance commands for PIM snooping

Execute **display** commands in any view and **reset** commands in user view.

Task	Command
Display PIM snooping neighbor information.	**display pim-snooping neighbor** [**vlan** *vlan-id*] [**slot** *slot-number*] [**verbose**]
Display PIM snooping router port information.	**display pim-snooping router-port** [**vlan** *vlan-id*] [**slot** *slot-number*] [**verbose**]
Display PIM snooping routing entries.	**display pim-snooping routing-table** [**vlan** *vlan-id*] [**slot** *slot-number*] [**verbose**]
Display statistics for the PIM messages learned through PIM snooping.	**display pim-snooping statistics**
Clear statistics for the PIM messages learned through PIM snooping.	**reset pim-snooping statistics**

PIM snooping configuration examples

Example: Configuring PIM snooping

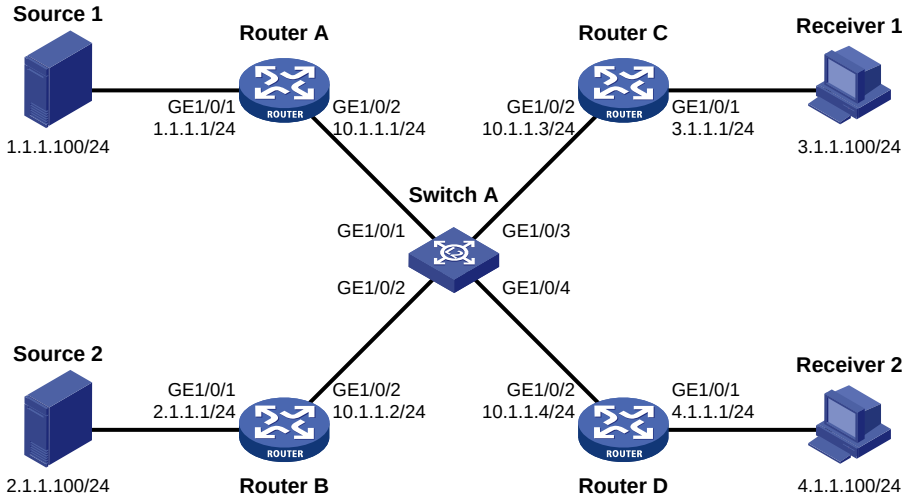
Network configuration

As shown in Figure 2:

- OSPF runs on the network.
- Source 1 and Source 2 send multicast data to multicast groups 224.1.1.1 and 225.1.1.1, respectively.
- Receiver 1 and Receiver 2 belong to multicast groups 224.1.1.1 and 225.1.1.1, respectively.
- Router C and Router D run IGMP on GigabitEthernet 1/0/1. Router A, Router B, Router C, and Router D run PIM-SM.
- GigabitEthernet 1/0/2 on Router A acts as a C-BSR and a C-RP.

Configure IGMP snooping and PIM snooping on Switch A. Then, Switch A forwards PIM protocol packets and multicast data packets only to the routers that are connected to receivers.

Figure 2 Network diagram



Procedure

1. Assign an IP address and subnet mask to each interface, as shown in Figure 2. (Details not shown.)
2. Configure OSPF on the routers. (Details not shown.)
3. Configure Router A:

   # Enable IP multicast routing.

   ```
   <RouterA> system-view
   [RouterA] multicast routing
   [RouterA-mrib] quit
   ```

   # Enable PIM-SM on each interface.

   ```
   [RouterA] interface gigabitethernet 1/0/1
   [RouterA-GigabitEthernet1/0/1] pim sm
   [RouterA-GigabitEthernet1/0/1] quit
   [RouterA] interface gigabitethernet 1/0/2
   [RouterA-GigabitEthernet1/0/2] pim sm
   [RouterA-GigabitEthernet1/0/2] quit
   ```

   # Configure GigabitEthernet 1/0/2 as a C-BSR and a C-RP.

   ```
   [RouterA] pim
   [RouterA-pim] c-bsr 10.1.1.1
   [RouterA-pim] c-rp 10.1.1.1
   [RouterA-pim] quit
   ```

4. Configure Router B:

   # Enable IP multicast routing.

   ```
   <RouterB> system-view
   [RouterB] multicast routing
   [RouterB-mrib] quit
   ```

   # Enable PIM-SM on each interface.

   ```
   [RouterB] interface gigabitethernet 1/0/1
   [RouterB-GigabitEthernet1/0/1] pim sm
   [RouterB-GigabitEthernet1/0/1] quit
   [RouterB] interface gigabitethernet 1/0/2
   ```

```
[RouterB-GigabitEthernet1/0/2] pim sm
[RouterB-GigabitEthernet1/0/2] quit
```

5. Configure Router C:

Enable IP multicast routing.

```
<RouterC> system-view
[RouterC] multicast routing
[RouterC-mrib] quit
```

Enable IGMP on GigabitEthernet 1/0/1.

```
[RouterC] interface gigabitethernet 1/0/1
[RouterC-GigabitEthernet1/0/1] igmp enable
[RouterC-GigabitEthernet1/0/1] quit
```

Enable PIM-SM on GigabitEthernet 1/0/2.

```
[RouterC] interface gigabitethernet 1/0/2
[RouterC-GigabitEthernet1/0/2] pim sm
[RouterC-GigabitEthernet1/0/2] quit
```

6. Configure Router D:

Enable IP multicast routing.

```
<RouterD> system-view
[RouterD] multicast routing
[RouterD-mrib] quit
```

Enable IGMP on GigabitEthernet 1/0/1.

```
[RouterD] interface gigabitethernet 1/0/1
[RouterD-GigabitEthernet1/0/1] igmp enable
[RouterD-GigabitEthernet1/0/1] quit
```

Enable PIM-SM on GigabitEthernet 1/0/2.

```
[RouterD] interface gigabitethernet 1/0/2
[RouterD-GigabitEthernet1/0/2] pim sm
[RouterD-GigabitEthernet1/0/2] quit
```

7. Configure Switch A:

Enable the IGMP snooping feature.

```
<SwitchA> system-view
[SwitchA] igmp-snooping
[SwitchA-igmp-snooping] quit
```

Create VLAN 100, and assign GigabitEthernet 1/0/1 through GigabitEthernet 1/0/4 to the VLAN.

```
[SwitchA] vlan 100
[SwitchA-vlan100] port gigabitethernet 1/0/1 to gigabitethernet 1/0/4
```

Enable IGMP snooping and PIM snooping for VLAN 100.

```
[SwitchA-vlan100] igmp-snooping enable
[SwitchA-vlan100] pim-snooping enable
[SwitchA-vlan100] quit
```

Verifying the configuration

On Switch A, display PIM snooping neighbor information for VLAN 100.

```
[SwitchA] display pim-snooping neighbor vlan 100
Total 4 neighbors.

VLAN 100: Total 4 neighbors.
```

```
  10.1.1.1
    Ports (1 in total):
      GE1/0/1                 (00:32:43)
  10.1.1.2
    Ports (1 in total):
      GE1/0/2                 (00:32:43)
  10.1.1.3
    Ports (1 in total):
      GE1/0/3                 (00:32:43)
  10.1.1.4
    Ports (1 in total):
      GE1/0/4                 (00:32:43)
```

The output shows that Router A, Router B, Router C, and Router D are PIM snooping neighbors.

On Switch A, display PIM snooping routing entries for VLAN 100.

```
[SwitchA] display pim-snooping routing-table vlan 100
Total 2 entries.
FSM Flag: NI-no info, J-join, PP-prune pending

VLAN 100: Total 2 entries.
  (*, 224.1.1.1)
    Upstream neighbor: 10.1.1.1
      Upstream Ports (1 in total):
        GE1/0/1
      Downstream Ports (1 in total):
        GE1/0/3
          Expires: 00:03:01, FSM: J
  (*, 225.1.1.1)
    Upstream neighbor: 10.1.1.2
      Upstream Ports (1 in total):
        GE1/0/2
      Downstream Ports (1 in total):
        GE1/0/4
          Expires: 00:03:11, FSM: J
```

The output shows the following information:

- Switch A will forward the multicast data intended for multicast group 224.1.1.1 only to Router C.
- Switch A will forward the multicast data intended for multicast group 225.1.1.1 only to Router D.

Troubleshooting PIM snooping

PIM snooping does not work on a Layer 2 device

Symptom

PIM snooping does not work on a Layer 2 device.

Solution

To resolve the problem:

1. Use the **display current-configuration** command to display information about IGMP snooping and PIM snooping.
2. If IGMP snooping is not enabled, enable the IGMP snooping feature, and then enable IGMP snooping and PIM snooping for the VLAN.
3. If PIM snooping is not enabled, enable PIM snooping for the VLAN.
4. If the problem persists, contact H3C Support.

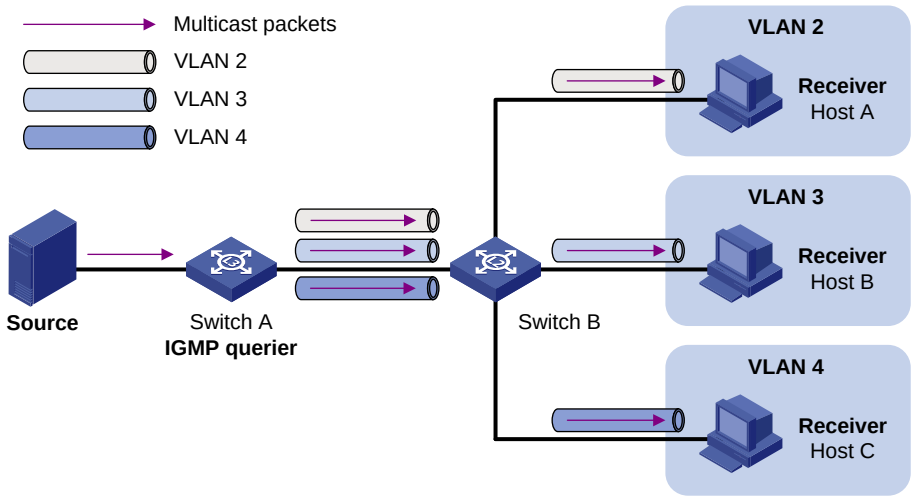
Contents

Configuring multicast VLANs

Multicast VLAN feature

As shown in Figure 1, Host A, Host B, and Host C are in three different VLANs and the same multicast group. When Switch A (Layer 3 device) receives multicast data for that group, it sends three copies of the multicast data to Switch B (Layer 2 device). This occupies a large amount of bandwidth and increases the burden on the Layer 3 device.

Figure 1 Multicast transmission without the multicast VLAN feature



After a multicast VLAN is configured on Switch B, Switch A sends only one copy of the multicast data to the multicast VLAN on Switch B. This method saves network bandwidth and lessens the burden on the Layer 3 device.

Multicast VLAN implementations

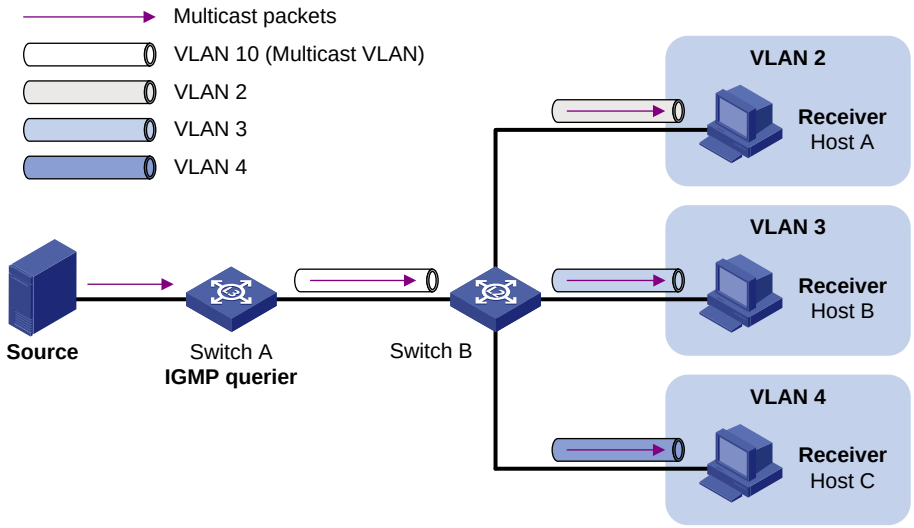
Multicast VLANs include sub-VLAN-based multicast VLANs and port-based multicast VLANs.

Sub-VLAN-based multicast VLAN

As shown in Figure 2:

- Host A, Host B, and Host C are in VLAN 2 through VLAN 4, respectively.
- On Switch B, VLAN 10 is a multicast VLAN. VLAN 2 through VLAN 4 are sub-VLANs of VLAN 10.
- IGMP snooping is enabled for the multicast VLAN and its sub-VLANs.

Figure 2 Sub-VLAN-based multicast VLAN



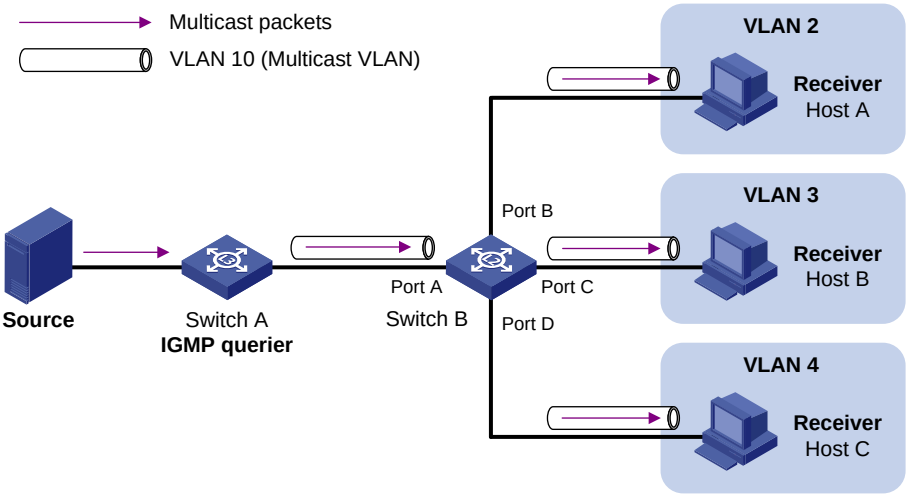
IGMP snooping manages router ports in the multicast VLAN and member ports in each sub-VLAN. When Switch A receives multicast data from the multicast source, it sends only one copy of the multicast data to the multicast VLAN on Switch B. Then, Switch B sends a separate copy to each sub-VLAN in the multicast VLAN.

Port-based multicast VLAN

As shown in Figure 3:

- Host A, Host B, and Host C are in VLAN 2 through VLAN 4, respectively.
- On Switch B, VLAN 10 is a multicast VLAN. All the user ports are hybrid ports and are assigned to VLAN 10.
- IGMP snooping is enabled for the multicast VLAN and VLAN 2 through VLAN 4.

Figure 3 Port-based multicast VLAN



IGMP snooping manages the router ports and member ports in the multicast VLAN. When Switch A receives multicast data from the multicast source, it sends only one copy of the multicast data to the multicast VLAN on Switch B. Switch B sends a separate copy to each user port in the multicast VLAN.

Restrictions and guidelines: Multicast VLAN configuration

The VLAN to be configured as a multicast VLAN must exist.

If you have configured both a sub-VLAN-based multicast VLAN and a port-based multicast VLAN on a device, the port-based multicast VLAN configuration takes effect.

The multicast VLAN feature does not take effect on secondary VLANs. As a best practice, do not configure the multicast VLAN feature for secondary VLANs. For more information about secondary VLANs, see *Layer 2—LAN Switching Configuration Guide.*

Configuring a sub-VLAN-based multicast VLAN

Restrictions and guidelines

The VLANs to be configured as sub-VLANs of a multicast VLAN must exist and cannot be multicast VLANs or sub-VLANs of any other multicast VLAN.

Prerequisites

Before you configure a sub-VLAN-based multicast VLAN, you must complete the following tasks:

- Create VLANs as required.
- Enable IGMP snooping for the VLAN to be configured as the multicast VLAN and for the VLANs to be configured as sub-VLANs.

Procedure

1. Enter system view.

   system-view
2. Configure a VLAN as a multicast VLAN and enter multicast VLAN view.

   multicast-vlan *vlan-id*

   By default, a VLAN is not a multicast VLAN.
3. Assign VLANs to the multicast VLAN as sub-VLANs.

   subvlan *vlan-list*

Configuring a port-based multicast VLAN

Restrictions and guidelines

You can assign user ports to a multicast VLAN in multicast VLAN view or assign a user port to a multicast VLAN in interface view. These configurations have the same priority.

A user port can belong to only one multicast VLAN.

Prerequisites

Before you configure a port-based multicast VLAN, you must complete the following tasks:

- Create VLANs as required.
- Enable IGMP snooping for the VLAN to be configured as the multicast VLAN.
- Enable IGMP snooping for all the VLANs that contain multicast receivers.
- Configure the attributes of user ports. Make sure the ports can forward packets from the VLAN to be configured as the multicast VLAN and send the packets with the VLAN tag removed. For

more information about configuring port attributes, see VLAN configuration in *Layer 2—LAN Switching Configuration Guide*.

Assigning user ports to a multicast VLAN in multicast VLAN view

1. Enter system view.
   system-view
2. Configure a VLAN as a multicast VLAN and enter multicast VLAN view.
   multicast-vlan *vlan-id*
   By default, a VLAN is not a multicast VLAN.
3. Assign ports to the multicast VLAN.
   port *interface-list*

Assigning user ports to a multicast VLAN in interface view

1. Enter system view.
   system-view
2. Configure a VLAN as a multicast VLAN and enter multicast VLAN view.
   multicast-vlan *vlan-id*
   By default, a VLAN is not a multicast VLAN.
3. Return to system view.
   quit
4. Enter Layer 2 interface view.
   - Enter Layer 2 Ethernet interface view.
     interface *interface-type interface-number*
   - Enter Layer 2 aggregate interface view.
     interface bridge-aggregation *interface-number*
5. Assign the port to the multicast VLAN.
   port multicast-vlan *vlan-id*
   By default, a port does not belong to any multicast VLAN.

Setting the maximum number of multicast VLAN forwarding entries

About setting the maximum number of multicast VLAN forwarding entries

You can set the maximum number of multicast VLAN forwarding entries on the device. When the upper limit is reached, the device does not create multicast VLAN forwarding entries until some entries age out or are manually removed.

Procedure

1. Enter system view.
   system-view
2. Set the maximum number of multicast VLAN forwarding entries.
   multicast-vlan entry-limit *limit*
   The default setting varies by device model. For more information, see the command reference.

Display and maintenance commands for multicast VLAN

Execute **display** commands in any view and **reset** commands in user view.

Task	Command
Display information about multicast VLANs.	**display multicast-vlan** [*vlan-id*]
Display information about multicast VLAN forwarding entries.	**display multicast-vlan forwarding-table** [*group-address* [**mask** { *mask-length* | *mask* }] | *source-address* [**mask** { *mask-length* | *mask* }] | **slot** *slot-number* | **subvlan** *vlan-id* | **vlan** *vlan-id*] *
Display information about multicast groups in multicast VLANs.	**display multicast-vlan group** [*source-address* | *group-address* | **slot** *slot-number* | **verbose** | **vlan** *vlan-id*] *
Clear multicast groups in multicast VLANs.	**reset multicast-vlan group** [*source-address* [**mask** { *mask-length* | *mask* }] | *group-address* [**mask** { *mask-length* | *mask* }] | **vlan** *vlan-id*] *

Multicast VLAN configuration examples

Example: Configuring sub-VLAN-based multicast VLAN

Network configuration

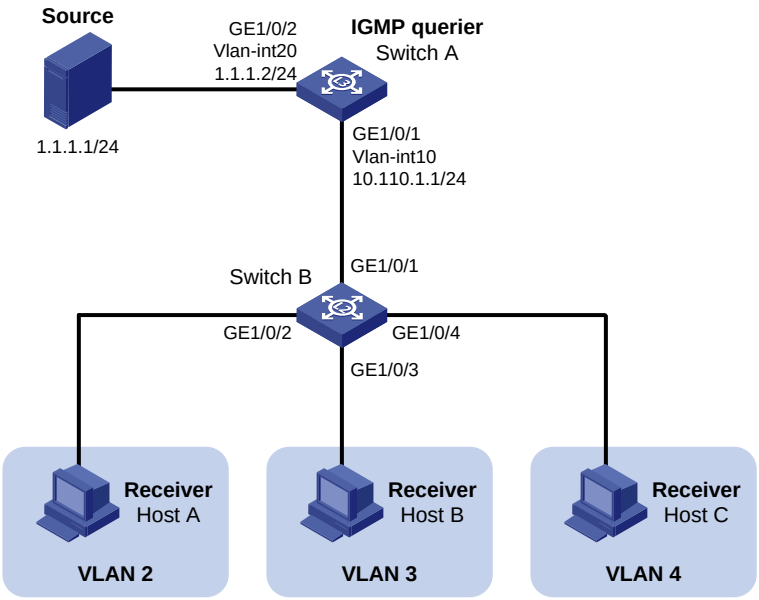
As shown in Figure 4:

- Layer 3 device Switch A runs IGMPv2 and acts as the IGMP querier. Layer 2 device Switch B runs IGMPv2 snooping.
- The multicast source sends multicast data to multicast group 224.1.1.1. Receivers Host A, Host B, and Host C belong to VLAN 2, VLAN 3, and VLAN 4, respectively.

Configure a sub-VLAN-based multicast VLAN on Switch B to meet the following requirements:

- Switch A sends the multicast data to Switch B through the multicast VLAN.
- Switch B forwards the multicast data to the receivers in different user VLANs.

Figure 4 Network diagram



Procedure

1. Configure Switch A:

   # Enable IP multicast routing.

   ```
   <SwitchA> system-view
   [SwitchA] multicast routing
   [SwitchA-mrib] quit
   ```

   # Create VLAN 20, and assign GigabitEthernet 1/0/2 to the VLAN.

   ```
   [SwitchA] vlan 20
   [SwitchA-vlan20] port gigabitethernet 1/0/2
   [SwitchA-vlan20] quit
   ```

   # Assign an IP address to VLAN-interface 20, and enable PIM-DM on the interface.

   ```
   [SwitchA] interface vlan-interface 20
   [SwitchA-Vlan-interface20] ip address 1.1.1.2 24
   [SwitchA-Vlan-interface20] pim dm
   [SwitchA-Vlan-interface20] quit
   ```

   # Create VLAN 10.

   ```
   [SwitchA] vlan 10
   [SwitchA-vlan10] quit
   ```

   # Configure GigabitEthernet 1/0/1 as a hybrid port, and assign the port to VLAN 10 as a tagged VLAN member.

   ```
   [SwitchA] interface gigabitethernet 1/0/1
   [SwitchA-GigabitEthernet1/0/1] port link-type hybrid
   [SwitchA-GigabitEthernet1/0/1] port hybrid vlan 10 tagged
   [SwitchA-GigabitEthernet1/0/1] quit
   ```

   # Assign an IP address to VLAN-interface 10, and enable IGMP on the interface.

   ```
   [SwitchA] interface vlan-interface 10
   [SwitchA-Vlan-interface10] ip address 10.110.1.1 24
   [SwitchA-Vlan-interface10] igmp enable
   [SwitchA-Vlan-interface10] quit
   ```

2. Configure Switch B:

Enable the IGMP snooping feature.

```
<SwitchB> system-view
[SwitchB] igmp-snooping
[SwitchB-igmp-snooping] quit
```

Create VLAN 2, assign GigabitEthernet 1/0/2 to the VLAN, and enable IGMP snooping for the VLAN.

```
[SwitchB] vlan 2
[SwitchB-vlan2] port gigabitethernet 1/0/2
[SwitchB-vlan2] igmp-snooping enable
[SwitchB-vlan2] quit
```

Create VLAN 3, assign GigabitEthernet 1/0/3 to the VLAN, and enable IGMP snooping in the VLAN.

```
[SwitchB] vlan 3
[SwitchB-vlan3] port gigabitethernet 1/0/3
[SwitchB-vlan3] igmp-snooping enable
[SwitchB-vlan3] quit
```

Create VLAN 4, assign GigabitEthernet 1/0/4 to the VLAN, and enable IGMP snooping in the VLAN.

```
[SwitchB] vlan 4
[SwitchB-vlan4] port gigabitethernet 1/0/4
[SwitchB-vlan4] igmp-snooping enable
[SwitchB-vlan4] quit
```

Create VLAN 10, and enable IGMP snooping for the VLAN.

```
[SwitchB] vlan 10
[SwitchB-vlan10] igmp-snooping enable
[SwitchB-vlan10] quit
```

Configure GigabitEthernet 1/0/1 as a hybrid port, and assign the port to VLAN 10 as a tagged VLAN member.

```
[SwitchB] interface gigabitethernet 1/0/1
[SwitchB-GigabitEthernet1/0/1] port link-type hybrid
[SwitchB-GigabitEthernet1/0/1] port hybrid vlan 10 tagged
[SwitchB-GigabitEthernet1/0/1] quit
```

Configure VLAN 10 as a multicast VLAN, and assign VLAN 2 through VLAN 4 as sub-VLANs to multicast VLAN 10.

```
[SwitchB] multicast-vlan 10
[SwitchB-mvlan-10] subvlan 2 to 4
[SwitchB-mvlan-10] quit
```

Verifying the configuration

Display information about all multicast VLANs on Switch B.

```
[SwitchB] display multicast-vlan
Total 1 multicast VLANs.

Multicast VLAN 10:
  Sub-VLAN list(3 in total):
     2-4
  Port list(0 in total):
```

Display information about multicast groups in multicast VLANs on Switch B.

```
[SwitchB] display multicast-vlan group
Total 1 entries.

Multicast VLAN 10: Total 1 entries.
  (0.0.0.0, 224.1.1.1)
    Sub-VLANs (3 in total):
      VLAN 2
      VLAN 3
      VLAN 4
```

The output shows that multicast group 224.1.1.1 belongs to multicast VLAN 10. Multicast VLAN 10 contains sub-VLANs VLAN 2 through VLAN 4. Switch B will replicate the multicast data of VLAN 10 to VLAN 2 through VLAN 4.

Example: Configuring port-based multicast VLAN

Network configuration

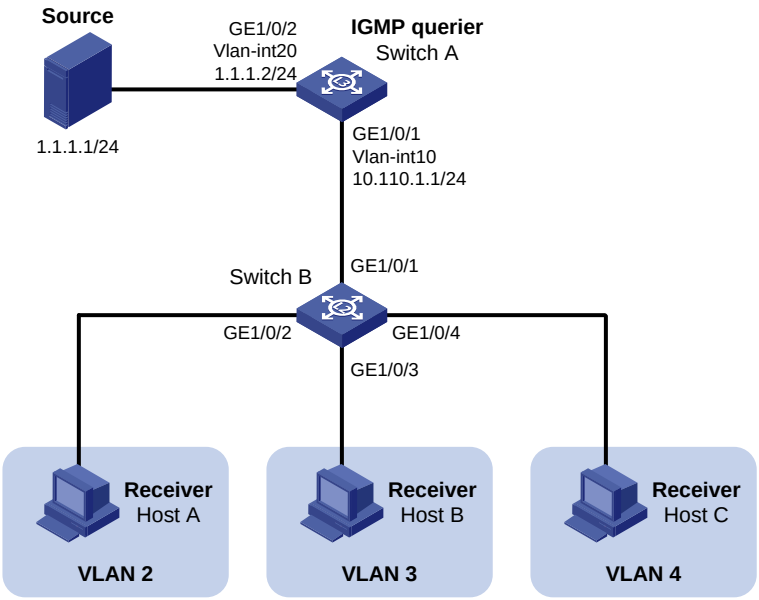
As shown in Figure 5:

- Layer 3 device Switch A runs IGMPv2 and acts as the IGMP querier. Layer 2 device Switch B runs IGMPv2 snooping.
- The multicast source sends multicast data to multicast group 224.1.1.1. Receivers Host A, Host B, and Host C belong to VLAN 2, VLAN 3, and VLAN 4, respectively.

Configure a port-based multicast VLAN on Switch B to meet the following requirements:

- Switch A sends multicast data to Switch B through the multicast VLAN.
- Switch B forwards the multicast data to the receivers in different user VLANs.

Figure 5 Network diagram



Procedure

1. Configure Switch A:

   # Enable IP multicast routing.

   ```
   <SwitchA> system-view
   ```

```
[SwitchA] multicast routing
[SwitchA-mrib] quit
```

Create VLAN 20, and assign GigabitEthernet 1/0/2 to the VLAN.

```
[SwitchA] vlan 20
[SwitchA-vlan20] port gigabitethernet 1/0/2
[SwitchA-vlan20] quit
```

Assign an IP address to VLAN-interface 20, and enable PIM-DM on the interface.

```
[SwitchA] interface vlan-interface 20
[SwitchA-Vlan-interface20] ip address 1.1.1.2 24
[SwitchA-Vlan-interface20] pim dm
[SwitchA-Vlan-interface20] quit
```

Create VLAN 10, and assign GigabitEthernet 1/0/1 to the VLAN.

```
[SwitchA] vlan 10
[SwitchA-vlan10] port gigabitethernet 1/0/1
[SwitchA-vlan10] quit
```

Assign an IP address to VLAN-interface 10, and enable IGMP on the interface.

```
[SwitchA] interface vlan-interface 10
[SwitchA-Vlan-interface10] ip address 10.110.1.1 24
[SwitchA-Vlan-interface10] igmp enable
[SwitchA-Vlan-interface10] quit
```

2. Configure Switch B:

Enable the IGMP snooping feature.

```
<SwitchB> system-view
[SwitchB] igmp-snooping
[SwitchB-igmp-snooping] quit
```

Create VLAN 10, assign GigabitEthernet 1/0/1 to the VLAN, and enable IGMP snooping for the VLAN.

```
[SwitchB] vlan 10
[SwitchB-vlan10] port gigabitethernet 1/0/1
[SwitchB-vlan10] igmp-snooping enable
[SwitchB-vlan10] quit
```

Create VLAN 2, and enable IGMP snooping for the VLAN.

```
[SwitchB] vlan 2
[SwitchB-vlan2] igmp-snooping enable
[SwitchB-vlan2] quit
```

Create VLAN 3, and enable IGMP snooping for the VLAN.

```
[SwitchB] vlan 3
[SwitchB-vlan3] igmp-snooping enable
[SwitchB-vlan3] quit
```

Create VLAN 4, and enable IGMP snooping for the VLAN.

```
[SwitchB] vlan 4
[SwitchB-vlan4] igmp-snooping enable
[SwitchB-vlan4] quit
```

Configure GigabitEthernet 1/0/2 as a hybrid port, and configure VLAN 2 as the PVID of the hybrid port.

```
[SwitchB] interface gigabitethernet 1/0/2
[SwitchB-GigabitEthernet1/0/2] port link-type hybrid
[SwitchB-GigabitEthernet1/0/2] port hybrid pvid vlan 2
```

Assign GigabitEthernet 1/0/2 to VLAN 2 and VLAN 10 as an untagged VLAN member.

```
[SwitchB-GigabitEthernet1/0/2] port hybrid vlan 2 untagged
[SwitchB-GigabitEthernet1/0/2] port hybrid vlan 10 untagged
[SwitchB-GigabitEthernet1/0/2] quit
```

Configure GigabitEthernet 1/0/3 as a hybrid port, and configure VLAN 3 as the PVID of the hybrid port.

```
[SwitchB] interface gigabitethernet 1/0/3
[SwitchB-GigabitEthernet1/0/3] port link-type hybrid
[SwitchB-GigabitEthernet1/0/3] port hybrid pvid vlan 3
```

Assign GigabitEthernet 1/0/3 to VLAN 3 and VLAN 10 as an untagged VLAN member.

```
[SwitchB-GigabitEthernet1/0/3] port hybrid vlan 3 untagged
[SwitchB-GigabitEthernet1/0/3] port hybrid vlan 10 untagged
[SwitchB-GigabitEthernet1/0/3] quit
```

Configure GigabitEthernet 1/0/4 as a hybrid port, and configure VLAN 4 as the PVID of the hybrid port.

```
[SwitchB] interface gigabitethernet 1/0/4
[SwitchB-GigabitEthernet1/0/4] port link-type hybrid
[SwitchB-GigabitEthernet1/0/4] port hybrid pvid vlan 4
```

Assign GigabitEthernet 1/0/4 to VLAN 4 and VLAN 10 as an untagged VLAN member.

```
[SwitchB-GigabitEthernet1/0/4] port hybrid vlan 4 untagged
[SwitchB-GigabitEthernet1/0/4] port hybrid vlan 10 untagged
[SwitchB-GigabitEthernet1/0/4] quit
```

Configure VLAN 10 as a multicast VLAN.

```
[SwitchB] multicast-vlan 10
```

Assign GigabitEthernet 1/0/2 and GigabitEthernet 1/0/3 to VLAN 10.

```
[SwitchB-mvlan-10] port gigabitethernet 1/0/2 to gigabitethernet 1/0/3
[SwitchB-mvlan-10] quit
```

Assign GigabitEthernet 1/0/4 to VLAN 10.

```
[SwitchB] interface gigabitethernet 1/0/4
[SwitchB-GigabitEthernet1/0/4] port multicast-vlan 10
[SwitchB-GigabitEthernet1/0/4] quit
```

Verifying the configuration

Display information about multicast VLANs on Switch B.

```
[SwitchB] display multicast-vlan
Total 1 multicast VLANs.

Multicast VLAN 10:
  Sub-VLAN list(0 in total):
  Port list(3 in total):
    GE1/0/2
    GE1/0/3
    GE1/0/4
```

Display dynamic IGMP snooping forwarding entries on Switch B.

```
[SwitchB] display igmp-snooping group
Total 1 entries.

VLAN 10: Total 1 entries.
```

```
(0.0.0.0, 224.1.1.1)
  Host slots (0 in total):
  Host ports (3 in total):
    GE1/0/2        (00:03:23)
    GE1/0/3        (00:04:07)
    GE1/0/4        (00:04:16)
```

The output shows that IGMP snooping maintains the user ports in the multicast VLAN (VLAN 10). Switch B will forward the multicast data of VLAN 10 through these user ports.

Contents

Configuring MLD snooping

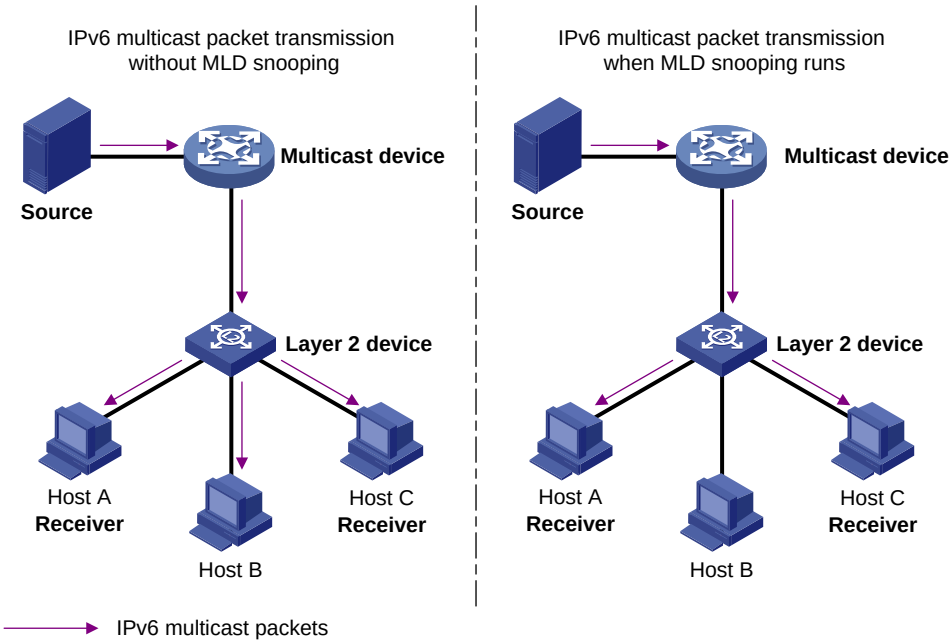
About MLD snooping

MLD snooping runs on a Layer 2 device as an IPv6 multicast constraining mechanism to improve multicast forwarding efficiency. It creates Layer 2 multicast forwarding entries from MLD messages that are exchanged between the hosts and the Layer 3 device.

Fundamentals of MLD snooping

As shown in Figure 1, when MLD snooping is not enabled, the Layer 2 switch floods IPv6 multicast packets all hosts in a VLAN. When MLD snooping is enabled, the Layer 2 switch forwards multicast packets of known IPv6 multicast groups to only the receivers.

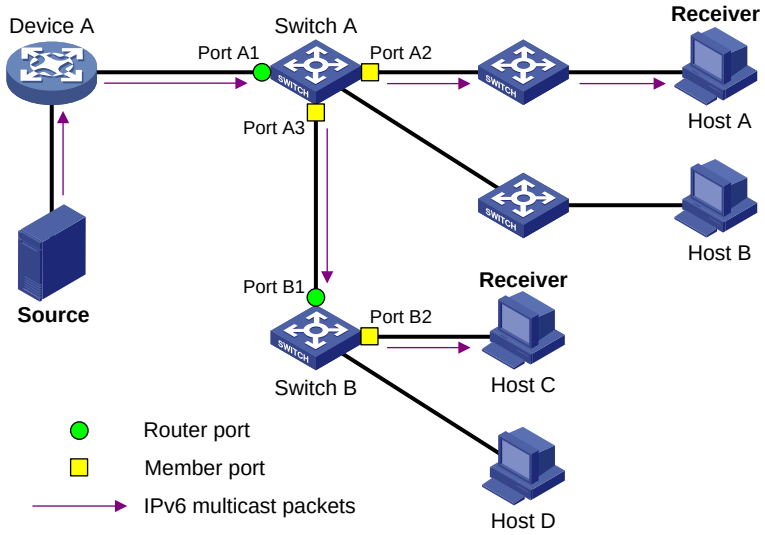
Figure 1 Multicast packet transmission processes without and with MLD snooping



MLD snooping ports

As shown in Figure 2, MLD snooping runs on Switch A and Switch B, and Host A and Host C are receiver hosts in an IPv6 multicast group. MLD snooping ports are divided into member ports and router ports.

Figure 2 MLD snooping ports



Router ports

On an MLD snooping Layer 2 device, the ports toward Layer 3 multicast devices are called router ports. In Figure 2, Port A1 of Switch A and Port B1 of Switch B are router ports.

Router ports contain the following types:

- **Dynamic router port**—When a port receives an MLD general query whose source address is not 0::0 or receives an IPv6 PIM hello message, the port is added into the dynamic router port list. At the same time, an aging timer is started for the port. If the port receives either of the messages before the timer expires, the timer is reset. If the port does not receive either of the messages when the timer expires, the port is removed from the dynamic router port list.
- **Static router port**—When a port is statically configured as a router port, it is added into the static router port list. The static router port does not age out, and it can be deleted only manually.

Do not confuse the "router port" in MLD snooping with the "routed interface" commonly known as the "Layer 3 interface." The router port in MLD snooping is a Layer 2 interface.

Member ports

On an MLD snooping Layer 2 device, the ports toward receiver hosts are called member ports. In Figure 2, Port A2 and Port A3 of Switch A and Port B2 of Switch B are member ports.

Member ports contain the following types:

- **Dynamic member port**—When a port receives an MLD report, it is added to the associated dynamic MLD snooping forwarding entry as an outgoing interface. At the same time, an aging timer is started for the port. If the port receives an MLD report before the timer expires, the timer is reset. If the port does not receive an MLD report when the timer expires, the port is removed from the associated dynamic forwarding entry.
- **Static member port**—When a port is statically configured as a member port, it is added to the associated static MLD snooping forwarding entry as an outgoing interface. The static member port does not age out, and it can be deleted only manually.

Unless otherwise specified, router ports and member ports in this document include both static and dynamic router ports and member ports.

How MLD snooping works

The ports in this section are dynamic ports. For information about how to configure and remove static ports, see "Configuring a static member port" and "Configuring a static router port."

MLD messages include general query, MLD report, and done message. An MLD snooping-enabled Layer 2 device performs differently depending on the MLD message types.

General query

The MLD querier periodically sends MLD general queries to all hosts and devices on the local subnet to check for the existence of IPv6 multicast group members.

After receiving an MLD general query, the Layer 2 device forwards the query to all ports in the VLAN except the receiving port. The Layer 2 device also performs one of the following actions:

- If the receiving port is a dynamic router port in the dynamic router port list, the Layer 2 device restarts the aging timer for the router port.
- If the receiving port does not exist in the dynamic router port list, the Layer 2 device adds the port to the dynamic router port list. It also starts an aging timer for the port.

MLD report

A host sends an MLD report to the MLD querier for the following purposes:

- Responds to queries if the host is an IPv6 multicast group member.
- Applies for an IPv6 multicast group membership.

After receiving an MLD report from a host, the Layer 2 device forwards the report through all the router ports in the VLAN. It also resolves the IPv6 address of the reported IPv6 multicast group, and looks up the forwarding table for a matching entry as follows:

- If no match is found, the Layer 2 device creates a forwarding entry for the group with the receiving port an outgoing interface. It also marks the receiving port as a dynamic member port and starts an aging timer for the port.
- If a match is found but the matching forwarding entry does not contain the receiving port, the Layer 2 device adds the receiving port to the outgoing interface list. It also marks the port as a dynamic member port to the forwarding entry and starts an aging timer for the port.
- If a match is found and the matching forwarding entry contains the receiving port, the Layer 2 device restarts the aging timer for the port.

NOTE:

A Layer 2 device does not forward an MLD report through a non-router port because of the host MLD report suppression mechanism. If a non-router port has member host attached, the member hosts suppress their MLD reports upon receiving MLD reports forwarded by the non-router port. The Layer 2 device cannot know the existence of the member hosts attached to the non-router port.

Done message

When a host leaves an IPv6 multicast group, the host sends an MLD done message to the Layer 3 devices. When the Layer 2 device receives the MLD done message on a dynamic member port, the Layer 2 device first examines whether a forwarding entry matches the IPv6 multicast group address in the message.

- If no match is found, the Layer 2 device discards the MLD done message.
- If a match is found but the receiving port is not an outgoing interface in the forwarding entry, the Layer 2 device discards the MLD done message.
- If a match is found and the receiving port is not the only outgoing interface in the forwarding entry, the Layer 2 device performs the following actions:
  - Discards the MLD done message.

- Sends an MLD multicast-address-specific query to identify whether the group has active listeners attached to the receiving port.
- Sets the aging timer for the receiving port to twice the MLD last listener query interval.

- If a match is found and the receiving port is the only outgoing interface in the forwarding entry, the Layer 2 device performs the following actions:
  - Forwards the MLD done message to all router ports in the VLAN.
  - Sends an MLD multicast-address-specific query to identify whether the group has active listeners attached to the receiving port.
  - Sets the aging timer for the receiving port to twice the MLD last listener query interval.

After receiving the MLD done message on a port, the MLD querier resolves the IPv6 multicast group address in the message. Then, it sends an MLD multicast-address-specific query to the IPv6 multicast group through the receiving port.

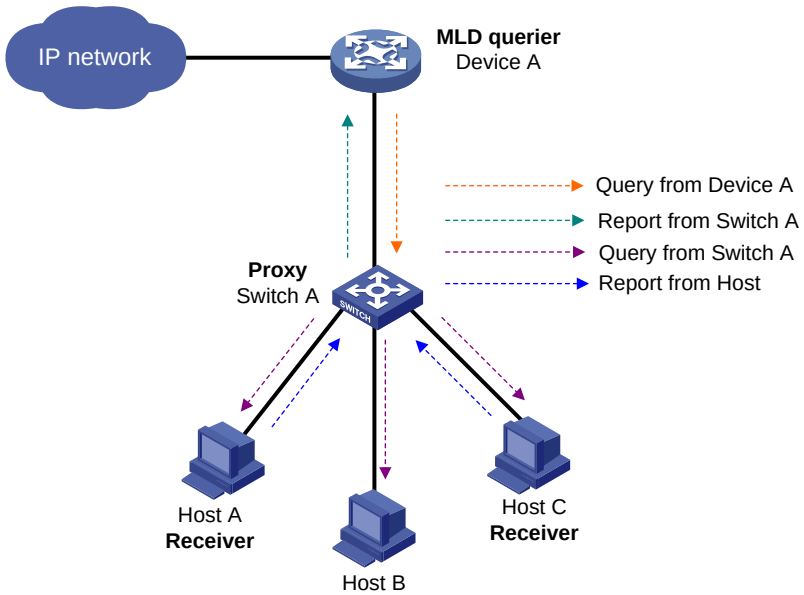
After receiving the MLD multicast-address-specific query, the Layer 2 device forwards the query through all router ports and member ports of the group in the VLAN. Then, it waits for the responding MLD report from the directly connected hosts. For the dynamic member port that received the done message, the Layer 2 device also performs one of the following actions:

- If the port receives an MLD report before the aging timer expires, the Layer 2 device resets the aging timer for the port.
- If the port does not receive any MLD report messages when the aging timer expires, the Layer 2 device removes the port from the forwarding entry for the IPv6 multicast group.

MLD snooping proxying

As shown in Figure 3, to reduce the number of MLD report and done messages received by the upstream device, you can enable MLD snooping proxying on the edge device. With MLD snooping proxying enabled, the edge device acts as a host for the upstream MLD snooping querier to send MLD report and done messages to Device A. The host MLD report suppression mechanism on the edge device does not take effect.

Figure 3 MLD snooping proxying



The MLD snooping proxy device processes different MLD messages as follows:

- General query.

After receiving an MLD general query, the device forwards the query to all ports in the VLAN except the receiving port. The device also generates an MLD report based on the local membership information and sends the report to all router ports.

- Multicast-address-specific query or multicast-address-and-source-specific query.

  After receiving an MLD multicast-address-specific query or multicast-address-and-source-specific query, the device forwards the query to all ports in the VLAN except the receiving port. If the forwarding entry has a member port, the device sends a response to all router ports in the VLAN.

- Report.

  After receiving an MLD report from a host, the device looks up the forwarding table for a matching entry as follows:

  - If a match is found and the matching forwarding entry contains the receiving port, the device resets the aging timer for the port.
  - If a match is found but the matching forwarding entry does not contain the receiving port, the device adds the receiving port to the outgoing interface list. It also marks the receiving port as a dynamic member port and starts an aging timer for the port.
  - If no match is found, the device creates a forwarding entry with the receiving port as an outgoing interface. It also marks the receiving port as a dynamic member port and starts an aging timer for the port. Then it sends the report to all router ports.

- Done message.

  After receiving the MLD done message on a port, the device sends an MLD multicast-address-specific query through the receiving port. The device sends the MLD done message to all router ports only when the last member port is removed from the forwarding entry.

Protocols and standards

RFC 4541, *Considerations for Internet Group Management Protocol (IGMP) and Multicast Listener Discovery (MLD) Snooping Switches*

Restrictions and guidelines: MLD snooping configuration

For MLD reports received from secondary VLANs, the relevant MLD snooping forwarding entries are maintained by the primary VLAN. Therefore, you need to enable MLD snooping only for the primary VLAN. The configuration made in secondary VLANs will not take effect. For more information about primary VLANs and secondary VLANs, see *Layer 2—LAN Switching Configuration Guide*.

The MLD snooping configurations made on Layer 2 aggregate interfaces do not interfere with the configurations made on member ports. In addition, the configurations made on Layer 2 aggregate interfaces do not take part in aggregation calculations. The configuration made on a member port of the aggregate group takes effect after the port leaves the aggregate group.

Some features can be configured for a VLAN in VLAN view or for multiple VLANs in MLD-snooping view. The VLAN-specific configuration and the configuration made in MLD-snooping view have the same priority, and the most recent configuration takes effect.

Some features can be configured for a VLAN in VLAN view or globally for all VLANs in MLD-snooping view. The VLAN-specific configuration takes priority over the global configuration.

Some features can be configured for an interface in interface view or for all interfaces of the specified VLANs in MLD-snooping view. The interface-specific configuration takes priority over the configuration made in MLD-snooping view.

VLAN-based MLD snooping tasks at a glance

To configure MLD snooping for VLANs, perform the following tasks:

1. Enabling the MLD snooping feature
2. Enabling MLD snooping

   Choose the following tasks as needed:

   - Enabling MLD snooping globally
   - Enabling MLD snooping for VLANs
3. (Optional.) Configuring basic MLD snooping features
   - Specifying an MLD snooping version
   - Setting the maximum number of MLD snooping forwarding entries
   - Configuring static IPv6 multicast MAC address entries
   - Setting the MLD last listener query interval
4. (Optional.) Configuring MLD snooping port features
   - Setting aging timers for dynamic ports
   - Configuring a static member port
   - Configuring a static router port
   - Configuring a port as a simulated member host
   - Enabling fast-leave processing
   - Disabling a port from becoming a dynamic router port
5. (Optional.) Configuring the MLD snooping querier
   - Enabling the MLD snooping querier
   - Enabling MLD snooping querier election
   - Configuring parameters for MLD general queries and responses
6. (Optional.) Enabling MLD snooping proxying
7. (Optional.) Configuring parameters for MLD messages
   - Configuring source IPv6 addresses for MLD messages
   - Setting the 802.1p priority for MLD messages
8. (Optional.) Configuring MLD snooping policies
   - Configuring an IPv6 multicast group policy
   - Enabling IPv6 multicast source port filtering
   - Enabling dropping unknown IPv6 multicast data
   - Enabling MLD report suppression
   - Setting the maximum number of IPv6 multicast groups on a port
   - Enabling IPv6 multicast group replacement
   - Enabling host tracking
9. (Optional.) Setting the DSCP value for outgoing MLD protocol packets

Enabling the MLD snooping feature

About enabling the MLD snooping feature

You must enable the MLD snooping feature before you configure other MLD snooping features.

Procedure

1. Enter system view.
   system-view
2. Enable the MLD snooping feature and enter MLD-snooping view.
   mld-snooping
   By default, the MLD snooping feature is disabled.

Enabling MLD snooping

Enabling MLD snooping globally

About enabling MLD snooping globally

After you enable MLD snooping globally, MLD snooping is enabled for all VLANs. You can disable MLD snooping for a VLAN when MLD snooping is globally enabled.

Restrictions and guidelines

To configure other MLD snooping features for VLANs, you must enable MLD snooping for the specific VLANs even though MLD snooping is enabled globally.

The VLAN-specific MLD snooping configuration takes priority over the global MLD snooping configuration. For example, if you enable MLD snooping globally and then use the **mld-snooping disable** command to disable MLD snooping for a VLAN, MLD snooping is disabled in the VLAN.

Procedure

1. Enter system view.
   system-view
2. Enter MLD-snooping view.
   mld-snooping
3. Enable MLD snooping globally.
   global-enable
   By default, MLD snooping is disabled globally.
4. (Optional.) Disable MLD snooping for a VLAN.
   a. Return to system view.
      quit
   b. Enter VLAN view.
      vlan *vlan-id*
   c. Disable MLD snooping for the VLAN.
      mld-snooping disable
      By default, the MLD snooping status in a VLAN is consistent with the global MLD snooping status.

Enabling MLD snooping for VLANs

Restrictions and guidelines

You can enable MLD snooping for multiple VLANs by using the **enable vlan** command in MLD-snooping view or for a VLAN by using the **mld-snooping enable** command in VLAN view. The configuration in VLAN view has the same priority as the configuration in MLD-snooping view.

MLD snooping configuration in a VLAN takes effect only on the member ports in the VLAN.

Enabling MLD snooping for multiple VLANs

1. Enter system view.
   system-view
2. Enter MLD-snooping view.
   mld-snooping
3. Enable MLD snooping for multiple VLANs.
   enable vlan *vlan-list*

   By default, the MLD snooping status in a VLAN is consistent with the global MLD snooping status.

Enabling MLD snooping for a VLAN

1. Enter system view.
   system-view
2. Enter VLAN view.
   vlan *vlan-id*
3. Enable MLD snooping for the VLAN.
   mld-snooping enable

   By default, the MLD snooping status in a VLAN is consistent with the global MLD snooping status.

Configuring basic MLD snooping features

Specifying an MLD snooping version

About MLD snooping versions

Different MLD snooping versions can process different versions of MLD messages:

- MLDv1 snooping can process MLDv1 messages and MLDv2 queries, but it floods MLDv2 reports in the VLAN instead of processing them.
- MLDv2 snooping can process MLDv1 and MLDv2 messages.

Restrictions and guidelines

If you change the version of MLD snooping from 2 to 1, the system performs the following actions:

- Clears all MLD snooping forwarding entries that are dynamically created.
- Keeps static MLDv2 snooping forwarding entries (*, G).
- Clears static MLDv2 snooping forwarding entries (S, G), which will be restored when MLD snooping is switched back to MLDv2 snooping.

For more information about static MLD snooping forwarding entries, see "Configuring a static member port."

Specifying an MLD snooping version for multiple VLANs

1. Enter system view.
   system-view
2. Enter MLD-snooping view.
   mld-snooping
3. Specify an MLD snooping version for multiple VLANs.

version *version-number* **vlan** *vlan-list*

By default, the MLD snooping version for a VLAN is 1.

Specifying an MLD snooping version for a VLAN

1. Enter system view.
   system-view
2. Enter VLAN view.
   vlan *vlan-id*
3. Specify an MLD snooping version for the VLAN.
   mld-snooping version *version-number*
   By default, the MLD snooping version for a VLAN is 1.

Setting the maximum number of MLD snooping forwarding entries

About setting the maximum number of MLD snooping forwarding entries

You can modify the maximum number of MLD snooping forwarding entries, including dynamic entries and static entries. When the number of forwarding entries on the device reaches the upper limit, the device does not automatically remove any existing entries. To allow new entries to be created, remove some entries manually.

Procedure

1. Enter system view.
   system-view
2. Enter MLD-snooping view.
   mld-snooping
3. Set the maximum number of MLD snooping forwarding entries.
   entry-limit *limit*
   By default, the maximum number of MLD snooping forwarding entries is 4294967295.

Configuring static IPv6 multicast MAC address entries

About static IPv6 multicast MAC address entries

In Layer 2 IPv6 multicast, IPv6 multicast MAC address entries can be dynamically created through Layer 2 multicast protocols (such as MLD snooping). You can also manually configure static IPv6 multicast MAC address entries by binding IPv6 multicast MAC addresses and ports to control the destination ports of the IPv6 multicast data.

Restrictions and guidelines

You must specify an unused multicast MAC address when configuring a static IPv6 multicast MAC address entry. A multicast MAC address is the MAC address in which the least significant bit of the most significant octet is 1.

Configuring a static IPv6 multicast MAC address entry in system view

1. Enter system view.
   system-view
2. Configure a static IPv6 multicast MAC address entry.
   mac-address multicast *mac-address* **interface** *interface-list* **vlan** *vlan-id*

Configuring a static IPv6 multicast MAC address entry in interface view

1. Enter system view.
   system-view
2. Enter Layer 2 interface view.
   - Enter Layer 2 Ethernet interface view.
     interface *interface-type interface-number*
   - Enter Layer 2 aggregate interface view.
     interface bridge-aggregation *interface-number*
3. Configure a static IPv6 multicast MAC address entry.
   mac-address multicast *mac-address* **vlan** *vlan-id*

Setting the MLD last listener query interval

About the MLD last listener query interval

A receiver host starts a report delay timer for an IPv6 multicast group when it receives an MLD multicast-address-specific query for the group. This timer is set to a random value in the range of 0 to the maximum response time advertised in the query. When the timer value decreases to 0, the host sends an MLD report to the group.

The MLD last listener query interval defines the maximum response time advertised in MLD multicast-address-specific queries. Set an appropriate value for the MLD last listener query interval to speed up hosts' responses to MLD multicast-address-specific queries and avoid MLD report traffic bursts.

Setting the MLD last listener query interval globally

1. Enter system view.
   system-view
2. Enter MLD-snooping view.
   mld-snooping
3. Set the MLD last listener query interval globally.
   last-listener-query-interval *interval*
   By default, the MLD last listener query interval is 1 second.

Setting the MLD last listener query interval for a VLAN

1. Enter system view.
   system-view
2. Enter VLAN view.
   vlan *vlan-id*
3. Set the MLD last listener query interval for the VLAN
   mld-snooping last-listener-query-interval *interval*
   By default, the MLD last listener query interval is 1 second for a VLAN.

Configuring MLD snooping port features

Setting aging timers for dynamic ports

About aging timers for dynamic ports

A dynamic router port is removed from the dynamic router port list if it does not receive an MLD general query or IPv6 PIM hello message when its aging timer expires.

A dynamic member port is removed from the dynamic member port if it does not receive an MLD report when its aging timer expires.

Restrictions and guidelines

Set an appropriate value for the aging timers of dynamic ports based on the actual network requirement. For example, if the memberships of IPv6 multicast groups frequently change, set a relatively small value for the aging timer of the dynamic member ports.

If a dynamic router port receives an IPv6 PIMv2 hello message, the aging timer for the port is specified by the hello message. In this case, the **mld-snooping router-aging-time** command does not take effect on the port.

MLD multicast-address-specific queries originated by the Layer 2 device trigger the adjustment of aging timers of dynamic member ports. If a dynamic member port receives such a query, its aging timer is set to twice the MLD last listener query interval. For more information about setting the MLD last listener query interval on the Layer 2 device, see "Setting the MLD last listener query interval."

Setting the aging timers for dynamic ports globally

1. Enter system view.
   system-view
2. Enter MLD-snooping view.
   mld-snooping
3. Set the aging timer for dynamic router ports globally.
   router-aging-time *seconds*
   By default, the aging timer for dynamic router ports is 260 seconds.
4. Set the aging timer for dynamic member ports globally.
   host-aging-time *seconds*
   By default, the aging timer for dynamic member ports is 260 seconds.

Setting the aging timers for dynamic ports in a VLAN

1. Enter system view.
   system-view
2. Enter VLAN view.
   vlan *vlan-id*
3. Set the aging timer for dynamic router ports in the VLAN.
   mld-snooping router-aging-time *seconds*
   By default, the aging timer for dynamic router ports is 260 seconds for a VLAN.
4. Set the aging timer for dynamic member ports in the VLAN.
   mld-snooping host-aging-time *seconds*
   By default, the aging timer for dynamic member ports is 260 seconds for a VLAN.

Configuring a static member port

About static member ports

You can configure a port as a static member port for an IPv6 multicast group so that all hosts attached to the port can always receive IPv6 multicast data for the group. The static member port does not respond to MLD queries. When you complete or cancel this configuration, the port does not send an unsolicited report or done message.

Procedure

1. Enter system view.

   system-view
2. Enter Layer 2 interface view.
   - Enter Layer 2 Ethernet interface view.

     interface *interface-type interface-number*
   - Enter Layer 2 aggregate interface view.

     interface bridge-aggregation *interface-number*
3. Configure the port as a static member port.

   mld-snooping static-group *ipv6-group-address* [**source-ip** *ipv6-source-address*] **vlan** *vlan-id*

   By default, a port is not a static member port.

Configuring a static router port

About static router ports

You can configure a port as a static router port for an IPv6 multicast group so that all IPv6 multicast data for the group received on the port will be forwarded.

Procedure

1. Enter system view.

   system-view
2. Enter Layer 2 interface view.
   - Enter Layer 2 Ethernet interface view.

     interface *interface-type interface-number*
   - Enter Layer 2 aggregate interface view.

     interface bridge-aggregation *interface-number*
3. Configure the port as a static router port.

   mld-snooping static-router-port vlan *vlan-id*

   By default, a port is not a static router port.

Configuring a port as a simulated member host

About simulated member hosts

When a port is configured as a simulated member host, it is equivalent to an independent host in the following ways:

- It sends an unsolicited MLD report when you complete the configuration.
- It responds to MLD general queries with MLD reports.

- It sends an MLD done message when you remove the configuration.

The version of MLD running on the simulated member host is the same as the version of MLD snooping running on the port. The port ages out in the same ways as a dynamic member port.

Procedure

1. Enter system view.
   system-view
2. Enter Layer 2 interface view.
   - Enter Layer 2 Ethernet interface view.
     interface *interface-type interface-number*
   - Enter Layer 2 aggregate interface view.
     interface bridge-aggregation *interface-number*
3. Configure the port as a simulated member host.
   mld-snooping host-join *ipv6-group-address* [**source-ip** *ipv6-source-address*] **vlan** *vlan-id*

   By default, the port is not a simulated member host.

Enabling fast-leave processing

About fast-leave processing

This feature enables the Layer 2 device to immediately remove a port from the forwarding entry for an IPv6 multicast group when the port receives a done message. The device no longer sends or forwards MLD multicast-address-specific queries for the group to the port.

Restrictions and guidelines

Do not enable fast-leave processing on a port that has multiple receiver hosts attached in a VLAN. If you do so, the remaining receivers cannot receive IPv6 multicast data for a group after a receiver leaves the group.

Enabling fast-leave processing globally

1. Enter system view.
   system-view
2. Enter MLD-snooping view.
   mld-snooping
3. Enable fast-leave processing globally.
   fast-leave [**vlan** *vlan-list*]

   By default, fast-leave processing is disabled globally.

Enabling fast-leave processing on a port

1. Enter system view.
   system-view
2. Enter Layer 2 interface view.
   - Enter Layer 2 Ethernet interface view.
     interface *interface-type interface-number*
   - Enter Layer 2 aggregate interface view.
     interface bridge-aggregation *interface-number*
3. Enable fast-leave processing on the port.
   mld-snooping fast-leave [**vlan** *vlan-list*]

By default, fast-leave processing is disabled on a port.

Disabling a port from becoming a dynamic router port

About disabling a port from becoming a dynamic router port

A receiver host might send MLD general queries or IPv6 PIM hello messages for testing purposes. On the Layer 2 device, the port that receives either of the messages becomes a dynamic router port. Before the aging timer for the port expires, the following problems might occur:

- All IPv6 multicast data for the VLAN to which the port belongs flows to the port. Then, the port forwards the data to attached receiver hosts. The receiver hosts will receive IPv6 multicast data that it does not expect.
- The port forwards the MLD general queries or IPv6 PIM hello messages to its upstream Layer 3 devices. These messages might affect the multicast routing protocol state (such as the MLD querier or DR election) on the Layer 3 devices. This might further cause network interruption.

To solve these problems, you can disable the port from becoming a dynamic router port when receiving either of the messages. This also improves network security and the control over receiver hosts.

Restrictions and guidelines

This configuration and the static router port configuration do not interfere with each other.

Procedure

1. Enter system view.
   system-view
2. Enter Layer 2 interface view.
   - Enter Layer 2 Ethernet interface view.
     interface *interface-type interface-number*
   - Enter Layer 2 aggregate interface view.
     interface bridge-aggregation *interface-number*
3. Disable the port from becoming a dynamic router port.
   mld-snooping router-port-deny [**vlan** *vlan-list*]
   By default, a port is allowed to become a dynamic router port.

Configuring the MLD snooping querier

Enabling the MLD snooping querier

About the MLD snooping querier

This feature enables the Layer 2 device to periodically send MLD general queries to establish and maintain multicast forwarding entries at the data link Layer. You can configure an MLD snooping querier on a network without Layer 3 multicast devices.

Restrictions and guidelines

Do not enable the MLD snooping querier on an IPv6 multicast network that runs MLD. An MLD snooping querier does not participate in MLD querier elections. However, it might affect MLD querier elections if it sends MLD general queries with a low source IPv6 address.

Enabling the MLD snooping querier for a VLAN

1. Enter system view.

system-view

2. Enter VLAN view.

   vlan *vlan-id*

3. Enable the MLD snooping querier for the VLAN.

   mld-snooping querier

   By default, the MLD snooping querier is disabled for a VLAN.

Enabling MLD snooping querier election

About MLD snooping querier election

To avoid traffic interruption caused by the failure of a single querier in a VLAN, configure multiple queriers in the VLAN and enable querier election. When the elected querier fails, the device starts a new querier election to ensure multicast forwarding. The mechanism for MLD snooping querier election is the same as that for MLD querier election.

Prerequisites

Before you enable MLD snooping querier election, you must complete the following tasks:

- Enable the MLD snooping querier for a VLAN. For more information about enabling the MLD snooping querier, see "Enabling the MLD snooping querier."
- Configure the source IPv6 address for MLD general queries as an IPv6 address different from :: and the local querier IPv6 address. An MLD snooping querier performs querier election only if the source IPv6 address of a received MLD general query is not :: or its own IPv6 address.
- Make sure the candidate MLD snooping queriers run the same MLD snooping version. To specify the MLD snooping version, use the **mld-snooping version** command.

Enabling MLD snooping querier election for a VLAN

1. Enter system view.

   system-view

2. Enter VLAN view.

   vlan *vlan-id*

3. Enable MLD snooping querier election for the VLAN.

   mld-snooping querier-election

   By default, MLD snooping querier election is disabled for a VLAN.

Configuring parameters for MLD general queries and responses

About parameters for MLD general queries and responses

You can modify the MLD general query interval based on the actual network conditions.

A receiver host starts a report delay timer for each IPv6 multicast group that it has joined when it receives an MLD general query. This timer is set to a random value in the range of 0 to the maximum response time advertised in the query. When the timer value decreases to 0, the host sends an MLD report to the corresponding IPv6 multicast group.

Set an appropriate value for the maximum response time for MLD general queries to speed up hosts' responses to MLD general queries and avoid MLD report traffic bursts.

Restrictions and guidelines

To avoid mistakenly deleting IPv6 multicast group members, make sure the MLD general query interval is greater than the maximum response time for MLD general queries.

Configuring parameters for MLD general queries and responses globally

1. Enter system view.
   system-view
2. Enter MLD-snooping view.
   mld-snooping
3. Set the maximum response time for MLD general queries.
   max-response-time *seconds*
   By default, the maximum response time for MLD general queries is 10 seconds.

Configuring parameters for MLD general queries and responses for a VLAN

1. Enter system view.
   system-view
2. Enter VLAN view.
   vlan *vlan-id*
3. Set the MLD general query interval in the VLAN.
   mld-snooping query-interval *interval*
   By default, the MLD general query interval for a VLAN is 125 seconds.
4. Set the maximum response time for MLD general queries in the VLAN.
   mld-snooping max-response-time *seconds*
   By default, the maximum response time for MLD general queries for a VLAN is 10 seconds.

Enabling MLD snooping proxying

About MLD snooping proxying

The device enabled with MLD snooping proxying is called an MLD snooping proxy. The MLD snooping proxy acts as a host to the upstream device. Enabled with MLD snooping querier, the MLD snooping proxy acts as the router to downstream devices and receives report and done messages on behalf of the upstream device. As a best practice, enable MLD snooping proxy on the edge device to alleviate the effect caused by excessive packets.

Restrictions and guidelines for enabling MLD snooping proxying

Before you enable MLD snooping proxying for a VLAN, you must first enable MLD snooping globally and enable MLD snooping for the VLAN. MLD snooping proxying does not take effect on sub VLANs of a multicast VLAN.

Use this feature with MLD snooping querier. For more information about enabling MLD snooping querier, see "Enabling the MLD snooping querier."

Enabling MLD snooping proxying for a VLAN

1. Enter system view.

system-view

2. Enter VLAN view.

   vlan *vlan-id*

3. Enable MLD snooping proxying for the VLAN.

   mld-snooping proxy enable

   By default, MLD snooping proxying is disabled for a VLAN.

Configuring parameters for MLD messages

Configuring source IPv6 addresses for MLD messages

About configuring source IPv6 addresses for MLD messages

You can change the source IPv6 address of the MLD queries sent by an MLD snooping querier. This configuration might affect MLD querier election within the subnet.

You can also change the source IPv6 address of MLD reports or done messages sent by a simulated member host or an MLD snooping proxy.

Configuring the source IPv6 addresses for MLD messages for a VLAN

1. Enter system view.

   system-view

2. Enter VLAN view.

   vlan *vlan-id*

3. Configure the source IPv6 address for MLD general queries.

   mld-snooping general-query source-ip *ipv6-address*

   By default, the source IPv6 address of MLD general queries is the IPv6 link-local address of the current VLAN interface. If the current VLAN interface does not have an IPv6 link-local address, the source IPv6 address is FE80::02FF:FFFF:FE00:0001.

4. Configure the source IPv6 address for MLD multicast-address-specific queries.

   mld-snooping special-query source-ip *ipv6-address*

   By default, the source IPv6 address of MLD multicast-address-specific queries is one of the following:

   - The source address of MLD general queries if the MLD snooping querier of the VLAN has received MLD general queries.
   - The IPv6 link-local address of the current VLAN interface if the MLD snooping querier does not receive an MLD general query.
   - FE80::02FF:FFFF:FE00:0001 if the MLD snooping querier does not receive an MLD general query and the current VLAN interface does not have an IPv6 link-local address.

5. Configure the source IPv6 address for MLD reports.

   mld-snooping report source-ip *ipv6-address*

   By default, the source IPv6 address of MLD reports is the IPv6 link-local address of the current VLAN interface. If the current VLAN interface does not have an IPv6 link-local address, the source IPv6 address is FE80::02FF:FFFF:FE00:0001.

6. Configure the source IPv6 address for MLD done messages.

   mld-snooping done source-ip *ipv6-address*

   By default, the source IPv6 address of MLD done messages is the IPv6 link-local address of the current VLAN interface. If the current VLAN interface does not have an IPv6 link-local address, the source IPv6 address is FE80::02FF:FFFF:FE00:0001.

Setting the 802.1p priority for MLD messages

About the 802.1p priority for MLD messages

When congestion occurs on outgoing ports of the Layer 2 device, it forwards MLD messages in their 802.1p priority order, from highest to lowest. You can assign a higher 802.1p priority to MLD messages that are created or forwarded by the device.

Setting the 802.1p priority for MLD messages globally

1. Enter system view.
   system-view
2. Enter MLD-snooping view.
   mld-snooping
3. Set the 802.1p priority for MLD messages globally.
   dot1p-priority *priority*
   By default, the global 802.1p priority is 6 for MLD messages.

Setting the 802.1p priority for MLD messages for a VLAN

1. Enter system view.
   system-view
2. Enter VLAN view.
   vlan *vlan-id*
3. Set the 802.1p priority for MLD messages in the VLAN.
   mld-snooping dot1p-priority *priority*
   By default, the 802.1p priority is 6 for MLD messages in a VLAN.

Configuring MLD snooping policies

Configuring an IPv6 multicast group policy

About IPv6 multicast group policies

This feature enables the Layer 2 device to filter MLD reports by using an ACL that specifies the IPv6 multicast groups and the optional sources. It is used to control the IPv6 multicast groups that receiver hosts can join. This configuration takes effect on the IPv6 multicast groups that ports join dynamically.

In an IPv6 multicast application, a host sends an unsolicited MLD report when a user requests an IPv6 multicast program. The Layer 2 device uses the IPv6 multicast group policy to filter the MLD report. The host can join the IPv6 multicast group only if the MLD report is permitted by the IPv6 multicast group policy.

Configuring an IPv6 multicast group policy globally

1. Enter system view.
   system-view
2. Enter MLD-snooping view.
   mld-snooping
3. Configure an IPv6 multicast group policy globally.
   group-policy *ipv6-acl-number* [**vlan** *vlan-list*]
   By default, no IPv6 multicast group policies exist. Hosts can join any IPv6 multicast groups.

Configuring an IPv6 multicast group policy on a port

1. Enter system view.
   system-view
2. Enter Layer 2 interface view.
   - Enter Layer 2 Ethernet interface view.
     interface *interface-type interface-number*
   - Enter Layer 2 aggregate interface view.
     interface bridge-aggregation *interface-number*
3. Configure an IPv6 multicast group policy on the port.
   mld-snooping group-policy *ipv6-acl-number* [**vlan** *vlan-list*]

   By default, no IPv6 multicast group policies exist on a port. Hosts attached to the port can join any IPv6 multicast groups.

Enabling IPv6 multicast source port filtering

About IPv6 multicast source port filtering

This feature enables the Layer 2 device to discard all IPv6 multicast data packets and to accept IPv6 multicast protocol packets. You can enable this feature on ports that connect to only IPv6 multicast receivers.

The configuration made in MLD-snooping view has the same priority over the interface-specific configuration.

Restrictions and guidelines

When IPv6 multicast source port filtering is enabled, the device automatically enables IPv4 multicast source port filtering.

The configuration made in MLD-snooping view has the same priority as the interface-specific configuration, and the most recent configuration takes effect.

Enabling IPv6 multicast source port filtering in MLD-snooping view

1. Enter system view.
   system-view
2. Enter MLD-snooping view.
   mld-snooping
3. Enable IPv6 multicast source port filtering globally.
   source-deny port *interface-list*

   By default, IPv6 multicast source port filtering is disabled globally.

Enabling IPv6 multicast source port filtering in interface view

1. Enter system view.
   system-view
2. Enter Layer 2 Ethernet interface view.
   interface *interface-type interface-number*
3. Enable IPv6 multicast source port filtering on the port.
   mld-snooping source-deny

   By default, IPv6 multicast source port filtering is disabled on a port.

Enabling dropping unknown IPv6 multicast data

About dropping unknown IPv6 multicast data

Unknown IPv6 multicast data refers to IPv6 multicast data for which no forwarding entries exist in the MLD snooping forwarding table. This feature enables the device to forward unknown IPv6 multicast data only to the router port. If the device does not have a router port, unknown IPv6 multicast data will be dropped.

If you do not enable this feature, the unknown IPv6 multicast data is flooded in the VLAN to which the data belongs.

Restrictions and guidelines

When dropping unknown IPv6 multicast data is enabled, the device also drops unknown IPv4 multicast data.

When this feature is enabled for a VLAN, the device still forwards unknown IPv6 multicast data out of router ports (except the receiving router port) in this VLAN.

Enabling dropping unknown IPv6 multicast data for a VLAN

1. Enter system view.

   `system-view`
2. Enter VLAN view.

   `vlan` *`vlan-id`*
3. Enable dropping unknown IPv6 multicast data for the VLAN.

   `mld-snooping drop-unknown`

   By default, dropping unknown IPv6 multicast data is disabled. Unknown IPv6 multicast data is flooded.

Enabling MLD report suppression

About MLD report suppression

This feature enables the Layer 2 device to forward only the first MLD report for an IPv6 multicast group to its directly connected Layer 3 device. Other reports for the same group in the same query interval are discarded. Use this feature to reduce the multicast traffic.

Procedure

1. Enter system view.

   `system-view`
2. Enter MLD-snooping view.

   `mld-snooping`
3. Enable MLD report suppression.

   `report-aggregation`

   By default, MLD report suppression is enabled.

Setting the maximum number of IPv6 multicast groups on a port

About setting the maximum number of IPv6 multicast groups on a port

You can set the maximum number of IPv6 multicast groups on a port to regulate the port traffic. This feature takes effect only on the IPv6 multicast groups that the port joins dynamically.

If the number of IPv6 multicast groups on a port exceeds the limit, the system removes all the forwarding entries related to that port. In this case, the receiver hosts attached to that port can join IPv6 multicast groups again before the number of IPv6 multicast groups on the port reaches the limit. When the number of IPv6 multicast groups on the port reaches the limit, the port automatically drops MLD reports for new IPv6 multicast groups.

Procedure

1. Enter system view.
   system-view
2. Enter Layer 2 interface view.
   - Enter Layer 2 Ethernet interface view.
     interface *interface-type interface-number*
   - Enter Layer 2 aggregate interface view.
     interface bridge-aggregation *interface-number*
3. Set the maximum number of IPv6 multicast groups on the port.
   mld-snooping group-limit *limit* [**vlan** *vlan-list*]
   By default, no limit is placed on the maximum number of IPv6 multicast groups on a port.

Enabling IPv6 multicast group replacement

About IPv6 multicast group replacement

When IPv6 multicast group replacement is enabled, the port does not drop MLD reports for new groups if the number of multicast groups on the port reaches the upper limit. Instead, the port leaves an IPv6 multicast group that has the lowest IPv6 address and joins the new group contained in the MLD report. The IPv6 multicast group replacement feature is typically used in the channel switching application.

Restrictions and guidelines

This feature takes effect only on the multicast groups that the port joins dynamically.

This feature does not take effect if the following conditions exist:

- The number of the MLD snooping forwarding entries on the device reaches the upper limit.
- The IPv6 multicast group that the port newly joins is not included in the multicast group list maintained by the device.

Enabling IPv6 multicast group replacement globally

1. Enter system view.
   system-view
2. Enter MLD-snooping view.
   mld-snooping
3. Enable IPv6 multicast group replacement globally.
   overflow-replace [**vlan** *vlan-list*]
   By default, IPv6 multicast group replacement is disabled globally.

Enabling IPv6 multicast group replacement on a port

1. Enter system view.
   system-view
2. Enter Layer 2 interface view.
   - Enter Layer 2 Ethernet interface view.
     interface *interface-type interface-number*

- Enter Layer 2 aggregate interface view.
  interface bridge-aggregation *interface-number*

3. Enable IPv6 multicast group replacement on the port.
   mld-snooping overflow-replace [**vlan** *vlan-list*]
   By default, IPv6 multicast group replacement is disabled on a port.

Enabling host tracking

About host tracking

This feature enables the Layer 2 device to record information about member hosts that are receiving IPv6 multicast data. The information includes IPv6 addresses of the hosts, length of time elapsed since the hosts joined IPv6 multicast groups, and remaining timeout time for the hosts. This feature facilitates monitoring and managing member hosts.

Enabling host tracking globally

1. Enter system view.
   system-view
2. Enter MLD-snooping view.
   mld-snooping
3. Enable host tracking globally.
   host-tracking
   By default, host tracking is disabled globally.

Enabling host tracking in a VLAN

1. Enter system view.
   system-view
2. Enter VLAN view.
   vlan *vlan-id*
3. Enable host tracking for the VLAN.
   mld-snooping host-tracking
   By default, host tracking is disabled in a VLAN.

Setting the DSCP value for outgoing MLD protocol packets

About the DSCP value for outgoing MLD protocol packets

The DSCP value determines the packet transmission priority. A greater DSCP value represents a higher priority.

Procedure

1. Enter system view.
   system-view
2. Enter MLD snooping view.
   mld-snooping
3. Set the DSCP value for outgoing MLD protocol packets.
   dscp *dscp-value*

By default, the DSCP value is 48 for outgoing MLD protocol packets.

Display and maintenance commands for MLD snooping

Execute **display** commands in any view and **reset** commands in user view.

Task	Command
Display Layer 2 IPv6 multicast fast forwarding entries.	**display ipv6 l2-multicast fast-forwarding cache** [**vlan** *vlan-id*] [*ipv6-source-address* | *ipv6-group-address*] * [**slot** *slot-number*]
Display information about Layer 2 IPv6 multicast groups.	**display ipv6 l2-multicast ip** [**group** *ipv6-group-address* | **source** *ipv6-source-address*] * [**vlan** *vlan-id*] [**slot** *slot-number*]
Display Layer 2 IPv6 multicast group entries.	**display ipv6 l2-multicast ip forwarding** [**group** *ipv6-group-address* | **source** *ipv6-source-address*] * [**vlan** *vlan-id*] [**slot** *slot-number*]
Display information about Layer 2 IPv6 MAC multicast groups.	**display ipv6 l2-multicast mac** [*mac-address*] [**vlan** *vlan-id*] [**slot** *slot-number*]
Display Layer 2 IPv6 MAC multicast group entries.	**display ipv6 l2-multicast mac forwarding** [*mac-address*] [**vlan** *vlan-id*] [**slot** *slot-number*]
Display static IPv6 multicast MAC address entries.	**display mac-address** [*mac-address* [**vlan** *vlan-id*] | [**multicast**] [**vlan** *vlan-id*] [**count**]]
Display MLD snooping status.	**display mld-snooping** [**global** | **vlan** *vlan-id*]
Display dynamic MLD snooping group entries.	**display mld-snooping group** [*ipv6-group-address* | *ipv6-source-address*] * [**vlan** *vlan-id*] [**interface** *interface-type interface-number* | [**verbose**] [**slot** *slot-number*]]
Display host tracking information.	**display mld-snooping host-tracking vlan** *vlan-id* **group** *ipv6-group-address* [**source** *ipv6-source-address*] [**slot** *slot-number*]
Display dynamic router port information.	**display mld-snooping router-port** [**vlan** *vlan-id*] [**verbose**] [**slot** *slot-number*]
Display static MLD snooping group entries.	**display mld-snooping static-group** [*ipv6-group-address* | *ipv6-source-address*] * [**vlan** *vlan-id*] [**verbose**] [**slot** *slot-number*]
Display static router port information.	**display mld-snooping static-router-port** [**vlan** *vlan-id*] [**verbose**] [**slot** *slot-number*]
Display statistics for the MLD messages and IPv6 PIM hello	**display mld-snooping statistics**

Task	Command
messages learned through MLD snooping.	
Clear Layer 2 IPv6 multicast fast forwarding entries.	**reset ipv6 l2-multicast fast-forwarding cache** [**vlan** *vlan-id*] { { *ipv6-source-address* | *ipv6-group-address* } * | **all** } [**slot** *slot-number*]
Clear dynamic MLD snooping group entries.	**reset mld-snooping group** { *ipv6-group-address* [*ipv6-source-address*] | **all** } [**vlan** *vlan-id*]
Clear dynamic router port information.	**reset mld-snooping router-port** { **all** | **vlan** *vlan-id* }
Clear statistics for MLD messages and IPv6 PIM hello messages learned through MLD snooping.	**reset mld-snooping statistics**

MLD snooping configuration examples

Example: Configuring VLAN-based IPv6 group policy and simulated joining

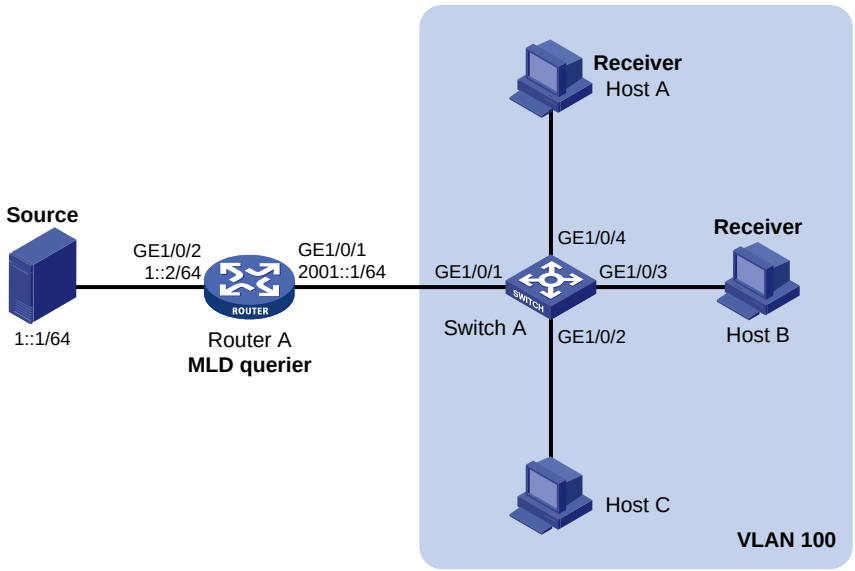
Network configuration

As shown in Figure 4, Router A runs MLDv1 and acts as the MLD querier, and Switch A runs MLDv1 snooping.

Configure the group policy and simulate joining to meet the following requirements:

- Host A and Host B receive only the IPv6 multicast data addressed to the IPv6 multicast group FF1E::101. IPv6 multicast data can be forwarded through GigabitEthernet 1/0/3 and GigabitEthernet 1/0/4 of Switch A uninterruptedly, even though Host A and Host B fail to receive the multicast data.
- Switch A will drop unknown IPv6 multicast data instead of flooding it in VLAN 100.

Figure 4 Network diagram



Procedure

1. Assign an IPv6 address and prefix length to each interface, as shown in Figure 4. (Details not shown.)
2. Configure Router A:

   # Enable IPv6 multicast routing.

   ```
   <RouterA> system-view
   [RouterA] ipv6 multicast routing
   [RouterA-mrib6] quit
   ```

   # Enable MLD on GigabitEthernet 1/0/1.

   ```
   [RouterA] interface gigabitethernet 1/0/1
   [RouterA-GigabitEthernet1/0/1] mld enable
   [RouterA-GigabitEthernet1/0/1] quit
   ```

   # Enable IPv6 PIM-DM on GigabitEthernet 1/0/2.

   ```
   [RouterA] interface gigabitethernet 1/0/2
   [RouterA-GigabitEthernet1/0/2] ipv6 pim dm
   [RouterA-GigabitEthernet1/0/2] quit
   ```
3. Configure Switch A:

   # Enable the MLD snooping feature.

   ```
   <SwitchA> system-view
   [SwitchA] mld-snooping
   [SwitchA-mld-snooping] quit
   ```

   # Create VLAN 100, and assign GigabitEthernet 1/0/1 through GigabitEthernet 1/0/4 to the VLAN.

   ```
   [SwitchA] vlan 100
   [SwitchA-vlan100] port gigabitethernet 1/0/1 to gigabitethernet 1/0/4
   ```

   # Enable MLD snooping, and enable dropping IPv6 unknown multicast data for VLAN 100.

   ```
   [SwitchA-vlan100] mld-snooping enable
   [SwitchA-vlan100] mld-snooping drop-unknown
   [SwitchA-vlan100] quit
   ```

Configure an IPv6 multicast group policy so that hosts in VLAN 100 can join only IPv6 multicast group FF1E::101.

```
[SwitchA] acl ipv6 basic 2001
[SwitchA-acl-ipv6-basic-2001] rule permit source ff1e::101 128
[SwitchA-acl-ipv6-basic-2001] quit
[SwitchA] mld-snooping
[SwitchA–mld-snooping] group-policy 2001 vlan 100
[SwitchA–mld-snooping] quit
```

Configure GigabitEthernet 1/0/3 and GigabitEthernet 1/0/4 as simulated member hosts to join IPv6 multicast group FF1E::101.

```
[SwitchA] interface gigabitethernet 1/0/3
[SwitchA-GigabitEthernet1/0/3] mld-snooping host-join ff1e::101 vlan 100
[SwitchA-GigabitEthernet1/0/3] quit
[SwitchA] interface gigabitethernet 1/0/4
[SwitchA-GigabitEthernet1/0/4] mld-snooping host-join ff1e::101 vlan 100
[SwitchA-GigabitEthernet1/0/4] quit
```

Verifying the configuration

Send MLD reports from Host A and Host B to join IPv6 multicast groups FF1E::101 and FF1E::202. (Details not shown.)

Display dynamic MLD snooping group entries for VLAN 100 on Switch A.

```
[SwitchA] display mld-snooping group vlan 100
Total 1 entries.

VLAN 100: Total 1 entries.
  (::, FF1E::101)
    Host ports (2 in total):
      GE1/0/3                              (00:03:23)
      GE1/0/4                              (00:04:10)
```

The output shows the following information:

- Host A and Host B have joined IPv6 multicast group FF1E::101 through the member ports GigabitEthernet 1/0/4 and GigabitEthernet 1/0/3 on Switch A, respectively.
- Host A and Host B have failed to join the multicast group FF1E::202.

Example: Configuring VLAN-based static ports

Network configuration

As shown in Figure 5:

- Router A runs MLDv1 and acts as the MLD querier. Switch A, Switch B, and Switch C run MLDv1 snooping.
- Host A and Host C are permanent receivers of IPv6 multicast group FF1E::101.

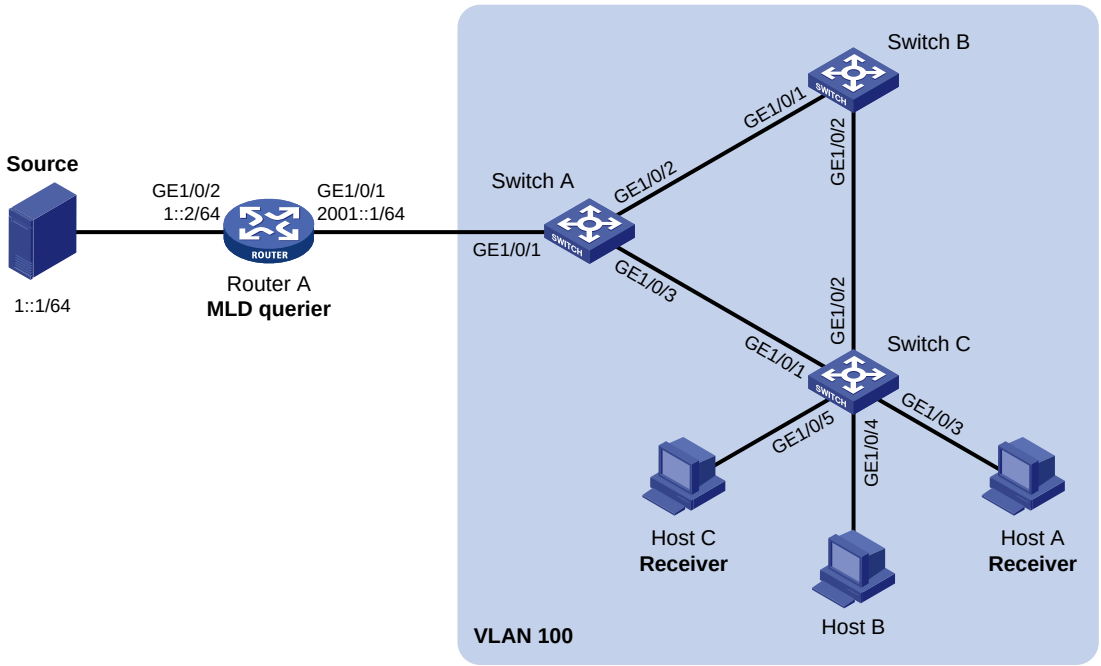
Configure static ports to meet the following requirements:

- To enhance the reliability of IPv6 multicast traffic transmission, configure GigabitEthernet 1/0/3 and GigabitEthernet 1/0/5 on Switch C as static member ports for IPv6 multicast group FF1E::101.
- Suppose the STP runs on the network. To avoid data loops, the forwarding path from Switch A to Switch C is blocked. IPv6 multicast data flows to the receivers attached to Switch C only along the path of Switch A—Switch B—Switch C. When this path is blocked, a minimum of one MLD query-response cycle must be completed before IPv6 multicast data flows to the receivers

along the path of Switch A—Switch C. In this case, the multicast delivery is interrupted during the process. For more information about the STP, see *Layer 2—LAN Switching Configuration Guide*.

Configure GigabitEthernet 1/0/3 on Switch A as a static router port. Then, IPv6 multicast data can flow to the receivers nearly uninterrupted along the path of Switch A—Switch C when the path of Switch A—Switch B—Switch C is blocked.

Figure 5 Network diagram



Procedure

1. Assign an IPv6 address and prefix length to each interface, as shown in Figure 5. (Details not shown.)
2. Configure Router A:

   # Enable IPv6 multicast routing.

   ```
   <RouterA> system-view
   [RouterA] ipv6 multicast routing
   [RouterA-mrib6] quit
   ```

   # Enable MLD on GigabitEthernet 1/0/1.

   ```
   [RouterA] interface gigabitethernet 1/0/1
   [RouterA-GigabitEthernet1/0/1] mld enable
   [RouterA-GigabitEthernet1/0/1] quit
   ```

   # Enable IPv6 PIM-DM on GigabitEthernet 1/0/2.

   ```
   [RouterA] interface gigabitethernet 1/0/2
   [RouterA-GigabitEthernet1/0/2] ipv6 pim dm
   [RouterA-GigabitEthernet1/0/2] quit
   ```
3. Configure Switch A:

   # Enable the MLD snooping feature.

   ```
   <SwitchA> system-view
   [SwitchA] mld-snooping
   [SwitchA-mld-snooping] quit
   ```

Create VLAN 100, and assign GigabitEthernet 1/0/1 through GigabitEthernet 1/0/3 to the VLAN.

```
[SwitchA] vlan 100
[SwitchA-vlan100] port gigabitethernet 1/0/1 to gigabitethernet 1/0/3
```

Enable MLD snooping for VLAN 100.

```
[SwitchA-vlan100] mld-snooping enable
[SwitchA-vlan100] quit
```

Configure GigabitEthernet 1/0/3 as a static router port.

```
[SwitchA] interface gigabitethernet 1/0/3
[SwitchA-GigabitEthernet1/0/3] mld-snooping static-router-port vlan 100
[SwitchA-GigabitEthernet1/0/3] quit
```

4. Configure Switch B:

Enable the MLD snooping feature.

```
<SwitchB> system-view
[SwitchB] mld-snooping
[SwitchB-mld-snooping] quit
```

Create VLAN 100, and assign GigabitEthernet 1/0/1 and GigabitEthernet 1/0/2 to the VLAN.

```
[SwitchB] vlan 100
[SwitchB-vlan100] port gigabitethernet 1/0/1 gigabitethernet 1/0/2
```

Enable MLD snooping for VLAN 100.

```
[SwitchB-vlan100] mld-snooping enable
[SwitchB-vlan100] quit
```

5. Configure Switch C:

Enable the MLD snooping feature.

```
<SwitchC> system-view
[SwitchC] mld-snooping
[SwitchC-mld-snooping] quit
```

Create VLAN 100, and assign GigabitEthernet 1/0/1 through GigabitEthernet 1/0/5 to the VLAN.

```
[SwitchC] vlan 100
[SwitchC-vlan100] port gigabitethernet 1/0/1 to gigabitethernet 1/0/5
```

Enable MLD snooping for VLAN 100.

```
[SwitchC-vlan100] mld-snooping enable
[SwitchC-vlan100] quit
```

Configure GigabitEthernet 1/0/3 and GigabitEthernet 1/0/5 as static member ports for IPv6 multicast group FF1E::101.

```
[SwitchC] interface gigabitethernet 1/0/3
[SwitchC-GigabitEthernet1/0/3] mld-snooping static-group ff1e::101 vlan 100
[SwitchC-GigabitEthernet1/0/3] quit
[SwitchC] interface gigabitethernet 1/0/5
[SwitchC-GigabitEthernet1/0/5] mld-snooping static-group ff1e::101 vlan 100
[SwitchC-GigabitEthernet1/0/5] quit
```

Verifying the configuration

Display static router port information for VLAN 100 on Switch A.

```
[SwitchA] display mld-snooping static-router-port vlan 100
VLAN 100:
  Router ports (1 in total):
```

```
    GE1/0/3
```

The output shows that GigabitEthernet 1/0/3 on Switch A has become a static router port.

Display static MLD snooping group entries in VLAN 100 on Switch C.

```
[SwitchC] display mld-snooping static-group vlan 100
Total 1 entries).

VLAN 100: Total 1 entries).
  (::, FF1E::101)
    Host ports (2 in total):
      GE1/0/3
      GE1/0/5
```

The output shows that GigabitEthernet 1/0/3 and GigabitEthernet 1/0/5 on Switch C have become static member ports of IPv6 multicast group FF1E::101.

Example: Configuring the VLAN-based MLD snooping querier

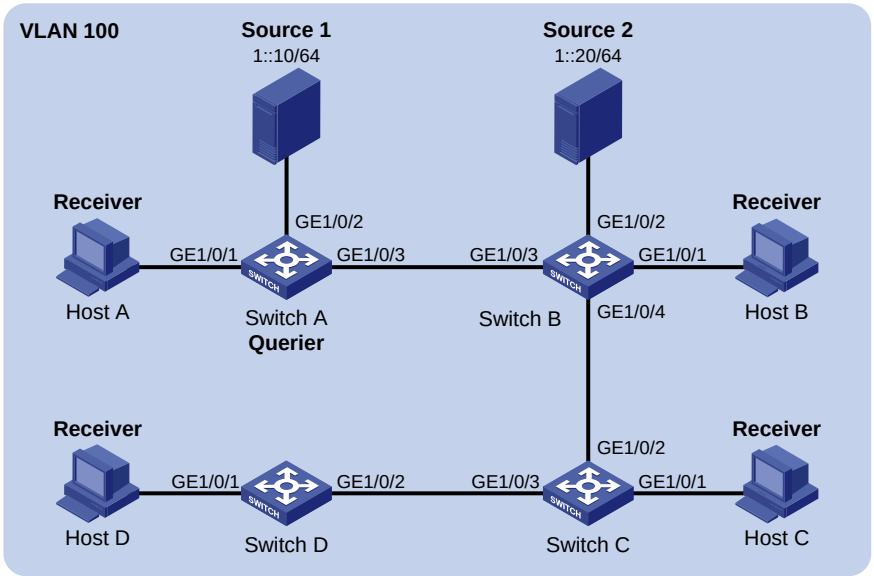
Network configuration

As shown in Figure 6:

- The network is a Layer 2-only network.
- Source 1 and Source 2 send multicast data to IPv6 multicast groups FF1E::101 and FF1E::102, respectively.
- Host A and Host C are receivers of IPv6 multicast group FF1E::101, and Host B and Host D are receivers of IPv6 multicast group FF1E::102.
- All host receivers run MLDv1 and all switches run MLDv1 snooping. Switch A (which is close to the multicast sources) acts as the MLD snooping querier.

To prevent the switches from flooding unknown IPv6 packets in the VLAN, enable all the switches to drop unknown IPv6 multicast packets.

Figure 6 Network diagram



Procedure

1. Configure Switch A:

   # Enable the MLD snooping feature.

   ```
   <SwitchA> system-view
   [SwitchA] mld-snooping
   [SwitchA-mld-snooping] quit
   ```

   # Create VLAN 100, and assign GigabitEthernet 1/0/1 through GigabitEthernet 1/0/3 to the VLAN.

   ```
   [SwitchA] vlan 100
   [SwitchA-vlan100] port gigabitethernet 1/0/1 to gigabitethernet 1/0/3
   ```

   # Enable MLD snooping, and enable dropping unknown IPv6 multicast data for VLAN 100.

   ```
   [SwitchA-vlan100] mld-snooping enable
   [SwitchA-vlan100] mld-snooping drop-unknown
   ```

   # Configure Switch A as the MLD snooping querier.

   ```
   [SwitchA-vlan100] MLD-snooping querier
   [SwitchA-vlan100] quit
   ```

2. Configure Switch B:

   # Enable the MLD snooping feature.

   ```
   <SwitchB> system-view
   [SwitchB] mld-snooping
   [SwitchB-mld-snooping] quit
   ```

   # Create VLAN 100, and assign GigabitEthernet 1/0/1 through GigabitEthernet 1/0/4 to the VLAN.

   ```
   [SwitchB] vlan 100
   [SwitchB-vlan100] port gigabitethernet 1/0/1 to gigabitethernet 1/0/4
   ```

   # Enable MLD snooping, and enable dropping unknown IPv6 multicast data for VLAN 100.

   ```
   [SwitchB-vlan100] mld-snooping enable
   [SwitchB-vlan100] mld-snooping drop-unknown
   [SwitchB-vlan100] quit
   ```

3. Configure Switch C:

   # Enable the MLD snooping feature.

   ```
   <SwitchC> system-view
   [SwitchC] mld-snooping
   [SwitchC-mld-snooping] quit
   ```

   # Create VLAN 100, and assign GigabitEthernet 1/0/1 through GigabitEthernet 1/0/3 to the VLAN.

   ```
   [SwitchC] vlan 100
   [SwitchC-vlan100] port gigabitethernet 1/0/1 to gigabitethernet 1/0/3
   ```

   # Enable MLD snooping, and enable dropping unknown IPv6 multicast data for VLAN 100.

   ```
   [SwitchC-vlan100] mld-snooping enable
   [SwitchC-vlan100] mld-snooping drop-unknown
   [SwitchC-vlan100] quit
   ```

4. Configure Switch D:

   # Enable the MLD snooping feature.

   ```
   <SwitchD> system-view
   [SwitchD] mld-snooping
   [SwitchD-mld-snooping] quit
   ```

Create VLAN 100, and assign GigabitEthernet 1/0/1 and GigabitEthernet 1/0/2 to the VLAN.

```
[SwitchD] vlan 100
[SwitchD-vlan100] port gigabitethernet 1/0/1 to gigabitethernet 1/0/2
```

Enable MLD snooping, and enable dropping unknown IPv6 multicast data for VLAN 100.

```
[SwitchD-vlan100] mld-snooping enable
[SwitchD-vlan100] mld-snooping drop-unknown
[SwitchD-vlan100] quit
```

Verifying the configuration

Display statistics for MLD messages and IPv6 PIM hello messages learned through MLD snooping on Switch B.

```
[SwitchB] display mld-snooping statistics
Received MLD general queries:  3
Received MLDv1 specific queries:  0
Received MLDv1 reports:  12
Received MLD dones:  0
Sent     MLDv1 specific queries:  0
Received MLDv2 reports:  0
Received MLDv2 reports with right and wrong records:  0
Received MLDv2 specific queries:  0
Received MLDv2 specific sg queries:  0
Sent     MLDv2 specific queries:  0
Sent     MLDv2 specific sg queries:  0
Received IPv6 PIM hello:  0
Received error MLD messages:  0
```

The output shows that all switches except Switch A can receive the MLD general queries after Switch A acts as the MLD snooping querier.

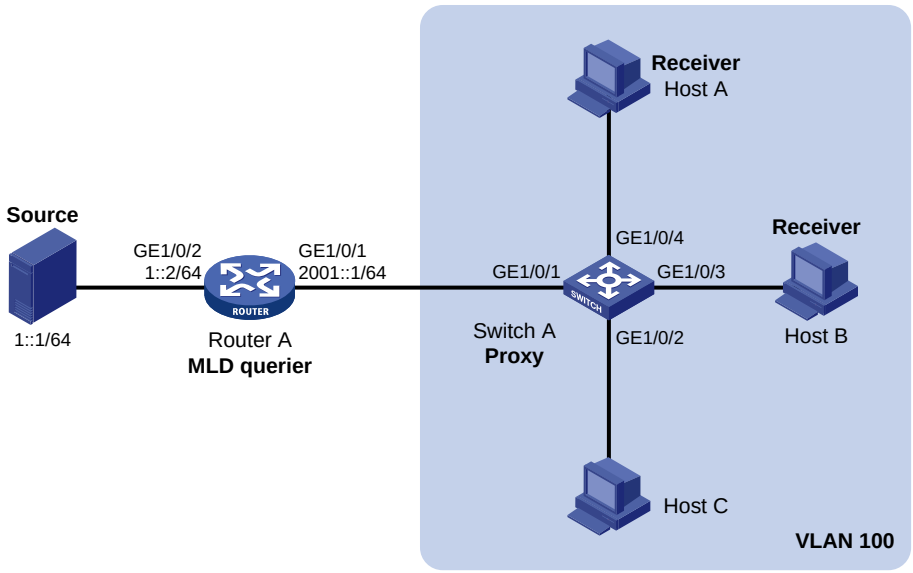
Example: Configuring VLAN-based MLD snooping proxying

Network configuration

As shown in Figure 7, Router A runs MLDv1 and acts as the MLD querier. Switch A runs MLDv1 snooping. Configure MLD snooping proxying so that Switch A can perform the following actions:

- Forward MLD report and done messages to Router A.
- Respond to MLD queries sent by Router A and forward the queries to downstream hosts.

Figure 7 Network diagram



Procedure

1. Assign an IPv6 address and subnet mask to each interface, as shown in Figure 7. (Details not shown.)
2. Configure Router A:

   # Enable IPv6 multicast routing.

   ```
   <RouterA> system-view
   [RouterA] ipv6 multicast routing
   [RouterA-mrib6] quit
   ```

   # Enable MLD and IPv6 PIM-DM on GigabitEthernet 1/0/1.

   ```
   [RouterA] interface gigabitethernet 1/0/1
   [RouterA-GigabitEthernet1/0/1] mld enable
   [RouterA-GigabitEthernet1/0/1] ipv6 pim dm
   [RouterA-GigabitEthernet1/0/1] quit
   ```

   # Enable IPv6 PIM-DM on GigabitEthernet 1/0/2.

   ```
   [RouterA] interface gigabitethernet 1/0/2
   [RouterA-GigabitEthernet1/0/2] ipv6 pim dm
   [RouterA-GigabitEthernet1/0/2] quit
   ```

3. Configure Switch A:

   # Enable the MLD snooping feature.

   ```
   <SwitchA> system-view
   [SwitchA] mld-snooping
   [SwitchA-mld-snooping] quit
   ```

   # Create VLAN 100, and assign GigabitEthernet 1/0/1 through GigabitEthernet 1/0/4 to the VLAN.

   ```
   [SwitchA] vlan 100
   [SwitchA-vlan100] port gigabitethernet 1/0/1 to gigabitethernet 1/0/4
   ```

   # Enable MLD snooping and MLD snooping proxying for the VLAN.

   ```
   [SwitchA-vlan100] mld-snooping enable
   [SwitchA-vlan100] mld-snooping proxy enable
   [SwitchA-vlan100] quit
   ```

Verifying the configuration

Send MLD reports from Host A and Host B to join IPv6 multicast group FF1E::101. (Details not shown.)

Display MLD snooping group entries on Switch A.

```
[SwitchA] display mld-snooping group
 Total 1 entries.

VLAN 100: Total 1 entries.
  (::, FF1E::101)
    Host ports (2 in total):
      GE1/0/3                                  (00:04:09)
      GE1/0/4                                  (00:03:06)
```

The output shows that GigabitEthernet 1/0/3 and GigabitEthernet 1/0/4 are member ports of IPv6 multicast group FF1E::101. Host A and Host B will receive IPv6 multicast data for the group.

Display MLD group membership information on Router A.

```
[RouterA] display mld group
MLD groups in total: 1
 GigabitEthernet1/0/1(2001::1):
  MLD groups reported in total: 1
   Group address: FF1E::101
    Last reporter: FE80::2FF:FFFF:FE00:1
    Uptime: 00:00:31
    Expires: 00:03:48
```

Send an MLD done message from Host A to leave IPv6 multicast group FF1E::101. (Details not shown.)

Display MLD snooping group entries on Switch A.

```
[SwitchA] display mld-snooping group
Total 1 entries.

VLAN 100: Total 1 entries.
  (::, FF1E::101)
    Host ports (1 in total):
      GE1/0/3                                  ( 00:01:23 )
```

The output shows that GigabitEthernet 1/0/3 is the only member port of IPv6 multicast group FF1E::101. Only Host B will receive IPv6 multicast data for the group.

Troubleshooting MLD snooping

Layer 2 multicast forwarding cannot function

Symptom

Layer 2 multicast forwarding cannot function through MLD snooping.

Solution

To resolve the problem:

1. Use the **display mld-snooping** command to display MLD snooping status.

2. If MLD snooping is not enabled, use the **mld-snooping** command in system view to enable the MLD snooping feature. Then, use the **mld-snooping enable** command in VLAN view to enable MLD snooping for the VLAN.
3. If MLD snooping is enabled globally but not enabled for the VLAN, use the **mld-snooping enable** command in VLAN view to enable MLD snooping for the VLAN.
4. If the problem persists, contact H3C Support.

IPv6 multicast group policy does not work

Symptom

Hosts can receive IPv6 multicast data for IPv6 multicast groups that are not permitted by the IPv6 multicast group policy.

Solution

To resolve the problem:

1. Use the **display acl ipv6** command to verify that the configured IPv6 ACL meets the IPv6 multicast group policy requirements.
2. Use the **display this** command in MLD-snooping view or in interface view to verify that the correct IPv6 multicast group policy has been applied. If the applied policy is not correct, use the **group-policy** or **mld-snooping group-policy** command to apply the correct IPv6 multicast group policy.
3. Use the **display mld-snooping** command to verify that dropping unknown IPv6 multicast data is enabled. If it is not, use the **mld-snooping drop-unknown** command to enable dropping unknown IPv6 multicast data.
4. If the problem persists, contact H3C Support.

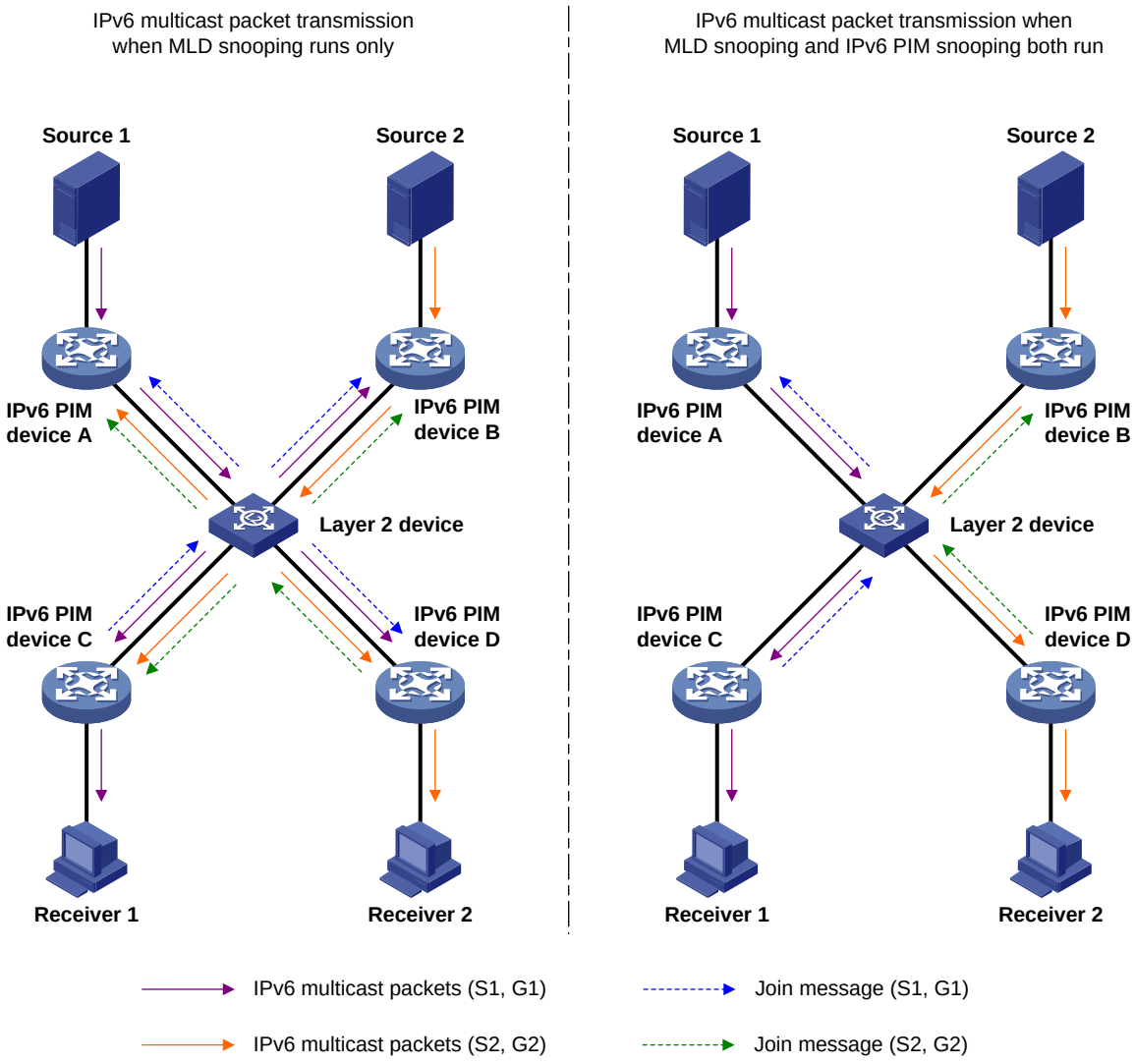
Contents

Configuring IPv6 PIM snooping

About IPv6 PIM snooping

IPv6 PIM snooping runs on Layer 2 devices. It works with MLD snooping to analyze received IPv6 PIM messages, and adds the ports that are interested in specific multicast data to an IPv6 PIM snooping routing entry. In this way, the multicast data can be forwarded to only the ports that are interested in the data.

Figure 1 Multicast packet transmission without or with IPv6 PIM snooping



As shown in Figure 1, Source 1 sends multicast data to multicast group G1, and Source 2 sends multicast data to multicast group G2. Receiver 1 belongs to G1, and Receiver 2 belongs to G2. The Layer 2 switch's interfaces that connect to the IPv6 PIM-capable routers are in the same VLAN.

- When the Layer 2 switch only runs MLD snooping, it performs the following actions:
  a. Maintains the router ports according to the received IPv6 PIM hello messages that IPv6 PIM-capable routers send.

b. Floods all other types of received IPv6 PIM messages except PIM hello messages in the VLAN.

c. Forwards all multicast data to all router ports in the VLAN.

Each IPv6 PIM-capable router in the VLAN, whether interested in the multicast data or not, can receive all multicast data and all IPv6 PIM messages except IPv6 PIM hello messages.

- When the Layer 2 switch runs both MLD snooping and IPv6 PIM snooping, it performs the following actions:

  a. Examines whether an IPv6 PIM router is interested in the multicast data destined for a multicast group according to the received IPv6 PIM messages that the router sends.

  b. Adds only the ports that connect to the router and are interested in the data to an IPv6 PIM snooping routing entry.

  c. Forwards IPv6 PIM messages and the multicast data only to the router according to the multicast forwarding entry, which saves network bandwidth.

For more information about MLD snooping and the router port, see "Configuring MLD snooping."

Restrictions and guidelines: IPv6 PIM snooping configuration

As a best practice, do not configure IPv6 PIM snooping for secondary VLANs because IPv6 PIM snooping does not take effect on secondary VLANs. For more information about secondary VLANs, see *Layer 2—LAN Switching Configuration Guide*.

After you enable IPv6 PIM snooping for a VLAN, IPv6 PIM snooping takes effect only on ports that belong to the VLAN.

IPv6 PIM snooping tasks at a glance

To configure IPv6 PIM snooping, perform the following tasks:

1. Enabling IPv6 PIM snooping
2. (Optional.) Setting the aging time for global ports after a master/subordinate switchover
   - Setting the aging time for global neighbor ports
   - Setting the aging time for global downstream ports and global router ports

Enabling IPv6 PIM snooping

1. Enter system view.
   system-view
2. Enable the MLD snooping feature and enter MLD -snooping view.
   mld-snooping
   By default, MLD snooping is disabled.
   For more information about this command, see *IP Multicast Command Reference*.
3. Return to system view.
   quit
4. Enter VLAN view.
   vlan *vlan-id*
5. Enable MLD snooping for the VLAN.

mld-snooping enable

By default, MLD snooping is disabled in a VLAN.

For more information about this command, see *IP Multicast Command Reference*.

6. Enable IPv6 PIM snooping for the VLAN.

   ipv6 pim-snooping enable

   By default, IPv6 PIM snooping is disabled in a VLAN.

Setting the aging time for global ports after a master/subordinate switchover

About global ports

A global port is a virtual port on the master device, such as a Layer 2 aggregate interface. A global port that acts as a neighbor port, downstream port, or router port is called a global neighbor port, global downstream port, and global router port, respectively.

Perform this task to decrease Layer 2 IPv6 multicast data interruption caused by the aging of IPv6 PIM snooping entries after a master/subordinate switchover.

Restrictions and guidelines

For a global neighbor port, the set aging time does not take effect when the port receives an IPv6 PIM hello message after a master/subordinate switchover. The aging time for the port is determined by the aging time in the IPv6 PIM hello message.

For a global router port or global downstream port, the set aging time does not take effect when the port receives an IPv6 PIM join message after a master/subordinate switchover. The aging time for the port is determined by the aging time in the IPv6 PIM join message.

Setting the aging time for global neighbor ports

1. Enter system view.

   system-view

2. Enter VLAN view.

   vlan *vlan-id*

3. Set the aging time for global neighbor ports after a master/subordinate switchover.

   pim-snooping graceful-restart neighbor-aging-time *seconds*

   By default, the aging time for global neighbor ports after a master/subordinate switchover is 105 seconds.

Setting the aging time for global downstream ports and global router ports

1. Enter system view.

   system-view

2. Enter VLAN view.

   vlan *vlan-id*

3. Set the aging time for global downstream ports and global router ports after a master/subordinate switchover.

   pim-snooping graceful-restart join-aging-time *seconds*

   By default, the aging time for downstream ports and global router ports after a master/subordinate switchover is 210 seconds.

Display and maintenance commands for IPv6 PIM snooping

Execute **display** commands in any view and **reset** commands in user view.

Task	Command
Display IPv6 PIM snooping neighbor information.	**display ipv6 pim-snooping neighbor** [**vlan** *vlan-id*] [**slot** *slot-number*] [**verbose**]
Display IPv6 PIM snooping router port information.	**display ipv6 pim-snooping router-port** [**vlan** *vlan-id*] [**slot** *slot-number*] [**verbose**]
Display IPv6 PIM snooping routing entries.	**display ipv6 pim-snooping routing-table** [**vlan** *vlan-id*] [**slot** *slot-number*] [**verbose**]
Display statistics for the IPv6 PIM messages learned through IPv6 PIM snooping.	**display ipv6 pim-snooping statistics**
Clear statistics for the IPv6 PIM messages learned through IPv6 PIM snooping.	**reset ipv6 pim-snooping statistics**

IPv6 PIM snooping configuration examples

Example: Configuring IPv6 PIM snooping

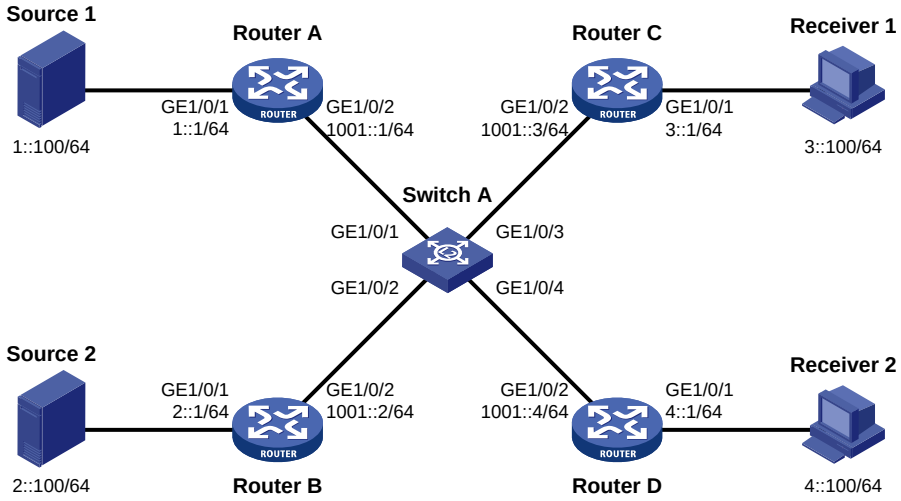
Network configuration

As shown in Figure 2:

- OSPFv3 runs on the network.
- Source 1 and Source 2 send IPv6 multicast data to IPv6 multicast groups FF1E::101 and FF2E::101, respectively.
- Receiver 1 and Receiver 2 belong to IPv6 multicast groups FF1E::101 and FF2E::101, respectively.
- Router C and Router D run MLD on GigabitEthernet 1/0/1.
- Router A, Router B, Router C, and Router D run IPv6 PIM-SM. GigabitEthernet 1/0/2 on Router A acts as a C-BSR and a C-RP.

Configure MLD snooping and IPv6 PIM snooping on Switch A. Then, Switch A forwards IPv6 PIM protocol packets and IPv6 multicast data packets only to routers that are connected to receivers.

Figure 2 Network diagram



Procedure

1. Assign an IPv6 address and prefix length to each interface, as shown in Figure 2. (Details not shown.)
2. Configure OSPFv3 on the routers. (Details not shown.)
3. Configure Router A:

   # Enable IPv6 multicast routing.

   ```
   <RouterA> system-view
   [RouterA] ipv6 multicast routing
   [RouterA-mrib6] quit
   ```

   # Enable IPv6 PIM-SM on each interface.

   ```
   [RouterA] interface gigabitethernet 1/0/1
   [RouterA-GigabitEthernet1/0/1] ipv6 pim sm
   [RouterA-GigabitEthernet1/0/1] quit
   [RouterA] interface gigabitethernet 1/0/2
   [RouterA-GigabitEthernet1/0/2] ipv6 pim sm
   [RouterA-GigabitEthernet1/0/2] quit
   ```

   # Configure GigabitEthernet 1/0/2 as a C-BSR and a C-RP.

   ```
   [RouterA] ipv6 pim
   [RouterA-pim6] c-bsr 1001::1
   [RouterA-pim6] c-rp 1001::1
   [RouterA-pim6] quit
   ```

4. Configure Router B:

   # Enable IPv6 multicast routing.

   ```
   <RouterB> system-view
   [RouterB] ipv6 multicast routing
   [RouterB-mrib6] quit
   ```

   # Enable IPv6 PIM-SM on each interface.

   ```
   [RouterB] interface gigabitethernet 1/0/1
   [RouterB-GigabitEthernet1/0/1] ipv6 pim sm
   [RouterB-GigabitEthernet1/0/1] quit
   [RouterB] interface gigabitethernet 1/0/2
   ```

```
[RouterB-GigabitEthernet1/0/2] ipv6 pim sm
[RouterB-GigabitEthernet1/0/2] quit
```

5. Configure Router C:

Enable IPv6 multicast routing.

```
<RouterC> system-view
[RouterC] ipv6 multicast routing
[RouterC-mrib6] quit
```

Enable MLD on GigabitEthernet 1/0/1.

```
[RouterC] interface gigabitethernet 1/0/1
[RouterC-GigabitEthernet1/0/1] mld enable
[RouterC-GigabitEthernet1/0/1] quit
```

Enable IPv6 PIM-SM on GigabitEthernet 1/0/2.

```
[RouterC] interface gigabitethernet 1/0/2
[RouterC-GigabitEthernet1/0/2] ipv6 pim sm
[RouterC-GigabitEthernet1/0/2] quit
```

6. Configure Router D:

Enable IPv6 multicast routing.

```
<RouterD> system-view
[RouterD] ipv6 multicast routing
[RouterD-mrib6] quit
```

Enable MLD on GigabitEthernet 1/0/1.

```
[RouterD] interface gigabitethernet 1/0/1
[RouterD-GigabitEthernet1/0/1] mld enable
[RouterD-GigabitEthernet1/0/1] quit
```

Enable IPv6 PIM-SM on GigabitEthernet 1/0/2.

```
[RouterD] interface gigabitethernet 1/0/2
[RouterD-GigabitEthernet1/0/2] ipv6 pim sm
[RouterD-GigabitEthernet1/0/2] quit
```

7. Configure Switch A:

Enable the MLD snooping feature.

```
<SwitchA> system-view
[SwitchA] mld-snooping
[SwitchA-mld-snooping] quit
```

Create VLAN 100, and assign GigabitEthernet 1/0/1 through GigabitEthernet 1/0/4 to the VLAN.

```
[SwitchA] vlan 100
[SwitchA-vlan100] port gigabitethernet 1/0/1 to gigabitethernet 1/0/4
```

Enable MLD snooping and IPv6 PIM snooping for VLAN 100.

```
[SwitchA-vlan100] mld-snooping enable
[SwitchA-vlan100] ipv6 pim-snooping enable
[SwitchA-vlan100] quit
```

Verifying the configuration

On Switch A, display IPv6 PIM snooping neighbor information for VLAN 100.

```
[SwitchA] display ipv6 pim-snooping neighbor vlan 100
Total 4 neighbors.

VLAN 100: Total 4 neighbors.
```

```
  FE80::1
    Ports (1 in total):
      GE1/0/1                 (00:32:43)
  FE80::2
   Ports (1 in total):
      GE1/0/2                 (00:32:43)
  FE80::3
    Ports (1 in total):
      GE1/0/3                 (00:32:43)
  FE80::4
    Ports (1 in total):
      GE1/0/4                 (00:32:43)
```

The output shows that Router A, Router B, Router C, and Router D are IPv6 PIM snooping neighbors.

On Switch A, display IPv6 PIM snooping routing entries for VLAN 100.

```
[SwitchA] display ipv6 pim-snooping routing-table vlan 100
Total 2 entries.
FSM flag: NI-no info, J-join, PP-prune pending

VLAN 100: Total 2 entries.
  (*, FF1E::101)
    Upstream neighbor: FE80::1
      Upstream ports (1 in total):
        GE1/0/1
      Downstream ports (1 in total):
        GE1/0/3
          Expires: 00:03:01, FSM: J
  (*, FF2E::101)
    Upstream neighbor: FE80::2
      Upstream ports (1 in total):
        GE1/0/2
      Downstream ports (1 in total):
        GE1/0/4
          Expires: 00:03:01, FSM: J
```

The output shows the following information:

- Switch A will forward the multicast data intended for IPv6 multicast group FF1E::101 to only Router C.
- Switch A will forward the multicast data intended for IPv6 multicast group FF2E::101 to only Router D.

Troubleshooting IPv6 PIM snooping

This section describes common IPv6 PIM snooping problems and how to troubleshoot them.

IPv6 PIM snooping does not work on a Layer 2 device

Symptom

IPv6 PIM snooping does not work on a Layer 2 device.

Solution

To resolve the problem:

1. Use the **`display current-configuration`** command to display information about MLD snooping and IPv6 PIM snooping.
2. If MLD snooping is not enabled, enable the MLD snooping feature, and then enable MLD snooping and IPv6 PIM snooping for the VLAN.
3. If IPv6 PIM snooping is not enabled, enable IPv6 PIM snooping for the VLAN.
4. If the problem persists, contact H3C Support.

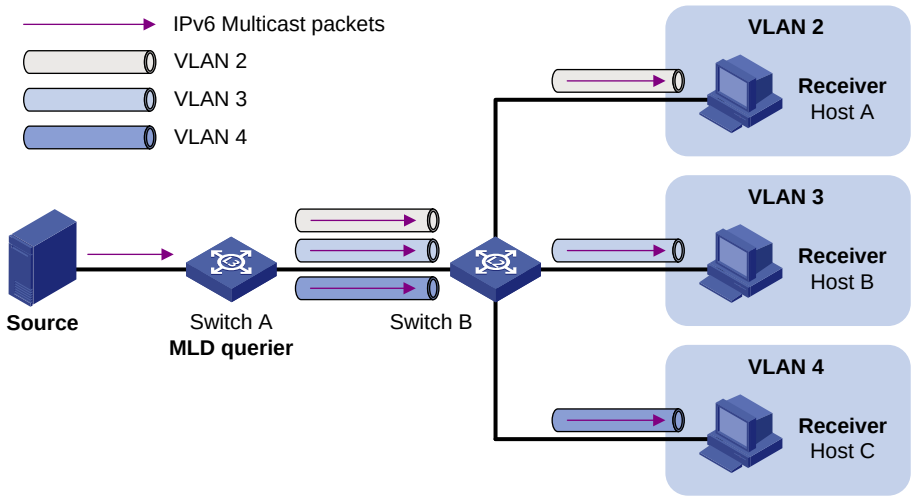
Contents

Configuring IPv6 multicast VLANs

IPv6 multicast VLAN feature

As shown in Figure 1, Host A, Host B, and Host C are in different VLANs and the same IPv6 multicast group. When Switch A (Layer 3 device) receives IPv6 multicast data for that group, it forwards three copies of the data to Switch B (Layer 2 device). This occupies a large amount of bandwidth and increases the burden on the Layer 3 device.

Figure 1 Multicast transmission without the IPv6 multicast VLAN feature



After an IPv6 multicast VLAN is configured on Switch B, Switch A sends one copy of the IPv6 multicast data to the IPv6 multicast VLAN on Switch B. This saves network bandwidth and lessens the burden on the Layer 3 device.

IPv6 multicast VLAN methods

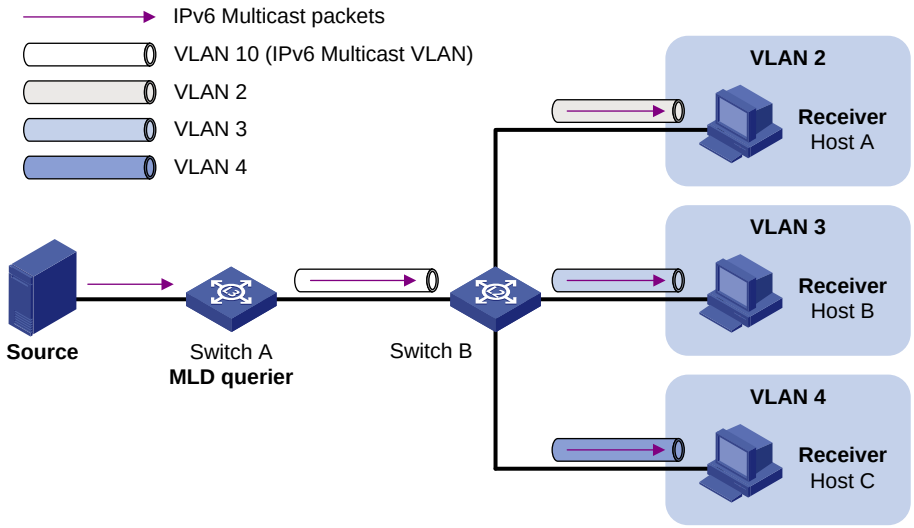
IPv6 multicast VLANs support sub-VLAN-based IPv6 multicast VLANs and port-based IPv6 multicast VLANs.

Sub-VLAN-based IPv6 multicast VLAN

As shown in Figure 2:

- Host A, Host B, and Host C are in VLAN 2 through VLAN 4, respectively.
- On Switch B, VLAN 10 is an IPv6 multicast VLAN. VLAN 2 through VLAN 4 are sub-VLANs of VLAN 10.
- MLD snooping is enabled for the multicast VLAN and its sub-VLANs.

Figure 2 Sub-VLAN-based multicast VLAN



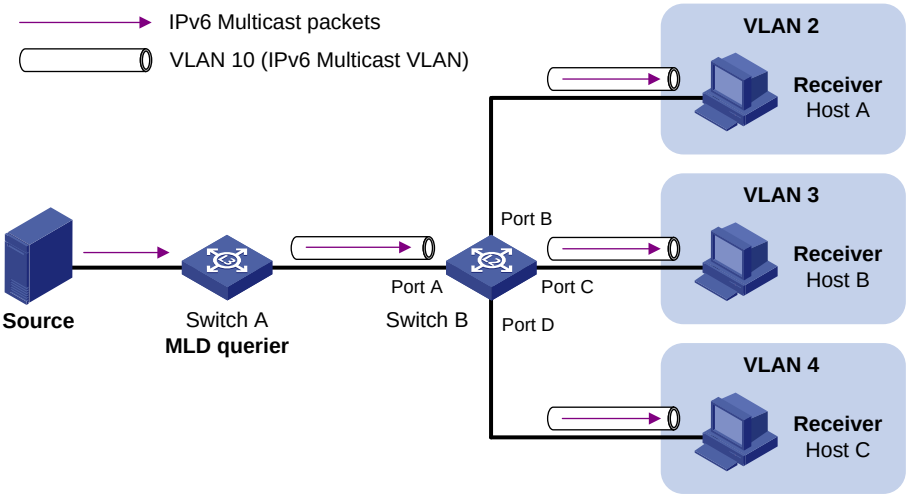
MLD snooping manages router ports in the IPv6 multicast VLAN and member ports in each sub-VLAN. When Switch A receives IPv6 multicast data from the IPv6 multicast source, it sends only one copy of the IPv6 multicast data to the IPv6 multicast VLAN on Switch B. Then, Switch B sends a separate copy to each sub-VLAN of the IPv6 multicast VLAN.

Port-based IPv6 multicast VLAN

As shown in Figure 3:

- Host A, Host B, and Host C are in VLAN 2 through VLAN 4, respectively. All the user ports (ports with attached hosts) on Switch B are hybrid ports.
- On Switch B, VLAN 10 is an IPv6 multicast VLAN. All the user ports are assigned to VLAN 10.
- MLD snooping is enabled for the IPv6 multicast VLAN and its sub-VLANs.

Figure 3 Port-based IPv6 multicast VLAN



MLD snooping manages the router ports and member ports in the IPv6 multicast VLAN. When Switch A receives IPv6 multicast data from the IPv6 multicast source, it sends only one copy of the IPv6 multicast data to the IPv6 multicast VLAN on Switch B. Then, Switch B sends a separate copy to each user port in the IPv6 multicast VLAN.

Restrictions and guidelines: IPv6 multicast VLAN configuration

The VLAN to be configured as an IPv6 multicast VLAN must exist.

If you have configured both a sub-VLAN-based IPv6 multicast VLAN and a port-based IPv6 multicast VLAN on a device, the port-based IPv6 multicast VLAN configuration takes effect.

The IPv6 multicast VLAN feature does not take effect on secondary VLANs. As a best practice, do not configure the IPv6 multicast VLAN feature for secondary VLANs. For more information about secondary VLAN, see *Layer 2—LAN Switching Configuration Guide.*

Configuring a sub-VLAN-based IPv6 multicast VLAN

Restrictions and guidelines

The VLANs to be configured as sub-VLANs of an IPv6 multicast VLAN must exist and cannot be IPv6 multicast VLANs or sub-VLANs of any other IPv6 multicast VLANs.

Prerequisites

Before you configure a sub-VLAN-based IPv6 multicast VLAN, you must complete the following tasks:

- Create VLANs as required.
- Enable MLD snooping for the VLAN to be configured as the IPv6 multicast VLAN, and for the VLANs to be configured as sub-VLANs.

Procedure

1. Enter system view.

   system-view
2. Configure a VLAN as an IPv6 multicast VLAN and enter IPv6 multicast VLAN view.

   ipv6 multicast-vlan *vlan-id*

   By default, a VLAN is not an IPv6 multicast VLAN.
3. Assign VLANs to the IPv6 multicast VLAN as sub-VLANs.

   subvlan *vlan-list*

   By default, an IPv6 multicast VLAN does not have any sub-VLANs.

Configuring a port-based IPv6 multicast VLAN

Restrictions and guidelines

You can assign user ports to an IPv6 multicast VLAN in IPv6 multicast VLAN view or assign a user port to an IPv6 multicast VLAN in interface view.

A user port can belong to only one IPv6 multicast VLAN.

Prerequisites

Before you configure a port-based IPv6 multicast VLAN, you must complete the following tasks:

- Create VLANs as required.
- Enable MLD snooping for the VLAN to be configured as the IPv6 multicast VLAN.

- Enable MLD snooping for all the VLANs that contain the multicast receivers.
- Configure the attributes of user ports. Make sure the ports can forward packets from the VLAN to be configured as the IPv6 multicast VLAN and send the packets with the VLAN tag removed. For more information about configuring port attributes, see VLAN configuration in *Layer 2—LAN Switching Configuration Guide*.

Assigning user ports to an IPv6 multicast VLAN in IPv6 multicast VLAN view

1. Enter system view.
   system-view
2. Configure an IPv6 VLAN as an IPv6 multicast VLAN and enter IPv6 multicast VLAN view.
   ipv6 multicast-vlan *vlan-id*
   By default, a VLAN is not an IPv6 multicast VLAN.
3. Assign ports to the IPv6 multicast VLAN as user ports.
   port *interface-list*

Assigning user ports to an IPv6 multicast VLAN in interface view

1. Enter system view.
   system-view
2. Configure an IPv6 VLAN as an IPv6 multicast VLAN and enter IPv6 multicast VLAN view.
   ipv6 multicast-vlan *vlan-id*
   By default, a VLAN is not an IPv6 multicast VLAN.
3. Return to system view.
   quit
4. Enter Layer 2 interface view.
   - Enter Layer 2 Ethernet interface view.
     interface *interface-type interface-number*
   - Enter Layer 2 aggregate interface view.
     interface bridge-aggregation *interface-number*
5. Assign the port to the IPv6 multicast VLAN as a user port.
   ipv6 port multicast-vlan *vlan-id*
   By default, a port does not belong to any IPv6 multicast VLAN.

Setting the maximum number of IPv6 multicast VLAN forwarding entries

About setting the maximum number of IPv6 multicast VLAN forwarding entries

You can set the maximum number of IPv6 multicast VLAN forwarding entries on the device. When the upper limit is reached, the device does not create IPv6 multicast VLAN forwarding entries until some entries age out or are manually removed.

Procedure

1. Enter system view.
   system-view
2. Set the maximum number of IPv6 multicast VLAN forwarding entries.
   ipv6 multicast-vlan entry-limit *limit*
   The default setting varies by device model. For more information, see the command reference.

Display and maintenance commands for IPv6 multicast VLANs

Execute **display** commands in any view and **reset** commands in user view.

Task	Command
Display information about IPv6 multicast VLANs.	**display ipv6 multicast-vlan** [*vlan-id*]
Display IPv6 multicast VLAN forwarding entries.	**display ipv6 multicast-vlan forwarding-table** [*ipv6-source-address* [*prefix-length*] | *ipv6-group-address* [*prefix-length*] | **slot** *slot-number* | **subvlan** *vlan-id* | **vlan** *vlan-id*] *
Display information about information about IPv6 multicast group entries in IPv6 multicast VLANs.	**display ipv6 multicast-vlan group** [*ipv6-source-address* | *ipv6-group-address* | **slot** *slot-number* | **verbose** | **vlan** *vlan-id*] *
Clear IPv6 multicast group entries in IPv6 multicast VLANs.	**reset ipv6 multicast-vlan group** [*ipv6-group-address* [*prefix-length*] | *ipv6-source-address* [*prefix-length*] | **vlan** *vlan-id*] *

IPv6 multicast VLAN configuration examples

Example: Configuring sub-VLAN-based IPv6 multicast VLAN

Network configuration

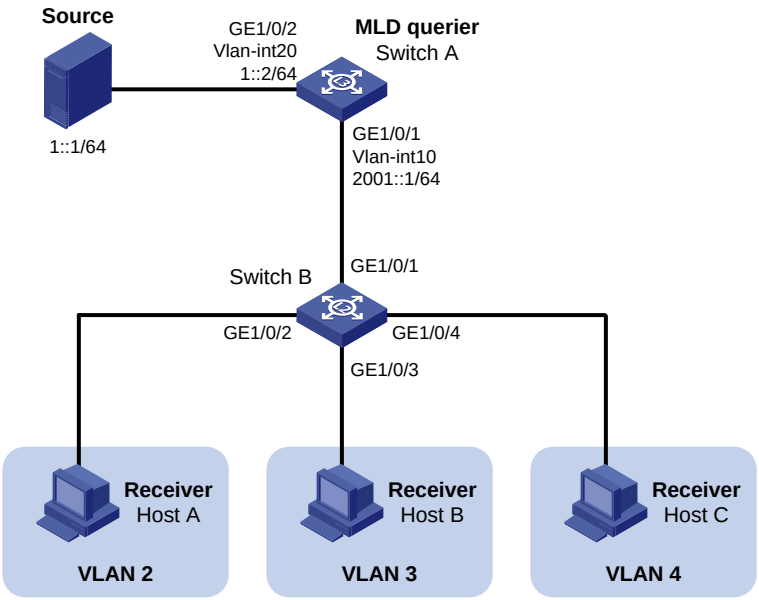
As shown in Figure 4:

- Layer 3 device Switch A runs MLD and acts as the MLD querier. Layer 2 device Switch B runs MLDv1 snooping.
- The IPv6 multicast source sends IPv6 multicast data to IPv6 multicast group FF1E::101. Receivers Host A, Host B, and Host C belong to VLAN 2, VLAN 3, and VLAN 4, respectively.

Configure a sub-VLAN-based IPv6 multicast VLAN on Switch B to meet the following requirements:

- Switch A sends the IPv6 multicast data to Switch B through the IPv6 multicast VLAN.
- Switch B forwards the IPv6 multicast data to the receivers in different user VLANs.

Figure 4 Network diagram



Procedure

1. Configure Switch A:

Enable IPv6 multicast routing.

```
<SwitchA> system-view
[SwitchA] ipv6 multicast routing
[SwitchA-mrib6] quit
```

Create VLAN 20, and assign GigabitEthernet 1/0/2 to the VLAN.

```
[SwitchA] vlan 20
[SwitchA-vlan20] port gigabitethernet 1/0/2
[SwitchA-vlan20] quit
```

Assign an IPv6 address to VLAN-interface 20, and enable IPv6 PIM-DM on the interface.

```
[SwitchA] interface vlan-interface 20
[SwitchA-Vlan-interface20] ipv6 address 1::2 64
[SwitchA-Vlan-interface20] ipv6 pim dm
[SwitchA-Vlan-interface20] quit
```

Create VLAN 10.

```
[SwitchA] vlan 10
[SwitchA-vlan10] quit
```

Configure GigabitEthernet 1/0/1 as a hybrid port, and assign the port to VLAN 10 as a tagged VLAN member.

```
[SwitchA] interface gigabitethernet 1/0/1
[SwitchA-GigabitEthernet1/0/1] port link-type hybrid
[SwitchA-GigabitEthernet1/0/1] port hybrid vlan 10 tagged
[SwitchA-GigabitEthernet1/0/1] quit
```

Assign an IPv6 address to VLAN-interface 10, and enable MLD on the interface.

```
[SwitchA] interface vlan-interface 10
[SwitchA-Vlan-interface10] ipv6 address 2001::1 64
[SwitchA-Vlan-interface10] mld enable
[SwitchA-Vlan-interface10] quit
```

2. Configure Switch B:

Enable the MLD snooping feature.

```
<SwitchB> system-view
[SwitchB] mld-snooping
[SwitchB-mld-snooping] quit
```

Create VLAN 2, assign GigabitEthernet 1/0/2 to the VLAN, and enable MLD snooping for the VLAN.

```
[SwitchB] vlan 2
[SwitchB-vlan2] port gigabitethernet 1/0/2
[SwitchB-vlan2] mld-snooping enable
[SwitchB-vlan2] quit
```

Create VLAN 3, assign GigabitEthernet 1/0/3 to the VLAN, and enable MLD snooping for the VLAN.

```
[SwitchB] vlan 3
[SwitchB-vlan3] port gigabitethernet 1/0/3
[SwitchB-vlan3] mld-snooping enable
[SwitchB-vlan3] quit
```

Create VLAN 4, assign GigabitEthernet 1/0/4 to the VLAN, and enable MLD snooping for the VLAN.

```
[SwitchB] vlan 4
[SwitchB-vlan4] port gigabitethernet 1/0/4
[SwitchB-vlan4] mld-snooping enable
[SwitchB-vlan4] quit
```

Create VLAN 10, and enable MLD snooping for the VLAN.

```
[SwitchB] vlan 10
[SwitchB-vlan10] mld-snooping enable
[SwitchB-vlan10] quit
```

Configure GigabitEthernet 1/0/1 as a hybrid port, and assign the port to VLAN 10 as a tagged VLAN member.

```
[SwitchB] interface gigabitethernet 1/0/1
[SwitchB-GigabitEthernet1/0/1] port link-type hybrid
[SwitchB-GigabitEthernet1/0/1] port hybrid vlan 10 tagged
[SwitchB-GigabitEthernet1/0/1] quit
```

Configure VLAN 10 as an IPv6 multicast VLAN, and assign VLAN 2 through VLAN 4 as sub-VLANs to multicast VLAN 10.

```
[SwitchB] ipv6 multicast-vlan 10
[SwitchB-ipv6-mvlan-10] subvlan 2 to 4
[SwitchB-ipv6-mvlan-10] quit
```

Verifying the configuration

Display information about all IPv6 multicast VLANs on Switch B.

```
[SwitchB] display ipv6 multicast-vlan
Total 1 IPv6 multicast VLANs.

IPv6 multicast VLAN 10:
  Sub-VLAN list(3 in total):
     2-4
  Port list(0 in total):
```

Display information about IPv6 multicast groups in IPv6 multicast VLANs on Switch B.

```
[SwitchB] display ipv6 multicast-vlan group
Total 1 entries.

IPv6 multicast VLAN 10: Total 1 entries.
  (::, FF1E::101)
    Sub-VLANs (3 in total):
      VLAN 2
      VLAN 3
      VLAN 4
```

The output shows that IPv6 multicast group FF1E::101 belongs to IPv6 multicast VLAN 10. IPv6 multicast VLAN 10 contains sub-VLANs VLAN 2 through VLAN 4. Switch B will replicate the IPv6 multicast data of VLAN 10 to VLAN 2 through VLAN 4.

Example: Configuring port-based IPv6 multicast VLAN

Network configuration

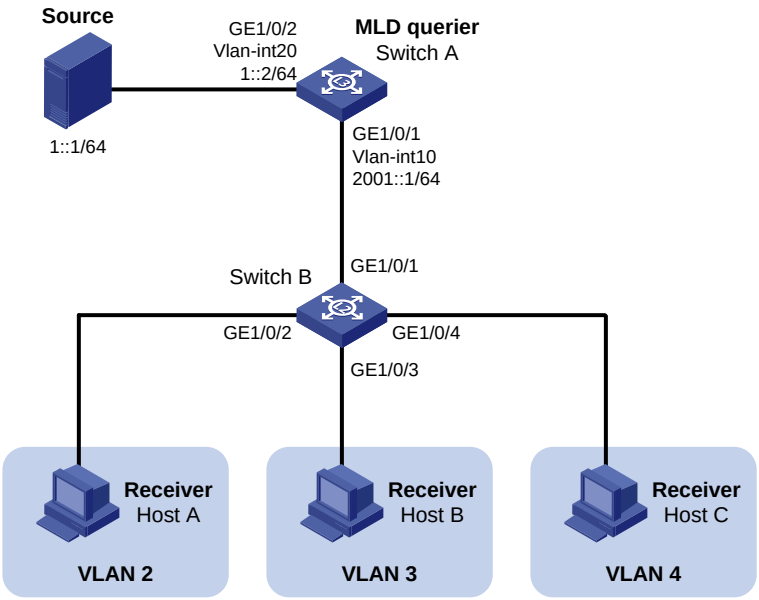
As shown in Figure 5:

- Layer 3 device Switch A runs MLDv1 and acts as the MLD querier. Layer 2 device Switch B runs MLDv1 snooping.
- The IPv6 multicast source sends IPv6 multicast data to IPv6 multicast group FF1E::101. Receivers Host A, Host B, and Host C belong to VLAN 2, VLAN 3, and VLAN 4, respectively.

Configure a port-based IPv6 multicast VLAN on Switch B to meet the following requirements:

- Switch A sends IPv6 multicast data to Switch B through the IPv6 multicast VLAN.
- Switch B forwards the IPv6 multicast data to the receivers in different user VLANs.

Figure 5 Network diagram



Procedure

1. Configure Switch A:

   # Enable IPv6 multicast routing.

   ```
   <SwitchA> system-view
   ```

```
[SwitchA] ipv6 multicast routing
[SwitchA-mrib6] quit
```

Create VLAN 20, and assign GigabitEthernet 1/0/2 to the VLAN.

```
[SwitchA] vlan 20
[SwitchA-vlan20] port gigabitethernet 1/0/2
[SwitchA-vlan20] quit
```

Assign an IPv6 address to VLAN-interface 20, and enable IPv6 PIM-DM on the interface.

```
[SwitchA] interface vlan-interface 20
[SwitchA-Vlan-interface20] ipv6 address 1::2 64
[SwitchA-Vlan-interface20] ipv6 pim dm
[SwitchA-Vlan-interface20] quit
```

Create VLAN 10, and assign GigabitEthernet 1/0/1 to the VLAN.

```
[SwitchA] vlan 10
[SwitchA-vlan10] port gigabitethernet 1/0/1
[SwitchA-vlan10] quit
```

Assign an IPv6 address to VLAN-interface 10, and enable MLD on the interface.

```
[SwitchA] interface vlan-interface 10
[SwitchA-Vlan-interface10] ipv6 address 2001::1 64
[SwitchA-Vlan-interface10] mld enable
[SwitchA-Vlan-interface10] quit
```

2. Configure Switch B:

Enable the MLD snooping feature.

```
<SwitchB> system-view
[SwitchB] mld-snooping
[SwitchB-mld-snooping] quit
```

Create VLAN 10, assign GigabitEthernet 1/0/1 to the VLAN, and enable MLD snooping for the VLAN.

```
[SwitchB] vlan 10
[SwitchB-vlan10] port gigabitethernet 1/0/1
[SwitchB-vlan10] mld-snooping enable
[SwitchB-vlan10] quit
```

Create VLAN 2, and enable MLD snooping for the VLAN.

```
[SwitchB] vlan 2
[SwitchB-vlan2] mld-snooping enable
[SwitchB-vlan2] quit
```

Create VLAN 3, and enable MLD snooping for the VLAN.

```
[SwitchB] vlan 3
[SwitchB-vlan3] mld-snooping enable
[SwitchB-vlan3] quit
```

Create VLAN 4, and enable MLD snooping for the VLAN.

```
[SwitchB] vlan 4
[SwitchB-vlan4] mld-snooping enable
[SwitchB-vlan4] quit
```

Configure GigabitEthernet 1/0/2 as a hybrid port, and configure VLAN 2 as the PVID of the hybrid port.

```
[SwitchB] interface gigabitethernet 1/0/2
[SwitchB-GigabitEthernet1/0/2] port link-type hybrid
[SwitchB-GigabitEthernet1/0/2] port hybrid pvid vlan 2
```

Assign GigabitEthernet 1/0/2 to VLAN 2 and VLAN 10 as an untagged VLAN member.

```
[SwitchB-GigabitEthernet1/0/2] port hybrid vlan 2 untagged
[SwitchB-GigabitEthernet1/0/2] port hybrid vlan 10 untagged
[SwitchB-GigabitEthernet1/0/2] quit
```

Configure GigabitEthernet 1/0/3 as a hybrid port, and configure VLAN 3 as the PVID of the hybrid port.

```
[SwitchB] interface gigabitethernet 1/0/3
[SwitchB-GigabitEthernet1/0/3] port link-type hybrid
[SwitchB-GigabitEthernet1/0/3] port hybrid pvid vlan 3
```

Assign GigabitEthernet 1/0/3 to VLAN 3 and VLAN 10 as an untagged VLAN member.

```
[SwitchB-GigabitEthernet1/0/3] port hybrid vlan 3 untagged
[SwitchB-GigabitEthernet1/0/3] port hybrid vlan 10 untagged
[SwitchB-GigabitEthernet1/0/3] quit
```

Configure GigabitEthernet 1/0/4 as a hybrid port, and configure VLAN 4 as the PVID of the hybrid port.

```
[SwitchB] interface gigabitethernet 1/0/4
[SwitchB-GigabitEthernet1/0/4] port link-type hybrid
[SwitchB-GigabitEthernet1/0/4] port hybrid pvid vlan 4
```

Assign GigabitEthernet 1/0/4 to VLAN 4 and VLAN 10 as an untagged VLAN member.

```
[SwitchB-GigabitEthernet1/0/4] port hybrid vlan 4 untagged
[SwitchB-GigabitEthernet1/0/4] port hybrid vlan 10 untagged
[SwitchB-GigabitEthernet1/0/4] quit
```

Configure VLAN 10 as an IPv6 multicast VLAN.

```
[SwitchB] ipv6 multicast-vlan 10
```

Assign GigabitEthernet 1/0/2 and GigabitEthernet 1/0/3 to VLAN 10.

```
[SwitchB-ipv6-mvlan-10] port gigabitethernet 1/0/2 to gigabitethernet 1/0/3
[SwitchB-ipv6-mvlan-10] quit
```

Assign GigabitEthernet 1/0/4 to VLAN 10.

```
[SwitchB] interface gigabitethernet 1/0/4
[SwitchB-GigabitEthernet1/0/4] ipv6 port multicast-vlan 10
[SwitchB-GigabitEthernet1/0/4] quit
```

Verifying the configuration

Display information about IPv6 multicast VLANs on Switch B.

```
[SwitchB] display ipv6 multicast-vlan
Total 1 IPv6 multicast VLANs.

IPv6 multicast VLAN 10:
  Sub-VLAN list(0 in total):
  Port list(3 in total):
    GE1/0/2
    GE1/0/3
    GE1/0/4
```

Display dynamic MLD snooping forwarding entries on Switch B.

```
[SwitchB] display mld-snooping group
Total 1 entries.

VLAN 10: Total 1 entries.
```

```
(::, FF1E::101)
  Host slots (0 in total):
  Host ports (3 in total):
    GE1/0/2         (00:03:23)
    GE1/0/3         (00:04:07)
    GE1/0/4         (00:04:16)
```

The output shows that MLD snooping maintains the user ports in the multicast VLAN (VLAN 10). Switch B will forward the IPv6 multicast data of VLAN 10 through these user ports.

ACL and QoS Configuration Guide

This command reference is applicable to the following switches and software versions:

H3C S5120V2-LI switch series (Release 6308P01 and later)
H3C S3100V3-SI switch series (Release 6309P01 and later)
H3C S5110V2 switch series (Release 6310 and later)
H3C S5110V2-SI switch series (Release 6310 and later)
H3C S5000V3-EI switch series (Release 6310 and later)
H3C S5000V5-EI switch series (Release 6319P01 and later)
H3C S5000E-X switch series (Release 6310 and later)
H3C S5130S-LI switch series (Release 6310 and later)
H3C MS4320V2 switch series (Release 6308P01 and later)
H3C MS4320 switch series (Release 6308P01 and later)
H3C MS4300V2 switch series (Release 6308P01 and later)
H3C MS4200 switch series (Release 6310 and later)
H3C WS5810-WiNet switch series (Release 6308P01 and later)
H3C WS5820-WiNet switch series (Release 6308P01 and later)
H3C WAS6000 switch series (Release 6308P01 and later)
H3C S5000X-EI switch series (Release 6329 and later)
H3C MS4320V3 switch series (Release 6329 and later)
H3C S5120V3-SI switch series (Release 6329 and later)
H3C S5120V3-LI switch series (Release 6329 and later)

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Software version: Release 63xx
Document version: 6W105-20230524

Preface

This configuration guide describes ACL and QoS fundamentals and configuration procedures, including ACL, QoS, data buffer, and time range.

This preface includes the following topics about the documentation:

Audience

This documentation is intended for:

- Network planners.
- Field technical support and servicing engineers.
- Network administrators.

Conventions

The following information describes the conventions used in the documentation.

Command conventions

Convention	Description
Boldface	**Bold** text represents commands and keywords that you enter literally as shown.
Italic	*Italic* text represents arguments that you replace with actual values.
[ ]	Square brackets enclose syntax choices (keywords or arguments) that are optional.
{ x | y | ... }	Braces enclose a set of required syntax choices separated by vertical bars, from which you select one.
[x | y | ...]	Square brackets enclose a set of optional syntax choices separated by vertical bars, from which you select one or none.
{ x | y | ... } *	Asterisk marked braces enclose a set of required syntax choices separated by vertical bars, from which you select a minimum of one.
[x | y | ...] *	Asterisk marked square brackets enclose optional syntax choices separated by vertical bars, from which you select one choice, multiple choices, or none.
&<1-n>	The argument or keyword and argument combination before the ampersand (&) sign can be entered 1 to n times.
#	A line that starts with a pound (#) sign is comments.

GUI conventions

Convention	Description
Boldface	Window names, button names, field names, and menu items are in Boldface. For example, the **New User** window opens; click **OK**.
>	Multi-level menus are separated by angle brackets. For example, **File** > **Create** > **Folder**.

Symbols

Convention	Description
WARNING!	An alert that calls attention to important information that if not understood or followed can result in personal injury.
CAUTION:	An alert that calls attention to important information that if not understood or followed can result in data loss, data corruption, or damage to hardware or software.
IMPORTANT:	An alert that calls attention to essential information.
NOTE:	An alert that contains additional or supplementary information.
TIP:	An alert that provides helpful information.

Network topology icons

Convention	Description
	Represents a generic network device, such as a router, switch, or firewall.
	Represents a routing-capable device, such as a router or Layer 3 switch.
	Represents a generic switch, such as a Layer 2 or Layer 3 switch, or a router that supports Layer 2 forwarding and other Layer 2 features.
	Represents an access controller, a unified wired-WLAN module, or the access controller engine on a unified wired-WLAN switch.
	Represents an access point.
	Represents a wireless terminator unit.
	Represents a wireless terminator.
	Represents a mesh access point.
	Represents omnidirectional signals.
	Represents directional signals.
	Represents a security product, such as a firewall, UTM, multiservice security gateway, or load balancing device.
	Represents a security module, such as a firewall, load balancing, NetStream, SSL VPN, IPS, or ACG module.

Examples provided in this document

Examples in this document might use devices that differ from your device in hardware model, configuration, or software version. It is normal that the port numbers, sample output, screenshots, and other information in the examples differ from what you have on your device.

Documentation feedback

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Contents

Configuring ACLs

About ACLs

An access control list (ACL) is a set of rules for identifying traffic based on criteria such as source IP address, destination IP address, and port number. The rules are also called permit or deny statements.

ACLs are primarily used for packet filtering. You can also use ACLs in QoS, security, routing, and other modules for identifying traffic. The packet drop or forwarding decisions depend on the modules that use ACLs.

Numbering and naming ACLs

When creating an ACL, you must assign it a number or name for identification. You can specify an existing ACL by its number or name. Each ACL type has a unique range of ACL numbers.

For basic or advanced ACLs with the same number, you must use the **`ipv6`** keyword to distinguish them. For ACLs with the same name, you must use the **`ipv6`** or **`mac`** keywords to distinguish them.

ACL types

Type	ACL number	IP version	Match criteria
Basic ACLs	2000 to 2999	IPv4	Source IPv4 address.
		IPv6	Source IPv6 address.
Advanced ACLs	3000 to 3999	IPv4	Source IPv4 address, destination IPv4 address, packet priority, protocol number, and other Layer 3 and Layer 4 header fields.
		IPv6	Source IPv6 address, destination IPv6 address, packet priority, protocol number, and other Layer 3 and Layer 4 header fields.
Layer 2 ACLs	4000 to 4999	IPv4 and IPv6	Layer 2 header fields, such as source and destination MAC addresses, 802.1p priority, and link layer protocol type.

Match order

The rules in an ACL are sorted in a specific order. When a packet matches a rule, the device stops the match process and performs the action defined in the rule. If an ACL contains overlapping or conflicting rules, the matching result and action to take depend on the rule order.

The following ACL match orders are available:

- **config**—Sorts ACL rules in ascending order of rule ID. A rule with a lower ID is matched before a rule with a higher ID. If you use this method, check the rules and their order carefully.
- **auto**—Sorts ACL rules in depth-first order. Depth-first ordering makes sure any subset of a rule is always matched before the rule. Table 1 lists the sequence of tie breakers that depth-first ordering uses to sort rules for each type of ACL.

Table 1 Sort ACL rules in depth-first order

ACL type	Sequence of tie breakers
IPv4 basic ACL	**1.** More 0s in the source IPv4 address wildcard (more 0s means a narrower IPv4 address range). **2.** Rule configured earlier.
IPv4 advanced ACL	**1.** Specific protocol number. **2.** More 0s in the source IPv4 address wildcard mask. **3.** More 0s in the destination IPv4 address wildcard. **4.** Narrower TCP/UDP service port number range. **5.** Rule configured earlier.
IPv6 basic ACL	**1.** Longer prefix for the source IPv6 address (a longer prefix means a narrower IPv6 address range). **2.** Rule configured earlier.
IPv6 advanced ACL	**1.** Specific protocol number. **2.** Longer prefix for the source IPv6 address. **3.** Longer prefix for the destination IPv6 address. **4.** Narrower TCP/UDP service port number range. **5.** Rule configured earlier.
Layer 2 ACL	**1.** More 1s in the source MAC address mask (more 1s means a smaller MAC address). **2.** More 1s in the destination MAC address mask. **3.** Rule configured earlier.

A wildcard mask, also called an inverse mask, is a 32-bit binary number represented in dotted decimal notation. In contrast to a network mask, the 0 bits in a wildcard mask represent "do care" bits, and the 1 bits represent "don't care" bits. If the "do care" bits in an IP address are identical to the "do care" bits in an IP address criterion, the IP address matches the criterion. All "don't care" bits are ignored. The 0s and 1s in a wildcard mask can be noncontiguous. For example, 0.255.0.255 is a valid wildcard mask.

Rule numbering

ACL rules can be manually numbered or automatically numbered. This section describes how automatic ACL rule numbering works.

Rule numbering step

If you do not assign an ID to the rule you are creating, the system automatically assigns it a rule ID. The rule numbering step sets the increment by which the system automatically numbers rules. For example, the default ACL rule numbering step is 5. If you do not assign IDs to rules you are creating, they are automatically numbered 0, 5, 10, 15, and so on. The wider the numbering step, the more rules you can insert between two rules.

By introducing a gap between rules rather than contiguously numbering rules, you have the flexibility of inserting rules in an ACL. This feature is important for a config-order ACL, where ACL rules are matched in ascending order of rule ID.

The rule numbering step sets the increment by which the system numbers rules automatically. If you do not specify a rule ID when creating an ACL rule, the system automatically assigns it a rule ID. This rule ID is the nearest higher multiple of the numbering step to the current highest rule ID, starting from the start rule ID. For example, if the rule numbering step is 5 and the current highest rule ID is 12, the rule is numbered 15.

The wider the numbering step, the more rules you can insert between two rules. Whenever the step or start rule ID changes, the rules are renumbered, starting from the start rule ID. For example, if there are five rules numbered 0, 5, 9, 10, and 15, changing the step from 5 to 2 causes the rules to be renumbered 0, 2, 4, 6, and 8.

Automatic rule numbering and renumbering

The ID automatically assigned to an ACL rule takes the nearest higher multiple of the numbering step to the current highest rule ID, starting with 0.

For example, if the step is 5, and there are five rules numbered 0, 5, 9, 10, and 12, the newly defined rule is numbered 15. If the ACL does not contain a rule, the first rule is numbered 0.

Whenever the step changes, the rules are renumbered, starting from 0. For example, changing the step from 5 to 2 renumbers rules 5, 10, 13, and 15 as rules 0, 2, 4, and 6.

For an ACL of the match order **auto**, rules are sorted in depth-first order, and are renumbered based on the match order. For example, rules are in the match order of 0, 10, and 5. Changing the numbering step to 2 renumbers rules 0, 10, and 5 (not 0, 5, and 10) as rules 0, 2, 4.

Fragment filtering with ACLs

Traditional packet filtering matches only first fragments of packets, and allows all subsequent non-first fragments to pass through. Attackers can fabricate non-first fragments to attack networks.

To avoid risks, the ACL feature is designed as follows:

- Filters all fragments by default, including non-first fragments.
- Allows for matching criteria modification for efficiency. For example, you can configure the ACL to filter only non-first fragments.

Restrictions and guidelines: ACL configuration

- If you create a numbered ACL, you can enter the view of the ACL by using either of the following commands:
  - **acl** [**ipv6**] **number** *acl-number*.
  - **acl** { [**ipv6**] { **advanced** | **basic** } | **mac** } *acl-number*.
- If you create a ACL by using the **acl** [**ipv6**] **number** *acl-number* **name** *acl-name* command, you can enter the view of the ACL by using either of the following commands:
  - **acl** [**ipv6**] **name** *acl-name* (for only basic ACLs and advanced ACLs).
  - **acl** [**ipv6**] **number** *acl-number* [**name** *acl-name*].
  - **acl** { [**ipv6**] { **advanced** | **basic** } | **mac**] } **name** *acl-name*.
- If you create a named ACL by using the **acl** { [**ipv6**] { **advanced** | **basic** } | **mac** } **name** *acl-name* command, you can enter the view of the ACL by using either of the following commands:
  - **acl** [**ipv6**] **name** *acl-name* (for only basic ACLs and advanced ACLs).
  - **acl** { [**ipv6**] { **advanced** | **basic** } | **mac** } **name** *acl-name*.
- Matching packets are forwarded through slow forwarding if an ACL rule contains match criteria or has functions enabled in addition to the following match criteria and functions:
  - Source and destination IP addresses.
  - Source and destination ports.
  - Transport layer protocol.
  - ICMP or ICMPv6 message type, message code, and message name.
  - Logging.
  - Time range.

  Slow forwarding requires packets to be sent to the control plane for forwarding entry calculation, which affects the device forwarding performance.

ACL tasks at a glance

To configure an ACL, perform the following tasks:

- Configure ACLs according to the characteristics of the packets to be matched
  - Configuring a basic ACL
  - Configuring an advanced ACL
  - Configuring a Layer 2 ACL
- (Optional.) Copying an ACL
- (Optional.) Configuring packet filtering with ACLs

Configuring a basic ACL

About basic ACLs

Basic ACLs match packets based only on source IP addresses.

Configuring an IPv4 basic ACL

1. Enter system view.

   system-view
2. Create an IPv4 basic ACL and enter its view. Choose one option as needed:
   - Create an IPv4 basic ACL by specifying an ACL number.

     acl number *acl-number* [**name** *acl-name*] [**match-order** { **auto** | **config** }]
   - Create an IPv4 basic ACL by specifying the **basic** keyword.

     acl basic { *acl-number* | **name** *acl-name* } [**match-order** { **auto** | **config** }]
3. (Optional.) Configure a description for the IPv4 basic ACL.

   description *text*

   By default, an IPv4 basic ACL does not have a description.
4. (Optional.) Set the rule numbering step.

   step *step-value* [**start** *start-value*]

   By default, the rule numbering step is 5 and the start rule ID is 0.
5. Create or edit a rule.

   rule [*rule-id*] { **deny** | **permit** } [**counting** | **fragment** | **logging**| **source** { *source-address source-wildcard* | **any** } | **time-range** *time-range-name*] *

   The **logging** keyword takes effect only when the module (for example, packet filtering) that uses the ACL supports logging.
6. (Optional.) Add or edit a rule comment.

   rule *rule-id* **comment** *text*

   By default, no rule comment is configured.

Configuring an IPv6 basic ACL

Restrictions and guidelines

If an IPv6 basic ACL is used for QoS traffic classification or packet filtering:

- Do not specify the **fragment** keyword.
- Do not specify the **routing** keyword if the ACL is for outbound application.

Procedure

1. Enter system view.
   system-view
2. Create an IPv6 basic ACL view and enter its view. Choose one option as needed:
   - Create an IPv6 basic ACL by specifying an ACL number.
     acl ipv6 number *acl-number* [**name** *acl-name*] [**match-order** { **auto** | **config** }]
   - Create an IPv6 basic ACL by specifying the **basic** keyword.
     acl ipv6 basic { *acl-number* | **name** *acl-name* } [**match-order** { **auto** | **config** }]
3. (Optional.) Configure a description for the IPv6 basic ACL.
   description *text*
   By default, an IPv6 basic ACL does not have a description.
4. (Optional.) Set the rule numbering step.
   step *step-value* [**start** *start-value*]
   By default, the rule numbering step is 5 and the start rule ID is 0.
5. Create or edit a rule.
   rule [*rule-id*] { **deny** | **permit** } [**counting** | **fragment** | **logging**| **routing** [**type** *routing-type*] | **source** { *source-address source-prefix* | *source-address*/*source-prefix* | **any** } | **time-range** *time-range-name*] *
   The **logging** keyword takes effect only when the module (for example, packet filtering) that uses the ACL supports logging.
6. (Optional.) Add or edit a rule comment.
   rule *rule-id* **comment** *text*
   By default, no rule comment is configured.

Configuring an advanced ACL

About advanced ACLs

Advanced ACLs match packets based on the following criteria:

- Source IP addresses.
- Destination IP addresses.
- Packet priorities.
- Protocol types.
- Other protocol header information, such as TCP/UDP source and destination port numbers, TCP flags, ICMP message types, and ICMP message codes.

Compared to basic ACLs, advanced ACLs allow more flexible and accurate filtering.

Configuring an IPv4 advanced ACL

1. Enter system view.

   system-view

2. Create an IPv4 advanced ACL and enter its view. Choose one option as needed:
   - Create a numbered IPv4 advanced ACL by specifying an ACL number.

     acl number *acl-number* [**name** *acl-name*] [**match-order** { **auto** | **config** }]
   - Create an IPv4 advanced ACL by specifying the **advanced** keyword.

     acl advanced { *acl-number* | **name** *acl-name* } [**match-order** { **auto** | **config** }]

3. (Optional.) Configure a description for the IPv4 advanced ACL.

   description *text*

   By default, an IPv4 advanced ACL does not have a description.

4. (Optional.) Set the rule numbering step.

   step *step-value* [**start** *start-value*]

   By default, the rule numbering step is 5 and the start rule ID is 0.

5. Create or edit a rule.

   rule [*rule-id*] { **deny** | **permit** } *protocol* [{ { **ack** *ack-value* | **fin** *fin-value* | **psh** *psh-value* | **rst** *rst-value* | **syn** *syn-value* | **urg** *urg-value* } * | **established** } | **counting** | **destination** { *dest-address dest-wildcard* | **any** } | **destination-port** *operator port* | { **dscp** *dscp* | { **precedence** *precedence* | **tos** *tos* } * } | **fragment** | **icmp-type** { *icmp-type* [*icmp-code*] | *icmp-message* } | **logging** | **source** { *source-address source-wildcard* | **any** } | **source-port** *operator port* | **time-range** *time-range-name*] *

   The **logging** keyword takes effect only when the module (for example, packet filtering) that uses the ACL supports logging.

6. (Optional.) Add or edit a rule comment.

   rule *rule-id* **comment** *text*

   By default, no rule comment is configured.

Configuring an IPv6 advanced ACL

Restrictions and guidelines

If an IPv6 advanced ACL is for QoS traffic classification or packet filtering:

- Do not specify the **fragment** keyword.
- Do not specify the **routing**, **hop-by-hop**, or **flow-label** keyword if the ACL is for outbound application.

Procedure

1. Enter system view.

   system-view

2. Create an IPv6 advanced ACL and enter its view. Choose one option as needed:
   - Create a numbered IPv6 advanced ACL by specifying an ACL number.

     acl ipv6 number *acl-number* [**name** *acl-name*] [**match-order** { **auto** | **config** }]

- Create an IPv6 advanced ACL by specifying the **advanced** keyword.

  acl ipv6 advanced { *acl-number* | **name** *acl-name* } [**match-order** { **auto** | **config** }]

3. (Optional.) Configure a description for the IPv6 advanced ACL.

   description *text*

   By default, an IPv6 advanced ACL does not have a description.

4. (Optional.) Set the rule numbering step.

   step *step-value* [**start** *start-value*]

   By default, the rule numbering step is 5 and the start rule ID is 0.

5. Create or edit a rule.

   rule [*rule-id*] { **deny** | **permit** } *protocol* [{ { **ack** *ack-value* | **fin** *fin-value* | **psh** *psh-value* | **rst** *rst-value* | **syn** *syn-value* | **urg** *urg-value* } * | **established** } | **counting** | **destination** { *dest-address dest-prefix* | *dest-address/dest-prefix* | **any** } | **destination-port** *operator port* | | **dscp** *dscp* | **flow-label** *flow-label-value* | **fragment** | **icmp6-type** { *icmp6-type icmp6-code* | *icmp6-message* } | **logging** | **routing** [**type** *routing-type*] | **hop-by-hop** [**type** *hop-type*] | **source** { *source-address source-prefix* | *source-address/source-prefix* | **any** } | **source-port** *operator port* | **time-range** *time-range-name*] *

   The **logging** keyword takes effect only when the module (for example, packet filtering) that uses the ACL supports logging.

6. (Optional.) Add or edit a rule comment.

   rule *rule-id* **comment** *text*

   By default, no rule comment is configured.

Configuring a Layer 2 ACL

About Layer 2 ACLs

Layer 2 ACLs, also called Ethernet frame header ACLs, match packets based on Layer 2 Ethernet header fields, such as:

- Source MAC address.
- Destination MAC address.
- 802.1p priority (VLAN priority).
- Link layer protocol type.
- Encapsulation type.

Procedure

1. Enter system view.

   system-view

2. Create a Layer 2 ACL and enter its view. Choose one option as needed:

   - Create a Layer 2 ACL by specifying an ACL number.

     acl number *acl-number* [**name** *acl-name*] [**match-order** { **auto** | **config** }]

   - Create a Layer 2 ACL by specifying the **mac** keyword.

     acl mac { *acl-number* | **name** *acl-name* } [**match-order** { **auto** | **config** }]

3. (Optional.) Configure a description for the Layer 2 ACL.

   description *text*

By default, a Layer 2 ACL does not have a description.

4. (Optional.) Set the rule numbering step.

   step *step-value* [**start** *start-value*]

   By default, the rule numbering step is 5 and the start rule ID is 0.

5. Create or edit a rule.

   rule [*rule-id*] { **deny** | **permit** } [**cos** *dot1p* | **counting** | **dest-mac** *dest-address dest-mask* | { **lsap** *lsap-type lsap-type-mask* | **type** *protocol-type protocol-type-mask* } | **source-mac** *source-address source-mask* | **time-range** *time-range-name*] *

6. (Optional.) Add or edit a rule comment.

   rule *rule-id* **comment** *text*

   By default, no rule comment is configured.

Copying an ACL

About copying an ACL

You can create an ACL by copying an existing ACL (source ACL). The new ACL (destination ACL) has the same properties and content as the source ACL, but uses a different number or name than the source ACL.

Restrictions and guidelines

To successfully copy an ACL, make sure:

- The destination ACL is the same type as the source ACL.
- The source ACL already exists, but the destination ACL does not.

Procedure

1. Enter system view.

   system-view

2. Copy an existing ACL to create a new ACL.

   acl [**ipv6** | **mac**] **copy** { *source-acl-number* | **name** *source-acl-name* } **to** { *dest-acl-number* | **name** *dest-acl-name* }

Configuring packet filtering with ACLs

About packet filtering with ACLs

This section describes procedures for using an ACL to filtering packets. For example, you can apply an ACL to an interface to filter incoming or outgoing packets.

Applying an ACL to an interface for packet filtering

Restrictions and guidelines

To the same direction of an interface, you can apply a maximum of three ACLs: one IPv4 ACL, one IPv6 ACL, and one Layer 2 ACL.

The term "interface" in this section collectively refers to Layer 2 Ethernet interfaces and VLAN interfaces.

Procedure

1. Enter system view.
   system-view
2. Enter interface view.
   interface *interface-type interface-number*
3. Apply an ACL to the interface to filter packets.
   packet-filter [**ipv6** | **mac**] { *acl-number* | **name** *acl-name* } { **inbound** | **outbound** } [**hardware-count**]
   By default, an interface does not filter packets.

Configuring logging and SNMP notifications for packet filtering

About configuring logging and SNMP notifications for packet filtering

You can configure the ACL module to generate log entries or SNMP notifications for packet filtering and output them to the information center or SNMP module at the output interval. The log entry or notification records the number of matching packets and the matched ACL rules. When the first packet of a flow matches an ACL rule, the output interval starts, and the device immediately outputs a log entry or notification for this packet. When the output interval ends, the device outputs a log entry or notification for subsequent matching packets of the flow.

For more information about the information center and SNMP, see *Network Management and Monitoring Configuration Guide.*

Procedure

1. Enter system view.
   system-view
2. Set the interval for outputting packet filtering logs or notifications.
   acl { **logging** | **trap** } **interval** *interval*
   The default setting is 0 minutes. By default, the device does not generate log entries or SNMP notifications for packet filtering.

Setting the packet filtering default action

1. Enter system view.
   system-view
2. Set the packet filtering default action to deny.
   packet-filter default deny
   By default, the packet filter permits packets that do not match any ACL rule to pass.

Display and maintenance commands for ACL

Execute **display** commands in any view and **reset** commands in user view.

Task	Command
Display ACL configuration and match statistics.	**display acl** [**ipv6** | **mac**] { *acl-number* | **all** | **name** *acl-name* }

Task	Command
Display ACL application information for packet filtering.	**display packet-filter interface** [*interface-type interface-number*] [**inbound** | **outbound**] [**slot** *slot-number*]
Display match statistics for packet filtering ACLs.	**display packet-filter statistics interface** *interface-type interface-number* { **inbound** | **outbound** } [[**ipv6** | **mac**] { *acl-number* | **name** *acl-name* }] [**brief**]
Display the accumulated statistics for packet filtering ACLs.	**display packet-filter statistics sum** { **inbound** | **outbound** } [**ipv6** | **mac**] { *acl-number* | **name** *acl-name* } [**brief**]
Display detailed ACL packet filtering information.	**display packet-filter verbose interface** *interface-type interface-number* { **inbound** | **outbound** } [[**ipv6** | **mac**] { *acl-number* | **name** *acl-name* }] [**slot** *slot-number*]
Display QoS and ACL resource usage.	**display qos-acl resource** [**slot** *slot-number*]
Clear match statistics for packet filtering ACLs.	**reset packet-filter statistics interface** [*interface-type interface-number*] { **inbound** | **outbound** } [[**ipv6** | **mac**] { *acl-number* | **name** *acl-name* }]

ACL configuration examples

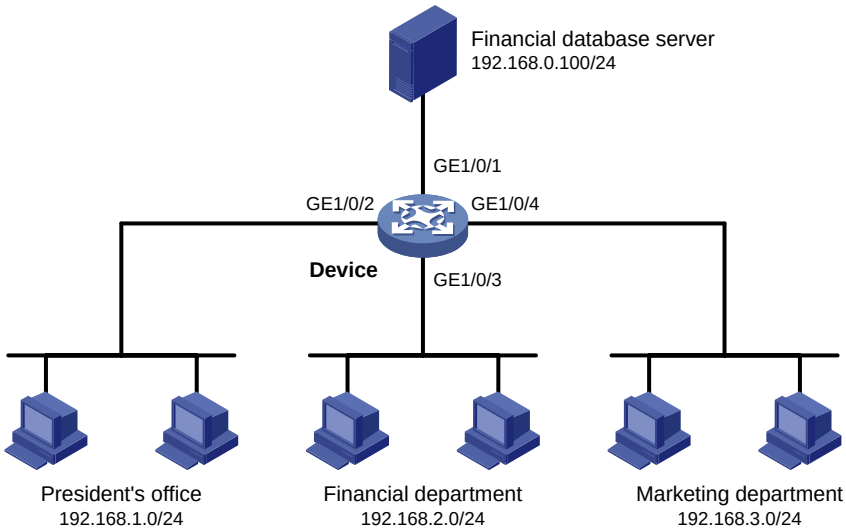
Example: Configuring interface-based packet filter

Network configuration

A company interconnects its departments through the device. Configure a packet filter to:

- Permit access from the President's office at any time to the financial database server.
- Permit access from the Finance department to the database server only during working hours (from 8:00 to 18:00) on working days.
- Deny access from any other department to the database server.

Figure 1 Network diagram



Procedure

Create a periodic time range from 8:00 to 18:00 on working days.

```
<Device> system-view
[Device] time-range work 08:0 to 18:00 working-day
```

Create an IPv4 advanced ACL numbered 3000.

```
[Device] acl advanced 3000
```

Configure a rule to permit access from the President's office to the financial database server.

```
[Device-acl-ipv4-adv-3000] rule permit ip source 192.168.1.0 0.0.0.255 destination
192.168.0.100 0
```

Configure a rule to permit access from the Finance department to the database server during working hours.

```
[Device-acl-ipv4-adv-3000] rule permit ip source 192.168.2.0 0.0.0.255 destination
192.168.0.100 0 time-range work
```

Configure a rule to deny access to the financial database server.

```
[Device-acl-ipv4-adv-3000] rule deny ip source any destination 192.168.0.100 0
[Device-acl-ipv4-adv-3000] quit
```

Apply IPv4 advanced ACL 3000 to filter outgoing packets on interface GigabitEthernet 1/0/1.

```
[Device] interface gigabitethernet 1/0/1
[Device-GigabitEthernet1/0/1] packet-filter 3000 outbound
[Device-GigabitEthernet1/0/1] quit
```

Verifying the configuration

Verify that a PC in the Finance department can ping the database server during working hours. (All PCs in this example use Windows XP).

```
C:\> ping 192.168.0.100

Pinging 192.168.0.100 with 32 bytes of data:

Reply from 192.168.0.100: bytes=32 time=1ms TTL=255
Reply from 192.168.0.100: bytes=32 time<1ms TTL=255
Reply from 192.168.0.100: bytes=32 time<1ms TTL=255
```

```
Reply from 192.168.0.100: bytes=32 time<1ms TTL=255

Ping statistics for 192.168.0.100:
    Packets: Sent = 4, Received = 4, Lost = 0 (0% loss),
Approximate round trip times in milli-seconds:
    Minimum = 0ms, Maximum = 1ms, Average = 0ms
```

Verify that a PC in the Marketing department cannot ping the database server during working hours.

```
C:\> ping 192.168.0.100

Pinging 192.168.0.100 with 32 bytes of data:

Request timed out.
Request timed out.
Request timed out.
Request timed out.

Ping statistics for 192.168.0.100:
    Packets: Sent = 4, Received = 0, Lost = 4 (100% loss),
```

Display configuration and match statistics for IPv4 advanced ACL 3000 on the device during working hours.

```
[Device] display acl 3000
Advanced IPv4 ACL 3000, 3 rules,
ACL's step is 5
 rule 0 permit ip source 192.168.1.0 0.0.0.255 destination 192.168.0.100 0
 rule 5 permit ip source 192.168.2.0 0.0.0.255 destination 192.168.0.100 0 time-range work (Active)
 rule 10 deny ip destination 192.168.0.100 0
```

The output shows that rule 5 is active. Rule 5 and rule 10 have been matched four times as the result of the ping operations.

Contents

QoS overview

In data communications, Quality of Service (QoS) provides differentiated service guarantees for diversified traffic in terms of bandwidth, delay, jitter, and drop rate, all of which can affect QoS.

QoS manages network resources and prioritizes traffic to balance system resources.

The following section describes typical QoS service models and widely used QoS techniques.

QoS service models

This section describes several typical QoS service models.

Best-effort service model

The best-effort model is a single-service model. The best-effort model is not as reliable as other models and does not guarantee delay-free delivery.

The best-effort service model is the default model for the Internet and applies to most network applications. It uses the First In First Out (FIFO) queuing mechanism.

IntServ model

The integrated service (IntServ) model is a multiple-service model that can accommodate diverse QoS requirements. This service model provides the most granularly differentiated QoS by identifying and guaranteeing definite QoS for each data flow.

In the IntServ model, an application must request service from the network before it sends data. IntServ signals the service request with the RSVP. All nodes receiving the request reserve resources as requested and maintain state information for the application flow.

The IntServ model demands high storage and processing capabilities because it requires all nodes along the transmission path to maintain resource state information for each flow. This model is suitable for small-sized or edge networks. However, it is not suitable for large-sized networks, for example, the core layer of the Internet, where billions of flows are present.

DiffServ model

The differentiated service (DiffServ) model is a multiple-service model that can meet diverse QoS requirements. It is easy to implement and extend. DiffServ does not signal the network to reserve resources before sending data, as IntServ does.

QoS techniques in a network

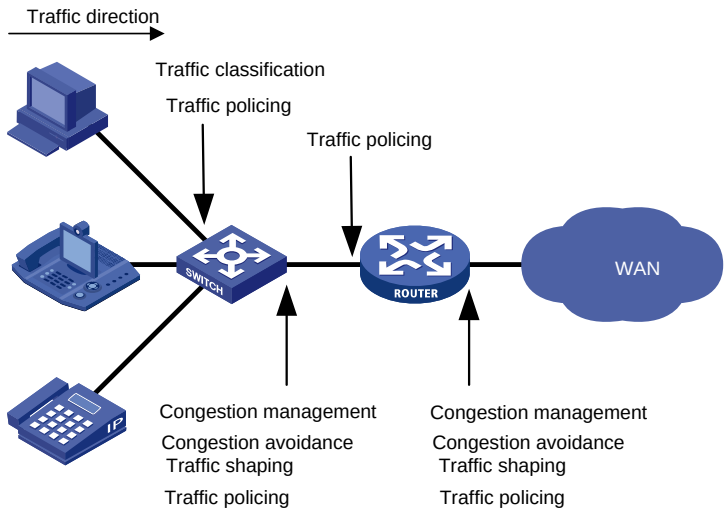
The QoS techniques include the following features:

- Traffic classification.
- Traffic policing.
- Traffic shaping.
- Rate limit.
- Congestion management.
- Congestion avoidance.

The following section briefly introduces these QoS techniques.

All QoS techniques in this document are based on the DiffServ model.

Figure 1 Position of the QoS techniques in a network



As shown in Figure 1, traffic classification, traffic shaping, traffic policing, congestion management, and congestion avoidance mainly implement the following functions:

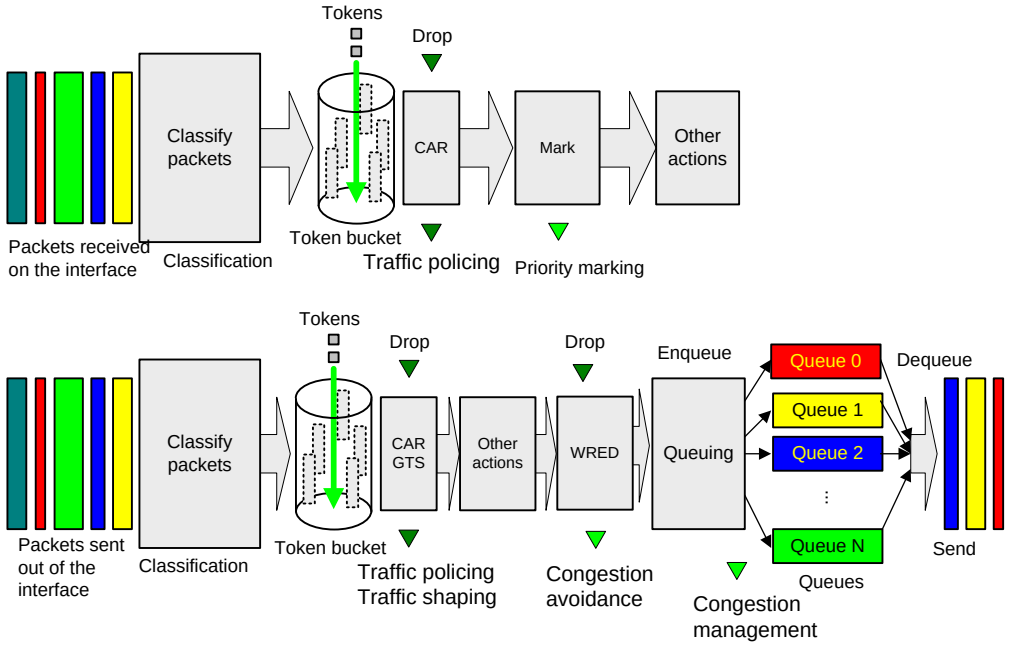
- **Traffic classification**—Uses match criteria to assign packets with the same characteristics to a traffic class. Based on traffic classes, you can provide differentiated services.
- **Traffic policing**—Polices flows and imposes penalties to prevent aggressive use of network resources. You can apply traffic policing to both incoming and outgoing traffic of a port.
- **Traffic shaping**—Adapts the output rate of traffic to the network resources available on the downstream device to eliminate packet drops. Traffic shaping usually applies to the outgoing traffic of a port.
- **Congestion management**—Provides a resource scheduling policy to determine the packet forwarding sequence when congestion occurs. Congestion management usually applies to the outgoing traffic of a port.
- **Congestion avoidance**—Monitors the network resource usage. It is usually applied to the outgoing traffic of a port. When congestion worsens, congestion avoidance reduces the queue length by dropping packets.

QoS processing flow in a device

Figure 2 briefly describes how the QoS module processes traffic.

1. Traffic classifier identifies and classifies traffic for subsequent QoS actions.
2. The QoS module takes various QoS actions on classified traffic as configured, depending on the traffic processing phase and network status. For example, you can configure the QoS module to perform the following operations:
   - Traffic policing for incoming traffic.
   - Traffic shaping for outgoing traffic.
   - Congestion avoidance before congestion occurs.
   - Congestion management when congestion occurs.

Figure 2 QoS processing flow



QoS configuration approaches

You can configure QoS by using the MQC approach or non-MQC approach.

In the modular QoS configuration (MQC) approach, you configure QoS service parameters by using QoS policies. A QoS policy defines QoS actions to take on different classes of traffic and can be applied to an object (such as an interface) to control traffic.

In the non-MQC approach, you configure QoS service parameters without using a QoS policy. For example, you can use the rate limit feature to set a rate limit on an interface without using a QoS policy.

Configuring a QoS policy

About QoS policies

A QoS policy has the following components:

- **Traffic class**—Defines criteria to match packets.
- **Traffic behavior**—Defines QoS actions to take on matching packets.

By associating a traffic class with a traffic behavior, a QoS policy can perform the QoS actions on matching packets.

A QoS policy can have multiple class-behavior associations.

QoS policy tasks at a glance

To configure a QoS policy, perform the following tasks:

1. Defining a traffic class
2. Defining a traffic behavior
3. Defining a QoS policy
4. Applying the QoS policy
   - Applying the QoS policy to an interface
   - Applying the QoS policy to VLANs
   - Applying the QoS policy globally
   - Applying the QoS policy to a user profile

Defining a traffic class

1. Enter system view.
   system-view
2. Create a traffic class and enter traffic class view.
   traffic classifier *classifier-name* [**operator** { **and** | **or** }]
3. (Optional.) Configure a description for the traffic class.
   description *text*

   By default, no description is configured for a traffic class.
4. Configure a match criterion.
   if-match *match-criteria*

   By default, no match criterion is configured.

   For more information, see the **if-match** command in *ACL and QoS Command Reference*.

Defining a traffic behavior

1. Enter system view.
   system-view
2. Create a traffic behavior and enter traffic behavior view.

traffic behavior *behavior-name*

3. Configure an action in the traffic behavior.

   By default, no action is configured for a traffic behavior.

   For more information about configuring an action, see the subsequent chapters for traffic policing, traffic filtering, priority marking, class-based accounting, and so on.

Defining a QoS policy

1. Enter system view.

   system-view

2. Create a QoS policy and enter QoS policy view.

   qos policy *policy-name*

3. Associate a traffic class with a traffic behavior to create a class-behavior association in the QoS policy.

   classifier *classifier-name* **behavior** *behavior-name* [**insert-before** *before-classifier-name*]

   By default, a traffic class is not associated with a traffic behavior.

   Repeat this step to create more class-behavior associations.

Applying the QoS policy

Application destinations

You can apply a QoS policy to the following destinations:

- **Interface**—The QoS policy takes effect on the traffic sent or received on the interface.
- **VLAN**—The QoS policy takes effect on the traffic sent or received on all ports in the VLAN.
- **Globally**—The QoS policy takes effect on the traffic sent or received on all ports.
- **User profile**—The QoS policy takes effect on the traffic sent or received by the online users of the user profile.

Restrictions and guidelines for applying a QoS policy

You can modify traffic classes, traffic behaviors, and class-behavior associations in a QoS policy even after it is applied (except that it is applied to a user profile). If a traffic class uses an ACL for traffic classification, you can delete or modify the ACL.

When a QoS policy containing a CAR action is applied on an IRF fabric, the traffic matching the QoS policy might enter the IRF fabric through interfaces on different IRF member devices. In this case, the actual rate limit that takes effect is the sum of the CIR and PIR in the CAR action multiplied by the number of involved port groups by default. Interfaces on different IRF member devices belong to different port groups. Interfaces on the same IRF member device can belong to the same or different port groups. To identify port group information, execute the **debug port mapping** command in probe view. Interfaces with the same **Unit** value belong to the same port group.

When a QoS policy containing a CAR action is applied on an IRF fabric, the traffic matching the QoS policy might leave the IRF fabric through interfaces on different IRF member devices. In this case, the actual rate limit that takes effect is the sum of the CIR and PIR in the CAR action multiplied by the number of IRF member devices that host the interfaces by default.

Applying the QoS policy to an interface

Restrictions and guidelines

A QoS policy can be applied to multiple interfaces. However, only one QoS policy can be applied to one direction (inbound or outbound) of an interface.

The QoS policy applied to the outgoing traffic on an interface does not regulate local packets. Local packets refer to critical protocol packets sent by the local system for operation maintenance. The most common local packets include link maintenance, RIP, LDP, and SSH packets.

The term "interface" in this section refers to Layer 2 Ethernet interfaces.

Procedure

1. Enter system view.
   system-view
2. Enter interface view.
   interface *interface-type interface-number*
3. Apply the QoS policy to the interface.
   qos apply policy *policy-name* { **inbound** | **outbound**
   By default, no QoS policy is applied to an interface.

Applying the QoS policy to VLANs

About QoS policy application to VLANs

You can apply a QoS policy to VLANs to regulate the traffic on all ports of the VLANs.

Restrictions and guidelines

QoS policies cannot be applied to dynamic VLANs, including VLANs created by GVRP.

When you apply a QoS policy to VLANs, the QoS policy is applied to the specified VLANs on all IRF member devices. If the hardware resources of an IRF member device are insufficient, applying a QoS policy to VLANs might fail on the IRF member device. The system does not automatically roll back the QoS policy configuration already applied to other IRF member devices. To ensure consistency, use the **undo qos vlan-policy** command to manually remove the QoS policy configuration applied to them.

Procedure

1. Enter system view.
   system-view
2. Apply the QoS policy to VLANs.
   qos vlan-policy *policy-name* **vlan** *vlan-id-list* { **inbound** | **outbound** }
   By default, no QoS policy is applied to a VLAN.

Applying the QoS policy globally

About global QoS policy application

You can apply a QoS policy globally to the inbound or outbound direction of all ports.

Restrictions and guidelines

If the hardware resources of an IRF member device are insufficient, applying a QoS policy globally might fail on the IRF member device. The system does not automatically roll back the QoS policy configuration already applied to other IRF member devices. To ensure consistency, you must use

the **undo qos apply policy global** command to manually remove the QoS policy configuration applied to them.

Procedure

1. Enter system view.
   system-view
2. Apply the QoS policy globally.
   qos apply policy *policy-name* **global** { **inbound** | **outbound**
   By default, no QoS policy is applied globally.

Applying the QoS policy to a user profile

About QoS policy application to a user profile

When a user profile is configured, you can perform traffic policing based on users. After a user passes authentication, the authentication server sends the name of the user profile associated with the user to the device. The QoS policy configured in user profile view takes effect only when users come online.

Restrictions and guidelines

You can apply a QoS policy to multiple user profiles. In one direction of each user profile, only one policy can be applied. To modify a QoS policy already applied to a direction, first remove the applied QoS policy.

Procedure

1. Enter system view.
   system-view
2. Enter user profile view.
   user-profile *profile-name*
3. Apply the QoS policy to the user profile.
   qos apply policy *policy-name* { **inbound** | **outbound** }
   By default, no QoS policy is applied to a user profile.

Parameter	Description
inbound	Applies a QoS policy to the traffic received by the device from the user profile.
outbound	Applies a QoS policy to the traffic sent by the device to the user profile.

Display and maintenance commands for QoS policies

Execute **display** commands in any view and **reset** commands in user view.

Task	Command
Display QoS policy configuration.	**display qos policy user-defined** [*policy-name* [**classifier** *classifier-name*]] [**slot** *slot-number*]

Task	Command
Display information about QoS policies applied globally.	**display qos policy global** [**slot** *slot-number*] [**inbound** | **outbound**]
Display information about QoS policies applied to interfaces.	**display qos policy interface** [*interface-type interface-number*] [**inbound** | **outbound**]
Display information about QoS policies applied to user profiles.	**display qos policy user-profile** [**name** *profile-name*] [**user-id** *user-id*] [**slot** *slot-number*] [**inbound** | **outbound**]
Display information about QoS policies applied to VLANs.	**display qos vlan-policy** { **name** *policy-name* | **vlan** [*vlan-id*] } [**slot** *slot-number*] [**inbound** | **outbound**]
Display QoS and ACL resource usage.	**display qos-acl resource** [**slot** *slot-number*]
Display traffic behavior configuration.	**display traffic behavior user-defined** [*behavior-name*] [**slot** *slot-number*]
Display traffic class configuration.	**display traffic classifier user-defined** [*classifier-name*] [**slot** *slot-number*]
Clear the statistics of the QoS policy applied in a certain direction of a VLAN.	**reset qos vlan-policy** [**vlan** *vlan-id*] [**inbound** | **outbound**]
Clear the statistics for a QoS policy applied globally.	**reset qos policy global** [**inbound** | **outbound**]
Clear the statistics for a QoS policy applied globally.	**reset qos policy global** [**inbound** | **outbound**]
Clear the statistics of the QoS policy applied in a certain direction of a VLAN.	**reset qos vlan-policy** [**vlan** *vlan-id*] [**inbound** | **outbound**]

Configuring priority mapping

About priority mapping

When a packet arrives, a device assigns a set of QoS priority parameters to the packet based on either of the following:

- A priority field carried in the packet.
- The port priority of the incoming port.

This process is called priority mapping. During this process, the device can modify the priority of the packet according to the priority mapping rules. The set of QoS priority parameters decides the scheduling priority and forwarding priority of the packet.

Priority mapping is implemented with priority maps and involves the following priorities:

- 802.1p priority.
- DSCP.
- EXP.
- IP precedence.
- Local precedence.
- Drop priority.

About priorities

Priorities include the following types: priorities carried in packets, and priorities locally assigned for scheduling only.

Packet-carried priorities include 802.1p priority, DSCP precedence, IP precedence, and EXP. These priorities have global significance and affect the forwarding priority of packets across the network. For more information about these priorities, see "Appendixes."

Locally assigned priorities only have local significance. They are assigned by the device only for scheduling. These priorities include the local precedence, drop priority, and user priority, as follows:

- **Local precedence**—Used for queuing. A local precedence value corresponds to an output queue. A packet with higher local precedence is assigned to a higher priority output queue to be preferentially scheduled.
- **Drop priority**—Used for making packet drop decisions. Packets with the highest drop priority are dropped preferentially.
- **User priority**—Precedence that the device automatically extracts from a priority field of the packet according to its forwarding path. It is a parameter for determining the scheduling priority and forwarding priority of the packet. The user priority represents the following items:
  - The 802.1p priority for Layer 2 packets.
  - The IP precedence for Layer 3 packets.
  - The EXP for MPLS packets.

The device supports only local precedence for scheduling.

Priority maps

The device provides various types of priority maps. By looking through a priority map, the device decides which priority value to assign to a packet for subsequent packet processing.

The default priority maps (as shown in Appendix B Default priority maps) are available for priority mapping. They are adequate in most cases. If a default priority map cannot meet your requirements, you can modify the priority map as required.

Priority mapping configuration methods

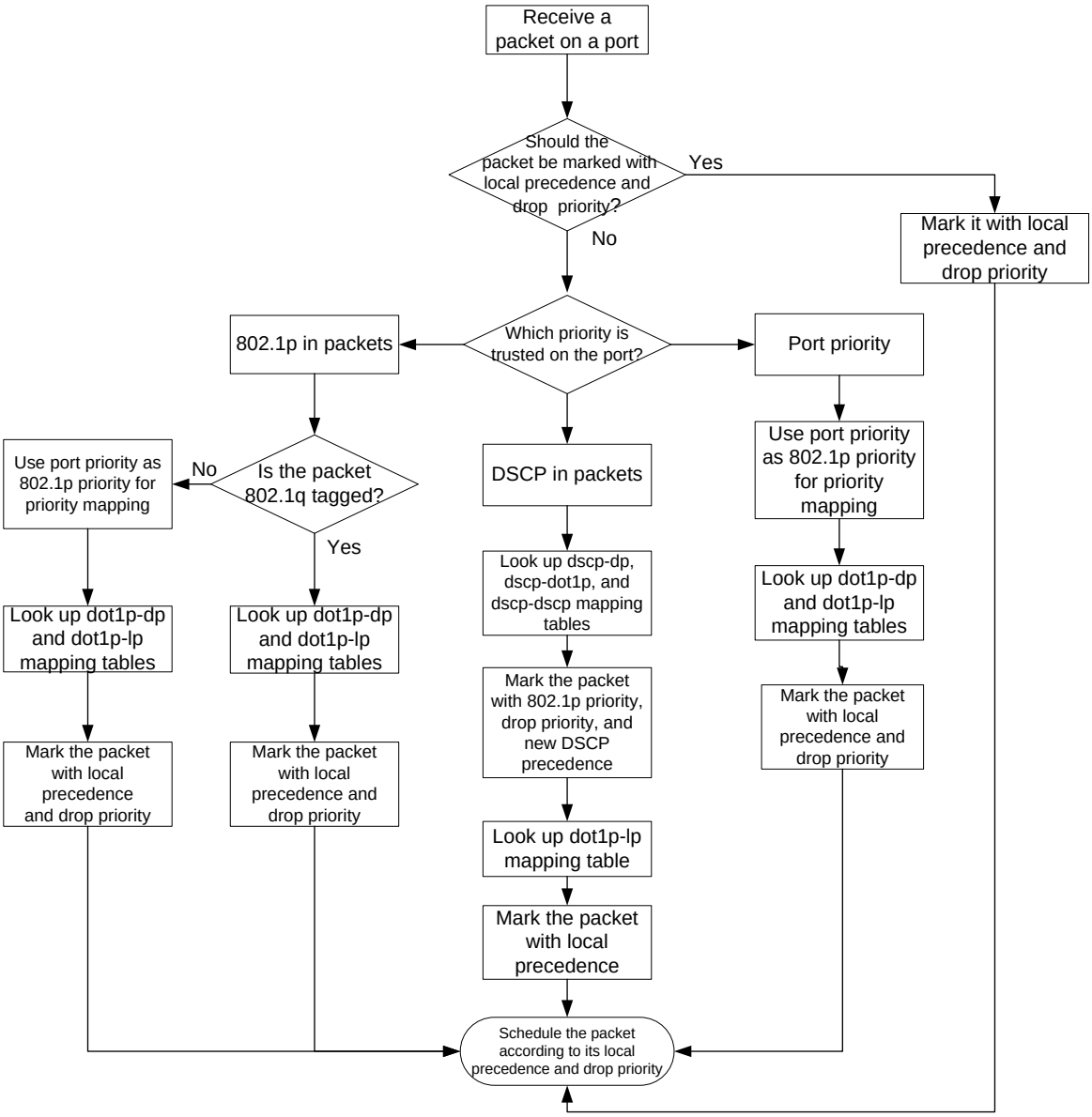
You can configure priority mapping by using any of the following methods:

- **Configuring priority trust mode**—In this method, you can configure a port to look up a trusted priority type (802.1p, for example) in incoming packets in the priority maps. Then, the system maps the trusted priority to the target priority types and values.
- **Changing port priority**—If no packet priority is trusted, the port priority of the incoming port is used. By changing the port priority of a port, you change the priority of the incoming packets on the port.

Priority mapping process

On receiving an Ethernet packet on a port, the switch marks the scheduling priorities (local precedence and drop precedence) for the Ethernet packet. This procedure is done according to the priority trust mode of the receiving port and the 802.1Q tagging status of the packet, as shown in Figure 3.

Figure 3 Priority mapping process for an Ethernet packet



For information about priority marking, see "Configuring priority marking."

Priority mapping tasks at a glance

To configure priority mapping, perform the following tasks:

1. (Optional.) Configuring a priority map
2. Configure a priority mapping method:
   - Configuring a port to trust packet priority for priority mapping
   - Changing the port priority of an interface

Configuring a priority map

1. Enter system view.

system-view

2. Enter priority map view.
   qos map-table{ **dot1p-lp** | **dscp-dot1p** | **dscp-dscp** }
3. Configure mappings for the priority map.
   import *import-value-list* **export** *export-value*

   By default, the default priority maps are used. For more information, see "Appendix B Default priority maps."

   If you execute this command multiple times, the most recent configuration takes effect.

Configuring a port to trust packet priority for priority mapping

About configuring a port to trust packet priority

You can configure the device to trust a particular priority field carried in packets for priority mapping on ports or globally. When you configure the trusted packet priority type on an interface, use the following available keywords:

- **dot1p**—Uses the 802.1p priority of received packets for mapping.
- **dscp**—Uses the DSCP precedence of received IP packets for mapping.

Restrictions and guidelines

The term "interface" in this section refers to Layer 2 Ethernet interfaces.

Procedure

1. Enter system view.
   system-view
2. Enter interface view.
   interface *interface-type interface-number*
3. Configure the trusted packet priority type.
   qos trust { **dot1p** | **dscp** }

   By default, an interface does not trust any packet priority and uses the port priority as the 802.1p priority for mapping.

Changing the port priority of an interface

About port priority

If an interface does not trust any packet priority, the device uses its port priority to look for priority parameters for the incoming packets. By changing port priority, you can prioritize traffic received on different interfaces.

Procedure

1. Enter system view.
   system-view
2. Enter interface view.
   interface *interface-type interface-number*
3. Set the port priority of the interface.
   qos priority [**dscp**] *priority-value*

The default setting is 0.

Display and maintenance commands for priority mapping

Execute **display** commands in any view.

Task	Command
Display priority map configuration.	**display qos map-table** [**dot1p-lp** | **dscp-dot1p** | **dscp-dscp**]
Display the trusted packet priority type on a port.	**display qos trust interface** [*interface-type interface-number*]

Priority mapping configuration examples

Example: Configuring a priority trust mode

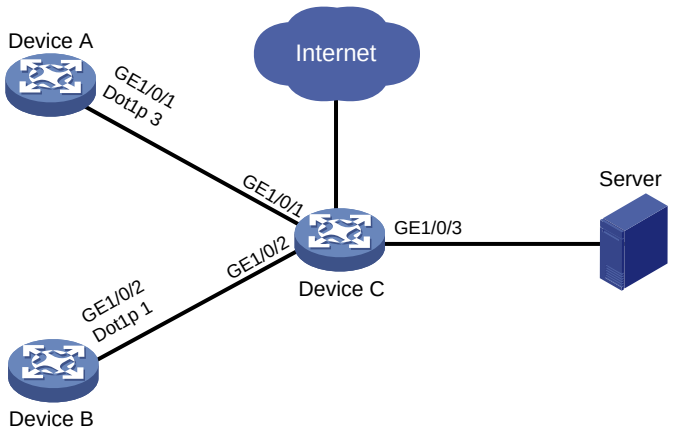
Network configuration

As shown in Figure 4:

- The 802.1p priority of traffic from Device A to Device C is 3.
- The 802.1p priority of traffic from Device B to Device C is 1.

Configure Device C to preferentially process packets from Device A to the server when GigabitEthernet 1/0/3 of Device C is congested.

Figure 4 Network diagram



Procedure

(Method 1) Configure Device C to trust packet priority

Configure GigabitEthernet 1/0/1 and GigabitEthernet 1/0/2 to trust the 802.1p priority for priority mapping.

```
<DeviceC> system-view
[DeviceC] interface gigabitethernet 1/0/1
[DeviceC-GigabitEthernet1/0/1] qos trust dot1p
```

```
[DeviceC-GigabitEthernet1/0/1] quit
[DeviceC] interface gigabitethernet 1/0/2
[DeviceC-GigabitEthernet1/0/2] qos trust dot1p
[DeviceC-GigabitEthernet1/0/2] quit
```

(Method 2) Configure Device C to trust port priority

Assign port priority to GigabitEthernet 1/0/1 and GigabitEthernet 1/0/2. Make sure the following requirements are met:

- The priority of GigabitEthernet 1/0/1 is higher than that of GigabitEthernet 1/0/2.
- No trusted packet priority type is configured on GigabitEthernet 1/0/1 or GigabitEthernet 1/0/2.

```
<DeviceC> system-view
[DeviceC] interface gigabitethernet 1/0/1
[DeviceC-GigabitEthernet1/0/1] qos priority 3
[DeviceC-GigabitEthernet1/0/1] quit
[DeviceC] interface gigabitethernet 1/0/2
[DeviceC-GigabitEthernet1/0/2] qos priority 1
[DeviceC-GigabitEthernet1/0/2] quit
```

Example: Configuring priority mapping tables and priority marking

Network configuration

As shown in Figure 5:

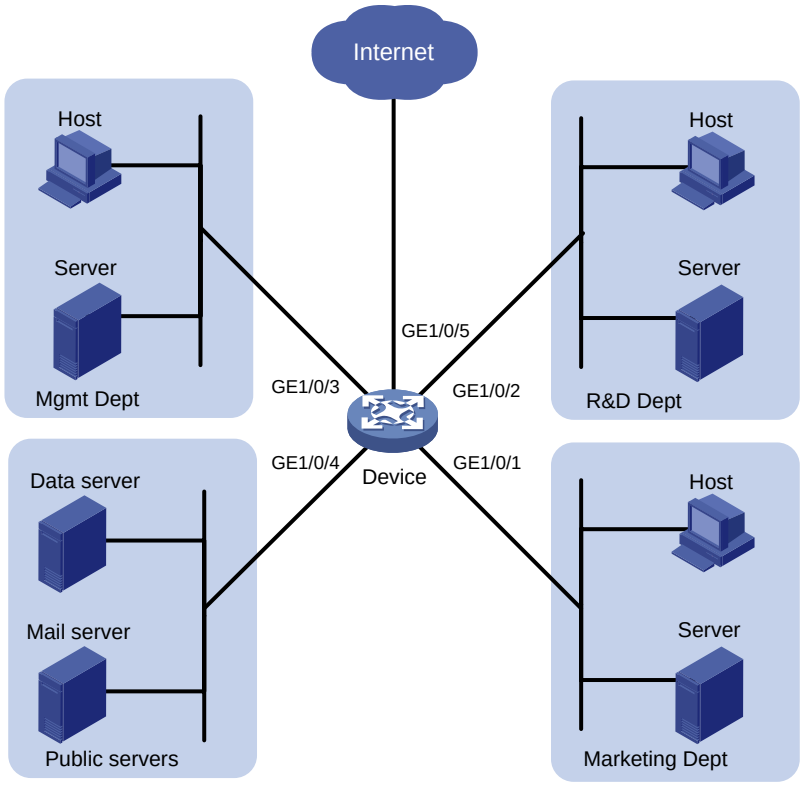
- The Marketing department connects to GigabitEthernet 1/0/1 of Device, which sets the 802.1p priority of traffic from the Marketing department to 3.
- The R&D department connects to GigabitEthernet 1/0/2 of Device, which sets the 802.1p priority of traffic from the R&D department to 4.
- The Management department connects to GigabitEthernet 1/0/3 of Device, which sets the 802.1p priority of traffic from the Management department to 5.

Configure port priority, 802.1p-to-local mapping table, and priority marking to implement the plan as described in Table 1.

Table 1 Configuration plan

Traffic destination	Traffic priority order	Queuing plan		
		Traffic source	Output queue	Queue priority
Public servers	R&D department > Management department > Marketing department	R&D department	6	High
		Management department	4	Medium
		Marketing department	2	Low
Internet	Management department > Marketing department > R&D department	R&D department	2	Low
		Management department	6	High
		Marketing department	4	Medium

Figure 5 Network diagram



Procedure

1. Configure trusting port priority:

   # Set the port priority of GigabitEthernet 1/0/1 to 3.

   ```
   <Device> system-view
   [Device] interface gigabitethernet 1/0/1
   [Device-GigabitEthernet1/0/1] qos priority 3
   [Device-GigabitEthernet1/0/1] quit
   ```

   # Set the port priority of GigabitEthernet 1/0/2 to 4.

   ```
   [Device] interface gigabitethernet 1/0/2
   [Device-GigabitEthernet1/0/2] qos priority 4
   [Device-GigabitEthernet1/0/2] quit
   ```

   # Set the port priority of GigabitEthernet 1/0/3 to 5.

   ```
   [Device] interface gigabitethernet 1/0/3
   [Device-GigabitEthernet1/0/3] qos priority 5
   [Device-GigabitEthernet1/0/3] quit
   ```

2. Configure the 802.1p-to-local mapping table to map 802.1p priority values 3, 4, and 5 to local precedence values 2, 6, and 4.

   This guarantees the R&D department, Management department, and Marketing department decreased priorities to access the public servers.

   ```
   [Device] qos map-table dot1p-lp
   [Device-maptbl-dot1p-lp] import 3 export 2
   [Device-maptbl-dot1p-lp] import 4 export 6
   [Device-maptbl-dot1p-lp] import 5 export 4
   [Device-maptbl-dot1p-lp] quit
   ```

3. Configure priority marking to mark the packets from Management department, Marketing department, and R&D department to the Internet with 802.1p priority values 4, 5, and 3.

This guarantees the Management department, Marketing department, and R&D department decreased priorities to access the Internet.

Create ACL 3000, and configure a rule to match HTTP packets.

```
[Device] acl advanced 3000
[Device-acl-adv-3000] rule permit tcp destination-port eq 80
[Device-acl-adv-3000] quit
```

Create a traffic class named **http**, and use ACL 3000 as a match criterion.

```
[Device] traffic classifier http
[Device-classifier-http] if-match acl 3000
[Device-classifier-http] quit
```

Create a traffic behavior named **admin**, and configure a marking action for the Management department.

```
[Device] traffic behavior admin
[Device-behavior-admin] remark dot1p 4
[Device-behavior-admin] quit
```

Create a QoS policy named **admin**, and associate traffic class **http** with traffic behavior **admin** in QoS policy **admin**.

```
[Device] qos policy admin
[Device-qospolicy-admin] classifier http behavior admin
[Device-qospolicy-admin] quit
```

Apply QoS policy **admin** to the inbound direction of GigabitEthernet 1/0/3.

```
[Device] interface gigabitethernet 1/0/3
[Device-GigabitEthernet1/0/3] qos apply policy admin inbound
```

Create a traffic behavior named **market**, and configure a marking action for the Marketing department.

```
[Device] traffic behavior market
[Device-behavior-market] remark dot1p 5
[Device-behavior-market] quit
```

Create a QoS policy named **market**, and associate traffic class **http** with traffic behavior **market** in QoS policy **market**.

```
[Device] qos policy market
[Device-qospolicy-market] classifier http behavior market
[Device-qospolicy-market] quit
```

Apply QoS policy **market** to the inbound direction of GigabitEthernet 1/0/1.

```
[Device] interface gigabitethernet 1/0/1
[Device-GigabitEthernet1/0/1] qos apply policy market inbound
```

Create a traffic behavior named **rd**, and configure a marking action for the R&D department.

```
[Device] traffic behavior rd
[Device-behavior-rd] remark dot1p 3
[Device-behavior-rd] quit
```

Create a QoS policy named **rd**, and associate traffic class **http** with traffic behavior **rd** in QoS policy **rd**.

```
[Device] qos policy rd
[Device-qospolicy-rd] classifier http behavior rd
[Device-qospolicy-rd] quit
```

Apply QoS policy **rd** to the inbound direction of GigabitEthernet 1/0/2.

```
[Device] interface gigabitethernet 1/0/2
[Device-GigabitEthernet1/0/2] qos apply policy rd inbound
```

Configuring traffic policing, GTS, and rate limit

About traffic policing, GTS, and rate limit

Traffic limit helps assign network resources (including bandwidth) and increase network performance. For example, you can configure a flow to use only the resources committed to it in a certain time range. This avoids network congestion caused by burst traffic.

Traffic policing, Generic Traffic Shaping (GTS), and rate limit control the traffic rate and resource usage according to traffic specifications. You can use token buckets for evaluating traffic specifications.

Traffic evaluation and token buckets

Token bucket features

A token bucket is analogous to a container that holds a certain number of tokens. Each token represents a certain forwarding capacity. The system puts tokens into the bucket at a constant rate. When the token bucket is full, the extra tokens cause the token bucket to overflow.

Evaluating traffic with the token bucket

A token bucket mechanism evaluates traffic by looking at the number of tokens in the bucket. If the number of tokens in the bucket is enough for forwarding the packets:

- The traffic conforms to the specification (called conforming traffic).
- The corresponding tokens are taken away from the bucket.

Otherwise, the traffic does not conform to the specification (called excess traffic).

A token bucket has the following configurable parameters:

- Mean rate at which tokens are put into the bucket, which is the permitted average rate of traffic. It is usually set to the committed information rate (CIR).
- Burst size or the capacity of the token bucket. It is the maximum traffic size permitted in each burst. It is usually set to the committed burst size (CBS). The set burst size must be greater than the maximum packet size.

Each arriving packet is evaluated.

Complicated evaluation

You can set two token buckets, bucket C and bucket E, to evaluate traffic in a more complicated environment and achieve more policing flexibility. The following are main mechanisms used for complicated evaluation:

- **Single rate two color**—Uses one token bucket and the following parameters:
  - **CIR**—Rate at which tokens are put into bucket C. It sets the average packet transmission or forwarding rate allowed by bucket C.
  - **CBS**—Size of bucket C, which specifies the transient burst of traffic that bucket C can forward.

  When a packet arrives, the following rules apply:
  - If bucket C has enough tokens to forward the packet, the packet is colored green.
  - Otherwise, the packet is colored red.
- **Single rate three color**—Uses two token buckets and the following parameters:

- **CIR**—Rate at which tokens are put into bucket C. It sets the average packet transmission or forwarding rate allowed by bucket C.
- **CBS**—Size of bucket C, which specifies the transient burst of traffic that bucket C can forward.
- **EBS**—Size of bucket E minus size of bucket C, which specifies the transient burst of traffic that bucket E can forward. The EBS cannot be 0. The size of E bucket is the sum of the CBS and EBS.

When a packet arrives, the following rules apply:

- If bucket C has enough tokens, the packet is colored green.
- If bucket C does not have enough tokens but bucket E has enough tokens, the packet is colored yellow.
- If neither bucket C nor bucket E has sufficient tokens, the packet is colored red.

- **Two rate three color**—Uses two token buckets and the following parameters:
  - **CIR**—Rate at which tokens are put into bucket C. It sets the average packet transmission or forwarding rate allowed by bucket C.
  - **CBS**—Size of bucket C, which specifies the transient burst of traffic that bucket C can forward.
  - **PIR**—Rate at which tokens are put into bucket E, which specifies the average packet transmission or forwarding rate allowed by bucket E.
  - **EBS**—Size of bucket E, which specifies the transient burst of traffic that bucket E can forward.

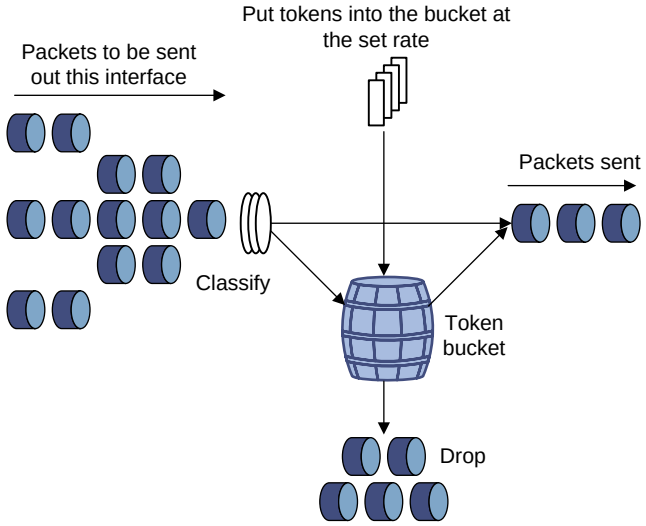
  When a packet arrives, the following rules apply:
  - If bucket C has enough tokens, the packet is colored green.
  - If bucket C does not have enough tokens but bucket E has enough tokens, the packet is colored yellow.
  - If neither bucket C nor bucket E has sufficient tokens, the packet is colored red.

Traffic policing

Traffic policing supports policing the inbound traffic and the outbound traffic.

A typical application of traffic policing is to supervise the specification of traffic entering a network and limit it within a reasonable range. Another application is to "discipline" the extra traffic to prevent aggressive use of network resources by an application. For example, you can limit bandwidth for HTTP packets to less than 50% of the total. If the traffic of a session exceeds the limit, traffic policing can drop the packets or reset the IP precedence of the packets. Figure 6 shows an example of policing outbound traffic on an interface.

Figure 6 Traffic policing



Traffic policing is widely used in policing traffic entering the ISP networks. It can classify the policed traffic and take predefined policing actions on each packet depending on the evaluation result:

- Forwarding the packet if the evaluation result is "conforming."
- Dropping the packet if the evaluation result is "excess."
- Forwarding the packet with its precedence re-marked if the evaluation result is "conforming."

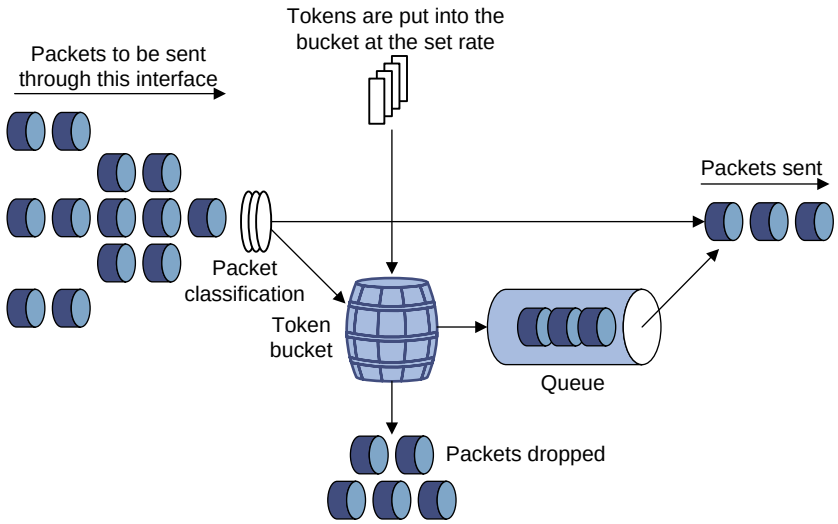
GTS

GTS supports shaping the outbound traffic. GTS limits the outbound traffic rate by buffering exceeding traffic. You can use GTS to adapt the traffic output rate on a device to the input traffic rate of its connected device to avoid packet loss.

The differences between traffic policing and GTS are as follows:

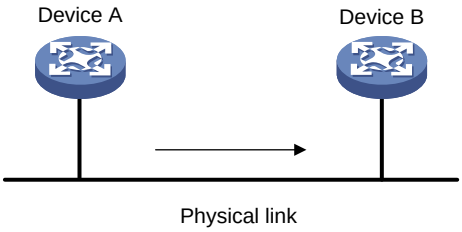
- Packets to be dropped with traffic policing are retained in a buffer or queue with GTS, as shown in Figure 7. When enough tokens are in the token bucket, the buffered packets are sent at an even rate.
- GTS can result in additional delay and traffic policing does not.

Figure 7 GTS



For example, in Figure 8, Device B performs traffic policing on packets from Device A and drops packets exceeding the limit. To avoid packet loss, you can perform GTS on the outgoing interface of Device A so that packets exceeding the limit are cached in Device A. Once resources are released, GTS takes out the cached packets and sends them out.

Figure 8 GTS application



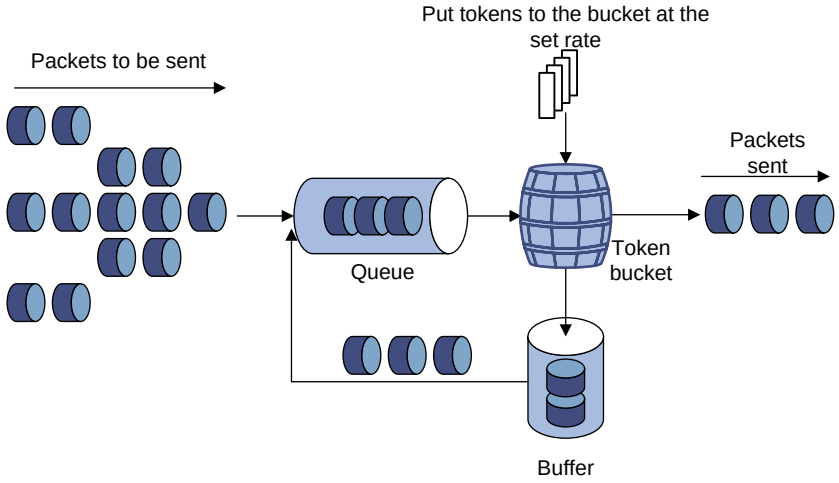
Rate limit

Rate limit controls the rate of inbound and outbound traffic. The outbound traffic is taken for example.

The rate limit of an interface specifies the maximum rate for forwarding packets (excluding critical packets).

Rate limit also uses token buckets for traffic control. When rate limit is configured on an interface, a token bucket handles all packets to be sent through the interface for rate limiting. If enough tokens are in the token bucket, packets can be forwarded. Otherwise, packets are put into QoS queues for congestion management. In this way, the traffic passing the interface is controlled.

Figure 9 Rate limit implementation



The token bucket mechanism limits traffic rate when accommodating bursts. It allows bursty traffic to be transmitted if enough tokens are available. If tokens are scarce, packets cannot be transmitted until efficient tokens are generated in the token bucket. It restricts the traffic rate to the rate for generating tokens.

Rate limit controls the total rate of all packets on an interface. It is easier to use than traffic policing in controlling the total traffic rate.

Restrictions and guidelines: Traffic policing, GTS, and rate limit configuration

The specified CIR does not take traffic transmitted in interframe gaps into account, and the actually allowed rate on an interface is greater than the specified CIR.

An interframe gap is a time interval for transmitting 12 bits between frames. This gap serves the following roles:

- Allows the device to differentiate one frame from another.
- Allows for time for the device to process the current frame and to prepare for receiving the next frame.

Configuring traffic policing

Restrictions and guidelines

The device supports the following application destinations for traffic policing:

- Interface.
- VLANs.
- Globally.
- User profile.

Procedure

1. Enter system view.
   `system-view`
2. Define a traffic class.

a. Create a traffic class and enter traffic class view.

traffic classifier *classifier-name* [**operator** { **and** | **or** }]

b. Configure a match criterion.

if-match *match-criteria*

By default, no match criterion is configured.

For more information about the **if-match** command, see *ACL and QoS Command Reference*.

c. Return to system view.

quit

3. Define a traffic behavior.

a. Create a traffic behavior and enter traffic behavior view.

traffic behavior *behavior-name*

b. Configure a traffic policing action.

car cir *committed-information-rate* [**cbs** *committed-burst-size* [**ebs** *excess-burst-size*]] [**green** *action* | **red** *action* | **yellow** *action*] *

car cir *committed-information-rate* [**cbs** *committed-burst-size*] **pir** *peak-information-rate* [**ebs** *excess-burst-size*] [**green** *action* | **red** *action* | **yellow** *action*] *

By default, no traffic policing action is configured.

c. Return to system view.

quit

4. Define a QoS policy.

a. Create a QoS policy and enter QoS policy view.

qos policy *policy-name*

b. Associate the traffic class with the traffic behavior in the QoS policy.

classifier *classifier-name* **behavior** *behavior-name*

By default, a traffic class is not associated with a traffic behavior.

c. Return to system view.

quit

5. Apply the QoS policy.

For more information, see "Applying the QoS policy."

By default, no QoS policy is applied.

Configuring GTS

Restrictions and guidelines

The term "interface" in this section refers to Layer 2 Ethernet interfaces.

Procedure

1. Enter system view.

system-view

2. Enter interface view.

interface *interface-type interface-number*

3. Configure GTS for a queue.

qos gts queue *queue-id* **cir** *committed-information-rate* [**cbs** *committed-burst-size*]

undo qos gts queue *queue-id*

By default, GTS is not configured on an interface.

Configuring the rate limit

Restrictions and guidelines

The term "interface" in this section refers to Layer 2 Ethernet interfaces.

Procedure

1. Enter system view.
   system-view
2. Enter interface view.
   interface *interface-type interface-number*
3. Configure the rate limit for the interface.
   qos lr { **inbound** | **outbound** } **cir** *committed-information-rate* [**cbs** *committed-burst-size*]

   By default, no rate limit is configured on an interface.

Display and maintenance commands for traffic policing, GTS, and rate limit

Execute **display** commands in any view.

Task	Command
Display GTS configuration and statistics for interfaces.	**display qos gts interface** [*interface-type interface-number*]
Display rate limit configuration and statistics.	**display qos lr interface** [*interface-type interface-number*]
Display QoS and ACL resource usage.	**display qos-acl resource** [**slot** *slot-number*]
Display traffic behavior configuration.	**display traffic behavior user-defined** [*behavior-name*]

Traffic policing, GTS, and rate limit configuration examples

Example: Configuring traffic policing and GTS

Network requirements

As shown in Figure 10:

- The server, Host A, and Host B can access the Internet through Device A and Device B.

- The server, Host A, and GigabitEthernet 1/0/1 of Device A are in the same network segment.
- Host B and GigabitEthernet 1/0/2 of Device A are in the same network segment.

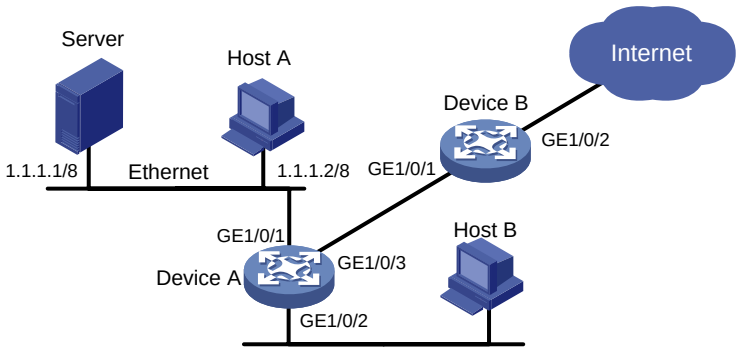
Perform traffic control for the packets that GigabitEthernet 1/0/1 of Device A receives from the server and Host A using the following guidelines:

- Limit the rate of packets from the server to 10240 kbps. When the traffic rate is below 10240 kbps, the traffic is forwarded. When the traffic rate exceeds 10240 kbps, the excess packets are marked with DSCP value 0 and then forwarded.
- Limit the rate of packets from Host A to 2560 kbps. When the traffic rate is below 2560 kbps, the traffic is forwarded. When the traffic rate exceeds 2560 kbps, the excess packets are dropped.

Perform traffic control on GigabitEthernet 1/0/1 and GigabitEthernet 1/0/2 of Device B using the following guidelines:

- Limit the incoming traffic rate on GigabitEthernet 1/0/1 to 20480 kbps, and the excess packets are dropped.
- Limit the outgoing traffic rate on GigabitEthernet 1/0/2 to 10240 kbps, and the excess packets are dropped.

Figure 10 Network diagram



Configuration procedure

1. Configure Device A:

Configure ACL 2001 and ACL 2002 to permit the packets from the server and Host A, respectively.

```
[DeviceA] acl basic 2001
[DeviceA-acl-ipv4-basic-2001] rule permit source 1.1.1.1 0
[DeviceA-acl-ipv4-basic-2001] quit
[DeviceA] acl basic 2002
[DeviceA-acl-ipv4-basic-2002] rule permit source 1.1.1.2 0
[DeviceA-acl-ipv4-basic-2002] quit
```

Create a traffic class named **server**, and use ACL 2001 as the match criterion.

```
[DeviceA] traffic classifier server
[DeviceA-classifier-server] if-match acl 2001
[DeviceA-classifier-server] quit
```

Create a traffic class named **host**, and use ACL 2002 as the match criterion.

```
[DeviceA] traffic classifier host
[DeviceA-classifier-host] if-match acl 2002
[DeviceA-classifier-host] quit
```

Create a traffic behavior named **server**, and configure a traffic policing action (CIR 10240 kbps).

```
[DeviceA] traffic behavior server
```

```
[DeviceA-behavior-server] car cir 10240 red remark-dscp-pass 0
[DeviceA-behavior-server] quit
```

Create a traffic behavior named **host**, and configure a traffic policing action (CIR 2560 kbps).

```
[DeviceA] traffic behavior host
[DeviceA-behavior-host] car cir 2560
[DeviceA-behavior-host] quit
```

Create a QoS policy named **car**, and associate traffic classes **server** and **host** with traffic behaviors **server** and **host** in QoS policy **car**, respectively.

```
[DeviceA] qos policy car
[DeviceA-qospolicy-car] classifier server behavior server
[DeviceA-qospolicy-car] classifier host behavior host
[DeviceA-qospolicy-car] quit
```

Apply QoS policy **car** to the inbound direction of GigabitEthernet 1/0/1.

```
[DeviceA] interface gigabitethernet 1/0/1
[DeviceA-GigabitEthernet1/0/1] qos apply policy car inbound
```

2. Configure Device B:

Create ACL 3001, and configure a rule to match HTTP packets.

```
<DeviceB> system-view
[DeviceB] acl advanced 3001
[DeviceB-acl-adv-3001] rule permit tcp destination-port eq 80
[DeviceB-acl-adv-3001] quit
```

Create a traffic class named **http**, and use ACL 3001 as a match criterion.

```
[DeviceB] traffic classifier http
[DeviceB-classifier-http] if-match acl 3001
[DeviceB-classifier-http] quit
```

Create a traffic class named **class**, and configure the traffic class to match all packets.

```
[DeviceB] traffic classifier class
[DeviceB-classifier-class] if-match any
[DeviceB-classifier-class] quit
```

Create a traffic behavior named **car_inbound**, and configure a traffic policing action (CIR 20480 kbps).

```
[DeviceB] traffic behavior car_inbound
[DeviceB-behavior-car_inbound] car cir 20480
[DeviceB-behavior-car_inbound] quit
```

Create a traffic behavior named **car_outbound**, and configure a traffic policing action (CIR 10240 kbps).

```
[DeviceB] traffic behavior car_outbound
[DeviceB-behavior-car_outbound] car cir 10240
[DeviceB-behavior-car_outbound] quit
```

Create a QoS policy named **car_inbound**, and associate traffic class **class** with traffic behavior **car_inbound** in QoS policy **car_inbound**.

```
[DeviceB] qos policy car_inbound
[DeviceB-qospolicy-car_inbound] classifier class behavior car_inbound
[DeviceB-qospolicy-car_inbound] quit
```

Create a QoS policy named **car_outbound**, and associate traffic class **http** with traffic behavior **car_outbound** in QoS policy **car_outbound**.

```
[DeviceB] qos policy car_outbound
[DeviceB-qospolicy-car_outbound] classifier http behavior car_outbound
```

```
[DeviceB-qospolicy-car_outbound] quit
```

Apply QoS policy **car_inbound** to the inbound direction of GigabitEthernet 1/0/1.

```
[DeviceB] interface gigabitethernet 1/0/1
[DeviceB-GigabitEthernet1/0/1] qos apply policy car_inbound inbound
```

Apply QoS policy **car_outbound** to the outbound direction of GigabitEthernet 1/0/2.

```
[DeviceB] interface gigabitethernet 1/0/2
[DeviceB-GigabitEthernet1/0/2] qos apply policy car_outbound outbound
```

Configuring congestion management

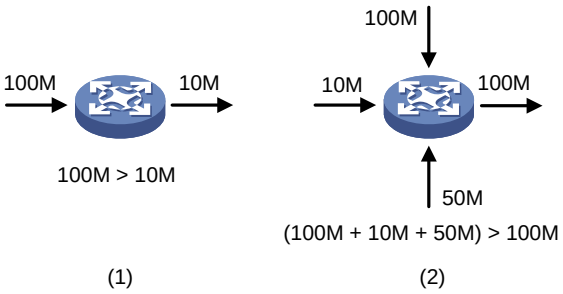
About congestion management

Cause, negative results, and countermeasure of congestion

Congestion occurs on a link or node when traffic size exceeds the processing capability of the link or node. It is typical of a statistical multiplexing network and can be caused by link failures, insufficient resources, and various other causes.

Figure 11 shows two typical congestion scenarios.

Figure 11 Traffic congestion scenarios



Congestion produces the following negative results:

- Increased delay and jitter during packet transmission.
- Decreased network throughput and resource use efficiency.
- Network resource (memory, in particular) exhaustion and even system breakdown.

Congestion is unavoidable in switched networks and multiuser application environments. To improve the service performance of your network, take measures to manage and control it.

The key to congestion management is defining a resource dispatching policy to prioritize packets for forwarding when congestion occurs.

Congestion management methods

Congestion management uses queuing and scheduling algorithms to classify and sort traffic leaving a port.

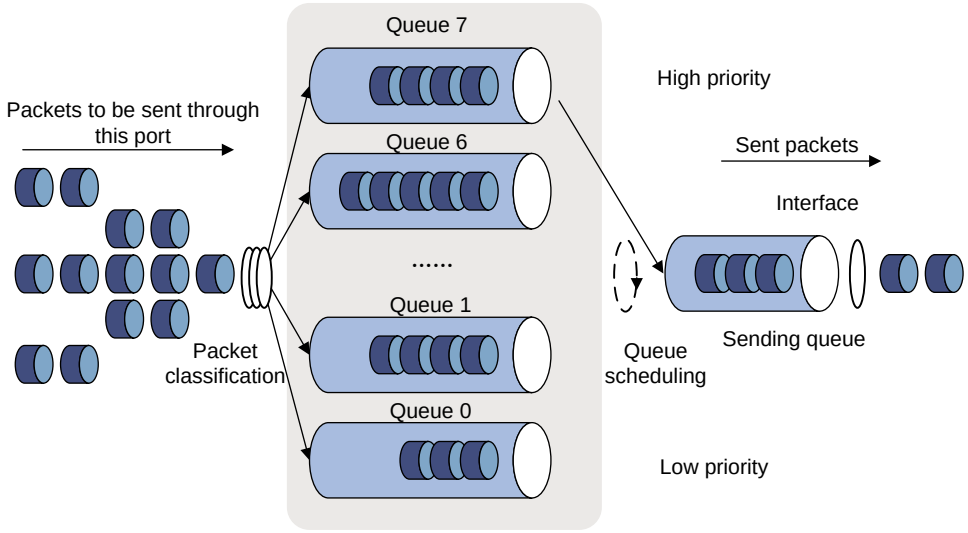
The device supports the following queuing mechanisms:

- SP.
- WRR.

SP queuing

SP queuing is designed for mission-critical applications that require preferential service to reduce the response delay when congestion occurs.

Figure 12 SP queuing



In Figure 12, SP queuing classifies eight queues on a port into eight classes, numbered 7 to 0 in descending priority order.

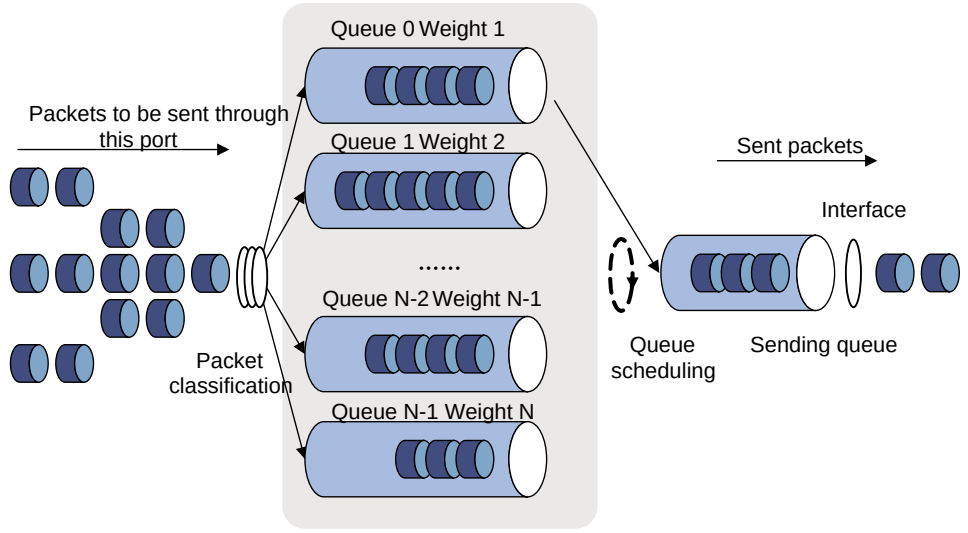
SP queuing schedules the eight queues in the descending order of priority. SP queuing sends packets in the queue with the highest priority first. When the queue with the highest priority is empty, it sends packets in the queue with the second highest priority, and so on. You can assign mission-critical packets to a high priority queue to make sure they are always served first. Common service packets can be assigned to low priority queues to be transmitted when high priority queues are empty.

The disadvantage of SP queuing is that packets in the lower priority queues cannot be transmitted if packets exist in the higher priority queues. In the worst case, lower priority traffic might never get serviced.

WRR queuing

WRR queuing schedules all the queues in turn to ensure that every queue is served for a certain time, as shown in Figure 13.

Figure 13 WRR queuing



Assume a port provides eight output queues. WRR assigns each queue a weight value (represented by w7, w6, w5, w4, w3, w2, w1, or w0). The weight value of a queue decides the proportion of resources assigned to the queue. On a 100 Mbps port, you can set the weight values to 50, 30, 10, 10, 50, 30, 10, and 10 for w7 through w0. In this way, the queue with the lowest priority can get a minimum of 5 Mbps of bandwidth. WRR solves the problem that SP queuing might fail to serve packets in low-priority queues for a long time.

Another advantage of WRR queuing is that when the queues are scheduled in turn, the service time for each queue is not fixed. If a queue is empty, the next queue will be scheduled immediately. This improves bandwidth resource use efficiency.

WRR queuing includes the following types:

- **Basic WRR queuing**—Contains multiple queues. You can set the weight for each queue, and WRR schedules these queues based on the user-defined parameters in a round robin manner.
- **Group-based WRR queuing**—All the queues are scheduled by WRR. You can divide output queues to WRR priority queue group 1 and WRR priority queue group 2. Round robin queue scheduling is performed for group 1 first. If group 1 is empty, round robin queue scheduling is performed for group 2. Only WRR priority queue group 1 is supported in the current software version.

On an interface enabled with group-based WRR queuing, you can assign queues to the SP group. Queues in the SP group are scheduled with SP. The SP group has higher scheduling priority than the WRR groups.

Congestion management tasks at a glance

To configure congestion management, perform the following tasks:

- Configuring queuing on an interface
  - Configuring SP queuing
  - Configuring WRR queuing
  - Configuring SP+WRR queuing
- Configuring a queue scheduling profile

Configuring queuing on an interface

Restrictions and guidelines for queuing configuration

The term "interface" in this section refers to Layer 2 Ethernet interfaces.

The queue ID, queue name, group, and weight in the **`display qos queue interface`** command output form a queue scheduling template. A queue scheduling template corresponds to a unique combination of queue parameter settings on an interface.

The device supports a maximum of eight queue scheduling templates, including the default queue scheduling template, the queue scheduling template for IRF physical interfaces, and predefined queue scheduling template for the CPU. If multiple interfaces use the same user-created queue scheduling template, make sure at least one other queue scheduling template has not been used on any interface.

If all queue scheduling templates are used, you can configure congestion management through a queue scheduling profile (see "Configuring a queue scheduling profile").

Configuring SP queuing

1. Enter system view.

system-view

2. Enter interface view.
   interface *interface-type interface-number*
3. Configure SP queuing.
   qos sp
   By default, an interface uses byte-count WRR queuing.

Configuring WRR queuing

1. Enter system view.
   system-view
2. Enter interface view.
   interface *interface-type interface-number*
3. Enable WRR queuing.
   qos wrr weight
   By default, an interface uses packet-count WRR queuing.
4. Assign a queue to a WRR group, and configure scheduling parameters for the queue.
   qos wrr *queue-id* **group 1 weight** *schedule-value*
   By default, all queues on a WRR-enabled interface are in WRR group 1, and queues 0 through 7 have a weight of 1, 2, 3, 4, 5, 9, 13, and 15, respectively.

Configuring SP+WRR queuing

Restrictions and guidelines

To configure the scheduling weight, you must specify the same scheduling unit as specified when enabling WRR queuing.

Procedure

1. Enter system view.
   system-view
2. Enter interface view.
   interface *interface-type interface-number*
3. Enable byte-count or packet-count WRR queuing.
   qos wrr weight
   By default, an interface uses packet-count WRR queuing.
4. Assign a queue to the SP group.
   qos wrr *queue-id* **group sp**
   By default, all queues on a WRR-enabled interface are in WRR group 1.
5. Assign a queue to a WRR group, and configure a scheduling weight for the queue.
   qos wrr *queue-id* **group 1 weight** *schedule-value*
   By default, all queues on a WRR-enabled interface are in WRR group 1, and queues 0 through 7 have a weight of 1, 2, 3, 4, 5, 9, 13, and 15, respectively.

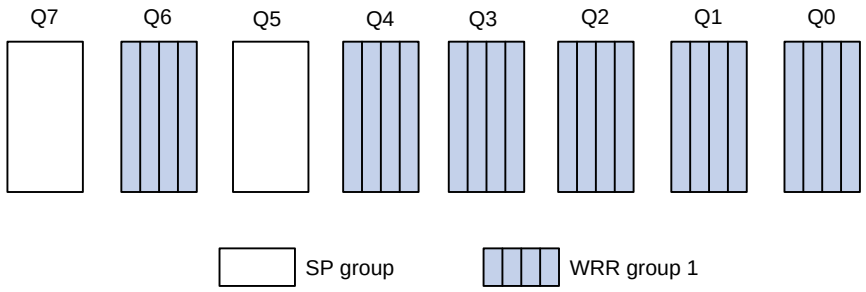
Configuring a queue scheduling profile

About queue scheduling profiles

In a queue scheduling profile, you can configure scheduling parameters for each queue. By applying the queue scheduling profile to an interface, you can implement congestion management on the interface.

Queue scheduling profiles support two queue scheduling algorithms: SP and WRR. In a queue scheduling profile, you can also configure SP+WRR. For information about each scheduling algorithm, see "About congestion management." When SP and WRR groups are configured in a queue scheduling profile, Figure 14 shows the scheduling order.

Figure 14 Queue scheduling profile configured with both SP and WRR



- Queue 7 has the highest priority in the SP group. Its packets are sent preferentially.
- Queue 5 has the second highest priority in the SP group. Packets in queue 5 are sent when queue 7 is empty.
- All queues in WRR group 1 are scheduled according to their weights. When queue 7 and queue 5 are empty, WRR group 1 is scheduled.

Restrictions and guidelines for queue scheduling profile configuration

When you configure a queue scheduling profile, follow these restrictions and guidelines:

- The term "interface" in this section refers to Layer 2 Ethernet interfaces.
- Only one queue scheduling profile can be applied to an interface.
- You can modify the scheduling parameters in a queue scheduling profile already applied to an interface.

Configuring a queue scheduling profile

1. Enter system view.
   `system-view`
2. Create a queue scheduling profile and enter queue scheduling profile view.
   `qos qmprofile` *`profile-name`*
3. (Optional.) Configure queue scheduling parameters.
   - Configure a queue to use SP.
     `queue` *`queue-id`* **`sp`**
   - Configure a queue to use WRR.

queue *queue-id* **wrr group** *group-id* { **weight** | **byte-count** } *schedule-value*

By default, all queues in a queue scheduling profile use SP queuing.

Applying a queue scheduling profile

1. Enter system view.
   system-view
2. Enter interface view.
   interface *interface-type interface-number*
3. Apply the queue scheduling profile to the outbound direction of the interface.
   qos apply qmprofile *profile-name*
   By default, no queue scheduling profile is applied to an interface.

Example: Configuring a queue scheduling profile

Network configuration

Configure a queue scheduling profile to meet the following requirements on GigabitEthernet 1/0/1:

- Queue 7 has the highest priority, and its packets are sent preferentially.
- Queue 0 through queue 6 are in the WRR group and are scheduled according to their packet-count weights, which are 2, 1, 2, 4, 6, 8, and 10, respectively. When queue 7 is empty, the WRR group is scheduled.

Procedure

Enter system view.

```
<Sysname> system-view
```

Create a queue scheduling profile named **qm1**.

```
[Sysname] qos qmprofile qm1
[Sysname-qmprofile-qm1]
```

Configure queue 7 to use SP queuing.

```
[Sysname-qmprofile-qm1] queue 7 sp
```

Assign queue 0 through queue 6 to WRR group 1, with their packet-count weights as 2, 1, 2, 4, 6, 8, and 10, respectively.

```
[Sysname-qmprofile-qm1] queue 0 wrr group 1 weight 2
[Sysname-qmprofile-qm1] queue 1 wrr group 1 weight 1
[Sysname-qmprofile-qm1] queue 2 wrr group 1 weight 2
[Sysname-qmprofile-qm1] queue 3 wrr group 1 weight 4
[Sysname-qmprofile-qm1] queue 4 wrr group 1 weight 6
[Sysname-qmprofile-qm1] queue 5 wrr group 1 weight 8
[Sysname-qmprofile-qm1] queue 6 wrr group 1 weight 10
[Sysname-qmprofile-qm1] quit
```

Apply queue scheduling profile **qm1** to GigabitEthernet 1/0/1.

```
[Sysname] interface gigabitethernet 1/0/1
[Sysname-GigabitEthernet1/0/1] qos apply qmprofile qm1
```

After the configuration is completed, GigabitEthernet 1/0/1 performs queue scheduling as specified in queue scheduling profile **qm1**.

Display and maintenance commands for congestion management

Execute **display** commands in any view.

Task	Command
Display the configuration of queue scheduling profiles.	**display qos qmprofile configuration** [*profile-name*] [**slot** *slot-number*]
Display the queue scheduling profiles applied to interfaces.	**display qos qmprofile interface** [*interface-type interface-number*]
Display outbound queue-based traffic statistics for interfaces.	**display qos queue-statistics interface outbound**
Display SP queuing configuration.	**display qos queue sp interface** [*interface-type interface-number*]
Display WRR queuing configuration.	**display qos queue wrr interface** [*interface-type interface-number*]

Configuring traffic filtering

About traffic filtering

You can filter in or filter out traffic of a class by associating the class with a traffic filtering action. For example, you can filter packets sourced from an IP address according to network status.

Restrictions and guidelines: Traffic filtering configuration

The device supports the following application destinations for traffic filtering:

- Interface.
- VLANs.
- Globally.
- User profile.

Procedure

1. Enter system view.
   system-view
2. Define a traffic class.
   a. Create a traffic class and enter traffic class view.
      traffic classifier *classifier-name* [**operator** { **and** | **or** }]
   b. Configure a match criterion.
      if-match *match-criteria*
      By default, no match criterion is configured.
      For more information about configuring match criteria, see *ACL and QoS Command Reference*.
   c. Return to system view.
      quit
3. Define a traffic behavior.
   a. Create a traffic behavior and enter traffic behavior view.
      traffic behavior *behavior-name*
   b. Configure the traffic filtering action.
      filter { **deny** | **permit** }
      By default, no traffic filtering action is configured.
      If a traffic behavior has the **filter deny** action, all other actions in the traffic behavior except class-based accounting do not take effect.
   c. Return to system view.
      quit
4. Define a QoS policy.
   a. Create a QoS policy and enter QoS policy view.

qos policy *policy-name*

b. Associate the traffic class with the traffic behavior in the QoS policy.
classifier *classifier-name* **behavior** *behavior-name*
By default, a traffic class is not associated with a traffic behavior.

c. Return to system view.
quit

5. Apply the QoS policy.
For more information, see "Applying the QoS policy."
By default, no QoS policy is applied.

6. (Optional.) Display the traffic filtering configuration.
display traffic behavior user-defined [*behavior-name*]
This command is available in any view.

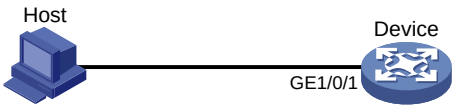
Traffic filtering configuration examples

Example: Configuring traffic filtering

Network configuration

As shown in Figure 15, configure traffic filtering on GigabitEthernet 1/0/1 to deny the incoming packets with a source port number other than 21.

Figure 15 Network diagram



Procedure

Create advanced ACL 3000, and configure a rule to match packets whose source port number is not 21.

```
<Device> system-view
[Device] acl advanced 3000
[Device-acl-ipv4-adv-3000] rule 0 permit tcp source-port neq 21
[Device-acl-ipv4-adv-3000] quit
```

Create a traffic class named **classifier_1**, and use ACL 3000 as the match criterion in the traffic class.

```
[Device] traffic classifier classifier_1
[Device-classifier-classifier_1] if-match acl 3000
[Device-classifier-classifier_1] quit
```

Create a traffic behavior named **behavior_1**, and configure the traffic filtering action to drop packets.

```
[Device] traffic behavior behavior_1
[Device-behavior-behavior_1] filter deny
[Device-behavior-behavior_1] quit
```

Create a QoS policy named **policy**, and associate traffic class **classifier_1** with traffic behavior **behavior_1** in the QoS policy.

```
[Device] qos policy policy
```

```
[Device-qospolicy-policy] classifier classifier_1 behavior behavior_1
[Device-qospolicy-policy] quit
```

Apply QoS policy **policy** to the incoming traffic of GigabitEthernet 1/0/1.

```
[Device] interface gigabitethernet 1/0/1
[Device-GigabitEthernet1/0/1] qos apply policy policy inbound
```

Configuring priority marking

About priority marking

Priority marking sets the priority fields or flag bits of packets to modify the priority of packets. For example, you can use priority marking to set IP precedence or DSCP for a class of IP packets to control the forwarding of these packets.

To configure priority marking to set the priority fields or flag bits for a class of packets, perform the following tasks:

1. Configure a traffic behavior with a priority marking action.
2. Associate the traffic class with the traffic behavior.

Priority marking can be used together with priority mapping. For more information, see "Configuring priority mapping."

Configuring priority marking

Restrictions and guidelines

The device supports applying a QoS policy containing a priority marking action only to the inbound direction.

Procedure

1. Enter system view.
   system-view
2. Define a traffic class.
   a. Create a traffic class and enter traffic class view.
      traffic classifier *classifier-name* [**operator** { **and** | **or** }]
   b. Configure a match criterion.
      if-match *match-criteria*
      By default, no match criterion is configured.
      For more information about the **if-match** command, see *ACL and QoS Command Reference*.
   c. Return to system view.
      quit
3. Define a traffic behavior.
   a. Create a traffic behavior and enter traffic behavior view.
      traffic behavior *behavior-name*
   b. Configure a priority marking action.
      For configurable priority marking actions, see the **remark** commands in *ACL and QoS Command Reference*.
   c. Return to system view.
      quit
4. Define a QoS policy.
   a. Create a QoS policy and enter QoS policy view.
      qos policy *policy-name*

b. Associate the traffic class with the traffic behavior in the QoS policy.
classifier *classifier-name* **behavior** *behavior-name*
By default, a traffic class is not associated with a traffic behavior.

c. Return to system view.
quit

5. Apply the QoS policy.
For more information, see "Applying the QoS policy."
By default, no QoS policy is applied.

6. (Optional.) Display the priority marking configuration.
display traffic behavior user-defined [*behavior-name*]
This command is available in any view.

Priority marking configuration examples

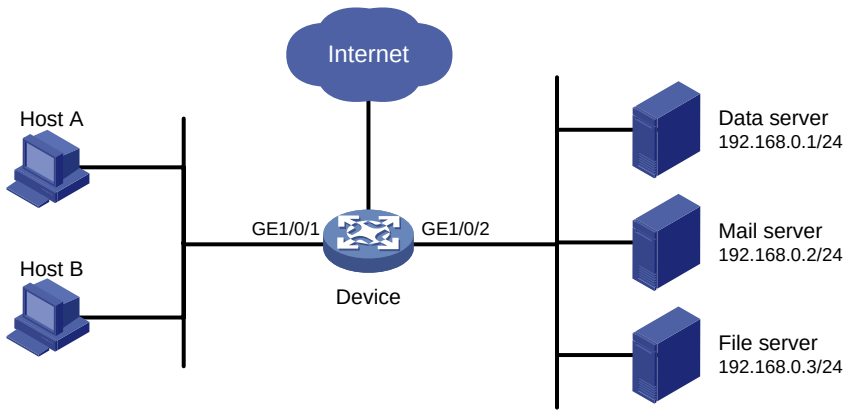
Example: Configuring priority marking

Network configuration

As shown in Figure 16, configure priority marking on the device to meet the following requirements:

Traffic source	Destination	Processing priority
Host A, B	Data server	High
Host A, B	Mail server	Medium
Host A, B	File server	Low

Figure 16 Network diagram



Procedure

Create advanced ACL 3000, and configure a rule to match packets with destination IP address 192.168.0.1.

```
<Device> system-view
[Device] acl advanced 3000
[Device-acl-ipv4-adv-3000] rule permit ip destination 192.168.0.1 0
[Device-acl-ipv4-adv-3000] quit
```

Create advanced ACL 3001, and configure a rule to match packets with destination IP address 192.168.0.2.

```
[Device] acl advanced 3001
[Device-acl-ipv4-adv-3001] rule permit ip destination 192.168.0.2 0
[Device-acl-ipv4-adv-3001] quit
```

Create advanced ACL 3002, and configure a rule to match packets with destination IP address 192.168.0.3.

```
[Device] acl advanced 3002
[Device-acl-ipv4-adv-3002] rule permit ip destination 192.168.0.3 0
[Device-acl-ipv4-adv-3002] quit
```

Create a traffic class named **classifier_dbserver**, and use ACL 3000 as the match criterion in the traffic class.

```
[Device] traffic classifier classifier_dbserver
[Device-classifier-classifier_dbserver] if-match acl 3000
[Device-classifier-classifier_dbserver] quit
```

Create a traffic class named **classifier_mserver**, and use ACL 3001 as the match criterion in the traffic class.

```
[Device] traffic classifier classifier_mserver
[Device-classifier-classifier_mserver] if-match acl 3001
[Device-classifier-classifier_mserver] quit
```

Create a traffic class named **classifier_fserver**, and use ACL 3002 as the match criterion in the traffic class.

```
[Device] traffic classifier classifier_fserver
[Device-classifier-classifier_fserver] if-match acl 3002
[Device-classifier-classifier_fserver] quit
```

Create a traffic behavior named **behavior_dbserver**, and configure the action of setting the local precedence value to 4.

```
[Device] traffic behavior behavior_dbserver
[Device-behavior-behavior_dbserver] remark local-precedence 4
[Device-behavior-behavior_dbserver] quit
```

Create a traffic behavior named **behavior_mserver**, and configure the action of setting the local precedence value to 3.

```
[Device] traffic behavior behavior_mserver
[Device-behavior-behavior_mserver] remark local-precedence 3
[Device-behavior-behavior_mserver] quit
```

Create a traffic behavior named **behavior_fserver**, and configure the action of setting the local precedence value to 2.

```
[Device] traffic behavior behavior_fserver
[Device-behavior-behavior_fserver] remark local-precedence 2
[Device-behavior-behavior_fserver] quit
```

Create a QoS policy named **policy_server**, and associate traffic classes with traffic behaviors in the QoS policy.

```
[Device] qos policy policy_server
[Device-qospolicy-policy_server] classifier classifier_dbserver behavior
behavior_dbserver
[Device-qospolicy-policy_server] classifier classifier_mserver behavior
behavior_mserver
[Device-qospolicy-policy_server] classifier classifier_fserver behavior
behavior_fserver
```

```
[Device-qospolicy-policy_server] quit
```

Apply QoS policy **policy_server** to the incoming traffic of GigabitEthernet 1/0/1.

```
[Device] interface gigabitethernet 1/0/1
[Device-GigabitEthernet1/0/1] qos apply policy policy_server inbound
[Device-GigabitEthernet1/0/1] quit
```

Configuring nesting

About nesting

Nesting adds a VLAN tag to the matching packets to allow the VLAN-tagged packets to pass through the corresponding VLAN. For example, you can add an outer VLAN tag to packets from a customer network to a service provider network. This allows the packets to pass through the service provider network by carrying a VLAN tag assigned by the service provider.

Restrictions and guidelines: Nesting configuration

The device supports applying a QoS policy containing a nesting action only to the inbound direction:

Do not enable QinQ and apply a QoS policy containing a nesting action on the same interface. Otherwise, QinQ or the QoS policy does not take effect.

To use the nesting action to add an outer VLAN tag to packets with the specified VLAN ID, you must use the **if-match customer-vlan-id** *vlan-id-list* command to match the single-tagged packets.

Procedure

1. Enter system view.
   system-view
2. Define a traffic class.
   a. Create a traffic class and enter traffic class view.
      traffic classifier *classifier-name* [**operator** { **and** | **or** }]
   b. Configure a match criterion.
      if-match *match-criteria*
      By default, no match criterion is configured for a traffic class.
      For more information about the match criteria, see the **if-match** command in *ACL and QoS Command Reference*.
   c. Return to system view.
      quit
3. Define a traffic behavior.
   a. Create a traffic behavior and enter traffic behavior view.
      traffic behavior *behavior-name*
   b. Configure an outer VLAN tag adding action.
      nest top-most vlan *vlan-id*
      By default, no outer VLAN tag adding action is configured for a traffic behavior.
   c. Return to system view.
      quit
4. Define a QoS policy.
   a. Create a QoS policy and enter QoS policy view.
      qos policy *policy-name*
   b. Associate the traffic class with the traffic behavior in the QoS policy.

classifier *classifier-name* **behavior** *behavior-name*

By default, a traffic class is not associated with a traffic behavior.

c. Return to system view.

quit

5. Apply the QoS policy.

For more information, see "Applying the QoS policy."

By default, no QoS policy is applied.

6. (Optional.) Display the nesting configuration.

display traffic behavior user-defined [*behavior-name*]

This command is available in any view.

Nesting configuration examples

Example: Configuring nesting

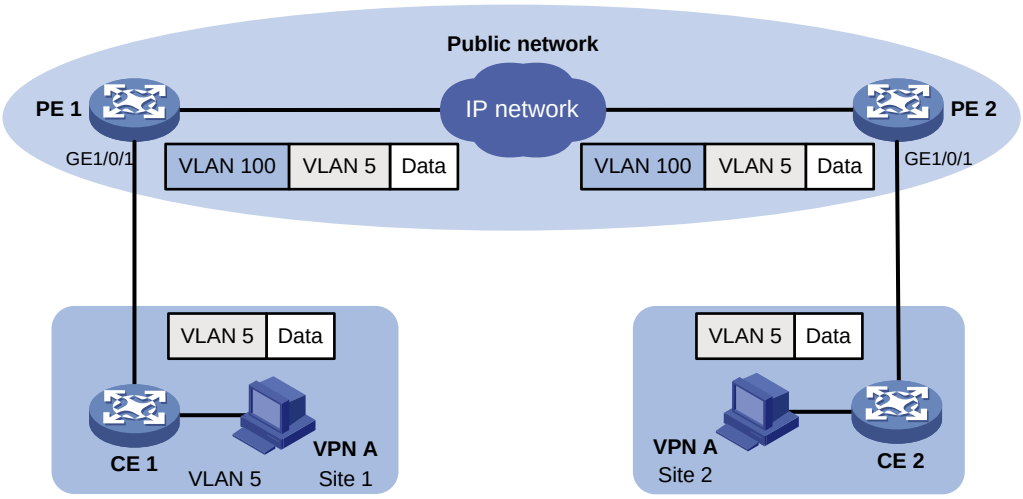
Network configuration

As shown in Figure 17:

- Site 1 and Site 2 in VPN A are two branches of a company. They use VLAN 5 to transmit traffic.
- Because Site 1 and Site 2 are located in different areas, the two sites use the VPN access service of a service provider. The service provider assigns VLAN 100 to the two sites.

Configure nesting, so that the two branches can communicate through the service provider network.

Figure 17 Network diagram



Procedure

1. Configuring PE 1:

Create a traffic class named **test** to match traffic with VLAN ID 5.

```
<PE1> system-view
[PE1] traffic classifier test
[PE1-classifier-test] if-match customer-vlan-id 5
[PE1-classifier-test] quit
```

Configure an action to add outer VLAN tag 100 in traffic behavior **test**.

```
[PE1] traffic behavior test
[PE1-behavior-test] nest top-most vlan 100
[PE1-behavior-test] quit
```

Create a QoS policy named **test**, and associate class **test** with behavior **test** in the QoS policy.

```
[PE1] qos policy test
[PE1-qospolicy-test] classifier test behavior test
[PE1-qospolicy-test] quit
```

Configure the downlink port (GigabitEthernet 1/0/1) as a hybrid port, and assign the port to VLAN 100 as an untagged member.

```
[PE1] interface gigabitethernet 1/0/1
[PE1-GigabitEthernet1/0/1] port link-type hybrid
[PE1-GigabitEthernet1/0/1] port hybrid vlan 100 untagged
```

Apply QoS policy **test** to the incoming traffic of GigabitEthernet 1/0/1.

```
[PE1-GigabitEthernet1/0/1] qos apply policy test inbound
[PE1-GigabitEthernet1/0/1] quit
```

Configure the uplink port (GigabitEthernet 1/0/2) as a trunk port, and assign it to VLAN 100.

```
[PE1] interface gigabitethernet 1/0/2
[PE1-GigabitEthernet1/0/2] port link-type trunk
[PE1-GigabitEthernet1/0/2] port trunk permit vlan 100
[PE1-GigabitEthernet1/0/2] quit
```

2. Configuring PE 2:

Configure PE 2 in the same way PE 1 is configured.

Configuring traffic redirecting

About traffic redirecting

Traffic redirecting redirects packets matching the specified match criteria to a location for processing.

You can redirect packets to the following destinations:

- CPU.
- Interface.

Restrictions and guidelines: Traffic redirecting configuration

- The device supports applying a QoS policy containing a traffic redirecting action only to the inbound direction of an interface.
- If you execute the **redirect** command multiple times, the most recent configuration takes effect.

Procedure

1. Enter system view.
   system-view
2. Define a traffic class.
   a. Create a traffic class and enter traffic class view.
      traffic classifier *classifier-name* [**operator** { **and** | **or** }]
   b. Configure a match criterion.
      if-match *match-criteria*
      By default, no match criterion is configured for a traffic class.
      For more information about the match criteria, see the **if-match** command in *ACL and QoS Command Reference*.
   c. Return to system view.
      quit
3. Define a traffic behavior.
   a. Create a traffic behavior and enter traffic behavior view.
      traffic behavior *behavior-name*
   b. Configure a traffic redirecting action.
      redirect { **cpu** | **interface** *interface-type interface-number* }
      By default, no traffic redirecting action is configured for a traffic behavior.
   c. Return to system view.
      quit
4. Define a QoS policy.
   a. Create a QoS policy and enter QoS policy view.

qos policy *policy-name*

b. Associate the traffic class with the traffic behavior in the QoS policy.

classifier *classifier-name* **behavior** *behavior-name*

By default, a traffic class is not associated with a traffic behavior.

c. Return to system view.

quit

5. Apply the QoS policy.

For more information, see "Applying the QoS policy."

By default, no QoS policy is applied.

6. (Optional.) Display traffic redirecting configuration.

display traffic behavior user-defined [*behavior-name*]

This command is available in any view.

Traffic redirecting configuration examples

Example: Configuring traffic redirecting

Network configuration

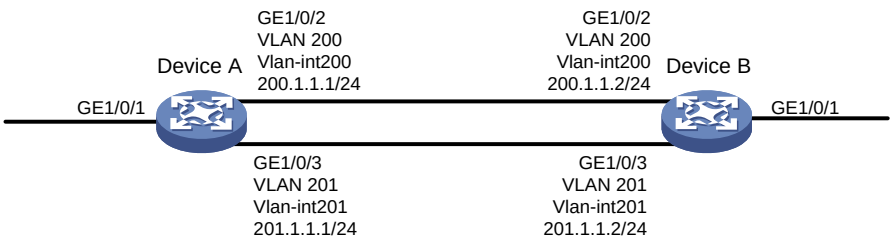
As shown in Figure 18:

- Device A is connected to Device B through two links. Device A and Device B are each connected to other devices.
- GigabitEthernet 1/0/1 of Device A is a trunk port and belongs to VLAN 200 and VLAN 201.
- GigabitEthernet 1/0/2 of Device A and GigabitEthernet 1/0/2 of Device B belong to VLAN 200.
- GigabitEthernet 1/0/3 of Device A and GigabitEthernet 1/0/3 of Device B belong to VLAN 201.
- On Device A, the IP address of VLAN-interface 200 is 200.1.1.1/24, and that of VLAN-interface 201 is 201.1.1.1/24.
- On Device B, the IP address of VLAN-interface 200 is 200.1.1.2/24, and that of VLAN-interface 201 is 201.1.1.2/24.

Configure the actions of redirecting traffic to an interface to meet the following requirements:

- Packets with source IP address 2.1.1.1 received on GigabitEthernet 1/0/1 of Device A are forwarded to GigabitEthernet 1/0/2.
- Packets with source IP address 2.1.1.2 received on GigabitEthernet 1/0/1 of Device A are forwarded to GigabitEthernet 1/0/3.
- Other packets received on GigabitEthernet 1/0/1 of Device A are forwarded according to the routing table.

Figure 18 Network diagram



Procedure

Create basic ACL 2000, and configure a rule to match packets with source IP address 2.1.1.1.

```
<DeviceA> system-view
[DeviceA] acl basic 2000
[DeviceA-acl-ipv4-basic-2000] rule permit source 2.1.1.1 0
[DeviceA-acl-ipv4-basic-2000] quit
```

Create basic ACL 2001, and configure a rule to match packets with source IP address 2.1.1.2.

```
[DeviceA] acl basic 2001
[DeviceA-acl-ipv4-basic-2001] rule permit source 2.1.1.2 0
[DeviceA-acl-ipv4-basic-2001] quit
```

Create a traffic class named **classifier_1**, and use ACL 2000 as the match criterion in the traffic class.

```
[DeviceA] traffic classifier classifier_1
[DeviceA-classifier-classifier_1] if-match acl 2000
[DeviceA-classifier-classifier_1] quit
```

Create a traffic class named **classifier_2**, and use ACL 2001 as the match criterion in the traffic class.

```
[DeviceA] traffic classifier classifier_2
[DeviceA-classifier-classifier_2] if-match acl 2001
[DeviceA-classifier-classifier_2] quit
```

Create a traffic behavior named **behavior_1**, and configure the action of redirecting traffic to GigabitEthernet 1/0/2.

```
[DeviceA] traffic behavior behavior_1
[DeviceA-behavior-behavior_1] redirect interface gigabitethernet 1/0/2
[DeviceA-behavior-behavior_1] quit
```

Create a traffic behavior named **behavior_2**, and configure the action of redirecting traffic to GigabitEthernet 1/0/3.

```
[DeviceA] traffic behavior behavior_2
[DeviceA-behavior-behavior_2] redirect interface gigabitethernet 1/0/3
[DeviceA-behavior-behavior_2] quit
```

Create a QoS policy named **policy**.

```
[DeviceA] qos policy policy
```

Associate traffic class **classifier_1** with traffic behavior **behavior_1** in the QoS policy.

```
[DeviceA-qospolicy-policy] classifier classifier_1 behavior behavior_1
```

Associate traffic class **classifier_2** with traffic behavior **behavior_2** in the QoS policy.

```
[DeviceA-qospolicy-policy] classifier classifier_2 behavior behavior_2
[DeviceA-qospolicy-policy] quit
```

Apply QoS policy **policy** to the incoming traffic of GigabitEthernet 1/0/1.

```
[DeviceA] interface gigabitethernet 1/0/1
[DeviceA-GigabitEthernet1/0/1] qos apply policy policy inbound
```

Configuring global CAR

About global CAR

Global committed access rate (CAR) is an approach to policing traffic flows globally. It adds flexibility to common CAR where traffic policing is performed only on a per-traffic class or per-interface basis. In this approach, CAR actions are created in system view and each can be used to police multiple traffic flows as a whole.

Global CAR provides the following CAR actions: aggregate CAR and hierarchical CAR.

Aggregate CAR

An aggregate CAR action is created globally. It can be directly applied to interfaces or used in the traffic behaviors associated with different traffic classes to police multiple traffic flows as a whole. The total rate of the traffic flows must conform to the traffic policing specifications set in the aggregate CAR action.

Hierarchical CAR

A hierarchical CAR action is created globally. It must be used in conjunction with a common CAR or aggregate CAR action. With a hierarchical CAR action, you can limit the total traffic of multiple traffic classes.

A hierarchical CAR action can be used in the common or aggregate CAR action for a traffic class in either AND mode or OR mode.

- In AND mode, the rate of the traffic class is strictly limited under the common or aggregate CAR. This mode applies to flows that must be strictly rate limited.
- In OR mode, the traffic class can use idle bandwidth of other traffic classes associated with the hierarchical CAR. This mode applies to high priority, bursty traffic like video.

By using the two modes appropriately, you can improve bandwidth efficiency.

For example, suppose two flows exist: a low priority data flow and a high priority, bursty video flow. Their total traffic rate cannot exceed 4096 kbps and the video flow must be assured of at least 2048 kbps bandwidth. You can perform the following tasks:

- Configure common CAR actions to set the traffic rate to 2048 kbps for the two flows.
- Configure a hierarchical CAR action to limit their total traffic rate to 4096 kbps.
- Use the action in AND mode in the common CAR action for the data flow.
- Use the action in OR mode in the common CAR action for the video flow.

The video flow is assured of 2048 kbps bandwidth and can use idle bandwidth of the data flow.

In a bandwidth oversubscription scenario, the uplink port bandwidth is lower than the total downlink port traffic rate. You can use hierarchical CAR to meet the following requirements:

- Limit the total rate of downlink port traffic.
- Allow each downlink port to forward traffic at the maximum rate when the other ports are idle.

For example, you can perform the following tasks:

- Use common CAR actions to limit the rates of Internet access flow 1 and flow 2 to both 128 kbps.
- Use a hierarchical CAR action to limit their total traffic rate to 192 kbps.

- Use the hierarchical CAR action for both flow 1 and flow 2 in AND mode.

When flow 1 is not present, flow 2 is transmitted at the maximum rate, 128 kbps. When both flows are present, the total rate of the two flows cannot exceed 192 kbps. As a result, the traffic rate of flow 2 might drop below 128 kbps.

Restrictions and guidelines: Global CAR configuration

- Only aggregate CAR is supported in the current software version.
- The device supports applying a QoS policy containing an aggregate CAR action only to the inbound direction.
- When a QoS policy containing an aggregate CAR action is applied on an IRF fabric, the traffic matching the QoS policy might enter the IRF fabric through interfaces on different IRF member devices. In this case, the actual rate limit that takes effect is the sum of the CIR and PIR in the aggregate CAR action multiplied by the number of involved port groups. Interfaces on different IRF member devices belong to different port groups. Interfaces on the same IRF member device can belong to the same or different port groups. To identify port group information, execute the **debug port mapping** command in probe view. Interfaces with the same **Unit** value belong to the same port group.

Configuring aggregate CAR

1. Enter system view.

   system-view
2. Define a traffic class.
   a. Create a traffic class and enter traffic class view.

      traffic classifier *classifier-name* [**operator** { **and** | **or** }]
   b. Configure a match criterion.

      if-match *match-criteria*

      By default, no match criterion is configured.

      For configurable match criteria, see the **if-match** command in *ACL and QoS Command Reference*.
   c. Return to system view.

      quit
3. Configure an aggregate CAR action.

   qos car *car-name* **aggregative cir** *committed-information-rate* [**cbs** *committed-burst-size* [**ebs** *excess-burst-size*]] [**green** *action* | **red** *action* | **yellow** *action*] *

   qos car *car-name* **aggregative cir** *committed-information-rate* [**cbs** *committed-burst-size*] **pir** *peak-information-rate* [**ebs** *excess-burst-size*] [**green** *action* | **red** *action* | **yellow** *action*] *

   By default, no aggregate CAR action is configured.
4. Define a traffic behavior.
   a. Enter traffic behavior view.

      traffic behavior *behavior-name*
   b. Use the aggregate CAR in the traffic behavior.

car name *car-name*

By default, no aggregate CAR action is used in a traffic behavior.

5. Apply the QoS policy.

   For more information, see "Applying the QoS policy."

   By default, no QoS policy is applied.

Display and maintenance commands for global CAR

Execute **display** commands in any view and **reset** commands in user view.

Task	Command
Display statistics for global CAR actions.	**display qos car name** [*car-name*]
Clear statistics for global CAR actions.	**reset qos car name** [*car-name*]

Configuring class-based accounting

About class-based accounting

Class-based accounting collects statistics on a per-traffic class basis. For example, you can define the action to collect statistics for traffic sourced from a certain IP address. By analyzing the statistics, you can determine whether anomalies have occurred and what action to take.

Restrictions and guidelines: Class-based accounting configuration

The device supports the following application destinations for class-based accounting:

- Interface.
- VLANs.
- Globally.
- User profile.

Procedure

1. Enter system view.
   system-view
2. Define a traffic class.
   a. Create a traffic class and enter traffic class view.
      traffic classifier *classifier-name* [**operator** { **and** | **or** }]
   b. Configure a match criterion.
      if-match *match-criteria*
      By default, no match criterion is configured.
      For more information about the **if-match** command, see *ACL and QoS Command Reference*.
   c. Return to system view.
      quit
3. Define a traffic behavior.
   a. Create a traffic behavior and enter traffic behavior view.
      traffic behavior *behavior-name*
   b. Configure an accounting action.
      accounting { **byte** | **packet** }
      By default, no traffic accounting action is configured.
   c. Return to system view.
      quit
4. Define a QoS policy.
   a. Create a QoS policy and enter QoS policy view.
      qos policy *policy-name*

b. Associate the traffic class with the traffic behavior in the QoS policy.
classifier *classifier-name* **behavior** *behavior-name*
By default, a traffic class is not associated with a traffic behavior.

c. Return to system view.
quit

5. Apply the QoS policy.
For more information, see "Applying the QoS policy."
By default, no QoS policy is applied.

6. (Optional.) Display the class-based accounting configuration.
display traffic behavior user-defined [*behavior-name*]

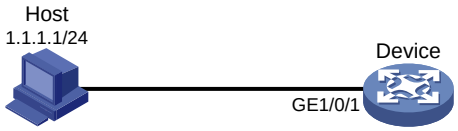
Class-based accounting configuration examples

Example: Configuring class-based accounting

Network configuration

As shown in Figure 19, configure class-based accounting on GigabitEthernet 1/0/1 to collect statistics for incoming traffic from 1.1.1.1/24.

Figure 19 Network diagram



Procedure

Create basic ACL 2000, and configure a rule to match packets with source IP address 1.1.1.1.

```
<Device> system-view
[Device] acl basic 2000
[Device-acl-ipv4-basic-2000] rule permit source 1.1.1.1 0
[Device-acl-ipv4-basic-2000] quit
```

Create a traffic class named **classifier_1**, and use ACL 2000 as the match criterion in the traffic class.

```
[Device] traffic classifier classifier_1
[Device-classifier-classifier_1] if-match acl 2000
[Device-classifier-classifier_1] quit
```

Create a traffic behavior named **behavior_1**, and configure the class-based accounting action.

```
[Device] traffic behavior behavior_1
[Device-behavior-behavior_1] accounting packet
[Device-behavior-behavior_1] quit
```

Create a QoS policy named **policy**, and associate traffic class **classifier_1** with traffic behavior **behavior_1** in the QoS policy.

```
[Device] qos policy policy
[Device-qospolicy-policy] classifier classifier_1 behavior behavior_1
[Device-qospolicy-policy] quit
```

Apply QoS policy **policy** to the incoming traffic of GigabitEthernet 1/0/1.

```
[Device] interface gigabitethernet 1/0/1
[Device-GigabitEthernet1/0/1] qos apply policy policy inbound
[Device-GigabitEthernet1/0/1] quit
```

Display traffic statistics to verify the configuration.

```
[Device] display qos policy interface gigabitethernet 1/0/1
Interface: GigabitEthernet1/0/1
  Direction: Inbound
  Policy: policy
   Classifier: classifier_1
     Operator: AND
     Rule(s) :
      If-match acl 2000
     Behavior: behavior_1
      Accounting enable:
        28529 (Packets)
```

Appendixes

Appendix A Acronyms

Table 2 Appendix A Acronyms

Acronym	Full spelling
BE	Best Effort
CAR	Committed Access Rate
CBS	Committed Burst Size
CE	Congestion Experienced
CIR	Committed Information Rate
DiffServ	Differentiated Service
DSCP	Differentiated Services Code Point
EBS	Excess Burst Size
FIFO	First in First out
FQ	Fair Queuing
GTS	Generic Traffic Shaping
IntServ	Integrated Service
ISP	Internet Service Provider
MPLS	Multiprotocol Label Switching
PE	Provider Edge
PIR	Peak Information Rate
QoS	Quality of Service
RED	Random Early Detection
RSVP	Resource Reservation Protocol
RTP	Real-Time Transport Protocol
SP	Strict Priority
ToS	Type of Service
VoIP	Voice over IP
VPN	Virtual Private Network
WFQ	Weighted Fair Queuing
WRED	Weighted Random Early Detection
WRR	Weighted Round Robin

Appendix B Default priority maps

For the default **dscp-dscp** priority map, an input value yields a target value equal to it.

Table 3 Default dot1p-lp priority map

Input priority value	dot1p-lp map
dot1p	**lp**
0	2
1	0
2	1
3	3
4	4
5	5
6	6
7	7

Table 4 Default dscp-dot1p priority map

Input priority value	dscp-dot1p map
dscp	**dot1p**
0 to 7	0
8 to 15	1
16 to 23	2
24 to 31	3
32 to 39	4
40 to 47	5
48 to 55	6
56 to 63	7

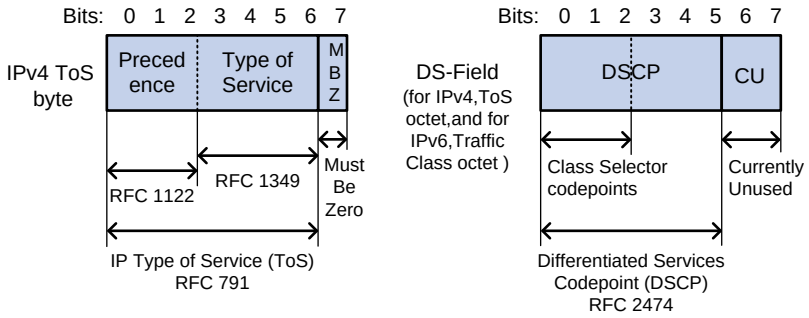
Table 5 Default port priority-local priority map

Port priority	Local precedence
0	0
1	1
2	2
3	3
4	4
5	5
6	6
7	7

Appendix C Introduction to packet precedence

IP precedence and DSCP values

Figure 20 ToS and DS fields



As shown in Figure 20, the ToS field in the IP header contains 8 bits. The first 3 bits (0 to 2) represent IP precedence from 0 to 7. According to RFC 2474, the ToS field is redefined as the differentiated services (DS) field. A DSCP value is represented by the first 6 bits (0 to 5) of the DS field and is in the range 0 to 63. The remaining 2 bits (6 and 7) are reserved.

Table 6 IP precedence

IP precedence (decimal)	IP precedence (binary)	Description
0	000	Routine
1	001	priority
2	010	immediate
3	011	flash
4	100	flash-override
5	101	critical
6	110	internet
7	111	network

Table 7 DSCP values

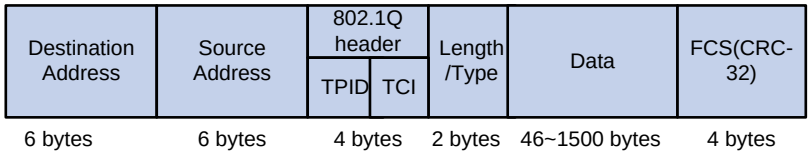
DSCP value (decimal)	DSCP value (binary)	Description
46	101110	ef
10	001010	af11
12	001100	af12
14	001110	af13
18	010010	af21
20	010100	af22
22	010110	af23
26	011010	af31
28	011100	af32

DSCP value (decimal)	DSCP value (binary)	Description
30	011110	af33
34	100010	af41
36	100100	af42
38	100110	af43
8	001000	cs1
16	010000	cs2
24	011000	cs3
32	100000	cs4
40	101000	cs5
48	110000	cs6
56	111000	cs7
0	000000	be (default)

802.1p priority

802.1p priority lies in the Layer 2 header. It applies to occasions where Layer 3 header analysis is not needed and QoS must be assured at Layer 2.

Figure 21 An Ethernet frame with an 802.1Q tag header



As shown in Figure 21, the 4-byte 802.1Q tag header contains the 2-byte tag protocol identifier (TPID) and the 2-byte tag control information (TCI). The value of the TPID is 0x8100. Figure 22 shows the format of the 802.1Q tag header. The Priority field in the 802.1Q tag header is called 802.1p priority, because its use is defined in IEEE 802.1p. Table 8 shows the values for 802.1p priority.

Figure 22 802.1Q tag header

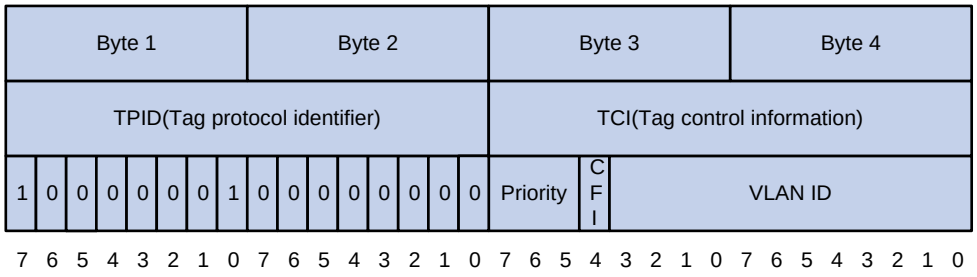


Table 8 Description on 802.1p priority

802.1p priority (decimal)	802.1p priority (binary)	Description
0	000	best-effort
1	001	background

802.1p priority (decimal)	802.1p priority (binary)	Description
2	010	spare
3	011	excellent-effort
4	100	controlled-load
5	101	video
6	110	voice
7	111	network-management

Contents

Configuring data buffers

About data buffers

Data buffer types

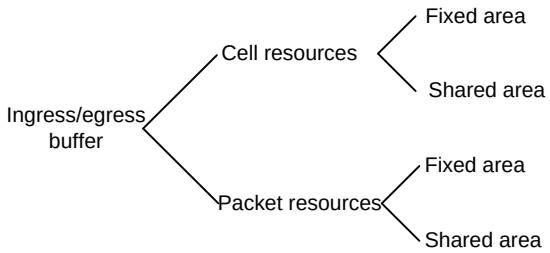
Data buffers temporarily store packets to avoid packet loss.

The following data buffers are available:

- **Ingress buffer**—Stores incoming packets when the CPU is busy.
- **Egress buffer**—Stores outgoing packets when network congestion occurs.

Figure 1 shows the structure of ingress and egress buffers.

Figure 1 Data buffer structure



Cell resources and packet resources

A buffer uses the following types of resources:

- **Cell resources**—Store packets. The buffer uses cell resources based on packet sizes. Suppose a cell resource provides 208 bytes. The buffer allocates one cell resource to a 128-byte packet and two cell resources to a 300-byte packet.
- **Packet resources**—Store packet pointers. A packet pointer indicates where the packet is located in cell resources. The buffer uses one packet resource for each incoming or outgoing packet.

Fixed area and shared area

Each type of resources has a fixed area and a shared area.

- **Fixed area**—Partitioned into queues, each of which is equally divided by all the interfaces on the switch, as shown in Figure 2. When congestion occurs or the CPU is busy, the following rules apply:

  a. An interface first uses the relevant queues of the fixed area to store packets.

  b. When a queue is full, the interface uses the corresponding queue of the shared area.

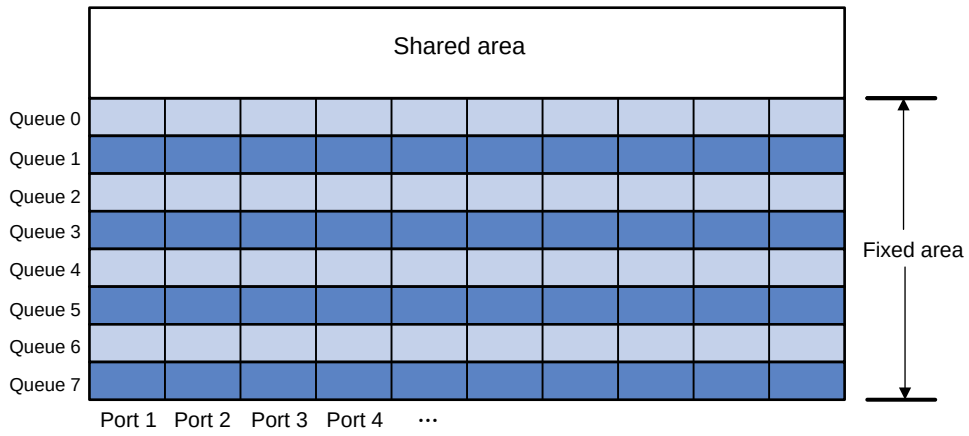
  c. When the queue in the shared area is also full, the interface discards subsequent packets.

  The system allocates the fixed area among queues as specified by the user. Even if a queue is not full, other queues cannot preempt its space. Similarly, the share of a queue for an interface cannot be preempted by other interfaces even if it is not full.
- **Shared area**—Partitioned into queues, each of which is not equally divided by the interfaces, as shown in Figure 2. The system determines the actual shared-area space for each queue

according to user configuration and the number of packets actually received and sent. If a queue is not full, other queues can preempt its space.

The system puts packets received or sent on all interfaces into a queue in the order they arrive. When the queue is full, subsequent packets are dropped.

Figure 2 Fixed area and shared area



Restrictions and guidelines: Data buffer configuration

You can configure data buffers either manually or automatically by enabling the Burst feature. If you have configured data buffers in one way, delete the configuration before using the other way. Otherwise, the new configuration does not take effect.

Inappropriate data buffer changes can cause system problems. Before manually changing data buffer settings, make sure you understand its impact on your device. As a best practice, use the **`burst-mode enable`** command if the system requires large buffer spaces.

Data buffer tasks at a glance

To configure the data buffer, perform the following tasks:

- Enabling the Burst feature
- Configuring data buffers manually

Enabling the Burst feature

About the Burst feature

The Burst feature enables the device to automatically allocate cell and packet resources. It is well suited to the following scenarios:

- Broadcast or multicast traffic is intensive, resulting in bursts of traffic.
- Traffic comes in and goes out in one of the following ways:
  - Enters a device from a high-speed interface and goes out of a low-speed interface.
  - Enters from multiple same-rate interfaces at the same time and goes out of an interface with the same rate.

The default data buffer settings are changed after the Burst feature is enabled. You can display the data buffer settings by using the **display buffer** command.

Procedure

1. Enter system view.

   system-view

2. Enable the Burst feature.

   burst-mode enable

   By default, the Burst feature is disabled.

Configuring data buffers manually

About manual data buffer configuration

Each type of resources of a buffer, packet or cell, has a fixed size. After you set the shared-area size for a type of resources, the rest is automatically assigned to the fixed area.

By default, all queues have an equal share of the shared area and the fixed area. You can change the maximum shared-area space and the fixed-area for a queue. The unconfigured queues use the default settings.

Restrictions and guidelines

In Release 6126P13 and later versions, you can set the following parameters to 100% in a multicast video scenario to relieve the problem of stuck pictures:

- The maximum shared-area ratio of cell resources for a queue.
- The total shared-area ratio of cell resources.
- The maximum shared-area ratio of packet resources for a queue.
- The total shared-area ratio of packet resources.

The preceding settings are mutually exclusive with the Burst function. Disable the Burst function before configuring these settings.

Procedure

1. Enter system view.

   system-view

2. Configure buffer assignment rules. Choose the options to configure as needed:
   - Set the total shared-area ratio.

     buffer egress [**slot** *slot-number*] { **cell** | **packet** } **total-shared ratio** *ratio*

     If this command is not configured, you can display the default value by using the **display buffer** command.
   - Set the maximum shared-area ratio for a queue.

     buffer egress [**slot** *slot-number*] { **cell** | **packet** } [**queue** *queue-id*] **shared ratio** *ratio*

     The default setting is 10% for both cell resources and packet resources.

     The actual maximum shared-area space for each queue is determined based on your configuration and the number of packets to be received and sent.
   - Set the fixed-area ratio for a queue.

     buffer egress [**slot** *slot-number*] { **cell** | **packet** } **queue** *queue-id* **guaranteed ratio** *ratio*

     The default setting is 12% for both cell resources and packet resources.

The sum of fixed-area ratios configured for all queues cannot exceed the total fixed-area ratio. Otherwise, the configuration fails.

3. Apply buffer assignment rules.

   buffer apply

   You cannot directly modify the applied configuration. To modify the configuration, you must cancel the application, reconfigure data buffers, and reapply the configuration.

Display and maintenance commands for data buffers

Execute **display** commands in any view.

Task	Command
Display buffer size settings.	**display buffer** [**slot** *slot-number*] [**queue** [*queue-id*]]
Display data buffer usage.	**display buffer usage** [**slot** *slot-number*]

Contents

Configuring time ranges

About time ranges

You can implement a service based on the time of the day by applying a time range to it. A time-based service takes effect only in time periods specified by the time range. For example, you can implement time-based ACL rules by applying a time range to them.

The following basic types of time ranges are available:

- **Periodic time range**—Recurs periodically on a day or days of the week.
- **Absolute time range**—Represents only a period of time and does not recur.

The active period of a time range is calculated as follows:

1. Combining all periodic statements.
2. Combining all absolute statements.
3. Taking the intersection of the two statement sets as the active period of the time range.

Restrictions and guidelines: Time range configuration

When you configure the ACL hardware mode, follow these restrictions and guidelines:

- If a time range does not exist, the service based on the time range does not take effect.
- You can create a maximum of 1024 time ranges, each with a maximum of 32 periodic statements and 12 absolute statements.

Procedure

1. Enter system view.

   system-view

2. Create or edit a time range.

   time-range *time-range-name* { *start-time* **to** *end-time days* [**from** *time1 date1*] [**to** *time2 date2*] | **from** *time1 date1* [**to** *time2 date2*] | **to** *time2 date2* }

   If an existing time range name is provided, this command adds a statement to the time range.

Display and maintenance commands for time ranges

Execute the **display** command in any view.

Task	Command
Display time range configuration and status.	**display time-range** { *time-range-name* | **all** }

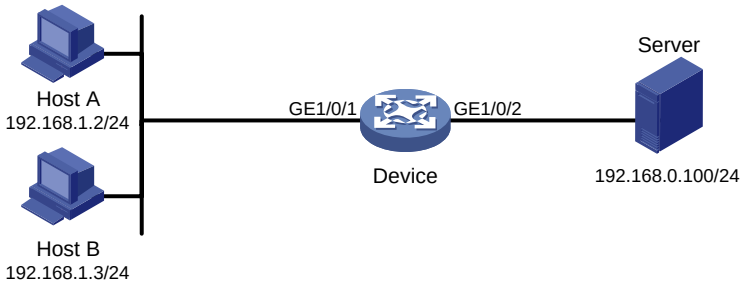
Time range configuration examples

Example: Configuring a time range

Network configuration

As shown in Figure 1, configure an ACL on the device to allow Host A to access the server only during 8:00 and 18:00 on working days from June 2015 to the end of the year.

Figure 1 Network diagram



Procedure

Create a periodic time range during 8:00 and 18:00 on working days from June 2015 to the end of the year.

```
<Device> system-view
[Device] time-range work 8:0 to 18:0 working-day from 0:0 6/1/2015 to 24:00 12/31/2015
```

Create an IPv4 basic ACL numbered 2001, and configure a rule in the ACL to permit packets only from 192.168.1.2/32 during the time range **work**.

```
[Device] acl basic 2001
[Device-acl-ipv4-basic-2001] rule permit source 192.168.1.2 0 time-range work
[Device-acl-ipv4-basic-2001] rule deny source any time-range work
[Device-acl-ipv4-basic-2001] quit
```

Apply IPv4 basic ACL 2001 to filter outgoing packets on GigabitEthernet 1/0/2.

```
[Device] interface gigabitethernet 1/0/2
[Device-GigabitEthernet1/0/2] packet-filter 2001 outbound
[Device-GigabitEthernet1/0/2] quit
```

Verifying the configuration

Verify that the time range **work** is active on the device.

```
[Device] display time-range all
Current time is 13:58:35 6/19/2015 Friday

Time-range : work (Active)
 08:00 to 18:00 working-day
 from 00:00 6/1/2015 to 00:00 1/1/2016
```

Security Configuration Guide

This command reference is applicable to the following switches and software versions:

H3C S5120V2-LI switch series (Release 6308P01 and later)
H3C S3100V3-SI switch series (Release 6309P01 and later)
H3C S5110V2 switch series (Release 6310 and later)
H3C S5110V2-SI switch series (Release 6310 and later)
H3C S5000V3-EI switch series (Release 6310 and later)
H3C S5000V5-EI switch series (Release 6319P01 and later)
H3C S5000E-X switch series (Release 6310 and later)
H3C S5130S-LI switch series (Release 6310 and later)
H3C MS4320V2 switch series (Release 6308P01 and later)
H3C MS4320 switch series (Release 6308P01 and later)
H3C MS4300V2 switch series (Release 6308P01 and later)
H3C MS4200 switch series (Release 6310 and later)
H3C WS5810-WiNet switch series (Release 6308P01 and later)
H3C WS5820-WiNet switch series (Release 6308P01 and later)
H3C WAS6000 switch series (Release 6308P01 and later)
H3C S5000X-EI switch series (Release 6329 and later)
H3C MS4320V3 switch series (Release 6329 and later)
H3C S5120V3-SI switch series (Release 6329 and later)
H3C S5120V3-LI switch series (Release 6329 and later)

New H3C Technologies Co., Ltd.
http://www.h3c.com

Software version: Release 63xx
Document version: 6W105-20230524

Preface

This configuration guide describes security fundamentals and configuration. It covers the following features:

This preface includes the following topics about the documentation:

Audience

This documentation is intended for:

- Network planners.
- Field technical support and servicing engineers.
- Network administrators.

Conventions

The following information describes the conventions used in the documentation.

Command conventions

Convention	Description
Boldface	**Bold** text represents commands and keywords that you enter literally as shown.
Italic	*Italic* text represents arguments that you replace with actual values.
[ ]	Square brackets enclose syntax choices (keywords or arguments) that are optional.
{ x | y | ... }	Braces enclose a set of required syntax choices separated by vertical bars, from which you select one.
[x | y | ...]	Square brackets enclose a set of optional syntax choices separated by vertical bars, from which you select one or none.
{ x | y | ... } *	Asterisk marked braces enclose a set of required syntax choices separated by vertical bars, from which you select a minimum of one.
[x | y | ...] *	Asterisk marked square brackets enclose optional syntax choices separated by vertical bars, from which you select one choice, multiple choices, or none.
&<1-n>	The argument or keyword and argument combination before the ampersand (&) sign can be entered 1 to n times.
#	A line that starts with a pound (#) sign is comments.

GUI conventions

Convention	Description
Boldface	Window names, button names, field names, and menu items are in Boldface. For example, the **New User** window opens; click **OK**.
>	Multi-level menus are separated by angle brackets. For example, **File** > **Create** > **Folder**.

Symbols

Convention	Description
WARNING!	An alert that calls attention to important information that if not understood or followed can result in personal injury.
CAUTION:	An alert that calls attention to important information that if not understood or followed can result in data loss, data corruption, or damage to hardware or software.
IMPORTANT:	An alert that calls attention to essential information.
NOTE:	An alert that contains additional or supplementary information.
TIP:	An alert that provides helpful information.

Network topology icons

Convention	Description
	Represents a generic network device, such as a router, switch, or firewall.
	Represents a routing-capable device, such as a router or Layer 3 switch.
	Represents a generic switch, such as a Layer 2 or Layer 3 switch, or a router that supports Layer 2 forwarding and other Layer 2 features.
	Represents an access controller, a unified wired-WLAN module, or the access controller engine on a unified wired-WLAN switch.
	Represents an access point.
	Represents a wireless terminator unit.
	Represents a wireless terminator.
	Represents a mesh access point.
	Represents omnidirectional signals.
	Represents directional signals.
	Represents a security product, such as a firewall, UTM, multiservice security gateway, or load balancing device.
	Represents a security module, such as a firewall, load balancing, NetStream, SSL VPN, IPS, or ACG module.

Examples provided in this document

Examples in this document might use devices that differ from your device in hardware model, configuration, or software version. It is normal that the port numbers, sample output, screenshots, and other information in the examples differ from what you have on your device.

Documentation feedback

You can e-mail your comments about product documentation to info@h3c.com.

We appreciate your comments.

Contents

Configuring AAA

About AAA

AAA implementation

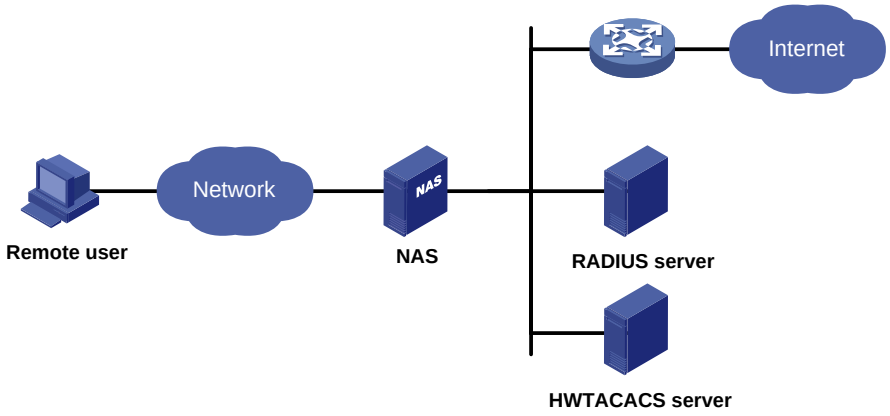
Authentication, Authorization, and Accounting (AAA) provides a uniform framework for implementing network access management. This feature specifies the following security functions:

- **Authentication**—Identifies users and verifies their validity.
- **Authorization**—Grants different users different rights, and controls the users' access to resources and services. For example, you can permit office users to read and print files and prevent guests from accessing files on the device.
- **Accounting**—Records network usage details of users, including the service type, start time, and traffic. This function enables time-based and traffic-based charging and user behavior auditing.

AAA network diagram

AAA uses a client/server model. The client runs on the access device, or the network access server (NAS), which authenticates user identities and controls user access. The server maintains user information centrally. See Figure 1.

Figure 1 AAA network diagram



To access networks or resources beyond the NAS, a user sends its identity information to the NAS. The NAS transparently passes the user information to AAA servers and waits for the authentication, authorization, and accounting result. Based on the result, the NAS determines whether to permit or deny the access request.

AAA has various implementations, including HWTACACS, LDAP, and RADIUS. RADIUS is most often used.

You can use different servers to implement different security functions. For example, you can use an HWTACACS server for authentication and authorization, and use a RADIUS server for accounting.

You can choose the security functions provided by AAA as needed. For example, if your company wants employees to be authenticated before they access specific resources, you would deploy an authentication server. If network usage information is needed, you would also configure an accounting server.

The device performs dynamic password authentication.

RADIUS

Remote Authentication Dial-In User Service (RADIUS) is a distributed information interaction protocol that uses a client/server model. The protocol can protect networks against unauthorized access and is often used in network environments that require both high security and remote user access.

The RADIUS authorization process is combined with the RADIUS authentication process, and user authorization information is piggybacked in authentication responses. RADIUS uses UDP port 1812 for authentication and UDP port 1813 for accounting.

RADIUS was originally designed for dial-in user access, and has been extended to support additional access methods, such as Ethernet and ADSL.

Client/server model

The RADIUS client runs on the NASs located throughout the network. It passes user information to RADIUS servers and acts on the responses to, for example, reject or accept user access requests.

The RADIUS server runs on the computer or workstation at the network center and maintains information related to user authentication and network service access.

The RADIUS server operates using the following process:

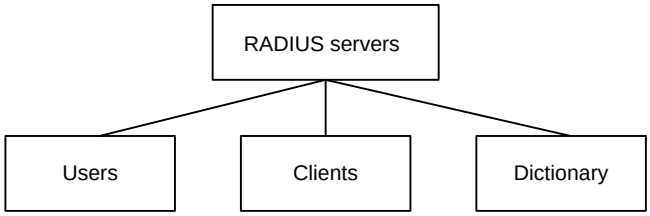
1. Receives authentication, authorization, and accounting requests from RADIUS clients.
2. Performs user authentication, authorization, or accounting.
3. Returns user access control information (for example, rejecting or accepting the user access request) to the clients.

The RADIUS server can also act as the client of another RADIUS server to provide authentication proxy services.

The RADIUS server maintains the following databases:

- **Users**—Stores user information, such as the usernames, passwords, applied protocols, and IP addresses.
- **Clients**—Stores information about RADIUS clients, such as shared keys and IP addresses.
- **Dictionary**—Stores RADIUS protocol attributes and their values.

Figure 2 RADIUS server databases



Information exchange security mechanism

The RADIUS client and server exchange information between them with the help of shared keys, which are preconfigured on the client and server. A RADIUS packet has a 16-byte field called Authenticator. This field includes a signature generated by using the MD5 algorithm, the shared key, and some other information. The receiver of the packet verifies the signature and accepts the packet only when the signature is correct. This mechanism ensures the security of information exchanged between the RADIUS client and server.

The shared keys are also used to encrypt user passwords that are included in RADIUS packets.

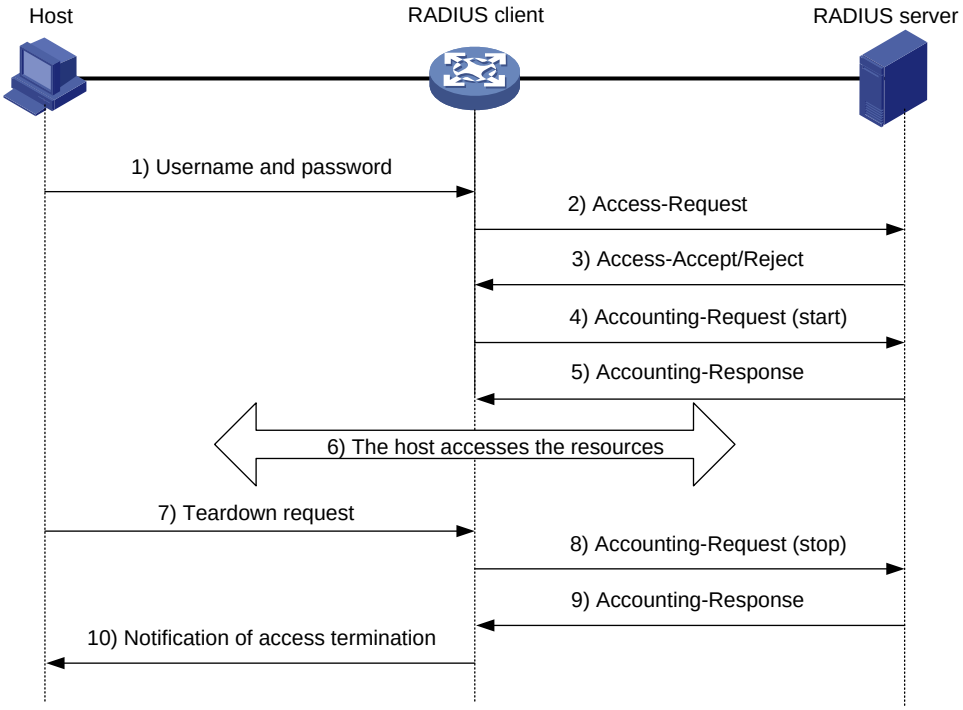
User authentication methods

The RADIUS server supports multiple user authentication methods, such as PAP, CHAP, and EAP.

Basic RADIUS packet exchange process

Figure 3 illustrates the interactions between a user host, the RADIUS client, and the RADIUS server.

Figure 3 Basic RADIUS packet exchange process



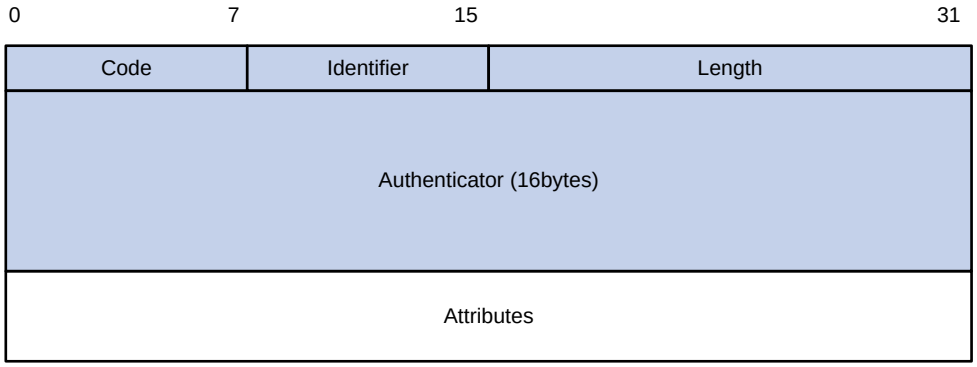
RADIUS uses in the following workflow:

1. The host sends a connection request that includes the user's username and password to the RADIUS client.
2. The RADIUS client sends an authentication request (Access-Request) to the RADIUS server. The request includes the user's password, which has been processed by the MD5 algorithm and shared key.
3. The RADIUS server authenticates the username and password. If the authentication succeeds, the server sends back an Access-Accept packet that contains the user's authorization information. If the authentication fails, the server returns an Access-Reject packet.
4. The RADIUS client permits or denies the user according to the authentication result. If the result permits the user, the RADIUS client sends a start-accounting request (Accounting-Request) packet to the RADIUS server.
5. The RADIUS server returns an acknowledgment (Accounting-Response) packet and starts accounting.
6. The user accesses the network resources.
7. The host requests the RADIUS client to tear down the connection.
8. The RADIUS client sends a stop-accounting request (Accounting-Request) packet to the RADIUS server.
9. The RADIUS server returns an acknowledgment (Accounting-Response) and stops accounting for the user.
10. The RADIUS client notifies the user of the termination.

RADIUS packet format

RADIUS uses UDP to transmit packets. The protocol also uses a series of mechanisms to ensure smooth packet exchange between the RADIUS server and the client. These mechanisms include the timer mechanism, the retransmission mechanism, and the backup server mechanism.

Figure 4 RADIUS packet format



Descriptions of the fields are as follows:

- The Code field (1 byte long) indicates the type of the RADIUS packet. Table 1 gives the main values and their meanings.

  Table 1 Main values of the Code field

Code	Packet type	Description
1	Access-Request	From the client to the server. A packet of this type includes user information for the server to authenticate the user. It must contain the User-Name attribute and can optionally contain the attributes of NAS-IP-Address, User-Password, and NAS-Port.
2	Access-Accept	From the server to the client. If all attribute values included in the Access-Request are acceptable, the authentication succeeds, and the server sends an Access-Accept response.
3	Access-Reject	From the server to the client. If any attribute value included in the Access-Request is unacceptable, the authentication fails, and the server sends an Access-Reject response.
4	Accounting-Request	From the client to the server. A packet of this type includes user information for the server to start or stop accounting for the user. The Acct-Status-Type attribute in the packet indicates whether to start or stop accounting.
5	Accounting-Response	From the server to the client. The server sends a packet of this type to notify the client that it has received the Accounting-Request and has successfully recorded the accounting information.

- The Identifier field (1 byte long) is used to match response packets with request packets and to detect duplicate request packets. The request and response packets of the same exchange process for the same purpose (such as authentication or accounting) have the same identifier.
- The Length field (2 bytes long) indicates the length of the entire packet (in bytes), including the Code, Identifier, Length, Authenticator, and Attributes fields. Bytes beyond this length are considered padding and are ignored by the receiver. If the length of a received packet is less than this length, the packet is dropped.
- The Authenticator field (16 bytes long) is used to authenticate responses from the RADIUS server and to encrypt user passwords. There are two types of authenticators: request authenticator and response authenticator.

- The Attributes field (variable in length) includes authentication, authorization, and accounting information. This field can contain multiple attributes, each with the following subfields:
  - **Type**—Type of the attribute.
  - **Length**—Length of the attribute in bytes, including the Type, Length, and Value subfields.
  - **Value**—Value of the attribute. Its format and content depend on the Type subfield.

Extended RADIUS attributes

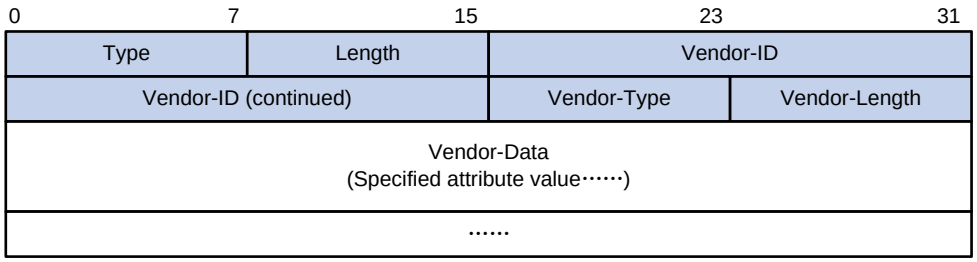
The RADIUS protocol features excellent extensibility. The Vendor-Specific attribute (attribute 26) allows a vendor to define extended attributes. The extended attributes can implement functions that the standard RADIUS protocol does not provide.

A vendor can encapsulate multiple subattributes in the TLV format in attribute 26 to provide extended functions. As shown in Figure 5, a subattribute encapsulated in attribute 26 consists of the following parts:

- **Vendor-ID**—ID of the vendor. The most significant byte is 0. The other three bytes contains a code compliant to RFC 1700.
- **Vendor-Type**—Type of the subattribute.
- **Vendor-Length**—Length of the subattribute.
- **Vendor-Data**—Contents of the subattribute.

The device supports RADIUS subattributes with a vendor ID of 25506. For more information, see "Appendix C RADIUS subattributes (vendor ID 25506)."

Figure 5 Format of attribute 26



HWTACACS

HW Terminal Access Controller Access Control System (HWTACACS) is an enhanced security protocol based on TACACS (RFC 1492). HWTACACS is similar to RADIUS, and uses a client/server model for information exchange between the NAS and the HWTACACS server.

HWTACACS typically provides AAA services for PPP, VPDN, and terminal users. In a typical HWTACACS scenario, terminal users need to log in to the NAS. Working as the HWTACACS client, the NAS sends users' usernames and passwords to the HWTACACS server for authentication. After passing authentication and obtaining authorized rights, a user logs in to the device and performs operations. The HWTACACS server records the operations that each user performs.

Differences between HWTACACS and RADIUS

HWTACACS and RADIUS have many features in common, such as using a client/server model, using shared keys for data encryption, and providing flexibility and scalability. Table 2 lists the primary differences between HWTACACS and RADIUS.

Table 2 Primary differences between HWTACACS and RADIUS

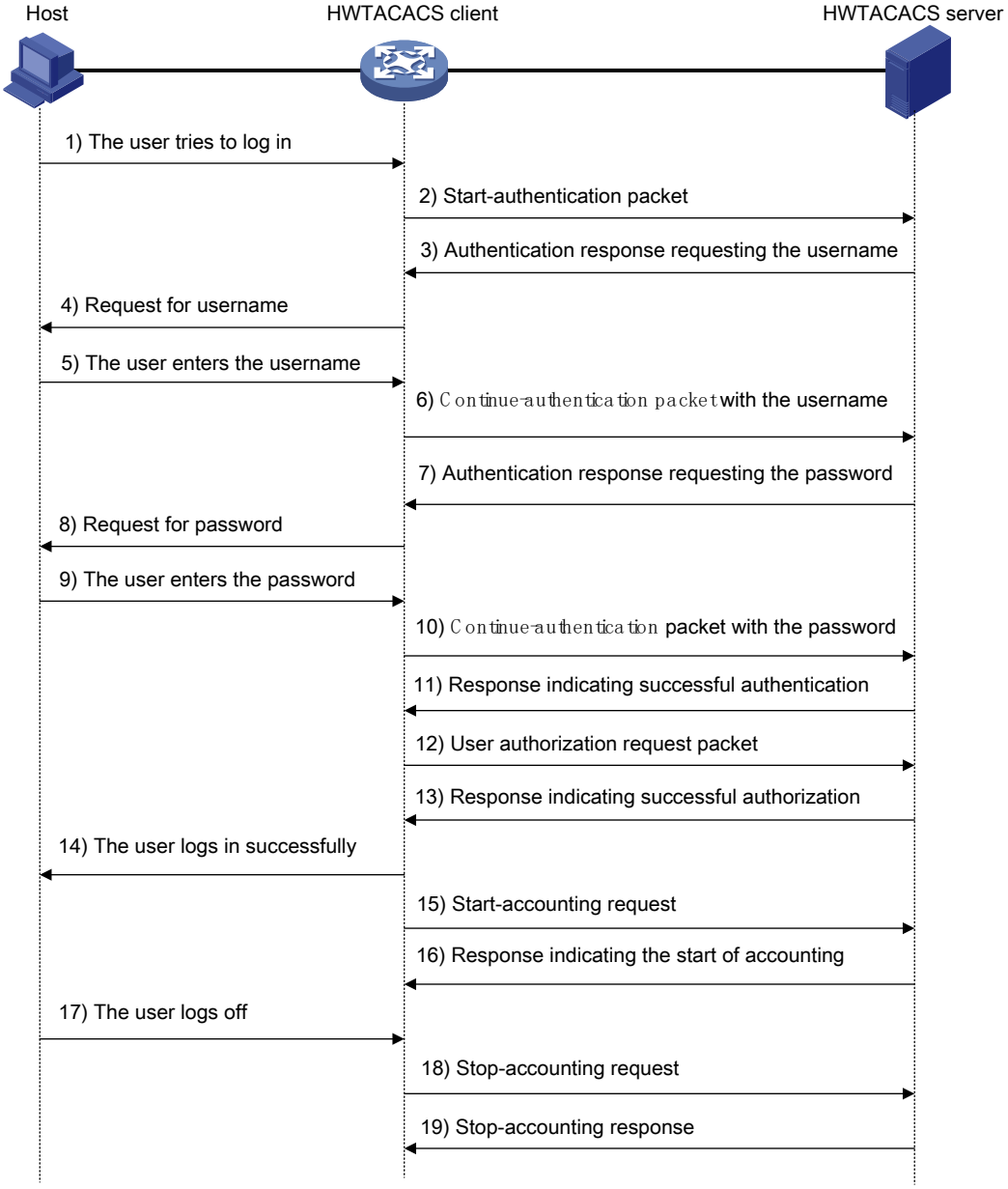
HWTACACS	RADIUS
Uses TCP, which provides reliable network	Uses UDP, which provides high transport efficiency.

HWTACACS	RADIUS
transmission.	
Encrypts the entire packet except for the HWTACACS header.	Encrypts only the user password field in an authentication packet.
Protocol packets are complicated and authorization is independent of authentication. Authentication and authorization can be deployed on different HWTACACS servers.	Protocol packets are simple and the authorization process is combined with the authentication process.
Supports authorization of configuration commands. Access to commands depends on both the user's roles and authorization. A user can use only commands that are permitted by the user roles and authorized by the HWTACACS server.	Does not support authorization of configuration commands. Access to commands solely depends on the user's roles. For more information about user roles, see *Fundamentals Configuration Guide*.

Basic HWTACACS packet exchange process

Figure 6 describes how HWTACACS performs user authentication, authorization, and accounting for a Telnet user.

Figure 6 Basic HWTACACS packet exchange process for a Telnet user



HWTACACS operates using in the following workflow:

1. A Telnet user sends an access request to the HWTACACS client.
2. The HWTACACS client sends a start-authentication packet to the HWTACACS server when it receives the request.
3. The HWTACACS server sends back an authentication response to request the username.
4. Upon receiving the response, the HWTACACS client asks the user for the username.
5. The user enters the username.
6. After receiving the username from the user, the HWTACACS client sends the server a continue-authentication packet that includes the username.
7. The HWTACACS server sends back an authentication response to request the login password.
8. Upon receipt of the response, the HWTACACS client prompts the user for the login password.
9. The user enters the password.

10. After receiving the login password, the HWTACACS client sends the HWTACACS server a continue-authentication packet that includes the login password.
11. If the authentication succeeds, the HWTACACS server sends back an authentication response to indicate that the user has passed authentication.
12. The HWTACACS client sends a user authorization request packet to the HWTACACS server.
13. If the authorization succeeds, the HWTACACS server sends back an authorization response, indicating that the user is now authorized.
14. Knowing that the user is now authorized, the HWTACACS client pushes its CLI to the user and permits the user to log in.
15. The HWTACACS client sends a start-accounting request to the HWTACACS server.
16. The HWTACACS server sends back an accounting response, indicating that it has received the start-accounting request.
17. The user logs off.
18. The HWTACACS client sends a stop-accounting request to the HWTACACS server.
19. The HWTACACS server sends back a stop-accounting response, indicating that the stop-accounting request has been received.

LDAP

The Lightweight Directory Access Protocol (LDAP) provides standard multiplatform directory service. LDAP was developed on the basis of the X.500 protocol. It improves the following functions of X.500:

- Read/write interactive access.
- Browse.
- Search.

LDAP is suitable for storing data that does not often change. The protocol is used to store user information. For example, LDAP server software Active Directory Server is used in Microsoft Windows operating systems. The software stores the user information and user group information for user login authentication and authorization.

LDAP directory service

LDAP uses directories to maintain the organization information, personnel information, and resource information. The directories are organized in a tree structure and include entries. An entry is a set of attributes with distinguished names (DNs). The attributes are used to store information such as usernames, passwords, emails, computer names, and phone numbers.

LDAP uses a client/server model, and all directory information is stored in the LDAP server. Commonly used LDAP server products include Microsoft Active Directory Server, IBM Tivoli Directory Server, and Sun ONE Directory Server.

LDAP authentication and authorization

AAA can use LDAP to provide authentication and authorization services for users. LDAP defines a set of operations to implement its functions. The main operations for authentication and authorization are the bind operation and search operation.

- The bind operation allows an LDAP client to perform the following operations:
  - Establish a connection with the LDAP server.
  - Obtain the access rights to the LDAP server.
  - Check the validity of user information.
- The search operation constructs search conditions and obtains the directory resource information of the LDAP server.

In LDAP authentication, the client completes the following tasks:

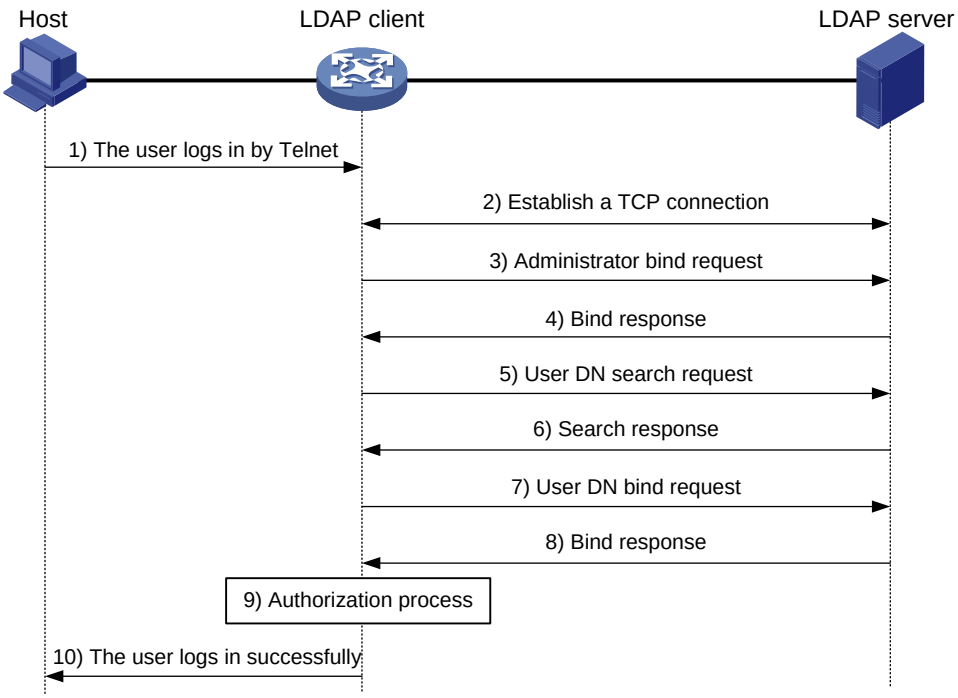
1. Uses the LDAP server administrator DN to bind with the LDAP server. After the binding is created, the client establishes a connection to the server and obtains the right to search.
2. Constructs search conditions by using the username in the authentication information of a user. The specified root directory of the server is searched and a user DN list is generated.
3. Binds with the LDAP server by using each user DN and password. If a binding is created, the user is considered legal.

In LDAP authorization, the client performs the same tasks as in LDAP authentication. When the client constructs search conditions, it obtains both authorization information and the user DN list.

Basic LDAP authentication process

The following example illustrates the basic LDAP authentication process for a Telnet user.

Figure 7 Basic LDAP authentication process for a Telnet user



The following shows the basic LDAP authentication process:

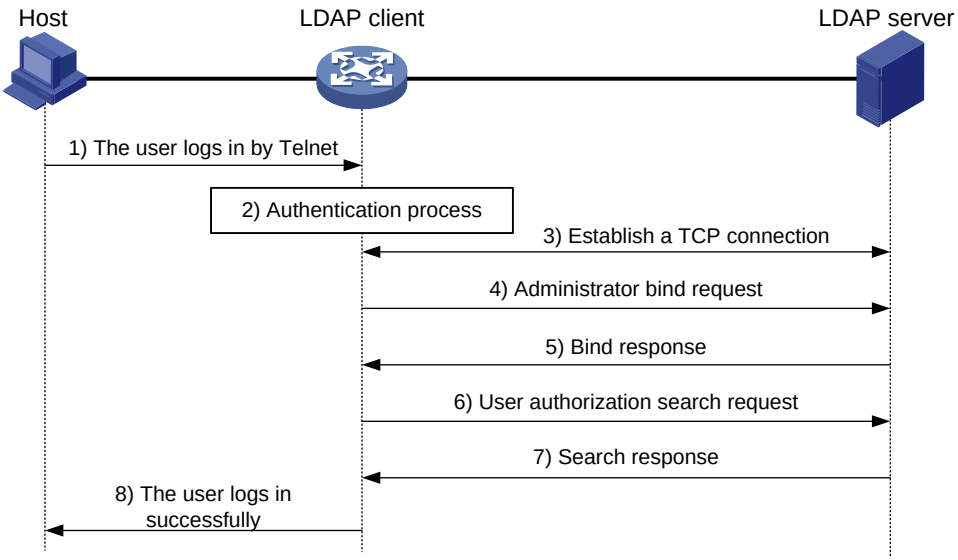
1. A Telnet user initiates a connection request and sends the username and password to the LDAP client.
2. After receiving the request, the LDAP client establishes a TCP connection with the LDAP server.
3. To obtain the right to search, the LDAP client uses the administrator DN and password to send an administrator bind request to the LDAP server.
4. The LDAP server processes the request. If the bind operation is successful, the LDAP server sends an acknowledgment to the LDAP client.
5. The LDAP client sends a user DN search request with the username of the Telnet user to the LDAP server.
6. After receiving the request, the LDAP server searches for the user DN by the base DN, search scope, and filtering conditions. If a match is found, the LDAP server sends a response to notify the LDAP client of the successful search. There might be one or more user DNs found.
7. The LDAP client uses the obtained user DN and the entered user password as parameters to send a user DN bind request to the LDAP server. The server will check whether the user password is correct.

8. The LDAP server processes the request, and sends a response to notify the LDAP client of the bind operation result. If the bind operation fails, the LDAP client uses another obtained user DN as the parameter to send a user DN bind request to the LDAP server. This process continues until a DN is bound successfully or all DNs fail to be bound. If all user DNs fail to be bound, the LDAP client notifies the user of the login failure and denies the user's access request.
9. The LDAP client saves the user DN that has been bound and exchanges authorization packets with the authorization server.
   - If LDAP authorization is used, see the authorization process shown in Figure 8.
   - If another method is expected for authorization, the authorization process of that method applies.
10. After successful authorization, the LDAP client notifies the user of the successful login.

Basic LDAP authorization process

The following example illustrates the basic LDAP authorization process for a Telnet user.

Figure 8 Basic LDAP authorization process for a Telnet user



The following shows the basic LDAP authorization process:

1. A Telnet user initiates a connection request and sends the username and password to the device. The device will act as the LDAP client during authorization.
2. After receiving the request, the device exchanges authentication packets with the authentication server for the user:
   - If LDAP authentication is used, see the authentication process shown in Figure 7.
     - If the device (the LDAP client) uses the same LDAP server for authentication and authorization, skip to step 6.
     - If the device (the LDAP client) uses different LDAP servers for authentication and authorization, skip to step 4.
   - If another authentication method is used, the authentication process of that method applies. The device acts as the LDAP client. Skip to step 3.
3. The LDAP client establishes a TCP connection with the LDAP authorization server.
4. To obtain the right to search, the LDAP client uses the administrator DN and password to send an administrator bind request to the LDAP server.
5. The LDAP server processes the request. If the bind operation is successful, the LDAP server sends an acknowledgment to the LDAP client.

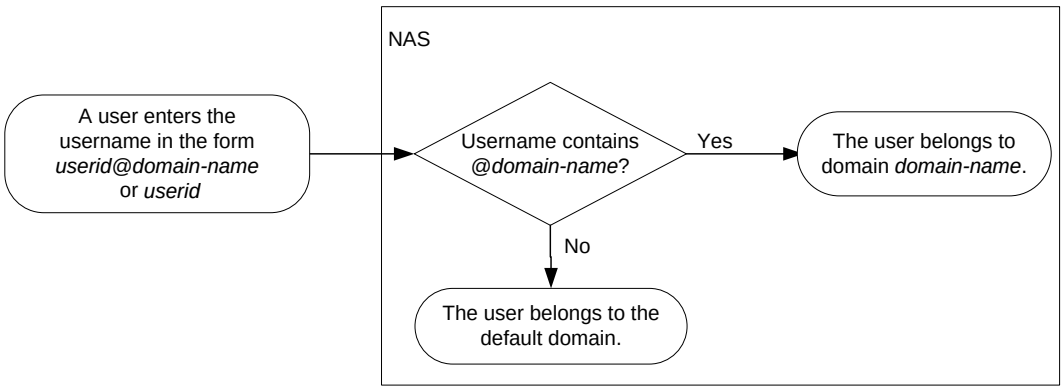
6. The LDAP client sends an authorization search request with the username of the Telnet user to the LDAP server. If the user uses the same LDAP server for authentication and authorization, the client sends the request with the saved user DN of the Telnet user to the LDAP server.
7. After receiving the request, the LDAP server searches for the user information by the base DN, search scope, filtering conditions, and LDAP attributes. If a match is found, the LDAP server sends a response to notify the LDAP client of the successful search.
8. After successful authorization, the LDAP client notifies the user of the successful login.

User management based on ISP domains and user access types

AAA manages users based on the users' ISP domains and access types.

On a NAS, each user belongs to one ISP domain. The NAS determines the ISP domain to which a user belongs based on the username entered by the user at login.

Figure 9 Determining the ISP domain for a user by username



AAA manages users in the same ISP domain based on the users' access types. The device supports the following user access types:

- **LAN**—LAN users must pass 802.1X or MAC authentication to come online.
- **Login**—Login users include SSH, Telnet, FTP, and terminal users that log in to the device. Terminal users can access through a console port.
- **Portal**—Portal users must pass portal authentication to access the network.
- **HTTP/HTTPS**—Users log in to the device through HTTP or HTTPS.

The device also provides authentication modules (such as 802.1X) for implementation of user authentication management policies. If you configure these authentication modules, the ISP domains for users of the access types depend on the configuration of the authentication modules.

Authentication, authorization, and accounting methods

AAA supports configuring different authentication, authorization, and accounting methods for different types of users in an ISP domain. The NAS determines the ISP domain and access type of a user. The NAS also uses the methods configured for the access type in the domain to control the user's access.

AAA also supports configuring a set of default methods for an ISP domain. These default methods are applied to users for whom no AAA methods are configured.

Authentication methods

The device supports the following authentication methods:

- **No authentication**—This method trusts all users and does not perform authentication. For security purposes, do not use this method.
- **Local authentication**—The NAS authenticates users by itself, based on the locally configured user information including the usernames, passwords, and attributes. Local authentication allows high speed and low cost, but the amount of information that can be stored is limited by the size of the storage space.
- **Remote authentication**—The NAS works with a remote server to authenticate users. The NAS communicates with the remote server through the RADIUS, LDAP, or HWTACACS protocol. The server manages user information in a centralized manner. Remote authentication provides high capacity, reliable, and centralized authentication services for multiple NASs. You can configure backup methods to be used when the remote server is not available.

Authorization methods

The device supports the following authorization methods:

- **No authorization**—The NAS performs no authorization exchange. The following default authorization information applies after users pass authentication:
  - Login users obtain the level-0 user role. For more information about the level-0 user role, see RBAC configuration in *Fundamentals Configuration Guide*.
  - The working directory for FTP, SFTP, and SCP login users is the root directory of the NAS. However, the users do not have permission to access the root directory.
  - Non-login users can access the network.
- **Local authorization**—The NAS performs authorization according to the user attributes locally configured for users.
- **Remote authorization**—The NAS works with a remote server to authorize users. RADIUS authorization is bound with RADIUS authentication. RADIUS authorization can work only after RADIUS authentication is successful, and the authorization information is included in the Access-Accept packet. HWTACACS or LDAP authorization is separate from authentication, and the authorization information is included in the authorization response after successful authentication. You can configure backup methods to be used when the remote server is not available.

Accounting methods

The device supports the following accounting methods:

- **No accounting**—The NAS does not perform accounting for the users.
- **Local accounting**—Local accounting is implemented on the NAS. It counts and controls the number of concurrent users that use the same local user account, but does not provide statistics for charging.
- **Remote accounting**—The NAS works with a RADIUS server or HWTACACS server for accounting. You can configure backup methods to be used when the remote server is not available.

AAA extended functions

The device provides the following login services to enhance device security:

- **Command authorization**—Enables the NAS to let the authorization server determine whether a command entered by a login user is permitted. Login users can execute only commands permitted by the authorization server. For more information about command authorization, see *Fundamentals Configuration Guide*.
- **Command accounting**—When command authorization is disabled, command accounting enables the accounting server to record all valid commands executed on the device. When command authorization is enabled, command accounting enables the accounting server to record all authorized commands. For more information about command accounting, see *Fundamentals Configuration Guide*.

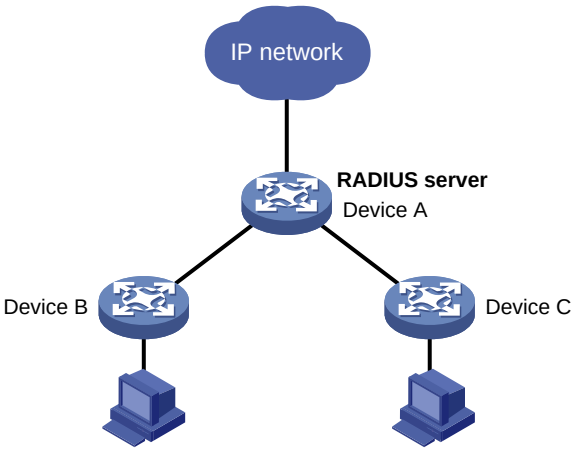
- **User role authentication**—Authenticates each user that wants to obtain another user role without logging out or getting disconnected. For more information about user role authentication, see *Fundamentals Configuration Guide*.

RADIUS server feature of the device

Enable the RADIUS server feature of the device to work with RADIUS clients for user authentication and authorization. The device can act as a dedicated RADIUS server or as both a RADIUS server and a RADIUS client at the same time.

The RADIUS server feature provides for flexible networks with less cost. As shown in Figure 10, Device A provides RADIUS server functions at the distribution layer; Device B and Device C are configured with RADIUS schemes to implement user authentication and authorization at the access layer.

Figure 10 Network diagram



The RADIUS server feature supports the following operations:

- Manages RADIUS user data, which is generated from local user information and includes user name, password, description, authorization ACL, authorization VLAN, and expiration time.
- Manages RADIUS clients. You can add, modify, and delete RADIUS clients. A RADIUS client is identified by the IP address, and it includes attribute information such as the shared key. The RADIUS server feature processes authentication requests only from the managed RADIUS clients and ignores requests from unknown clients.
- Authenticates and authorizes users of the network access type. The server does not provide accounting.

When the RADIUS server receives a RADIUS packet, it performs the following actions:

1. Verifies that the packet is sent from a managed RADIUS client.
2. Verifies the packet with the shared key.
3. Verifies that the user account exists, the password is correct, and other attributes meet the requirements (for example, the account is in the validity period).
4. Determines the authentication result and authorizes specific privileges to the authenticated user.

The RADIUS server feature of the device has the following restrictions:

- The authentication port is fixed at UDP 1812 and cannot be modified.
- The feature is supported on IPv4 networks, but not on IPv6 networks.
- The server provides only PAP and CHAP authentication methods.
- User names sent to the RADIUS server cannot include a domain name.

Protocols and standards

- RFC 2865, *Remote Authentication Dial In User Service (RADIUS)*
- RFC 2866, *RADIUS Accounting*
- RFC 2867, *RADIUS Accounting Modifications for Tunnel Protocol Support*
- RFC 2868, *RADIUS Attributes for Tunnel Protocol Support*
- RFC 2869, *RADIUS Extensions*
- RFC 3576, *Dynamic Authorization Extensions to Remote Authentication Dial In User Service (RADIUS)*
- RFC 4818, *RADIUS Delegated-IPv6-Prefix Attribute*
- RFC 5176, *Dynamic Authorization Extensions to Remote Authentication Dial In User Service (RADIUS)*
- RFC 1492, *An Access Control Protocol, Sometimes Called TACACS*
- RFC 1777, *Lightweight Directory Access Protocol*
- RFC 2251, *Lightweight Directory Access Protocol (v3)*

FIPS compliance

The device supports the FIPS mode that complies with NIST FIPS 140-2 requirements. Support for features, commands, and parameters might differ in FIPS mode (see "Configuring FIPS") and non-FIPS mode.

AAA tasks at a glance

To configure AAA, perform the following tasks:

1. Configuring AAA schemes

   If local authentication is used, configure local users and the related attributes. If remote authentication is used, configure the required RADIUS, LDAP, or HWTACACS schemes.

   - Configuring local users
   - Configuring RADIUS
   - Configuring HWTACACS
   - Configuring LDAP
2. Configuring an ISP domain
   a. Creating an ISP domain
   b. Configuring ISP domain attributes
3. Configuring AAA methods for an ISP domain

   Configure authentication, authorization, and accounting methods for an ISP domain as needed. These methods use existing AAA schemes.

   - Configuring authentication methods for an ISP domain
   - Configuring authorization methods for an ISP domain
   - Configuring accounting methods for an ISP domain
4. (Optional.) Configuring advanced AAA features
   - Setting the maximum number of concurrent login users
   - Configuring a NAS-ID
   - Configuring the device ID

Configuring local users

About local users

To implement local authentication, authorization, and accounting, create local users and configure user attributes on the device. The local users and attributes are stored in the local user database on the device. A local user is uniquely identified by the combination of a username and a user type.

Local users are classified into the following types:

- **Device management user**—User that logs in to the device for device management.
- **Network access user**—User that accesses network resources through the device.

The following shows the configurable local user attributes:

- **Description**—Descriptive information of the user.
- **Service type**—Services that the user can use. Local authentication checks the service types of a local user. If none of the service types is available, the user cannot pass authentication.
- **User state**—Whether or not a local user can request network services. There are two user states: active and blocked. A user in active state can request network services, but a user in blocked state cannot.
- **Upper limit of concurrent logins using the same user name**—Maximum number of users that can concurrently access the device by using the same user name. When the number reaches the upper limit, no more local users can access the device by using the user name.
- **User group**—Each local user belongs to a local user group and has all attributes of the group. The attributes include the password control attributes and authorization attributes. For more information about local user group, see "Configuring user group attributes."
- **Binding attributes**—Binding attributes control the scope of users, and are checked during local authentication of a user. If the attributes of a user do not match the binding attributes configured for the local user account, the user cannot pass authentication.
- **Authorization attributes**—Authorization attributes indicate the user's rights after it passes local authentication.

  Configure the authorization attributes based on the service type of local users.

  You can configure an authorization attribute in user group view or local user view. The setting of an authorization attribute in local user view takes precedence over the attribute setting in user group view.

  The attribute configured in user group view takes effect on all local users in the user group.

  The attribute configured in local user view takes effect only on the local user.
- **Password control attributes**—Password control attributes help control password security for local users. Password control attributes include password aging time, minimum password length, password composition checking, password complexity checking, and login attempt limit.

  You can configure a password control attribute in system view, user group view, or local user view. A password control attribute with a smaller effective range has a higher priority. For more information about password management and global password configuration, see "Configuring password control."
- **Validity period**—Time period in which a network access user is considered valid for authentication.

Local user configuration tasks at a glance

To configure local users, perform the following tasks:

1. Configuring local user attributes
   - Configuring attributes for device management users
   - Configuring attributes for network access users
2. (Optional.) Configuring user group attributes
3. (Optional.) Configuring the local user auto-delete feature

Restrictions and guidelines for local user configuration

As from release 6348P01, the factory defaults of the device provide a default local user named **clouduser** of the HTTP type. The user password is **admin** and the user role is **network-admin**. In versions earlier than 6348P01, no default local user is provided.

Configuring attributes for device management users

Restrictions and guidelines

When you configure the interface binding attribute for a device management user, follow these restrictions and guidelines to avoid authentication failure:

- Specify the actual access interface of the user as the binding interface for the user.
- Make sure the user's authentication packets include the user's access interface.

If password control is globally enabled for device management users by using the **password-control enable** command, the device neither displays local user passwords nor retains them in the running configuration. When you globally disable password control for device management users, local user passwords are automatically restored to the running configuration. To display the running configuration, use the **display current-configuration** command.

You can configure authorization attributes and password control attributes in local user view or user group view. The setting in local user view takes precedence over the setting in user group view.

Procedure

1. Enter system view.

   system-view

2. Add a device management user and enter device management user view.

   local-user *user-name* **class manage**

3. Configure a password for the device management user.

   In non-FIPS mode:

   password [{ **hash** | **simple** } *string*]

   A non-password-protected user passes authentication if the user provides the correct username and passes attribute checks. To enhance security, configure a password for each device management user.

   In FIPS mode:

   password

   Only password-protected users can pass authentication. You must set the password in interactive mode for a device management user.

4. Assign services to the device management user.

   In non-FIPS mode:

service-type { **ftp** | { **http** | **https** | **ssh** | **telnet** | **terminal** } * }

In FIPS mode:

service-type { **https** | **ssh** | **terminal** } *

By default, no services are authorized to a device management user.

5. (Optional.) Set the status of the device management user.

   state { **active** | **block** }

   By default, a device management user is in active state and can request network services.

6. (Optional.) Set the upper limit of concurrent logins using the device management username.

   access-limit *max-user-number*

   By default, the number of concurrent logins is not limited for a device management user.

   This command takes effect only when local accounting is configured for device management users. This command does not apply to FTP, SFTP, or SCP users that do not support accounting.

7. (Optional.) Configure the interface binding attribute for the device management user.

   bind-attribute location interface *interface-type interface-number*

   By default, no interface binding attribute is configured for a device management user.

8. (Optional.) Configure authorization attributes for the device management user.

   authorization-attribute { **idle-cut** *minutes* | **user-role** *role-name* | **work-directory** *directory-name* } *

   The following default settings apply:

   - The working directory for FTP, SFTP, and SCP users is the root directory of the NAS. However, the users do not have permission to access the root directory.
   - The network-operator user role is assigned to local users that are created by a network-admin or level-15 user.

9. (Optional.) Configure password control attributes for the device management user. Choose the following tasks as needed:

   - Set the password aging time.

     password-control aging *aging-time*

   - Set the minimum password length.

     password-control length *length*

   - Configure the password composition policy.

     password-control composition type-number *type-number* [**type-length** *type-length*]

   - Configure the password complexity checking policy.

     password-control complexity { **same-character** | **user-name** } **check**

   - Configure the maximum login attempts and the action to take if there is a login failure.

     password-control login-attempt *login-times* [**exceed** { **lock** | **lock-time** *time* | **unlock** }]

   By default, a device management user uses password control attributes of the user group to which the user belongs.

10. (Optional.) Assign the device management user to a user group.

    group *group-name*

    By default, a device management user belongs to user group **system**.

Configuring attributes for network access users

Restrictions and guidelines

If password control is globally enabled for network access users by using the **password-control enable network-class** command, the device neither displays local user passwords nor retains them in the running configuration. When you globally disable password control for network access users, local user passwords are automatically restored to the running configuration. To display the running configuration, use the **display current-configuration** command.

You can configure authorization attributes and password control attributes in local user view or user group view. The setting in local user view takes precedence over the setting in user group view.

Configure the **location** binding attribute based on the service types of users.

- For 802.1X users, specify the 802.1X-enabled Layer 2 Ethernet interfaces through which the users access the device.
- For MAC authentication users, specify the MAC authentication-enabled Layer 2 Ethernet interfaces through which the users access the device.
- For Web authentication users, specify the Web authentication-enabled Layer 2 Ethernet interfaces through which the users access the device.
- For portal users, specify the portal-enabled interfaces through which the users access the device. Specify the Layer 2 Ethernet interfaces if portal is enabled on VLAN interfaces and the **portal roaming enable** command is not used.

Procedure

1. Enter system view.

   system-view
2. Add a network access user and enter network access user view.

   local-user *user-name* **class network**
3. (Optional.) Configure a password for the network access user.

   password { **cipher** | **simple** } *string*
4. (Optional.) Configure a description for the network access user.

   description *text*

   By default, no description is configured for a local user.
5. Assign services to the network access user.

   service-type { **lan-access** | **portal** }

   By default, no services are authorized to a network access user.
6. (Optional.) Set the status of the network access user.

   state { **active** | **block** }

   By default, a network access user is in active state and can request network services.
7. (Optional.) Set the upper limit of concurrent logins using the network access username.

   access-limit *max-user-number*

   By default, the number of concurrent logins is not limited for a network access user.
8. (Optional.) Configure binding attributes for the network access user.

   bind-attribute { **ip** *ip-address* | **location interface** *interface-type interface-number* | **mac** *mac-address* | **vlan** *vlan-id* } *

   By default, no binding attributes are configured for a network access user.
9. (Optional.) Configure authorization attributes for the network access user.

authorization-attribute { **acl** *acl-number* | **idle-cut** *minutes* | **ip-pool** *ipv4-pool-name* | **ipv6-pool** *ipv6-pool-name* | **session-timeout** *minutes* | **user-profile** *profile-name* | **vlan** *vlan-id* } *

By default, a network access user does not have authorization attributes.

10. (Optional.) Configure password control attributes for the network access user. Choose the following tasks as needed:
    - Set the minimum password length.

      password-control length *length*
    - Configure the password composition policy.

      password-control composition type-number *type-number* [**type-length** *type-length*]
    - Configure the password complexity checking policy.

      password-control complexity { **same-character** | **user-name** } **check**

    By default, a network access user uses password control attributes of the user group to which the user belongs.
11. (Optional.) Assign the network access user to a user group.

    group *group-name*

    By default, a network access user belongs to user group **system**.
12. (Optional.) specify the validity period for the local user.

    validity-datetime { **from** *start-date start-time* **to** *expiration-date expiration-time* | **from** *start-date start-time* | **to** *expiration-date expiration-time* }

    By default, the validity period for a network access user does not expire.

Configuring user group attributes

About user group attributes

User groups simplify local user configuration and management. A user group contains a group of local users and has a set of local user attributes. You can configure local user attributes for a user group to implement centralized user attributes management for the local users in the group. Local user attributes that are manageable include authorization attributes.

Procedure

1. Enter system view.

   system-view
2. Create a user group and enter user group view.

   user-group *group-name*

   By default, a system-defined user group exists. The group name is **system**.
3. Configure authorization attributes for the user group.

   authorization-attribute { **acl** *acl-number* | **idle-cut** *minutes* | **ip-pool** *ipv4-pool-name* | **ipv6-pool** *ipv6-pool-name* | **session-timeout** *minutes* | **user-profile** *profile-name* | **vlan** *vlan-id* | **work-directory** *directory-name* } *

   By default, no authorization attributes are configured for a user group.
4. (Optional.) Configure password control attributes for the user group. Choose the following tasks as needed:
   - Set the password aging time.

     password-control aging *aging-time*

- Set the minimum password length.
  password-control length *length*
- Configure the password composition policy.
  password-control composition type-number *type-number* [**type-length** *type-length*]
- Configure the password complexity checking policy.
  password-control complexity { **same-character** | **user-name** } **check**
- Configure the maximum login attempts and the action to take for login failures.
  password-control login-attempt *login-times* [**exceed** { **lock** | **lock-time** *time* | **unlock** }]

By default, a user group uses the global password control settings. For more information, see "Configuring password control."

Configuring the local user auto-delete feature

About the local user auto-delete feature

This feature enables the device to examine the validity of local users at fixed time periods of 10 minutes and automatically delete expired local users.

Procedure

1. Enter system view
   system-view
2. Enable the local user auto-delete feature.
   local-user auto-delete enable
   By default, the local user auto-delete feature is disabled.

Display and maintenance commands for local users and local user groups

Execute **display** commands in any view.

Task	Command
Display the local user configuration and online user statistics.	**display local-user** [**class** { **manage** | **network** } | **idle-cut** { **disable** | **enable** } | **service-type** { **ftp** | **http** | **https** | **lan-access** | **portal** | **ssh** | **telnet** | **terminal** } | **state** { **active** | **block** } | **user-name** *user-name* **class** { **manage** | **network** } | **vlan** *vlan-id*]
Display user group configuration.	**display user-group** { **all** | **name** *group-name* }

Configuring RADIUS

RADIUS tasks at a glance

To configure RADIUS, perform the following tasks:

1. Configuring an EAP profile

   To perform EAP-based RADIUS server status detection, you must configure an EAP profile and specify the EAP profile in a test profile.
2. Configuring a test profile for RADIUS server status detection

   To detect the status of a RADIUS server, you must configure a test profile and configure the RADIUS server to use the test profile in a RADIUS scheme.
3. Creating a RADIUS scheme
4. Specifying RADIUS authentication servers
5. Specifying the RADIUS accounting servers
6. Specifying the shared keys for secure RADIUS communication

   Perform this task if no shared keys are specified when configuring RADIUS authentication or accounting servers.
7. (Optional.) Setting the status of RADIUS servers
8. (Optional.) Setting RADIUS timers
9. (Optional.) Configuring parameters for RADIUS packets
   - Specifying the source IP address for outgoing RADIUS packets
   - Setting the username format and traffic statistics units
   - Setting the maximum number of RADIUS request transmission attempts
   - Setting the maximum number of real-time accounting attempts
   - Setting the DSCP priority for RADIUS packets
10. (Optional.) Configuring parameters for RADIUS attributes
    - Specifying the format of the NAS-Port attribute
    - Configuring the Login-Service attribute check method for SSH, FTP, and terminal users
    - Interpreting the RADIUS class attribute as CAR parameters
    - Configuring the MAC address format for RADIUS attribute 31
    - Specifying the format of the NAS-Port-ID attribute
    - Setting the data measurement unit for the Remanent_Volume attribute
    - Configuring the RADIUS attribute translation feature
11. (Optional.) Configuring extended RADIUS features
    - Configuring RADIUS stop-accounting packet buffering
    - Enabling forcibly sending stop-accounting packets
    - Enabling the RADIUS server load sharing feature
    - Configuring the RADIUS accounting-on feature
    - Configuring the RADIUS session-control feature
    - Configuring the RADIUS DAS feature
    - Enabling SNMP notifications for RADIUS
    - Disabling the RADIUS service

Restrictions and guidelines for RADIUS configuration

If the authentication server in a RADIUS scheme is provided by the RADIUS server feature on the device, you need to configure only the following items for the RADIUS scheme:

- RADIUS authentication server.
- Shared key for RADIUS communication.
- Username format for interaction with the RADIUS server.

Configuring an EAP profile

About EAP profiles

An EAP profile is a collection of EAP authentication settings, including the EAP authentication method and the CA certificate file to be used for some EAP authentication methods.

Restrictions and guidelines

You can specify an EAP profile in multiple test profiles.

You can configure a maximum of 16 EAP profiles.

Prerequisites

Before you specify a CA certificate file, use FTP or TFTP to transfer the CA certificate file to the root directory of the default storage medium on the device.

In an IRF fabric, make sure a CA certificate file already exists in the root directory of the default storage medium on the master device before you specify the file.

Procedure

1. Enter system view.

   system-view

2. Create an EAP profile and enter EAP profile view.

   eap-profile *eap-profile-name*

3. Specify the EAP authentication method.

   method { **md5** | **peap-gtc** | **peap-mschapv2** | **ttls-gtc** | **ttls-mschapv2** }

   By default, the EAP authentication method is MD5-challenge.

4. Specify a CA certificate file for EAP authentication.

   ca-file *file-name*

   By default, no CA certificate file is specified for EAP authentication.

   You must specify a CA certificate file to verify the RADIUS server certificate if the EAP authentication method is PEAP-GTC, PEAP-MSCHAPv2, TTLS-GTC, or TTLS-MSCHAPv2.

Configuring a test profile for RADIUS server status detection

About test profiles for RADIUS server status detection

To detect the reachability or availability of a RADIUS authentication server, specify a test profile for the RADIUS server when you specify the server in a RADIUS scheme. With the test profile, the device refreshes the RADIUS server status at each detection interval according to the detection result. If the server is unreachable or unavailable, the device sets the status of the server to blocked. If the server is reachable or available, the device sets the status of the server to active.

The device supports the following RADIUS server status detection methods:

- **Simple detection**—For a RADIUS server, the device simulates an authentication request with the username and password specified in the test profile used by the server. The authentication request is sent to the RADIUS server within each detection interval. The device determines that the RADIUS server is reachable if the device receives a response from the server within the interval.
- **EAP-based detection**—For a RADIUS server, the device simulates an EAP authentication with the username and password specified in the test profile used by the server. The simulated EAP authentication starts at the beginning of each detection interval. If the EAP authentication completes within a detection interval, the device determines that the RADIUS server is available.

Simulating a complete EAP authentication process, EAP-based detection provides more reliable detection results than simple detection. As a best practice, configure EAP-based detection on a network environment where EAP authentication is configured.

Restrictions and guidelines

You can configure multiple test profiles in the system.

The device starts detecting the status of a RADIUS authentication server only if an existing test profile is specified for the server.

If you specify a nonexistent EAP profile in a test profile, the device performs simple detection for the RADIUS servers that use the test profile. After the EAP profile is configured, the device will start EAP-based detection at the next detection interval.

The device stops detecting the status of a RADIUS server when one of the following operations is performed:

- The RADIUS server is removed from the RADIUS scheme.
- The test profile configuration for the RADIUS server is removed in RADIUS scheme view.
- The test profile specified for the RADIUS server is deleted.
- The RADIUS server is manually set to the blocked state.
- The RADIUS scheme that contains the RADIUS server is deleted.

Procedure

1. Enter system view.

   system-view

2. Configure a test profile for detecting the status of RADIUS authentication servers.

   radius-server test-profile *profile-name* **username** *name* [**password** { **cipher** | **simple** } *string*] [**interval** *interval*] [**eap-profile** *eap-profile-name*]

Creating a RADIUS scheme

Restrictions and guidelines

You can configure a maximum of 16 RADIUS schemes. A RADIUS scheme can be used by multiple ISP domains.

Procedure

1. Enter system view.

   system-view

2. Create a RADIUS scheme and enter RADIUS scheme view.

   radius scheme *radius-scheme-name*

Specifying RADIUS authentication servers

About RADIUS authentication servers

A RADIUS authentication server completes authentication and authorization together, because authorization information is piggybacked in authentication responses sent to RADIUS clients.

You can specify one primary authentication server and a maximum of 16 secondary authentication servers for a RADIUS scheme. Secondary servers provide AAA services when the primary server becomes unreachable. The device searches for an active server in the order the secondary servers are configured.

When RADIUS server load sharing is enabled, the device distributes the workload over all servers without considering the primary and secondary server roles. The device checks the weight value and number of currently served users for each active server, and then determines the most appropriate server in performance to receive an authentication request.

Restrictions and guidelines

If redundancy is not required, specify only the primary server.

A RADIUS authentication server can function as the primary authentication server for one scheme and a secondary authentication server for another scheme at the same time.

Two authentication servers in a scheme, primary or secondary, cannot have the same combination of host name, IP address, and port number.

Procedure

1. Enter system view.

   system-view

2. Enter RADIUS scheme view.

   radius scheme *radius-scheme-name*

3. Specify the primary RADIUS authentication server.

   primary authentication { *host-name* | *ipv4-address* | **ipv6** *ipv6-address* } [*port-number* | **key** { **cipher** | **simple** } *string* | **test-profile** *profile-name* | **weight** *weight-value*] *

   By default, no primary RADIUS authentication server is specified.

   The **weight** keyword takes effect only when the RADIUS server load sharing feature is enabled for the RADIUS scheme.

4. (Optional.) Specify a secondary RADIUS authentication server.

   secondary authentication { *host-name* | *ipv4-address* | **ipv6** *ipv6-address* } [*port-number* | **key** { **cipher** | **simple** } *string* | **test-profile** *profile-name* | **weight** *weight-value*] *

   By default, no secondary RADIUS authentication servers are specified.

   The **weight** keyword takes effect only when the RADIUS server load sharing feature is enabled for the RADIUS scheme.

Specifying the RADIUS accounting servers

About RADIUS accounting servers

You can specify one primary accounting server and a maximum of 16 secondary accounting servers for a RADIUS scheme. Secondary servers provide AAA services when the primary server becomes unavailable. The device searches for an active server in the order the secondary servers are configured.

When RADIUS server load sharing is enabled, the device distributes the workload over all servers without considering the primary and secondary server roles. The device checks the weight value and number of currently served users for each active server, and then determines the most appropriate server in performance to receive an accounting request.

Restrictions and guidelines

If redundancy is not required, specify only the primary server.

A RADIUS accounting server can function as the primary accounting server for one scheme and a secondary accounting server for another scheme at the same time.

Two accounting servers in a scheme, primary or secondary, cannot have the same combination of host name, IP address, and port number.

RADIUS does not support accounting for FTP, SFTP, and SCP users.

Procedure

1. Enter system view.
   system-view
2. Enter RADIUS scheme view.
   radius scheme *radius-scheme-name*
3. Specify the primary RADIUS accounting server.
   primary accounting { *host-name* | *ipv4-address* | **ipv6** *ipv6-address* } [*port-number* | **key** { **cipher** | **simple** } *string* | **weight** *weight-value*] *
   By default, no primary RADIUS accounting server is specified.
   The **weight** keyword takes effect only when the RADIUS server load sharing feature is enabled for the RADIUS scheme.
4. (Optional.) Specify a secondary RADIUS accounting server.
   secondary accounting { *host-name* | *ipv4-address* | **ipv6** *ipv6-address* } [*port-number* | **key** { **cipher** | **simple** } *string* | **weight** *weight-value*] *
   By default, no secondary RADIUS accounting servers are specified.
   The **weight** keyword takes effect only when the RADIUS server load sharing feature is enabled for the RADIUS scheme.

Specifying the shared keys for secure RADIUS communication

About the shared keys for secure RADIUS communication

The RADIUS client and server use the MD5 algorithm and shared keys to generate the Authenticator value for packet authentication and user password encryption. The client and server must use the same key for each type of communication.

A key configured in this task is for all servers of the same type (accounting or authentication) in the scheme. The key has a lower priority than a key configured individually for a RADIUS server.

Restrictions and guidelines

The shared key configured on the device must be the same as the shared key configured on the RADIUS server.

Procedure

1. Enter system view.
   system-view
2. Enter RADIUS scheme view.
   radius scheme *radius-scheme-name*
3. Specify a shared key for secure RADIUS communication.
   key { **accounting** | **authentication** } { **cipher** | **simple** } *string*
   By default, no shared key is specified for secure RADIUS communication.

Setting the status of RADIUS servers

About RADIUS server status

To control the RADIUS servers with which the device communicates when the current servers are no longer available, set the status of RADIUS servers to blocked or active. You can specify one primary

RADIUS server and multiple secondary RADIUS servers. The secondary servers function as the backup of the primary server. When the RADIUS server load sharing feature is disabled, the device chooses servers based on the following rules:

- When the primary server is in active state, the device first tries to communicate with the primary server. If the primary server is unreachable, the device searches for an active secondary server in the order the servers are configured.
- When one or more servers are in active state, the device tries to communicate with these active servers only, even if the servers are unavailable.
- When all servers are in blocked state, the device only tries to communicate with the primary server.
- If a server is unreachable, the device performs the following operations:
  - Changes the server status to blocked.
  - Starts a quiet timer for the server.
  - Tries to communicate with the next secondary server in active state that has the highest priority.
- When the quiet timer of a server expires or you manually set the server to the active state, the status of the server changes back to active. The device does not check the server again during the authentication or accounting process.
- The search process continues until the device finds an available secondary server or has checked all secondary servers in active state. If no server is reachable, the device considers the authentication or accounting attempt a failure.
- When you remove a server in use, communication with the server times out. The device looks for a server in active state by first checking the primary server, and then checking secondary servers in the order they are configured.
- When a RADIUS server's status changes automatically, the device changes this server's status accordingly in all RADIUS schemes in which this server is specified.
- When a RADIUS server is manually set to blocked, server detection is disabled for the server, regardless of whether a test profile has been specified for the server. When the RADIUS server is set to active state, server detection is enabled for the server on which an existing test profile is specified.

By default, the device sets the status of all RADIUS servers to active. However, in some situations, you must change the status of a server. For example, if a server fails, you can change the status of the server to blocked to avoid communication attempts to the server.

Restrictions and guidelines

The configured server status cannot be saved to any configuration file, and can only be viewed by using the **display radius scheme** command.

After the device restarts, all servers are restored to the active state.

The device selects a reachable server for the authentication or accounting of a new user according to the server selection rules in this section if the RADIUS server load sharing feature is disabled. However, these rules are inapplicable to the reauthentication of online users if the RADIUS server selection mode for reauthentication is set to inherit by using the **reauthentication server-select inherit** command.

Procedure

1. Enter system view.
   system-view
2. Enter RADIUS scheme view.
   radius scheme *radius-scheme-name*
3. Set the RADIUS server status. Choose the following tasks as needed:

- Set the status of the primary RADIUS authentication server.

  state primary authentication { **active** | **block** }
- Set the status of the primary RADIUS accounting server.

  state primary accounting { **active** | **block** }
- Set the status of a secondary RADIUS authentication server.

  state secondary authentication [{ *host-name* | *ipv4-address* | **ipv6** *ipv6-address* } [*port-number*]] { **active** | **block** }
- Set the status of a secondary RADIUS accounting server.

  state secondary accounting [{ *host-name* | *ipv4-address* | **ipv6** *ipv6-address* } [*port-number*]] { **active** | **block** }

By default, a RADIUS server is in active state.

Setting RADIUS timers

About RADIUS timers

The device uses the following types of timers to control communication with a RADIUS server:

- **Server response timeout timer** (**response-timeout**)—Defines the RADIUS request retransmission interval. The timer starts immediately after a RADIUS request is sent. If the device does not receive a response from the RADIUS server before the timer expires, it resends the request.
- **Server quiet timer** (**quiet**)—Defines the duration to keep an unreachable server in blocked state. If one server is not reachable, the device changes the server status to blocked, starts this timer for the server, and tries to communicate with another server in active state. After the server quiet timer expires, the device changes the status of the server back to active.
- **Real-time accounting timer** (**realtime-accounting**)—Defines the interval at which the device sends real-time accounting packets to the RADIUS accounting server for online users.

Restrictions and guidelines

Consider the number of secondary servers when you configure the maximum number of RADIUS packet transmission attempts and the RADIUS server response timeout timer. If the RADIUS scheme includes many secondary servers, the retransmission process might be too long and the client connection in the access module, such as Telnet, can time out.

When the client connections have a short timeout period, a large number of secondary servers can cause the initial authentication or accounting attempt to fail. In this case, reconnect the client rather than adjusting the RADIUS packet transmission attempts and server response timeout timer. Typically, the next attempt will succeed, because the device has blocked the unreachable servers to shorten the time to find a reachable server.

Make sure the server quiet timer is set correctly. A timer that is too short might result in frequent authentication or accounting failures. This is because the device will continue to attempt to communicate with an unreachable server that is in active state. A timer that is too long might temporarily block a reachable server that has recovered from a failure. This is because the server will remain in blocked state until the timer expires.

A short real-time accounting interval helps improve accounting precision but requires many system resources. When there are 1000 or more users, set the interval to 15 minutes or longer.

Procedure

1. Enter system view.

   system-view
2. Enter RADIUS scheme view.

   radius scheme *radius-scheme-name*

3. Set RADIUS timers. Choose the following tasks as needed:
   - Set the RADIUS server response timeout timer.
     timer response-timeout *seconds*
     The default setting is 3 seconds.
   - Set the quiet timer for the servers.
     timer quiet *minutes*
     The default setting is 5 minutes.
   - Set the real-time accounting timer.
     timer realtime-accounting *interval* [**second**]
     The default setting is 12 minutes.

Specifying the source IP address for outgoing RADIUS packets

About the source IP address for outgoing RADIUS packets

The source IP address of RADIUS packets that a NAS sends must match the IP address of the NAS configured on the RADIUS server. A RADIUS server identifies a NAS by its IP address. Upon receiving a RADIUS packet, the RADIUS server checks the source IP address of the packet.

- If it is the IP address of a managed NAS, the server processes the packet.
- If it is not the IP address of a managed NAS, the server drops the packet.

Before sending a RADIUS packet, the NAS selects a source IP address in the following order:

1. The source IP address specified for the RADIUS scheme.
2. The source IP address specified in system view.
3. The IP address of the outbound interface specified by the route.

Restrictions and guidelines for source IP address configuration

You can specify a source IP address for outgoing RADIUS packets in RADIUS scheme view or in system view.

- The IP address specified in RADIUS scheme view applies only to one RADIUS scheme.
- The IP address specified in system view applies to all RADIUS schemes.

The source IP address of RADIUS packets that a NAS sends must match the IP address of the NAS that is configured on the RADIUS server.

As a best practice, specify a loopback interface address as the source IP address for outgoing RADIUS packets to avoid RADIUS packet loss caused by physical port errors.

The source address of outgoing RADIUS packets is typically the IP address of an egress interface on the NAS to communicate with the RADIUS server. However, in some situations, you must change the source IP address. For example, when VRRP is configured for stateful failover, configure the virtual IP of the uplink VRRP group as the source address.

You can directly specify a source IP address for outgoing RADIUS packets or specify a source interface to provide the source IP address for outgoing RADIUS packets. The source interface configuration and the source IP address configuration overwrite each other.

Specifying a source interface or source IP address for all RADIUS schemes

1. Enter system view.
   system-view
2. Specify a source interface or source IP address for outgoing RADIUS packets.

radius nas-ip { **interface** *interface-type interface-number* | { *ipv4-address* | **ipv6** *ipv6-address* } }

By default, the source IP address of an outgoing RADIUS packet is the primary IPv4 address or the IPv6 address of the outbound interface.

Specifying a source interface or source IP address for a RADIUS scheme

1. Enter system view.

   system-view

2. Enter RADIUS scheme view.

   radius scheme *radius-scheme-name*

3. Specify a source interface or source IP address for outgoing RADIUS packets.

   nas-ip { *ipv4-address* | **interface** *interface-type interface-number* | **ipv6** *ipv6-address* }

   By default, the source IP address of an outgoing RADIUS packet is that specified by using the **radius nas-ip** command in system view. If the **radius nas-ip** command is not used, the source IP address is the primary IP address of the outbound interface.

Setting the username format and traffic statistics units

About the username format and traffic statistics units

A username is in the *userid@isp-name* format, where the *isp-name* part represents the user's ISP domain name. By default, the ISP domain name is included in a username. However, older RADIUS servers might not recognize usernames that contain the ISP domain names. In this case, you can configure the device to remove the domain name of each username to be sent.

The device reports online user traffic statistics in accounting packets. The traffic measurement units are configurable.

Restrictions and guidelines

If two or more ISP domains use the same RADIUS scheme, configure the RADIUS scheme to keep the ISP domain name in usernames for domain identification.

For accounting accuracy, make sure the traffic statistics units configured on the device and on the RADIUS accounting servers are the same.

Procedure

1. Enter system view.

   system-view

2. Enter RADIUS scheme view.

   radius scheme *radius-scheme-name*

3. Set the format for usernames sent to the RADIUS servers.

   user-name-format { **keep-original** | **with-domain** | **without-domain** }

   By default, the ISP domain name is included in a username.

   If the device is specified as the RADIUS server in the scheme, the username format must be set to **without-domain**.

4. Set the data flow and packet measurement units for traffic statistics.

   data-flow-format { **data** { **byte** | **giga-byte** | **kilo-byte** | **mega-byte** } | **packet** { **giga-packet** | **kilo-packet** | **mega-packet** | **one-packet** } }*

   By default, traffic is counted in bytes and packets.

Setting the maximum number of RADIUS request transmission attempts

About setting the maximum number of RADIUS request transmission attempts

RADIUS uses UDP packets to transfer data. Because UDP communication is not reliable, RADIUS uses a retransmission mechanism to improve reliability. A RADIUS request is retransmitted if the NAS does not receive a server response for the request within the response timeout timer. For more information about the RADIUS server response timeout timer, see "Setting the status of RADIUS servers."

You can set the maximum number for the NAS to retransmit a RADIUS request to the same server. When the maximum number is reached, the NAS tries to communicate with other RADIUS servers in active state. If no other servers are in active state at the time, the NAS considers the authentication or accounting attempt a failure.

Procedure

1. Enter system view.
   system-view
2. Enter RADIUS scheme view.
   radius scheme *radius-scheme-name*
3. Set the maximum number of RADIUS request transmission attempts.
   retry *retries*
   By default, the maximum number is 3 for RADIUS request transmission attempts.

Setting the maximum number of real-time accounting attempts

About setting the maximum number of real-time accounting attempts

If you set the maximum number of real-time accounting attempts, the device will disconnect users from whom no accounting responses are received within the permitted attempts.

Procedure

1. Enter system view.
   system-view
2. Enter RADIUS scheme view.
   radius scheme *radius-scheme-name*
3. Set the maximum number of real-time accounting attempts.
   retry realtime-accounting *retries*
   By default, the maximum number is 5 for real-time accounting attempts.

Setting the DSCP priority for RADIUS packets

About the DSCP priority for RADIUS packets

The DSCP priority in the ToS field determines the transmission priority of RADIUS packets. A larger value represents a higher priority.

Procedure

1. Enter system view.

system-view

2. Set the DSCP priority for RADIUS packets.
   radius [**ipv6**] **dscp** *dscp-value*
   By default, the DSCP priority is 0 for RADIUS packets.

Specifying the format of the NAS-Port attribute

About this task

Perform this task to specify the format of the NAS-Port attribute (attribute 5) sent by the device to the RADIUS server. The following formats are available:

- **Default format**—Contains the following portions:
  - 8-bit IRF member ID.
  - 4-bit slot number.
  - 8-bit port index.
  - 12-bit VLAN ID.
- **Port format**—Contains the value in the last segment of the user access interface. For example, if a user comes online from GigabitEthernet 1/0/2, the value for the NAS-Port attribute is 2.

Software version and feature compatibility

This feature is supported only in Release 6342 and later.

Restrictions and guidelines

To exchange RADIUS packets correctly with a RADIUS server, configure the device with the same NAS-Port attribute format as the RADIUS server.

Procedure

1. Enter system view.
   system-view
2. Enter RADIUS scheme view.
   radius scheme *radius-scheme-name*
3. Set the NAS-Port attribute format to the port format.
   attribute 5 format port
   By default, the NAS-Port attribute uses the default format.

Configuring the Login-Service attribute check method for SSH, FTP, and terminal users

About Login-Service attribute check methods

The device supports the following check methods for the Login-Service attribute (RADIUS attribute 15) of SSH, FTP, and terminal users:

- **Strict**—Matches Login-Service attribute values 50, 51, and 52 for SSH, FTP, and terminal services, respectively.
- **Loose**—Matches the standard Login-Service attribute value 0 for SSH, FTP, and terminal services.

An Access-Accept packet received for a user must contain the matching attribute value. Otherwise, the user cannot log in to the device.

Restrictions and guidelines

Use the loose check method only when the server does not issue Login-Service attribute values 50, 51, and 52 for SSH, FTP, and terminal users.

Procedure

1. Enter system view.

   system-view

2. Enter RADIUS scheme view.

   radius scheme *radius-scheme-name*

3. Configure the Login-Service attribute check method for SSH, FTP, and terminal users.

   attribute 15 check-mode { **loose** | **strict** }

   The default check method is strict.

Interpreting the RADIUS class attribute as CAR parameters

About interpreting the RADIUS class attribute as CAR parameters

A RADIUS server may deliver CAR parameters for user-based traffic monitoring and control by using the RADIUS class attribute (attribute 25) in RADIUS packets. You can configure the device to interpret the class attribute to CAR parameters.

Procedure

1. Enter system view.

   system-view

2. Enter RADIUS scheme view.

   radius scheme *radius-scheme-name*

3. Interpret the RADIUS class attribute as CAR parameters.

   attribute 25 car

   By default, the RADIUS class attribute is not interpreted as CAR parameters.

Configuring the MAC address format for RADIUS attribute 31

Restrictions and guidelines

RADIUS servers of different types might have different requirements for the MAC address format in RADIUS attribute 31. Configure the MAC address format for RADIUS attribute 31 to meet the requirements of the RADIUS servers.

Procedure

1. Enter system view.

   system-view

2. Enter RADIUS scheme view.

   radius scheme *radius-scheme-name*

3. Configure the MAC address format for RADIUS attribute 31.

   attribute 31 mac-format section { **one** |{ **six** | **three** } **separator** *separator-character* } { **lowercase** | **uppercase** }

   By default, a MAC address is in the format of HH-HH-HH-HH-HH-HH. The MAC address is separated by hyphen (-) into six sections with letters in upper case.

   The **one** keyword is available only in Release 6312 and later.

Specifying the format of the NAS-Port-ID attribute

About this task

Perform this task to specify the format of the NAS-Port-ID attribute (attribute 87) sent by the device to the RADIUS server. The following formats are available:

- **Default format**—The default format varies by user access type.
  - For portal users, the NAS-Port-Id attribute is in the *SlotID***00***IfNOVlanID* format:
    - *SlotID*—Represents a 2-byte IRF member ID.
    - **00**—Represents a 2-byte string of 0s.
    - *IfNO*—Represents a 3-byte port index.
    - *VLANID*—Represents a 9-byte VLAN ID.
  - For 802.1X and MAC authentication users, the NAS-Port-Id attribute is in the **slot=***xx***;subslot=***xx***;port=***xx***;vlanid=***xx* format.
    - **slot**—IRF member ID.
    - **subslot**—Slot number.
    - **port**—Port index.
    - **vlanid**—VLAN ID
  - For login users, the device does not include the NAS-Port-Id attribute in RADIUS packets.
- **Interface-name format**—Contains the name of the user access interface. For example, if a user accesses the network from GigabitEthernet 1/0/1, the NAS-Port-ID attribute is set to **GigabitEthernet1/0/1**.

Software version and feature compatibility

This feature is supported only in Release 6342 and later.

Restrictions and guidelines

To exchange RADIUS packets correctly with a RADIUS server, configure the device with the same NAS-Port-ID attribute format as the RADIUS server.

Procedure

1. Enter system view.

   `system-view`
2. Enter RADIUS scheme view.

   `radius scheme` *`radius-scheme-name`*
3. Set the NAS-Port-ID attribute format to the interface name format.

   `attribute 87 format interface-name`

   By default, the NAS-Port attribute uses the default format.

Setting the data measurement unit for the Remanent_Volume attribute

About the data measurement unit for the Remanent_Volume attribute

The RADIUS server uses the Remanent_Volume attribute in authentication or real-time accounting responses to notify the device of the current amount of data available for online users.

Restrictions and guidelines

Make sure the configured measurement unit is the same as the user data measurement unit on the RADIUS server.

Procedure

1. Enter system view.
   system-view
2. Enter RADIUS scheme view.
   radius scheme *radius-scheme-name*
3. Set the data measurement unit for the Remanent_Volume attribute.
   attribute remanent-volume unit { **byte** | **giga-byte** | **kilo-byte** | **mega-byte** }
   By default, the data measurement unit is kilobyte.

Configuring the RADIUS attribute translation feature

About RADIUS attribute translation

The RADIUS attribute translation feature enables the device to work correctly with the RADIUS servers of different vendors that support RADIUS attributes incompatible with the device.

RADIUS attribute translation has the following implementations:

- **Attribute conversion**—Converts source RADIUS attributes into destination RADIUS attributes based on RADIUS attribute conversion rules.
- **Attribute rejection**—Rejects RADIUS attributes based on RADIUS attribute rejection rules.

When the RADIUS attribute translation feature is enabled, the device processes RADIUS packets as follows:

- For the sent RADIUS packets:
  - Deletes the rejected attributes from the packets.
  - Uses the destination RADIUS attributes to replace the attributes that match RADIUS attribute conversion rules in the packets.
- For the received RADIUS packets:
  - Ignores the rejected attributes in the packets.
  - Interprets the attributes that match RADIUS attribute conversion rules as the destination RADIUS attributes.

To identify proprietary RADIUS attributes, you can define the attributes as extended RADIUS attributes, and then convert the extended RADIUS attributes to device-supported attributes.

Restrictions and guidelines for RADIUS attribute translation configuration

Configure either conversion rules or rejection rules for a RADIUS attribute.

Configure either direction-based rules or packet type-based rules for a RADIUS attribute.

For direction-based translation of a RADIUS attribute, you can configure a rule for each direction (inbound or outbound). For packet type-based translation of a RADIUS attribute, you can configure a rule for each RADIUS packet type (RADIUS Access-Accept, RADIUS Access-Request, or RADIUS accounting).

Configuring the RADIUS attribute translation feature for a RADIUS scheme

1. Enter system view.
   system-view
2. (Optional.) Define an extended RADIUS attribute.

radius attribute extended *attribute-name* [**vendor** *vendor-id*] **code** *attribute-code* **type** { **binary** | **date** | **integer** | **interface-id** | **ip** | **ipv6** | **ipv6-prefix** | **octets** | **string** }

3. Enter RADIUS scheme view.

   radius scheme *radius-scheme-name*

4. Enable the RADIUS attribute translation feature.

   attribute translate

   By default, this feature is disabled.

5. Configure a RADIUS attribute conversion rule or a RADIUS attribute reject rule. Choose the following tasks as needed:

   - Configure a RADIUS attribute conversion rule.

     attribute convert *src-attr-name* **to** *dest-attr-name* { { **access-accept** | **access-request** | **accounting** } * | { **received** | **sent** } * }

     By default, no RADIUS attribute conversion rules are configured.

   - Configure a RADIUS attribute rejection rule.

     attribute reject *attr-name* { { **access-accept** | **access-request** | **accounting** } * | { **received** | **sent** } * }

     By default, no RADIUS attribute rejection rules are configured.

Configuring the RADIUS attribute translation feature for a RADIUS DAS

1. Enter system view.

   system-view

2. (Optional.) Define an extended RADIUS attribute.

   radius attribute extended *attribute-name* [**vendor** *vendor-id*] **code** *attribute-code* **type** { **binary** | **date** | **integer** | **interface-id** | **ip** | **ipv6** | **ipv6-prefix** | **octets** | **string** }

3. Enter RADIUS DAS view.

   radius dynamic-author server

4. Enable the RADIUS attribute translation feature.

   attribute translate

   By default, this feature is disabled.

5. Configure a RADIUS attribute conversion rule or a RADIUS attribute rejection rule. Choose the following tasks as needed:

   - Configure a RADIUS attribute conversion rule.

     attribute convert *src-attr-name* **to** *dest-attr-name* { { **coa-ack** | **coa-request** } * | { **received** | **sent** } * }

     By default, no RADIUS attribute conversion rules are configured.

   - Configure a RADIUS attribute rejection rule.

     attribute reject *attr-name* { { **coa-ack** | **coa-request** } * | { **received** | **sent** } * }

     By default, no RADIUS attribute rejection rules are configured.

Configuring RADIUS stop-accounting packet buffering

About RADIUS stop-accounting packet buffering

The device sends RADIUS stop-accounting requests when it receives connection teardown requests from hosts or connection teardown commands from an administrator. However, the device might fail

to receive a response for a stop-accounting request in a single transmission. Enable the device to buffer RADIUS stop-accounting requests that have not received responses from the accounting server. The device will resend the requests until responses are received.

To limit the transmission times, set a maximum number of transmission attempts that can be made for individual RADIUS stop-accounting requests. When the maximum attempts are made for a request, the device discards the buffered request.

Procedure

1. Enter system view.

   system-view

2. Enter RADIUS scheme view.

   radius scheme *radius-scheme-name*

3. Enable buffering of RADIUS stop-accounting requests to which no responses have been received.

   stop-accounting-buffer enable

   By default, the buffering feature is enabled.

4. (Optional.) Set the maximum number of transmission attempts for individual RADIUS stop-accounting requests.

   retry stop-accounting *retries*

   The default setting is 500.

Enabling forcibly sending stop-accounting packets

About forcibly sending stop-accounting packets

Typically, if the device does not send a start-accounting packet to the RADIUS server for an authenticated user, it does not send a stop-accounting packet when the user goes offline. If the server has generated a user entry for the user without start-accounting packets, it does not release the user entry when the user goes offline. This feature forces the device to send stop-accounting packets to the RADIUS server when the user goes offline for timely releasing the user entry on the server.

Procedure

1. Enter system view.

   system-view

2. Enter RADIUS scheme view.

   radius scheme *radius-scheme-name*

3. Enable the device to send stop-accounting packets when users for which no start-accounting packets are sent go offline.

   stop-accounting-packet send-force

   By default, forcibly sending stop-accounting packets is disabled. The device does not send stop-accounting packets when users for which no start-accounting packets are sent go offline.

Enabling the RADIUS server load sharing feature

About RADIUS server load sharing

By default, the device communicates with RADIUS servers based on the server roles. It first attempts to communicate with the primary server, and, if the primary server is unreachable, it then searches for the secondary servers in the order they are configured. The first secondary server in active state is used for communication. In this process, the workload is always placed on the active server.

Use the RADIUS server load sharing feature to dynamically distribute the workload over multiple servers regardless of their server roles. The device forwards an AAA request to the most appropriate server of all active servers in the scheme after it compares the weight values and numbers of currently served users. Specify a weight value for each RADIUS server based on the AAA capacity of the server. A larger weight value indicates a higher AAA capacity.

In RADIUS server load sharing, once the device sends a start-accounting request to a server for a user, it forwards all subsequent accounting requests of the user to the same server. If the accounting server is unreachable, the device returns an accounting failure message rather than searching for another active accounting server.

Procedure

1. Enter system view.
   system-view
2. Enter RADIUS scheme view.
   radius scheme *radius-scheme-name*
3. Enable the RADIUS server load sharing feature.
   server-load-sharing enable
   By default, this feature is disabled.

Configuring the RADIUS accounting-on feature

About RADIUS accounting-on

When the accounting-on feature is enabled, the device automatically sends an accounting-on packet to the RADIUS server after the entire device reboots. Upon receiving the accounting-on packet, the RADIUS server logs out all online users so they can log in again through the device. Without this feature, users cannot log in again after the reboot, because the RADIUS server considers them to come online.

You can configure the interval for which the device waits to resend the accounting-on packet and the maximum number of retries.

The extended accounting-on feature enhances the accounting-on feature in a distributed architecture.

The extended accounting-on feature is applicable to LAN users. The user data is saved to the IRF member devices through which the users access the system. When the extended accounting-on feature is enabled, the system automatically sends an accounting-on packet to the RADIUS server after a member device reboots. The packet contains the member device identifier. Upon receiving the accounting-on packet, the RADIUS server logs out all online users that access the system through the member device. If no users have come online through the member device, the IRF fabric does not send an accounting-on packet after the member device reboots.

Restrictions and guidelines

For the extended accounting-on feature to take effect, the RADIUS server must run on IMC and the accounting-on feature must be enabled.

Procedure

1. Enter system view.
   system-view
2. Enter RADIUS scheme view.
   radius scheme *radius-scheme-name*
3. Enable accounting-on.
   accounting-on enable [**interval** *interval* | **send** *send-times*] *
   By default, the accounting-on feature is disabled.

4. (Optional.) Enable extended accounting-on.

   accounting-on extended

   By default, extended accounting-on is disabled.

Configuring the RADIUS session-control feature

About RADIUS session-control

Enable this feature for the RADIUS server to dynamically change the user authorization information (such as the authorization ACL, VLAN, and user group) or forcibly disconnect users by using session-control packets. This task enables the device to receive RADIUS session-control packets on UDP port 1812.

To verify the session-control packets sent from a RADIUS server, specify the RADIUS server as a session-control client to the device.

Restrictions and guidelines

The RADIUS session-control feature can only work with RADIUS servers running on IMC. The session-control client configuration takes effect only when the session-control feature is enabled.

If the device acts as the NAS and the IMC server deployed with EAD assigns authorization ACLs to the device, you must enable the session-control feature on the device. This ensures that the authorization ACLs can take effect.

Procedure

1. Enter system view.

   system-view

2. Enable the session-control feature.

   radius session-control enable

   By default, the session-control feature is disabled.

3. Specify a session-control client.

   radius session-control client { **ip** *ipv4-address* | **ipv6** *ipv6-address* } [**key** { **cipher** | **simple** } *string*]

   By default, no session-control clients are specified.

Configuring the RADIUS DAS feature

About the RADIUS DAS feature

Dynamic Authorization Extensions (DAE) to RADIUS, defined in RFC 5176, can log off online users and change online user authorization information.

In a RADIUS network, the RADIUS server typically acts as the DAE client (DAC) and the NAS acts as the DAE server (DAS).

When the RADIUS DAS feature is enabled, the NAS performs the following operations:

1. Listens to the default or specified UDP port to receive DAE requests.
2. Logs off online users that match the criteria in the requests, changes their authorization information, shuts down or reboots their access ports, or reauthenticates the users.
3. Sends DAE responses to the DAC.

DAE defines the following types of packets:

- **Disconnect Messages (DMs)**—The DAC sends DM requests to the DAS to log off specific online users.

- **Change of Authorization Messages (CoA Messages)**—The DAC sends CoA requests to the DAS to change the authorization information of specific online users.

Procedure

1. Enter system view.

   system-view

2. Enable the RADIUS DAS feature and enter RADIUS DAS view.

   radius dynamic-author server

   By default, the RADIUS DAS feature is disabled.

3. Specify a RADIUS DAC.

   client { **ip** *ipv4-address* | **ipv6** *ipv6-address* } [**key** { **cipher** | **simple** } *string*]

   By default, no RADIUS DACs are specified.

4. (Optional.) Specify the RADIUS DAS port.

   port *port-number*

   By default, the RADIUS DAS port is 3799.

Enabling SNMP notifications for RADIUS

About SNMP notifications for RADIUS

When SNMP notifications are enabled for RADIUS, the SNMP agent supports the following notifications generated by RADIUS:

- **RADIUS server unreachable notification**—The RADIUS server cannot be reached. RADIUS generates this notification if it does not receive a response to an accounting or authentication request within the specified number of RADIUS request transmission attempts.
- **RADIUS server reachable notification**—The RADIUS server can be reached. RADIUS generates this notification for a previously blocked RADIUS server after the quiet timer expires.
- **Excessive authentication failures notification**—The number of authentication failures compared to the total number of authentication attempts exceeds the specified threshold.

For RADIUS SNMP notifications to be sent correctly, you must also configure SNMP on the device. For more information about SNMP configuration, see *Network Management and Monitoring Configuration Guide*.

Procedure

1. Enter system view.

   system-view

2. Enable SNMP notifications for RADIUS.

   snmp-agent trap enable radius [**accounting-server-down** | **accounting-server-up** | **authentication-error-threshold** | **authentication-server-down** | **authentication-server-up**] *

   By default, all SNMP notifications are disabled for RADIUS.

Disabling the RADIUS service

About disabling the RADIUS service

By default, the RADIUS service is enabled. The device can send and receive RADIUS packets. Attackers might use RADIUS session-control and DAE ports to attack the device. To protect the device when such an attack occurs, disable the RADIUS service temporarily on the device. After the network is secure, re-enable the RADIUS service.

If settings on the RADIUS servers require modification or the RADIUS servers cannot provide services temporarily, you can temporarily disable the RADIUS service on the device.

When the RADIUS service is disabled, the device stops sending and receiving RADIUS packets. If a new user comes online, the device uses the backup authentication, authorization, or accounting method to process that user. If the device has not finished requesting authentication or accounting for a user before the RADIUS service is disabled, it uses the following rules to process that user:

- If the device has sent RADIUS authentication requests for that user to a RADIUS server, the device processes that user depending on whether it receives a response from the RADIUS server.
  - If the device receives a response from the RADIUS server, it uses the response to determine whether that user has passed authentication. If that user has passed authentication, the device assigns authorization information to that user according to the response.
  - If the device does not receive any response from the RADIUS server, it attempts to use the backup authentication method to authenticate that user.
- If the device has sent RADIUS start-accounting requests for that user to a RADIUS server, the device processes that user depending on whether it receives a response from the RADIUS server.
  - If the device receives a response from the RADIUS server, it allows that user to come online. However, the device cannot send out accounting-update or stop-accounting requests to the RADIUS server. It cannot buffer the accounting requests, either. When that user goes offline, the RADIUS server cannot log off that user in time. The accounting result might be inaccurate.
  - If the device does not receive any response from the RADIUS server, it attempts to use the backup accounting method.

Restrictions and guidelines

Disabling the RADIUS service does not affect the RADIUS server feature of the device.

The authentication, authorization, and accounting processes undertaken by other methods are not switched to RADIUS when you re-enable the RADIUS service.

Procedure

1. Enter system view.

   `system-view`
2. Disable the RADIUS service.

   `undo radius enable`

   By default, the RADIUS service is enabled.

   To re-enable the RADIUS service, use the **`radius enable`** command.

Display and maintenance commands for RADIUS

Execute **`display`** commands in any view and **`reset`** commands in user view.

Task	Command
Display the RADIUS scheme configuration.	**`display radius scheme`** [*`radius-scheme-name`*]
Display authentication and accounting load statistics for all RADIUS servers.	**`display radius server-load statistics`**
Display RADIUS packet statistics.	**`display radius statistics`**
Display information about buffered	**`display stop-accounting-buffer`**

Task	Command
RADIUS stop-accounting requests to which no responses have been received.	{ **radius-scheme** *radius-scheme-name* | **session-id** *session-id* | **time-range** *start-time end-time* | **user-name** *user-name* }
Clear history authentication and accounting load statistics for all RADIUS servers.	**reset radius server-load statistics**
Clear RADIUS statistics.	**reset radius statistics**
Clear the buffered RADIUS stop-accounting requests to which no responses have been received.	**reset stop-accounting-buffer** { **radius-scheme** *radius-scheme-name* | **session-id** *session-id* | **time-range** *start-time end-time* | **user-name** *user-name* }

Configuring HWTACACS

HWTACACS tasks at a glance

To configure HWTACACS, perform the following tasks:

1. Creating an HWTACACS scheme
2. Specifying the HWTACACS authentication servers
3. Specifying the HWTACACS authorization servers
4. Specifying the HWTACACS accounting servers
5. Specifying the shared keys for secure HWTACACS communication

   Perform this task if no shared keys are specified when configuring HWTACACS servers.
6. (Optional.) Setting HWTACACS timers
7. (Optional.) Configuring parameters for HWTACACS packets

Specifying the source IP address for outgoing HWTACACS packets

Setting the username format and traffic statistics units

8. (Optional.) Configuring HWTACACS stop-accounting packet buffering

Creating an HWTACACS scheme

Restrictions and guidelines

You can configure a maximum of 16 HWTACACS schemes. An HWTACACS scheme can be used by multiple ISP domains.

Procedure

1. Enter system view.

   system-view
2. Create an HWTACACS scheme and enter HWTACACS scheme view.

   hwtacacs scheme *hwtacacs-scheme-name*

Specifying the HWTACACS authentication servers

About HWTACACS authentication servers

You can specify one primary authentication server and a maximum of 16 secondary authentication servers for an HWTACACS scheme. When the primary server is unreachable, the device searches for the secondary servers in the order they are configured. The first secondary server in active state is used for communication.

Restrictions and guidelines

If redundancy is not required, specify only the primary server.

An HWTACACS server can function as the primary authentication server in one scheme and as the secondary authentication server in another scheme at the same time.

Two HWTACACS authentication servers in a scheme, primary or secondary, cannot have the same combination of host name, IP address, and port number.

Procedure

1. Enter system view.

   system-view

2. Enter HWTACACS scheme view.

   hwtacacs scheme *hwtacacs-scheme-name*

3. Specify the primary HWTACACS authentication server.

   primary authentication { *host-name* | *ipv4-address* | **ipv6** *ipv6-address* } [*port-number* | **key** { **cipher** | **simple** } *string* | **single-connection**] *

   By default, no primary HWTACACS authentication server is specified.

4. (Optional.) Specify a secondary HWTACACS authentication server.

   secondary authentication { *host-name* | *ipv4-address* | **ipv6** *ipv6-address* } [*port-number* | **key** { **cipher** | **simple** } *string* | **single-connection**] *

   By default, no secondary HWTACACS authentication servers are specified.

Specifying the HWTACACS authorization servers

About HWTACACS authorization servers

You can specify one primary authorization server and a maximum of 16 secondary authorization servers for an HWTACACS scheme. When the primary server is not available, the device searches for the secondary servers in the order they are configured. The first secondary server in active state is used for communication.

Restrictions and guidelines

If redundancy is not required, specify only the primary server.

An HWTACACS server can function as the primary authorization server of one scheme and as the secondary authorization server of another scheme at the same time.

Two HWTACACS authorization servers in a scheme, primary or secondary, cannot have the same combination of host name, IP address, and port number.

Procedure

1. Enter system view.

   system-view

2. Enter HWTACACS scheme view.

hwtacacs scheme *hwtacacs-scheme-name*

3. Specify the primary HWTACACS authorization server.

   primary authorization { *host-name* | *ipv4-address* | **ipv6** *ipv6-address* } [*port-number* | **key** { **cipher** | **simple** } *string* | **single-connection**] *

   By default, no primary HWTACACS authorization server is specified.

4. (Optional.) Specify a secondary HWTACACS authorization server.

   secondary authorization { *host-name* | *ipv4-address* | **ipv6** *ipv6-address* } [*port-number* | **key** { **cipher** | **simple** } *string* | **single-connection**] *

   By default, no secondary HWTACACS authorization servers are specified.

Specifying the HWTACACS accounting servers

About HWTACACS accounting servers

You can specify one primary accounting server and a maximum of 16 secondary accounting servers for an HWTACACS scheme. When the primary server is not available, the device searches for the secondary servers in the order they are configured. The first secondary server in active state is used for communication.

Restrictions and guidelines

If redundancy is not required, specify only the primary server.

An HWTACACS server can function as the primary accounting server of one scheme and as the secondary accounting server of another scheme at the same time.

Two HWTACACS accounting servers in a scheme, primary or secondary, cannot have the same combination of host name, IP address, and port number.

HWTACACS does not support accounting for FTP, SFTP, and SCP users.

Procedure

1. Enter system view.

   system-view

2. Enter HWTACACS scheme view.

   hwtacacs scheme *hwtacacs-scheme-name*

3. Specify the primary HWTACACS accounting server.

   primary accounting { *host-name* | *ipv4-address* | **ipv6** *ipv6-address* } [*port-number* | **key** { **cipher** | **simple** } *string* | **single-connection**] *

   By default, no primary HWTACACS accounting server is specified.

4. (Optional.) Specify a secondary HWTACACS accounting server.

   secondary accounting { *host-name* | *ipv4-address* | **ipv6** *ipv6-address* } [*port-number* | **key** { **cipher** | **simple** } *string* | **single-connection**] *

   By default, no secondary HWTACACS accounting servers are specified.

Specifying the shared keys for secure HWTACACS communication

About shared keys for secure HWTACACS communication

The HWTACACS client and server use the MD5 algorithm and shared keys to generate the Authenticator value for packet authentication and user password encryption. The client and server must use the same key for each type of communication.

Perform this task to configure shared keys for servers in an HWTACACS scheme. The keys take effect on all servers for which a shared key is not individually configured.

Restrictions and guidelines

Make sure the shared key configured on the device is the same as the shared key configured on the HWTACACS server.

Procedure

1. Enter system view.

   system-view

2. Enter HWTACACS scheme view.

   hwtacacs scheme *hwtacacs-scheme-name*

3. Specify a shared key for secure HWTACACS authentication, authorization, or accounting communication.

   key { **accounting** | **authentication** | **authorization** } { **cipher** | **simple** } *string*

   By default, no shared key is specified for secure HWTACACS communication.

Setting HWTACACS timers

About HWTACACS timers and server status

The device uses the following timers to control communication with an HWTACACS server:

- **Server response timeout timer (response-timeout)**—Defines the HWTACACS server response timeout timer. The device starts this timer immediately after an HWTACACS authentication, authorization, or accounting request is sent. If the device does not receive a response from the server within the timer, it sets the server to blocked. Then, the device sends the request to another HWTACACS server.
- **Real-time accounting timer (realtime-accounting)**—Defines the interval at which the device sends real-time accounting packets to the HWTACACS accounting server for online users.
- **Server quiet timer (quiet)**—Defines the duration to keep an unreachable server in blocked state. If a server is not reachable, the device changes the server status to blocked, starts this timer for the server, and tries to communicate with another server in active state. After the server quiet timer expires, the device changes the status of the server back to active.

The server quiet timer setting affects the status of HWTACACS servers. If the scheme includes one primary HWTACACS server and multiple secondary HWTACACS servers, the device communicates with the HWTACACS servers based on the following rules:

- When the primary server is in active state, the device communicates with the primary server. When the primary server is unreachable, the device researches a secondary server in active status in the order they are configured.
- When one or more servers are in active state, the device tries to communicate with these servers only, even if they are unreachable.
- When all servers are in blocked state, the device only tries to communicate with the primary server.
- If the primary server is unreachable, the device changes the server status to blocked and starts a quiet timer for the server. When the quiet timer of the server expires, the status of the server changes back to active. The device does not check the server again during the authentication, authorization, or accounting process.
- The search process continues until the device finds an available secondary server or has checked all secondary servers in active state. If no server is available, the device considers the authentication, authorization, or accounting attempt a failure.

- When you remove a server in use, communication with the server times out. The device looks for a server in active state by first checking the primary server, and then checking secondary servers in the order they are configured.
- When an HWTACACS server's status changes automatically, the device changes this server's status accordingly in all HWTACACS schemes in which this server is specified.

Restrictions and guidelines

A short real-time accounting interval helps improve accounting precision but requires many system resources. When there are 1000 or more users, set a real-time accounting interval longer than 15 minutes.

Procedure

1. Enter system view.
   system-view
2. Enter HWTACACS scheme view.
   hwtacacs scheme *hwtacacs-scheme-name*
3. Set the HWTACACS timers. Choose the following tasks as needed:
   - Set the HWTACACS server response timeout timer.
     timer response-timeout *seconds*
     By default, the HWTACACS server response timeout timer is 5 seconds.
   - Set the real-time accounting interval.
     timer realtime-accounting *minutes*
     By default, the real-time accounting interval is 12 minutes.
   - Set the server quiet timer.
     timer quiet *minutes*
     By default, the server quiet timer is 5 minutes.

Specifying the source IP address for outgoing HWTACACS packets

About the source IP address for outgoing HWTACACS packets

The source IP address of HWTACACS packets that a NAS sends must match the IP address of the NAS configured on the HWTACACS server. An HWTACACS server identifies a NAS by IP address. When the HWTACACS server receives a packet, it checks the source IP address of the packet.

- If it is the IP address of a managed NAS, the server processes the packet.
- If it is not the IP address of a managed NAS, the server drops the packet.

Before sending an HWTACACS packet, the NAS selects a source IP address in the following order:

1. The source IP address specified for the HWTACACS scheme.
2. The source IP address specified in system view.
3. The IP address of the outbound interface specified by the route.

Restrictions and guidelines for source IP address configuration

You can specify the source IP address for outgoing HWTACACS packets in HWTACACS scheme view or in system view.

- The IP address specified in HWTACACS scheme view applies to one HWTACACS scheme.
- The IP address specified in system view applies to all HWTACACS schemes.

The source IP address of HWTACACS packets that a NAS sends must match the IP address of the NAS that is configured on the HWTACACS server.

As a best practice, specify a loopback interface address as the source IP address for outgoing HWTACACS packets to avoid HWTACACS packet loss caused by physical port errors.

To communicate with the HWTACACS server, the source address of outgoing HWTACACS packets is typically the IP address of an egress interface on the NAS. However, in some situations, you must change the source IP address. For example, when VRRP is configured for stateful failover, configure the virtual IP of the uplink VRRP group as the source address.

You can directly specify a source IP address for outgoing HWTACACS packets or specify a source interface to provide the source IP address for outgoing HWTACACS packets. The source interface configuration and the source IP address configuration overwrite each other.

Specifying a source interface or source IP address for all HWTACACS schemes

1. Enter system view.

   system-view

2. Specify a source interface or source IP address for outgoing HWTACACS packets.

   hwtacacs nas-ip { **interface** *interface-type interface-number* | { *ipv4-address* | **ipv6** *ipv6-address* } }

   By default, the source IP address of an HWTACACS packet sent to the server is the primary IPv4 address or the IPv6 address of the outbound interface.

Specifying a source interface or source IP address for an HWTACACS scheme

1. Enter system view.

   system-view

2. Enter HWTACACS scheme view.

   hwtacacs scheme *hwtacacs-scheme-name*

3. Specify a source interface or source IP address for outgoing HWTACACS packets.

   nas-ip { *ipv4-address* | **interface** *interface-type interface-number* | **ipv6** *ipv6-address* }

   By default, the source IP address of an outgoing HWTACACS packet is that configured by using the **hwtacacs nas-ip** command in system view. If the **hwtacacs nas-ip** command is not used, the source IP address is the primary IP address of the outbound interface.

Setting the username format and traffic statistics units

About the username format and traffic statistics units

A username is typically in the *userid@isp-name* format, where the *isp-name* part represents the user's ISP domain name. By default, the ISP domain name is included in a username. If HWTACACS servers do not recognize usernames that contain ISP domain names, you can configure the device to send usernames without domain names to the servers.

The device reports online user traffic statistics in accounting packets.

Restrictions and guidelines

If two or more ISP domains use the same HWTACACS scheme, configure the HWTACACS scheme to keep the ISP domain name in usernames for domain identification.

For accounting accuracy, make sure the traffic measurement units configured on the device are the same as the traffic measurement units configured on the HWTACACS accounting servers.

Procedure

1. Enter system view.

system-view

2. Enter HWTACACS scheme view.

   hwtacacs scheme *hwtacacs-scheme-name*

3. Set the format of usernames sent to the HWTACACS servers.

   user-name-format { **keep-original** | **with-domain** | **without-domain** }

   By default, the ISP domain name is included in a username.

4. Set the data flow and packet measurement units for traffic statistics.

   data-flow-format { **data** { **byte** | **giga-byte** | **kilo-byte** | **mega-byte** } | **packet** { **giga-packet** | **kilo-packet** | **mega-packet** | **one-packet** } }*

   By default, traffic is counted in bytes and packets.

Configuring HWTACACS stop-accounting packet buffering

About HWTACACS stop-accounting packet buffering

The device sends HWTACACS stop-accounting requests when it receives connection teardown requests from hosts or connection teardown commands from an administrator. However, the device might fail to receive a response for a stop-accounting request in a single transmission. Enable the device to buffer HWTACACS stop-accounting requests that have not received responses from the accounting server. The device will resend the requests until responses are received.

To limit the transmission times, set a maximum number of attempts that can be made for transmitting individual HWTACACS stop-accounting requests. When the maximum attempts are made for a request, the device discards the buffered request.

Procedure

1. Enter system view.

   system-view

2. Enter HWTACACS scheme view.

   hwtacacs scheme *hwtacacs-scheme-name*

3. Enable buffering of HWTACACS stop-accounting requests to which no responses have been received.

   stop-accounting-buffer enable

   By default, the buffering feature is enabled.

4. (Optional.) Set the maximum number of transmission attempts for individual HWTACACS stop-accounting requests.

   retry stop-accounting *retries*

   The default setting is 100.

Display and maintenance commands for HWTACACS

Execute **display** commands in any view and **reset** commands in user view.

Task	Command
Display the configuration or server statistics of HWTACACS schemes.	**display hwtacacs scheme** [*hwtacacs-scheme-name* [**statistics**]]
Display information about buffered HWTACACS stop-accounting requests to which no responses have been received.	**display stop-accounting-buffer hwtacacs-scheme** *hwtacacs-scheme-name*

Task	Command
Clear HWTACACS statistics.	**reset hwtacacs statistics** { **accounting** | **all** | **authentication** | **authorization** }
Clear the buffered HWTACACS stop-accounting requests to which no responses have been received.	**reset stop-accounting-buffer hwtacacs-scheme** *hwtacacs-scheme-name*

Configuring LDAP

LDAP tasks at a glance

To configure LDAP, perform the following tasks:

1. Configuring an LDAP server
   a. Creating an LDAP server
   b. Configuring the IP address of the LDAP server
   c. (Optional.) Specifying the LDAP version
   d. (Optional.) Setting the LDAP server timeout period
   e. Configuring administrator attributes
   f. Configuring LDAP user attributes
2. (Optional.) Configuring an LDAP attribute map
3. Creating an LDAP scheme
4. Specifying the LDAP authentication server
5. (Optional.) Specifying the LDAP authorization server
6. (Optional.) Specifying an LDAP attribute map for LDAP authorization

Creating an LDAP server

1. Enter system view.
   system-view
2. Create an LDAP server and enter LDAP server view.
   ldap server *server-name*

Configuring the IP address of the LDAP server

Restrictions and guidelines

You can configure either an IPv4 address or an IPv6 address for an LDAP server. If you configure the IP address for an LDAP server multiple times, the most recent configuration takes effect.

Procedure

1. Enter system view.
   system-view
2. Enter LDAP server view.
   ldap server *server-name*
3. Configure the IP address of the LDAP server.

{ ip *ipv4-address* | **ipv6** *ipv6-address* **}** [**port** *port-number*]

By default, an LDAP server does not have an IP address.

Specifying the LDAP version

Restrictions and guidelines

The device supports LDAPv2 and LDAPv3.

A Microsoft LDAP server supports only LDAPv3.

The LDAP version specified on the device must be consistent with the version specified on the LDAP server.

Procedure

1. Enter system view.
   system-view
2. Enter LDAP server view.
   ldap server *server-name*
3. Specify the LDAP version.
   protocol-version { **v2** | **v3** }
   By default, LDAPv3 is used.

Setting the LDAP server timeout period

About the LDAP server timeout period

If the device sends a bind or search request to an LDAP server without receiving the server's response within the server timeout period, the authentication or authorization request times out. Then, the device tries the backup authentication or authorization method. If no backup method is configured in the ISP domain, the device considers the authentication or authorization attempt a failure.

Procedure

1. Enter system view.
   system-view
2. Enter LDAP server view.
   ldap server *server-name*
3. Set the LDAP server timeout period.
   server-timeout *time-interval*
   By default, the LDAP server timeout period is 10 seconds.

Configuring administrator attributes

About administrator attributes

To configure the administrator DN and password for binding with the LDAP server during LDAP authentication:

Procedure

1. Enter system view.
   system-view

2. Enter LDAP server view.
   ldap server *server-name*
3. Specify the administrator DN.
   login-dn *dn-string*
   By default, no administrator DN is specified.
   The administrator DN specified on the device must be the same as the administrator DN configured on the LDAP server.
4. Configure the administrator password.
   login-password { **cipher** | **simple** } *string*
   By default, no administrator password is specified.

Configuring LDAP user attributes

About LDAP user attributes

To authenticate a user, an LDAP client must complete the following operations:

1. Establish a connection to the LDAP server.
2. Obtain the user DN from the LDAP server.
3. Use the user DN and the user's password to bind with the LDAP server.

LDAP provides a DN search mechanism for obtaining the user DN. According to the mechanism, an LDAP client sends search requests to the server based on the search policy determined by the LDAP user attributes of the LDAP client.

The LDAP user attributes include:

- Search base DN.
- Search scope.
- Username attribute.
- Username format.
- User object class.

Restrictions and guidelines

If the LDAP server contains many directory levels, a user DN search starting from the root directory can take a long time. To improve efficiency, you can change the start point by specifying the search base DN.

Procedure

1. Enter system view.
   system-view
2. Enter LDAP server view.
   ldap server *server-name*
3. Specify the user search base DN.
   search-base-dn *base-dn*
   By default, no user search base DN is specified.
4. (Optional.) Specify the user search scope.
   search-scope { **all-level** | **single-level** }
   By default, the user search scope is **all-level**.
5. (Optional.) Specify the username attribute.
   user-parameters user-name-attribute { *name-attribute* | **cn** | **uid** }

By default, the username attribute is **cn**.

6. (Optional.) Specify the username format.

   user-parameters user-name-format { **with-domain** | **without-domain** }

   By default, the username format is **without-domain**.

7. (Optional.) Specify the user object class.

   user-parameters user-object-class *object-class-name*

   By default, no user object class is specified, and the default user object class on the LDAP server is used. The default user object class for this command varies by server model.

Configuring an LDAP attribute map

About LDAP attribute maps

Configure an LDAP attribute map to define a list of LDAP-AAA attribute mapping entries. To apply the LDAP attribute map, specify the name of the LDAP attribute map in the LDAP scheme used for authorization.

The LDAP attribute map feature enables the device to convert LDAP attributes obtained from an LDAP authorization server to device-recognizable AAA attributes based on the mapping entries. Because the device ignores unrecognized LDAP attributes, configure the mapping entries to include important LDAP attributes that should not be ignored.

An LDAP attribute can be mapped only to one AAA attribute. Different LDAP attributes can be mapped to the same AAA attribute.

Procedure

1. Enter system view.

   system-view

2. Create an LDAP attribute map and enter LDAP attribute map view.

   ldap attribute-map *map-name*

3. Configure a mapping entry.

   map ldap-attribute *ldap-attribute-name* [**prefix** *prefix-value* **delimiter** *delimiter-value*] **aaa-attribute** { **user-group** | **user-profile** }

Creating an LDAP scheme

Restrictions and guidelines

You can configure a maximum of 16 LDAP schemes. An LDAP scheme can be used by multiple ISP domains.

Procedure

1. Enter system view.

   system-view

2. Create an LDAP scheme and enter LDAP scheme view.

   ldap scheme *ldap-scheme-name*

Specifying the LDAP authentication server

1. Enter system view.

   system-view

2. Enter LDAP scheme view.

ldap scheme *ldap-scheme-name*

3. Specify the LDAP authentication server.
   authentication-server *server-name*
   By default, no LDAP authentication server is specified.

Specifying the LDAP authorization server

1. Enter system view.
   system-view
2. Enter LDAP scheme view.
   ldap scheme *ldap-scheme-name*
3. Specify the LDAP authorization server.
   authorization-server *server-name*
   By default, no LDAP authorization server is specified.

Specifying an LDAP attribute map for LDAP authorization

About the LDAP attribute map for LDAP authorization

Specify an LDAP attribute map for LDAP authorization to convert LDAP attributes obtained from the LDAP authorization server to device-recognizable AAA attributes.

Restrictions and guidelines

You can specify only one LDAP attribute map in an LDAP scheme.

Procedure

1. Enter system view.
   system-view
2. Enter LDAP scheme view.
   ldap scheme *ldap-scheme-name*
3. Specify an LDAP attribute map.
   attribute-map *map-name*
   By default, no LDAP attribute map is specified.

Display and maintenance commands for LDAP

Execute **display** commands in any view.

Task	Command
Display the configuration of LDAP schemes.	**display ldap scheme** [*ldap-scheme-name*]

Creating an ISP domain

About ISP domains

In a networking scenario with multiple ISPs, the device can connect to users of different ISPs. These users can have different user attributes, such as different username and password structures, different service types, and different rights. To manage users of different ISPs, configure authentication, authorization, and accounting methods and domain attributes for each ISP domain as needed.

The device supports a maximum of 16 ISP domains, including the system-defined ISP domain **system**. You can specify one of the ISP domains as the default domain.

On the device, each user belongs to an ISP domain. If a user does not provide an ISP domain name at login, the device considers the user belongs to the default ISP domain.

Each ISP domain has a set of system-defined AAA methods, which are local authentication, local authorization, and local accounting. If you do not configure any AAA methods for an ISP domain, the device uses the system-defined AAA methods for users in the domain.

The device chooses an authentication domain for each user in the following order:

1. The authentication domain specified for the access module.
2. The ISP domain in the username.
3. The default ISP domain of the device.

If the chosen domain does not exist on the device, the device searches for the ISP domain that accommodates users assigned to nonexistent domains. (Support for the authentication domain configuration depends on the access module.) If no such ISP domain is configured, user authentication fails.

Restrictions and guidelines for ISP domain configuration

An ISP domain cannot be deleted when it is the default ISP domain. Before you use the **undo domain** command, change the domain to a non-default ISP domain by using the **undo domain default enable** command.

You can modify the settings of the system-defined ISP domain **system**, but you cannot delete the domain.

To avoid RADIUS authentication, authorization, or accounting failures, use short domain names to ensure that usernames containing a domain name do not exceed 253 characters.

Creating an ISP domain

1. Enter system view.
   system-view
2. Create an ISP domain and enter ISP domain view.
   domain *isp-name*
   By default, a system-defined ISP domain exists. The domain name is **system**.

Specifying the default ISP domain

1. Enter system view.
   system-view

2. Specify the default ISP domain.

   domain default enable *isp-name*

   By default, the default ISP domain is the system-defined ISP domain **system**.

Specifying an ISP domain for users that are assigned to nonexistent domains

1. Enter system view.

   system-view

2. Specify the ISP domain to accommodate users that are assigned to nonexistent domains.

   domain if-unknown *isp-name*

   By default, no ISP domain is specified to accommodate users that are assigned to nonexistent domains.

Configuring ISP domain attributes

Setting ISP domain status

About the ISP domain status

By placing the ISP domain in active or blocked state, you allow or deny network service requests from users in the domain.

Procedure

1. Enter system view.

   system-view

2. Enter ISP domain view.

   domain *isp-name*

3. Set the status of the ISP domain.

   state { **active** | **block** }

   By default, an ISP domain is in active state, and users in the domain can request network services.

Configuring authorization attributes for an ISP domain

About authorization attributes

The device supports the following authorization attributes:

- **ACL**—The device restricts authenticated users to access only the network resources permitted by the ACL.
- **CAR action**—The attribute controls the traffic flow of authenticated users.
- **Maximum number of multicast groups**—The attribute restricts the maximum number of multicast groups that an authenticated user can join concurrently.
- **IPv4 address pool**—The device assigns IPv4 addresses from the pool to authenticated users in the domain.
- **IPv6 address pool**—The device assigns IPv6 addresses from the pool to authenticated users in the domain.

- **Redirect URL**—The device redirects users in the domain to the URL after they pass authentication.
- **User group**—Authenticated users in the domain obtain all attributes of the user group.
- **User profile**—The device restricts the user's behavior based on the user profile.

The device assigns the authorization attributes in the ISP domain to the authenticated users that do not receive these attributes from the server.

Procedure

1. Enter system view.

   system-view
2. Enter ISP domain view.

   domain *isp-name*
3. Configure authorization attributes for authenticated users in the ISP domain.

   authorization-attribute { **acl** *acl-number* | **car inbound cir** *committed-information-rate* [**pir** *peak-information-rate*] **outbound cir** *committed-information-rate* [**pir** *peak-information-rate*] | **igmp max-access-number** *max-access-number* | **ip-pool** *ipv4-pool-name* | **ipv6-pool** *ipv6-pool-name* | **mld max-access-number** *max-access-number* | **url** *url-string* | **user-group** *user-group-name* | **user-profile** *profile-name* }

   The default settings are as follows:
   - An IPv4 user can concurrently join a maximum of four IGMP multicast groups.
   - An IPv6 user can concurrently join a maximum of four MLD multicast groups.
   - No other authorization attributes exist.

Including the idle timeout period in the user online duration to be sent to the server

About including the idle timeout period in the user online duration to be sent to the server

If a user goes offline due to connection failure or malfunction, the user's online duration sent to the server includes the idle timeout period assigned by the authorization server. The online duration generated on the server is longer than the actual online duration of the user.

For portal users, the device includes the idle timeout period set for the online portal user detection feature in the user online duration. For more information about online detection for portal users, see "Configuring portal authentication."

Procedure

1. Enter system view.

   system-view
2. Enter ISP domain view.

   domain *isp-name*
3. Configure the device to include the idle timeout period in the user online duration to be sent to the server.

   session-time include-idle-time

   By default, the user online duration sent to the server does not include the idle timeout period.

Configuring AAA methods for an ISP domain

Configuring authentication methods for an ISP domain

Restrictions and guidelines

When you configure remote authentication, follow these restrictions and guidelines:

- If the authentication method uses a RADIUS scheme and the authorization method does not use a RADIUS scheme, AAA accepts only the authentication result from the RADIUS server. The Access-Accept message from the RADIUS server also includes the authorization information, but the device ignores the information.
- If an HWTACACS scheme is specified, the device uses the entered username for role authentication. If a RADIUS scheme is specified, the device uses username **$enab***n***$** on the RADIUS server for role authentication. The variable *n* represents a user role level. For more information about user role authentication, see *Fundamentals Configuration Guide*.

The **none** keyword is not supported in FIPS mode.

Prerequisites

Before configuring authentication methods, complete the following tasks:

1. Determine the access type or service type to be configured. With AAA, you can configure an authentication method for each access type and service type.
2. Determine whether to configure the default authentication method for all access types or service types. The default authentication method applies to all access users. However, the method has a lower priority than the authentication method that is specified for an access type or service type.

Procedure

1. Enter system view.

   system-view

2. Enter ISP domain view.

   domain *isp-name*

3. (Optional.) Specify default authentication methods for all types of users.

   authentication default { **hwtacacs-scheme** *hwtacacs-scheme-name* [**radius-scheme** *radius-scheme-name*] [**local**] [**none**] | **ldap-scheme** *ldap-scheme-name* [**local**] [**none**] | **local** [**none**] | **none** | **radius-scheme** *radius-scheme-name* [**hwtacacs-scheme** *hwtacacs-scheme-name*] [**local**] [**none**] }

   By default, the default authentication method is **local**.

4. Specify authentication methods for a user type or a service.
   - Specify authentication methods for LAN users.

     authentication lan-access { **ldap-scheme** *ldap-scheme-name* [**local**] [**none**] | **local** [**none**] | **none** | **radius-scheme** *radius-scheme-name* [**local**] [**none**] }

     By default, the default authentication methods are used for LAN users.
   - Specify authentication methods for login users.

     authentication login { **hwtacacs-scheme** *hwtacacs-scheme-name* [**radius-scheme** *radius-scheme-name*] [**local**] [**none**] | **ldap-scheme** *ldap-scheme-name* [**local**] [**none**] | **local** [**none**] | **none** | **radius-scheme** *radius-scheme-name* [**hwtacacs-scheme** *hwtacacs-scheme-name*] [**local**] [**none**] }

By default, the default authentication methods are used for login users.

- Specify authentication methods for portal users.

  authentication portal { **ldap-scheme** *ldap-scheme-name* [**local**] [**none**] | **local** [**none**] | **none** | **radius-scheme** *radius-scheme-name* [**local**] [**none**] }

  By default, the default authentication methods are used for portal users.

- Specify authentication methods for obtaining a temporary user role.

  authentication super { **hwtacacs-scheme** *hwtacacs-scheme-name* | **radius-scheme** *radius-scheme-name* } *

  By default, the default authentication methods are used for obtaining a temporary user role.

Configuring authorization methods for an ISP domain

Restrictions and guidelines

The device does not support LDAP authorization in the current software version.

To use a RADIUS scheme as the authorization method, specify the name of the RADIUS scheme that is configured as the authentication method for the ISP domain. If an invalid RADIUS scheme is specified as the authorization method, RADIUS authentication and authorization fail.

The **none** keyword is not supported in FIPS mode.

Prerequisites

Before configuring authorization methods, complete the following tasks:

1. Determine the access type or service type to be configured. With AAA, you can configure an authorization scheme for each access type and service type.
2. Determine whether to configure the default authorization method for all access types or service types. The default authorization method applies to all access users. However, the method has a lower priority than the authorization method that is specified for an access type or service type.

Procedure

1. Enter system view.

   system-view

2. Enter ISP domain view.

   domain *isp-name*

3. (Optional.) Specify default authorization methods for all types of users.

   authorization default { **hwtacacs-scheme** *hwtacacs-scheme-name* [**radius-scheme** *radius-scheme-name*] [**local**] [**none**] | **local** [**none**] | **none** | **radius-scheme** *radius-scheme-name* [**hwtacacs-scheme** *hwtacacs-scheme-name*] [**local**] [**none**] }

   By default, the authorization method is **local**.

4. Specify authorization methods for a user type or a service.

   - Specify command authorization methods.

     authorization command { **hwtacacs-scheme** *hwtacacs-scheme-name* [**local**] [**none**] | **local** [**none**] | **none** }

     By default, the default authorization methods are used for command authorization.

   - Specify authorization methods for LAN users.

     authorization lan-access { **local** [**none**] | **none** | **radius-scheme** *radius-scheme-name* [**local**] [**none**] }

     By default, the default authorization methods are used for LAN users.

- Specify authorization methods for login users.

  authorization login { **hwtacacs-scheme** *hwtacacs-scheme-name* [**radius-scheme** *radius-scheme-name*] [**local**] [**none**] | **local** [**none**] | **none** | **radius-scheme** *radius-scheme-name* [**hwtacacs-scheme** *hwtacacs-scheme-name*] [**local**] [**none**] }

  By default, the default authorization methods are used for login users.
- Specify authorization methods for portal users.

  authorization portal { **local** [**none**] | **none** | **radius-scheme** *radius-scheme-name* [**local**] [**none**] }

  By default, the default authorization methods are used for portal users.

Configuring accounting methods for an ISP domain

Restrictions and guidelines

FTP, SFTP, and SCP users do not support accounting.

Local accounting does not provide statistics for charging. It only counts and controls the number of concurrent users that use the same local user account. The threshold is configured by using the **access-limit** command.

The **none** keyword is not supported in FIPS mode.

Prerequisites

Before configuring accounting methods, complete the following tasks:

1. Determine the access type or service type to be configured. With AAA, you can configure an accounting method for each access type and service type.
2. Determine whether to configure the default accounting method for all access types or service types. The default accounting method applies to all access users. However, the method has a lower priority than the accounting method that is specified for an access type or service type.

Procedure

1. Enter system view.

   system-view
2. Enter ISP domain view.

   domain *isp-name*
3. (Optional.) Specify default accounting methods for all types of users.

   accounting default { **hwtacacs-scheme** *hwtacacs-scheme-name* [**radius-scheme** *radius-scheme-name*] [**local**] [**none**] | **local** [**none**] | **none** | **radius-scheme** *radius-scheme-name* [**hwtacacs-scheme** *hwtacacs-scheme-name*] [**local**] [**none**] }

   By default, the accounting method is **local**.
4. Specify accounting methods for a user type.
   - Specify the command accounting method.

     accounting command hwtacacs-scheme *hwtacacs-scheme-name*

     By default, the default accounting methods are used for command accounting.
   - Specify accounting methods for LAN users.

     accounting lan-access { **broadcast radius-scheme** *radius-scheme-name1* **radius-scheme** *radius-scheme-name2* [**local**] [**none**] | **local** [**none**] | **none** | **radius-scheme** *radius-scheme-name* [**local**] [**none**] }

By default, the default accounting methods are used for LAN users.

- Specify accounting methods for login users.

  accounting login { **hwtacacs-scheme** *hwtacacs-scheme-name* [**radius-scheme** *radius-scheme-name*] [**local**] [**none**] | **local** [**none**] | **none** | **radius-scheme** *radius-scheme-name* [**hwtacacs-scheme** *hwtacacs-scheme-name*] [**local**] [**none**] }

  By default, the default accounting methods are used for login users.

- Specify accounting methods for portal users.

  accounting portal { **broadcast radius-scheme** *radius-scheme-name1* **radius-scheme** *radius-scheme-name2* [**local**] [**none**] | **local** [**none**] | **none** | **radius-scheme** *radius-scheme-name* [**local**] [**none**] }

  By default, the default accounting methods are used for portal users.

5. (Optional.) Configure extended accounting policies.
   - Configure access control for users that encounter accounting-start failures.

     accounting start-fail { **offline** | **online** }

     By default, the device allows users that encounter accounting-start failures to stay online.
   - Configure access control for users that have failed all their accounting-update attempts.

     accounting update-fail { [**max-times** *max-times*] **offline** | **online** }

     By default, the device allows users that have failed all their accounting-update attempts to stay online.
   - Configure access control for users that have used up their data or time accounting quotas.

     accounting quota-out { **offline** | **online** }

     By default, the device logs off users that have used up their accounting quotas.

Display and maintenance commands for ISP domains

Execute **display** commands in any view.

Task	Command
Display configuration information about an ISP domain or all ISP domains.	**display domain** [*isp-name*]

Setting the maximum number of concurrent login users

About setting the maximum number of concurrent login users

Perform this task to set the maximum number of concurrent users that can log on to the device through a specific protocol, regardless of their authentication methods. The authentication methods include no authentication, local authentication, and remote authentication.

Procedure

1. Enter system view.

   system-view

2. Set the maximum number of concurrent login users.

   In non-FIPS mode:

aaa session-limit { **ftp** | **http** | **https** | **ssh** | **telnet** } *max-sessions*

In FIPS mode:

aaa session-limit { **https** | **ssh** } *max-sessions*

By default, the maximum number of concurrent login users is 32 for each user type.

Configuring a NAS-ID

About NAS-IDs

During RADIUS authentication, the device uses a NAS-ID to set the NAS-Identifier attribute of RADIUS packets so that the RADIUS server can identify the access location of users.

Configure a NAS-ID profile to maintain NAS-ID and VLAN bindings on the device so that the device can send different NAS-Identifier attribute strings in RADIUS requests from different VLANs.

Restrictions and guidelines

You can apply a NAS-ID profile to portal- or port security-enabled interfaces. For more information, see "Configuring portal authentication" and "Configuring port security."

You can configure multiple NAS-ID and VLAN bindings in a NAS-ID profile.

A NAS-ID can be bound with more than one VLAN, but a VLAN can be bound with only one NAS-ID. If you configure multiple bindings for the same VLAN, the most recent configuration takes effect.

Procedure

1. Enter system view.

   system-view
2. Create a NAS-ID profile and enter NAS-ID profile view.

   aaa nas-id profile *profile-name*
3. Configure a NAS-ID and VLAN binding in the profile.

   nas-id *nas-identifier* **bind vlan** *vlan-id*

Configuring the device ID

About the device ID

RADIUS uses the value of the Acct-Session-ID attribute as the accounting ID for a user. The device generates an Acct-Session-ID value for each online user based on the system time, random digits, and device ID.

Procedure

1. Enter system view.

   system-view
2. Configure the device ID.

   aaa device-id *device-id*

   By default, the device ID is 0.

Enabling password change prompt logging

About this task

Use this feature to enhance the protection of passwords for Telnet, SSH, HTTP, HTTPS, NETCONF over SSH, and NETCONF over SOAP users and improve the system security.

This feature enables the device to generate logs to prompt users to change their weak passwords at an interval of 24 hours and at the users' login.

A password is a weak password if it does not meet the following requirements:

- Password composition restriction configured by using the **password-control composition** command.
- Minimum password length restriction set by using the **password-control length** command.
- It cannot contain the username or the reverse letters of the username.

For a NETCONF over SSH or NETCONF over SOAP user, the device also generates a password change prompt log if any of the following conditions exists:

- The current password of the user is the default password or has expired.
- The user logs in to the device for the first time or uses a new password to log in after global password control is enabled.

The device will no longer generate password change prompt logs for a user when one of the following conditions exists:

- The password change prompt logging feature is disabled.
- The user has changed the password and the new password meets the password control requirements.
- The enabling status of a related password control feature has changed so the current password of the user meets the password control requirements.
- The password composition policy or the minimum password length has changed.

Software version and feature compatibility

This feature is supported only in Release 6318P01 and later.

Restrictions and guidelines

You can use the **display password-control** command to display password control configuration. For more information about password control commands, see password control commands in *Security Command Reference*.

Procedure

1. Enter system view.

   system-view
2. Enable password change prompt logging.

   local-server log change-password-prompt

   By default, password change prompt logging is enabled.

Configuring the RADIUS server feature

RADIUS server feature tasks at a glance

To configure the RADIUS server feature, perform the following tasks:

1. Configuring RADIUS users
2. Specifying RADIUS clients
3. Activating the RADIUS server configuration

Restrictions and guidelines for the RADIUS server feature

To use this feature, install the FreeRadius feature package compatible with the device software version. For more information about installing a feature package, see upgrading software in *Fundamentals Configuration Guide*.

To ensure correct operation of the RADIUS server feature, disable RADIUS session-control on the device.

Configuring RADIUS users

To configure RADIUS users, you must configure network access users, which are the basis of RADIUS user data.

A RADIUS user has the following attributes: user name, password, description, authorization ACL, authorization VLAN, and expiration time. For more information, see "Configuring attributes for network access users."

Specifying RADIUS clients

About specifying RADIUS clients

Perform this task to specify RADIUS clients and shared keys for centralized management. The RADIUS server feature does not accept requests from RADIUS clients that are not managed by the system.

Restrictions and guidelines

The IP address of a RADIUS client must be the same as the source IP address for outgoing RADIUS packets specified on the RADIUS client.

The shared key of a RADIUS client specified on the RADIUS server must be the same as the setting on the RADIUS client.

Procedure

1. Enter system view.

   `system-view`

2. Specify a RADIUS client.

   `radius-server client ip` *`ipv4-address`* **`key`** { **`cipher`** | **`simple`** } *`string`*

Activating the RADIUS server configuration

About activating the RADIUS server configuration

At the device startup, the RADIUS server configuration is automatically activated, including RADIUS users and RADIUS clients. You can immediately activate the most recent RADIUS server configuration if you have added, modified, or deleted RADIUS clients and network access users from which RADIUS user data is generated.

Procedure

1. Enter system view.

   `system-view`

2. Activate the RADIUS server configuration.

   `radius-server activate`

   Executing this command restarts the RADIUS server process and an authentication service interruption will occur during the restart.

Display and maintenance commands for RADIUS users and clients

Execute **display** commands in any view.

Task	Command
Display information about activated RADIUS users.	**display radius-server active-user** [*user-name*]
Display information about activated RADIUS clients.	**display radius-server active-client**

Configuring the connection recording policy

About the connection recording policy

Use this feature on scenarios where the device acts as an FTP, SSH, SFTP, or Telnet login client to establish a connection with a login server. This feature enables the device to provide an accounting server with the connection start and termination information. When the login client establishes a connection with the login server, the system sends a start-accounting request to the accounting server. When the connection is terminated, the system sends a stop-accounting request to the accounting server.

Restrictions and guidelines

The device includes the username entered by a user in the accounting packets to be sent to the AAA server for connection recording. The username format configured by using the **user-name-format** command in the accounting scheme does not take effect.

Procedure

1. Enter system view.
   system-view
2. Create a connection recording policy and enter its view.
   aaa connection-recording policy
3. Specify the accounting method for the connection recording policy.
   accounting hwtacacs-scheme *hwtacacs-scheme-name*

Display and maintenance commands for the connection recording policy

Execute **display** commands in any view.

Task	Command
Display the connection recording policy configuration.	**display aaa connection-recording policy**

Configuring the AAA test feature

About the AAA test feature

This feature enables the device to send authentication or accounting requests to the specified AAA servers to simulate an authentication or accounting process of a user. Use this feature to identify the reasons for the failure of the interaction between the device and the AAA servers. This feature is applicable only to RADIUS.

When performing an AAA test, the device ignores the status of the specified AAA servers and the RADIUS server load sharing feature. The process of an AAA test is as follows:

1. The device sends authentication requests that carry the specified username and password to the specified authentication server or to the authentication servers in the specified RADIUS scheme. The device tries to communicate with the authentication servers in the specified scheme in sequence.

   The process goes to the next step in the following situations:

   - The device receives an authentication response (no matter the authentication succeeds or fails).
   - The device does not receive any authentication response after making all authentication request attempts.

   This step is skipped if no correct authentication server is specified for the AAA test or no authentication servers are configured in the specified RADIUS scheme.
2. The device sends start-accounting requests to the specified accounting server or to the accounting servers in the specified RADIUS scheme. The device tries to communicate with the accounting servers in the specified scheme in sequence.

   The process goes to the next step in the following situations:

   - The device receives a start-accounting response (no matter the accounting succeeds or fails).
   - The device does not receive any start-accounting response after making all start-accounting request attempts.

   This step and the next step are skipped if no correct accounting server is specified for the AAA test or no accounting servers are configured in the specified RADIUS scheme.
3. The device sends stop-accounting requests to the accounting servers to which it has sent a start-accounting request.

   The process finishes in the following situations:

   - The device receives a stop-accounting response.
   - The device does not receive any stop-accounting response after making all stop-accounting request attempts.

To identify attributes that cause authentication or accounting failures, you can configure the device to carry specific attributes in RADIUS requests or define values for specific attributes in the requests. Table 3 shows the attributes that RADIUS requests carry by default.

Table 3 Attributes that RADIUS requests carry by default

Packet type	Attributes that the type of packets carry by default
RADIUS authentication request	User-Name CHAP-Password (or User-Password) CHAP-Challenge NAS-IP-Address (or NAS-IPv6-Address) Service-Type Framed-Protocol

Packet type	Attributes that the type of packets carry by default
	NAS-Identifier NAS-Port-Type Acct-Session-Id
RADIUS accounting request	User-Name Acct-Status-Type NAS-IP-Address (or NAS-IPv6-Address) NAS-Identifier Acct-Session-Id Acct-Delay-Time Acct-Terminate-Cause

Restrictions and guidelines

When you perform an AAA test, follow these restrictions and guidelines:

- The device might communicate with the AAA servers incorrectly during an AAA test. Make sure no users come online or go offline during an AAA text.
- If the configuration of the specified RADIUS scheme changes, the new configuration does not affect the current AAA test. The modification will take effect in the next test.
- The system can have only one AAA test at a time. Another AAA test can be performed only after the current test finishes.

When you configure attributes to be included in or excluded from RADIUS requests, follow these restrictions and guidelines:

- Before you include an attribute that is already configured to be excluded from RADIUS requests, you must cancel the exclusion configuration by using the **undo exclude** command.
- Before you exclude an attribute that is already configured to be included in RADIUS requests, you must cancel the inclusion configuration by using the **undo include** command.

Prerequisites

Before you perform an AAA test, you must configure a RADIUS scheme that contains the RADIUS servers to be tested.

Plan the RADIUS attributes to be included in RADIUS requests. Besides the attributes carried by default, the device adds the specified attributes to RADIUS packets in the order that they are specified by using the **include** command. Additional attributes cannot be added to a RADIUS request if the length of the RADIUS request reaches 4096 bytes.

Procedure

1. (Optional.) Configure a RADIUS attribute test group:
   a. Enter system view.
      system-view
   b. Create a RADIUS attribute test group and enter its view.
      radius attribute-test-group *attr-test-group-name*
      You can create multiple RADIUS attribute test groups.
   c. Include an attribute in RADIUS requests.
      include { **accounting** | **authentication** } { **name** *attribute-name* | [**vendor** *vendor-id*] **code** *attribute-code* } **type** { **binary** | **date** | **integer** | **interface-id** | **ip** | **ipv6** | **ipv6-prefix** | **octets** | **string** } value *attribute-value*

Use this command to add attributes that RADIUS requests do not carry by default to the RADIUS requests.

For an attribute that RADIUS requests carry by default, you can use this command to change its attribute value.

d. Exclude an attribute from RADIUS requests.

exclude { **accounting** | **authentication** } **name** *attribute-name*

Use this command to exclude an attribute that RADIUS requests carry by default from the RADIUS requests sent during an AAA test to help troubleshoot authentication or accounting failures.

e. Return to system view.

quit

f. Return to user view.

quit

2. Perform an AAA test in user view.

test-aaa user *user-name* **password** *password* **radius-scheme** *radius-scheme-name* [**radius-server** { *ipv4-address* | **ipv6** *ipv6-address* } *port-number*] [**chap** | **pap**] [**attribute-test-group** attr-*test-group-name*] [**trace**]

AAA configuration examples

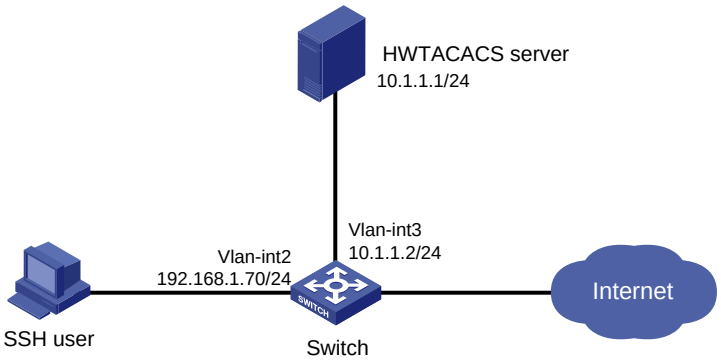
Example: Configuring AAA for SSH users by an HWTACACS server

Network configuration

As shown in Figure 11, configure the switch to meet the following requirements:

- Use the HWTACACS server for SSH user authentication, authorization, and accounting.
- Assign the default user role **network-operator** to SSH users after they pass authentication.
- Exclude domain names from the usernames sent to the HWTACACS server.
- Use **expert** as the shared keys for secure HWTACACS communication.

Figure 11 Network diagram



Configuring the HWTACACS server

Set the shared keys to **expert** for secure communication with the switch, add an account for the SSH user, and specify the password. (Details not shown.)

Configuring the switch

Configure IP addresses for the interfaces. (Details not shown.)

Create an HWTACACS scheme.

```
<Switch> system-view
[Switch] hwtacacs scheme hwtac
```

Specify the primary authentication server.

```
[Switch-hwtacacs-hwtac] primary authentication 10.1.1.1 49
```

Specify the primary authorization server.

```
[Switch-hwtacacs-hwtac] primary authorization 10.1.1.1 49
```

Specify the primary accounting server.

```
[Switch-hwtacacs-hwtac] primary accounting 10.1.1.1 49
```

Set the shared keys to **expert** in plaintext form for secure HWTACACS communication.

```
[Switch-hwtacacs-hwtac] key authentication simple expert
[Switch-hwtacacs-hwtac] key authorization simple expert
[Switch-hwtacacs-hwtac] key accounting simple expert
```

Exclude domain names from the usernames sent to the HWTACACS server.

```
[Switch-hwtacacs-hwtac] user-name-format without-domain
[Switch-hwtacacs-hwtac] quit
```

Create an ISP domain named **bbb** and configure the domain to use the HWTACACS scheme for authentication, authorization, and accounting of login users.

```
[Switch-isp-bbb] authentication login hwtacacs-scheme hwtac
[Switch-isp-bbb] authorization login hwtacacs-scheme hwtac
[Switch-isp-bbb] accounting login hwtacacs-scheme hwtac
[Switch-isp-bbb] quit
```

Create local RSA and DSA key pairs.

```
[Switch] public-key local create rsa
[Switch] public-key local create dsa
```

Enable the Stelnet service.

```
[Switch] ssh server enable
```

Enable scheme authentication for user lines VTY 0 through VTY 63.

```
[Switch] line vty 0 63
[Switch-line-vty0-63] authentication-mode scheme
[Switch-line-vty0-63] quit
```

Enable the default user role feature to assign authenticated SSH users the default user role **network-operator**.

```
[Switch] role default-role enable
```

Verifying the configuration

Initiate an SSH connection to the switch, and enter the correct username and password. The user logs in to the switch. (Details not shown.)

Verify that the user can use the commands permitted by the network-operator user role. (Details not shown.)

Example: Configuring local authentication, HWTACACS authorization, and RADIUS accounting for SSH users

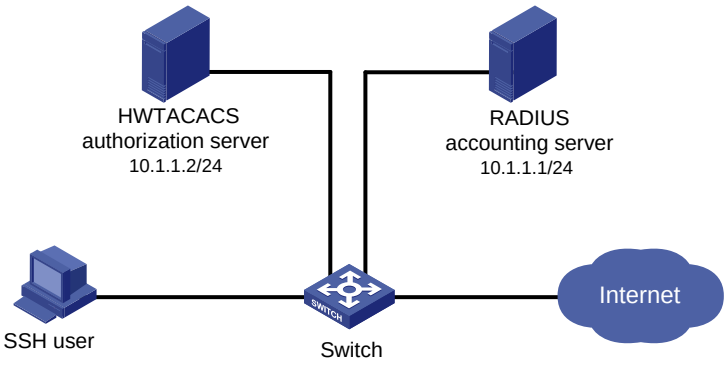
Network configuration

As shown in Figure 12, configure the switch to meet the following requirements:

- Perform local authentication for SSH users.
- Use the HWTACACS server and RADIUS server for SSH user authorization and accounting, respectively.
- Exclude domain names from the usernames sent to the servers.
- Assign the default user role **network-operator** to SSH users after they pass authentication.

Configure an account named **hello** for the SSH user. Configure the shared keys to **expert** for secure communication with the HWTACACS server and RADIUS server.

Figure 12 Network diagram



Configuring the HWTACACS server

Set the shared keys to **expert** for secure communication with the switch, add an account for the SSH user, and specify the password. (Details not shown.)

Configuring the RADIUS server

Set the shared keys to **expert** for secure communication with the switch, add an account for the SSH user, and specify the password. (Details not shown.)

Configuring the switch

Configure IP addresses for interfaces. (Details not shown.)

Create local RSA and DSA key pairs.

```
<Switch> system-view
[Switch] public-key local create rsa
[Switch] public-key local create dsa
```

Enable the Stelnet service.

```
[Switch] ssh server enable
```

Enable scheme authentication for user lines VTY 0 through VTY 63.

```
[Switch] line vty 0 63
[Switch-line-vty0-63] authentication-mode scheme
[Switch-line-vty0-63] quit
```

Configure an HWTACACS scheme.

```
[Switch] hwtacacs scheme hwtac
```

```
[Switch-hwtacacs-hwtac] primary authorization 10.1.1.2 49
[Switch-hwtacacs-hwtac] key authorization simple expert
[Switch-hwtacacs-hwtac] user-name-format without-domain
[Switch-hwtacacs-hwtac] quit
```

Configure a RADIUS scheme.

```
[Switch] radius scheme rd
[Switch-radius-rd] primary accounting 10.1.1.1 1813
[Switch-radius-rd] key accounting simple expert
[Switch-radius-rd] user-name-format without-domain
[Switch-radius-rd] quit
```

Create a device management user.

```
[Switch] local-user hello class manage
```

Assign the SSH service to the local user.

```
[Switch-luser-manage-hello] service-type ssh
```

Set the password to **123456TESTplat&!** in plaintext form for the local user. In FIPS mode, you must set the password in interactive mode.

```
[Switch-luser-manage-hello] password simple 123456TESTplat&!
[Switch-luser-manage-hello] quit
```

Create an ISP domain named **bbb** and configure the login users to use local authentication, HWTACACS authorization, and RADIUS accounting.

```
[Switch] domain bbb
[Switch-isp-bbb] authentication login local
[Switch-isp-bbb] authorization login hwtacacs-scheme hwtac
[Switch-isp-bbb] accounting login radius-scheme rd
[Switch-isp-bbb] quit
```

Enable the default user role feature to assign authenticated SSH users the default user role **network-operator**.

```
[Switch] role default-role enable
```

Verifying the configuration

Initiate an SSH connection to the switch, and enter username **hello@bbb** and the correct password. The user logs in to the switch. (Details not shown.)

Verify that the user can use the commands permitted by the network-operator user role. (Details not shown.)

Example: Configuring authentication and authorization for SSH users by a RADIUS server

Network configuration

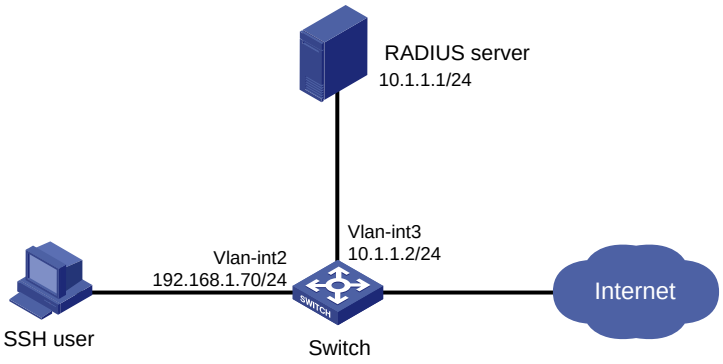
As shown in Figure 13, configure the switch to meet the following requirements:

- Use the RADIUS server for SSH user authentication and authorization.
- Include domain names in the usernames sent to the RADIUS server.
- Assign the default user role **network-operator** to SSH users after they pass authentication.

The RADIUS server runs on IMC PLAT 5.0 (E0101) and IMC UAM 5.0 (E0101). Add an account with username **hello@bbb** on the RADIUS server.

The RADIUS server and the switch use **expert** as the shared key for secure RADIUS communication. The ports for authentication and accounting are **1812** and **1813**, respectively.

Figure 13 Network diagram



Configuring the RADIUS server

1. Add the switch to the IMC Platform as an access device:

   Log in to IMC, click the **Service** tab, and select **User Access Manager** > **Access Device Management** > **Access Device** from the navigation tree. Then, click **Add** to configure an access device as follows:

   a. Set the shared key to **expert** for secure RADIUS communication.

   b. Set the ports for authentication and accounting to 1812 and 1813, respectively.

   c. Select **Device Management Service** from the **Service Type** list.

   d. Select **H3C** from the **Access Device Type** list.

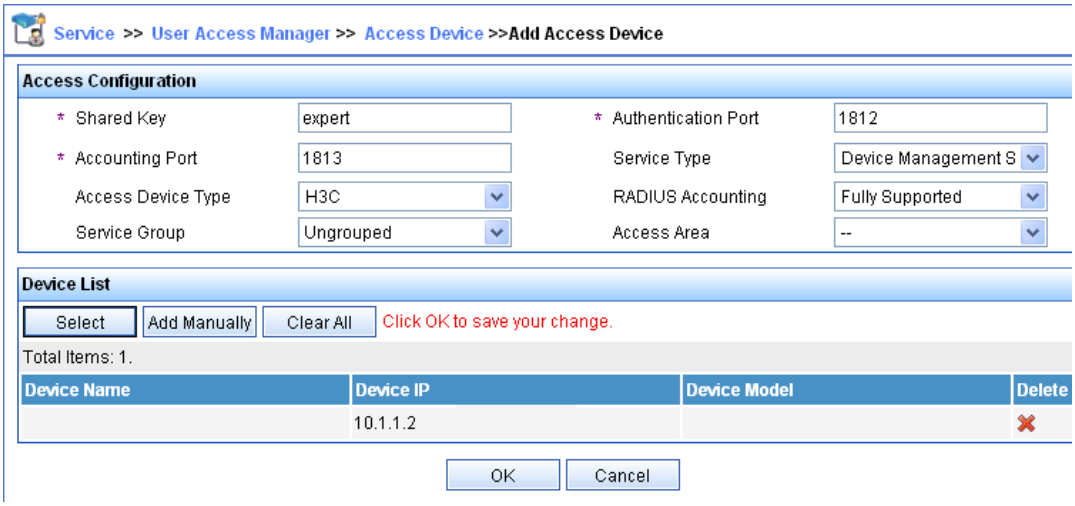
   e. Select an access device from the device list or manually add an access device. In this example, the device IP address is 10.1.1.2.

   f. Use the default values for other parameters and click **OK**.

   The IP address of the access device specified here must be the same as the source IP address of the RADIUS packets sent from the switch. The source IP address is chosen in the following order on the switch:

   - IP address specified by using the **`nas-ip`** command.
   - IP address specified by using the **`radius nas-ip`** command.
   - IP address of the outbound interface (the default).

   Figure 14 Adding the switch as an access device



2. Add an account for device management:

Click the **User** tab, and select **Access User View** > **Device Mgmt User** from the navigation tree. Then, click **Add** to configure a device management account as follows:

a. Enter account name **hello@bbb** and specify the password.

b. Select **SSH** from the **Service Type** list.

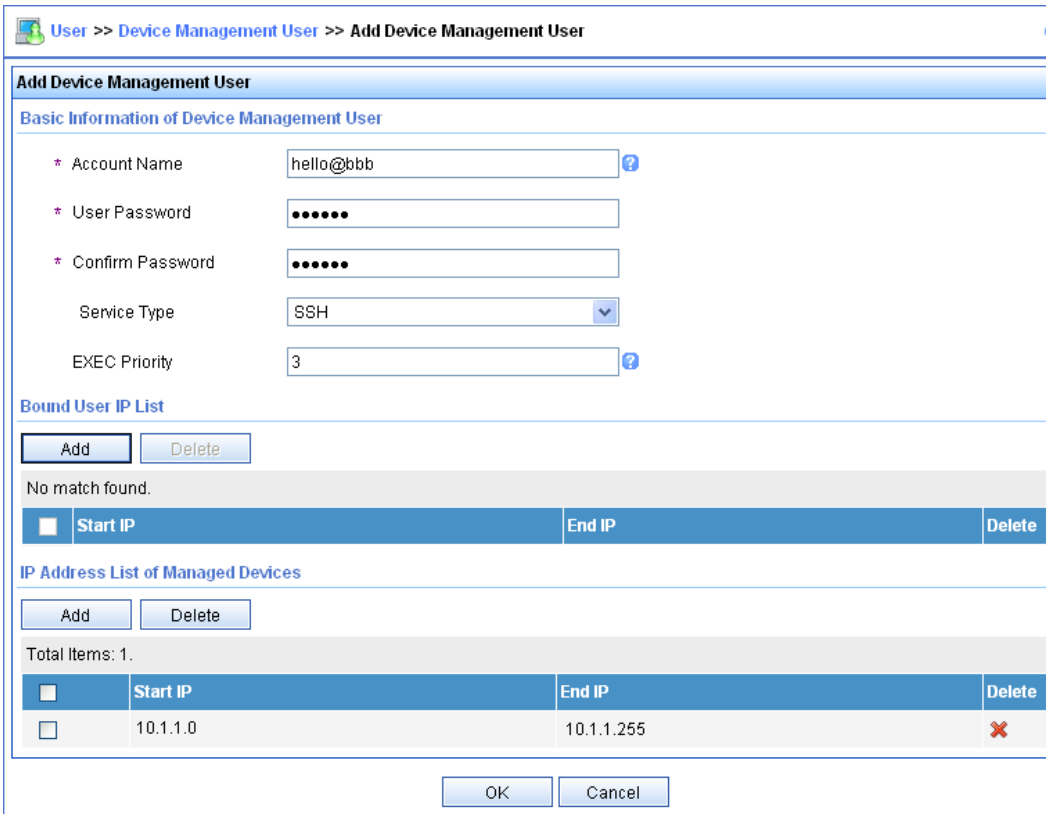
c. Specify 10.1.1.0 to 10.1.1.255 as the IP address range of the hosts to be managed.

d. Click **OK**.

NOTE:

The IP address range must contain the IP address of the switch.

Figure 15 Adding an account for device management



Configuring the switch

Configure IP addresses for interfaces. (Details not shown.)

Create local RSA and DSA key pairs.

```
<Switch> system-view
[Switch] public-key local create rsa
[Switch] public-key local create dsa
```

Enable the Stelnet service.

```
[Switch] ssh server enable
```

Enable scheme authentication for user lines VTY 0 through VTY 63.

```
[Switch] line vty 0 63
[Switch-line-vty0-63] authentication-mode scheme
[Switch-line-vty0-63] quit
```

Enable the default user role feature to assign authenticated SSH users the default user role **network-operator**.

```
[Switch] role default-role enable
```

Create a RADIUS scheme.

```
[Switch] radius scheme rad
```

Specify the primary authentication server.

```
[Switch-radius-rad] primary authentication 10.1.1.1 1812
```

Set the shared key to **expert** in plaintext form for secure communication with the server.

```
[Switch-radius-rad] key authentication simple expert
```

Include domain names in the usernames sent to the RADIUS server.

```
[Switch-radius-rad] user-name-format with-domain
[Switch-radius-rad] quit
```

Create an ISP domain named **bbb** and configure authentication, authorization, and accounting methods for login users.

```
[Switch] domain bbb
[Switch-isp-bbb] authentication login radius-scheme rad
[Switch-isp-bbb] authorization login radius-scheme rad
[Switch-isp-bbb] accounting login none
[Switch-isp-bbb] quit
```

Verifying the configuration

Initiate an SSH connection to the switch, and enter username **hello@bbb** and the correct password. The user logs in to the switch. (Details not shown.)

Verify that the user can use the commands permitted by the network-operator user role. (Details not shown.)

Example: Configuring authentication for SSH users by an LDAP server

Network configuration

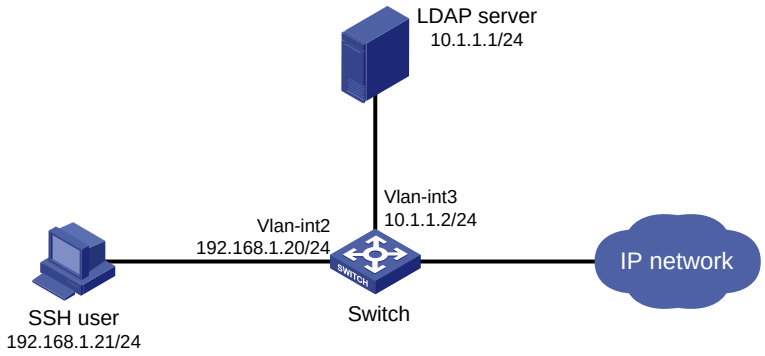
As shown in Figure 16, the LDAP server uses domain **ldap.com** and runs Microsoft Windows 2003 Server Active Directory.

Configure the switch to meet the following requirements:

- Use the LDAP server to authenticate SSH users.
- Assign the level-0 user role to SSH users after they pass authentication.

On the LDAP server, set the administrator password to **admin!123456**, add a user named **aaa**, and set the user's password to **ldap!123456**.

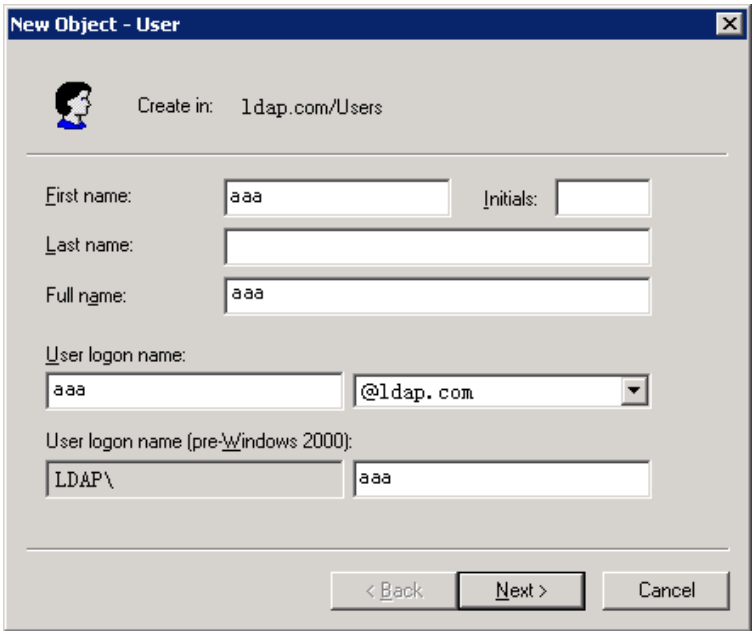
Figure 16 Network diagram



Configuring the LDAP server

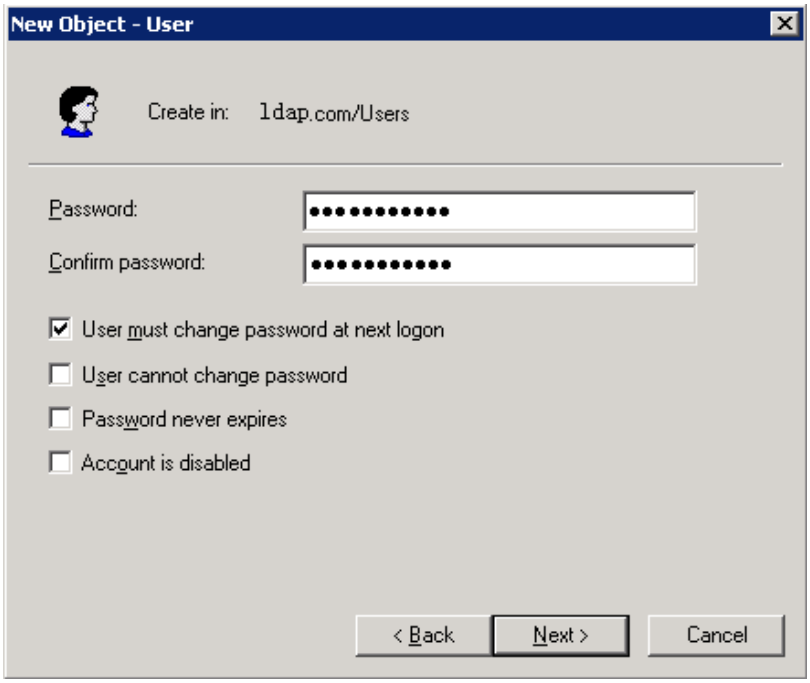
1. Add a user named **aaa** and set the password to **ldap!123456**:
   a. On the LDAP server, select **Start** > **Control Panel** > **Administrative Tools**.
   b. Double-click **Active Directory Users and Computers**.
      The **Active Directory Users and Computers** window is displayed.
   c. From the navigation tree, click **Users** under the **ldap.com** node.
   d. Select **Action** > **New** > **User** from the menu to display the dialog box for adding a user.
   e. Enter logon name **aaa** and click **Next**.

      Figure 17 Adding user aaa



   f. In the dialog box, enter password **ldap!123456**, select options as needed, and click **Next**.

Figure 18 Setting the user's password



g. Click **OK**.

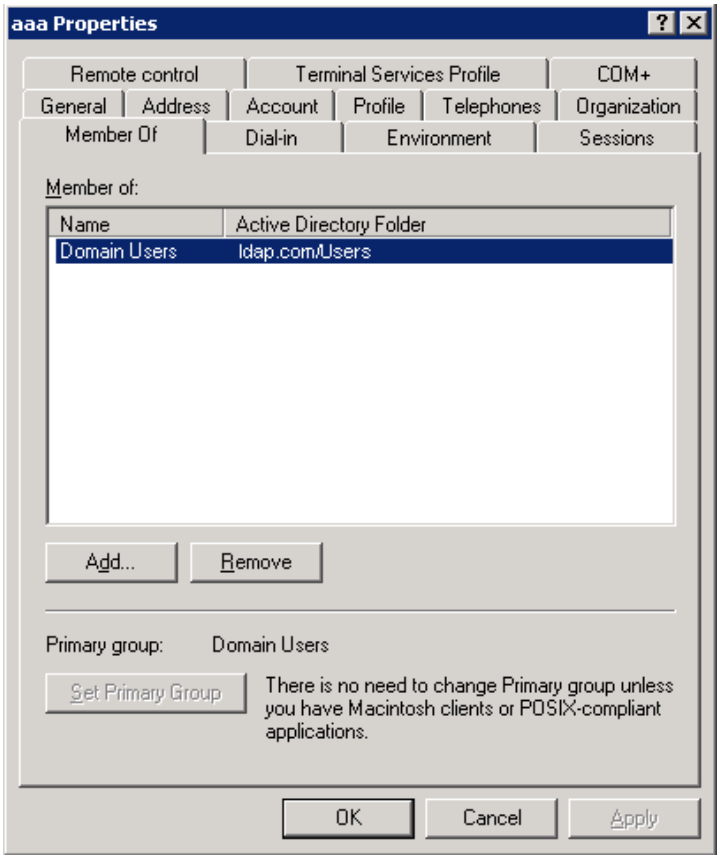
2. Add user **aaa** to group **Users**:

a. From the navigation tree, click **Users** under the **ldap.com** node.

b. In the right pane, right-click user **aaa** and select **Properties**.

c. In the dialog box, click the **Member Of** tab and click **Add**.

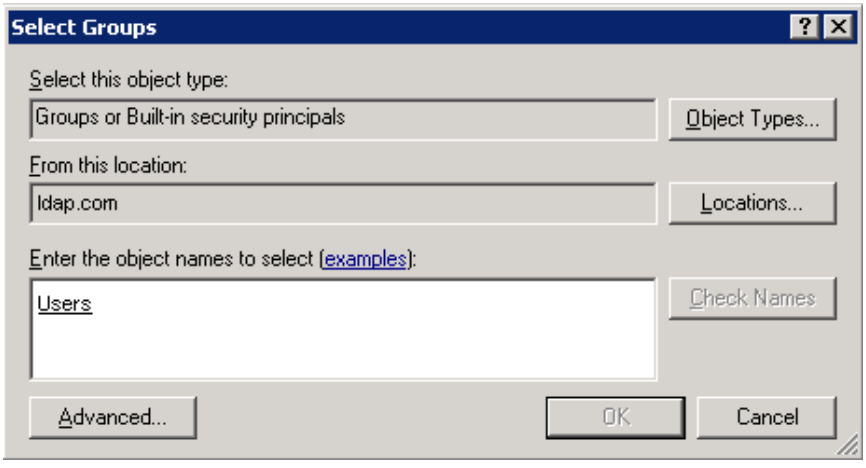
Figure 19 Modifying user properties



d. In the **Select Groups** dialog box, enter **Users** in the **Enter the object names to select** field, and click **OK**.

User **aaa** is added to group **Users**.

Figure 20 Adding user aaa to group Users



3. Set the administrator password to **admin!123456**:

a. In the right pane, right-click user **Administrator** and select **Set Password**.

b. In the dialog box, enter the administrator password. (Details not shown.)

Configuring the switch

Configure IP addresses for interfaces. (Details not shown.)

Create local RSA and DSA key pairs.

```
<Switch> system-view
[Switch] public-key local create rsa
[Switch] public-key local create dsa
```

Enable the Stelnet service.

```
[Switch] ssh server enable
```

Enable scheme authentication for user lines VTY 0 through VTY 63.

```
[Switch] line vty 0 63
[Switch-line-vty0-63] authentication-mode scheme
[Switch-line-vty0-63] quit
```

Configure an LDAP server.

```
[Switch] ldap server ldap1
```

Specify the IP address of the LDAP authentication server.

```
[Switch-ldap-server-ldap1] ip 10.1.1.1
```

Specify the administrator DN.

```
[Switch-ldap-server-ldap1] login-dn cn=administrator,cn=users,dc=ldap,dc=com
```

Specify the administrator password.

```
[Switch-ldap-server-ldap1] login-password simple admin!123456
```

Configure the base DN for user search.

```
[Switch-ldap-server-ldap1] search-base-dn dc=ldap,dc=com
[Switch-ldap-server-ldap1] quit
```

Create an LDAP scheme.

```
[Switch] ldap scheme ldap-shm1
```

Specify the LDAP authentication server.

```
[Switch-ldap-ldap-shm1] authentication-server ldap1
[Switch-ldap-ldap-shm1] quit
```

Create an ISP domain named **bbb** and configure authentication, authorization, and accounting methods for login users.

```
[Switch] domain bbb
[Switch-isp-bbb] authentication login ldap-scheme ldap-shm1
[Switch-isp-bbb] authorization login none
[Switch-isp-bbb] accounting login none
[Switch-isp-bbb] quit
```

Verifying the configuration

Initiate an SSH connection to the switch, and enter username **aaa@bbb** and password **ldap!123456**. The user logs in to the switch. (Details not shown.)

Verify that the user can use the commands permitted by the level-0 user role. (Details not shown.)

Example: Configuring AAA for 802.1X users by a RADIUS server

Network configuration

As shown in Figure 21, configure the switch to meet the following requirements:

- Use the RADIUS server for authentication, authorization, and accounting of 802.1X users.

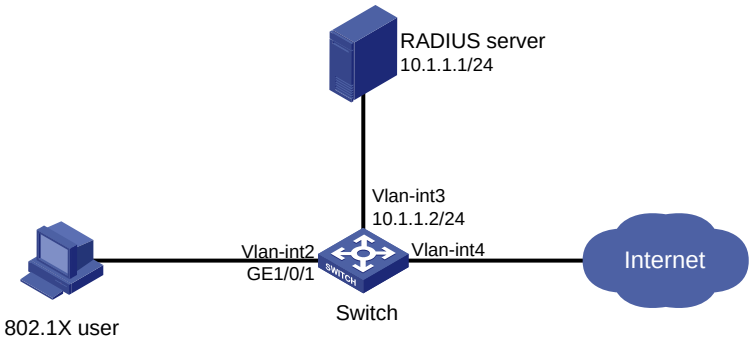
- Use MAC-based access control on GigabitEthernet 1/0/1 to authenticate all 802.1X users on the port separately.
- Include domain names in the usernames sent to the RADIUS server.

In this example, the RADIUS server runs on IMC PLAT 5.0 (E0101) and IMC UAM 5.0 (E0101). On the RADIUS server, perform the following tasks:

- Add a service that charges 120 dollars for up to 120 hours per month and assigns authenticated users to VLAN 4.
- Configure a user with name **dot1x@bbb** and assign the service to the user.

Set the shared keys to **expert** for secure RADIUS communication. Set the ports for authentication and accounting to 1812 and 1813, respectively.

Figure 21 Network diagram



Configuring the RADIUS server

1. Add the switch to the IMC Platform as an access device:

   Log in to IMC, click the **Service** tab, and select **User Access Manager** > **Access Device Management** > **Access Device** from the navigation tree. Then, click **Add** to configure an access device as follows:

   a. Set the shared key to **expert** for secure authentication and accounting communication.

   b. Set the ports for authentication and accounting to 1812 and 1813, respectively.

   c. Select **LAN Access Service** from the **Service Type** list.

   d. Select **H3C(General)** from the **Access Device Type** list.

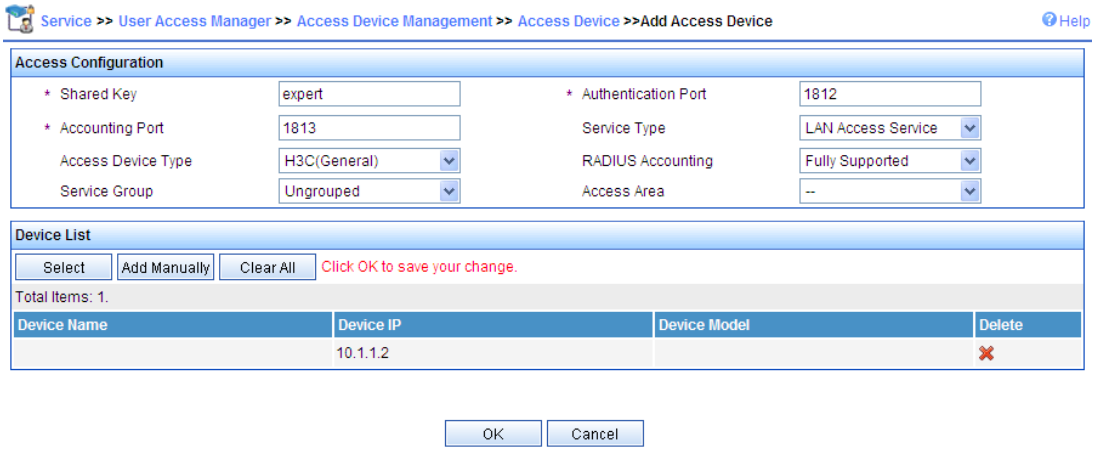
   e. Select an access device from the device list or manually add an access device. In this example, the device IP address is 10.1.1.2.

   f. Use the default values for other parameters and click **OK**.

   The IP address of the access device specified here must be the same as the source IP address of the RADIUS packets sent from the switch. The source IP address is chosen in the following order on the switch:

   - IP address specified by using the **`nas-ip`** command.
   - IP address specified by using the **`radius nas-ip`** command.
   - IP address of the outbound interface (the default).

Figure 22 Adding the switch as an access device



2. Add a charging plan:

   Click the **Service** tab, and select **Accounting Manager** > **Charging Plans** from the navigation tree to enter the charging plan configuration page. Then, click **Add** to configure a charging plan as follows:

   a. Add a plan named **UserAcct**.

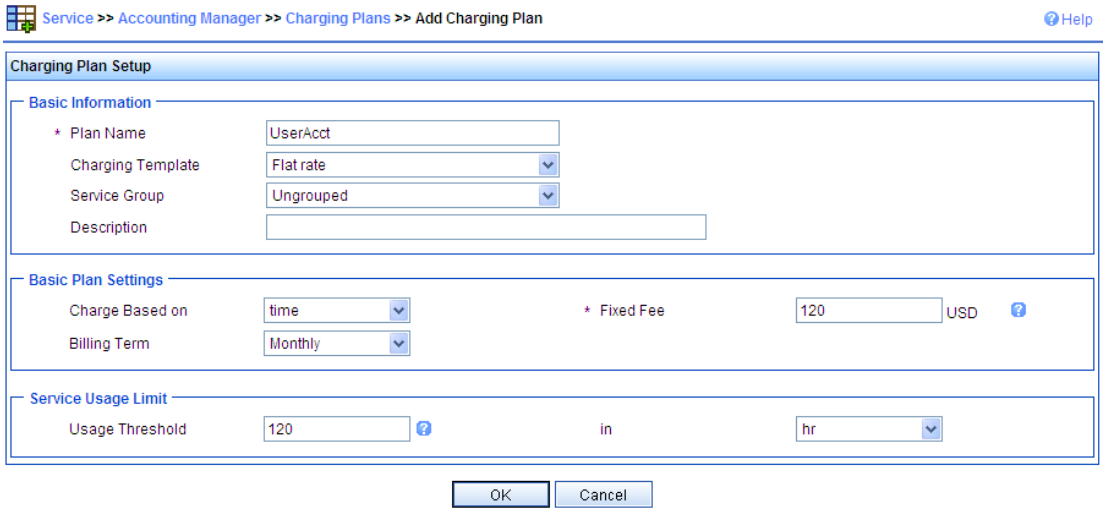
   b. Select **Flat rate** from the **Charging Template** list.

   c. Select **time** for **Charge Based on**, select **Monthly** for **Billing Term**, and enter **120** in the **Fixed Fee** field.

   d. Enter **120** in the **Usage Threshold** field and select **hr** (hours) for the **in** field. The configuration allows the user to access the Internet for up to 120 hours per month.

   e. Use the default values for other parameters and click **OK**.

Figure 23 Adding a charging plan



3. Add a service:

   Click the **Service** tab, and select **User Access Manager** > **Service Configuration** from the navigation tree. Then, click **Add** to configure a service as follows:

   a. Add a service named **Dot1x auth,** and set the service suffix to **bbb**, the authentication domain for the 802.1X user. With the service suffix configured, you must configure the access device to send usernames that include domain names to the RADIUS server.

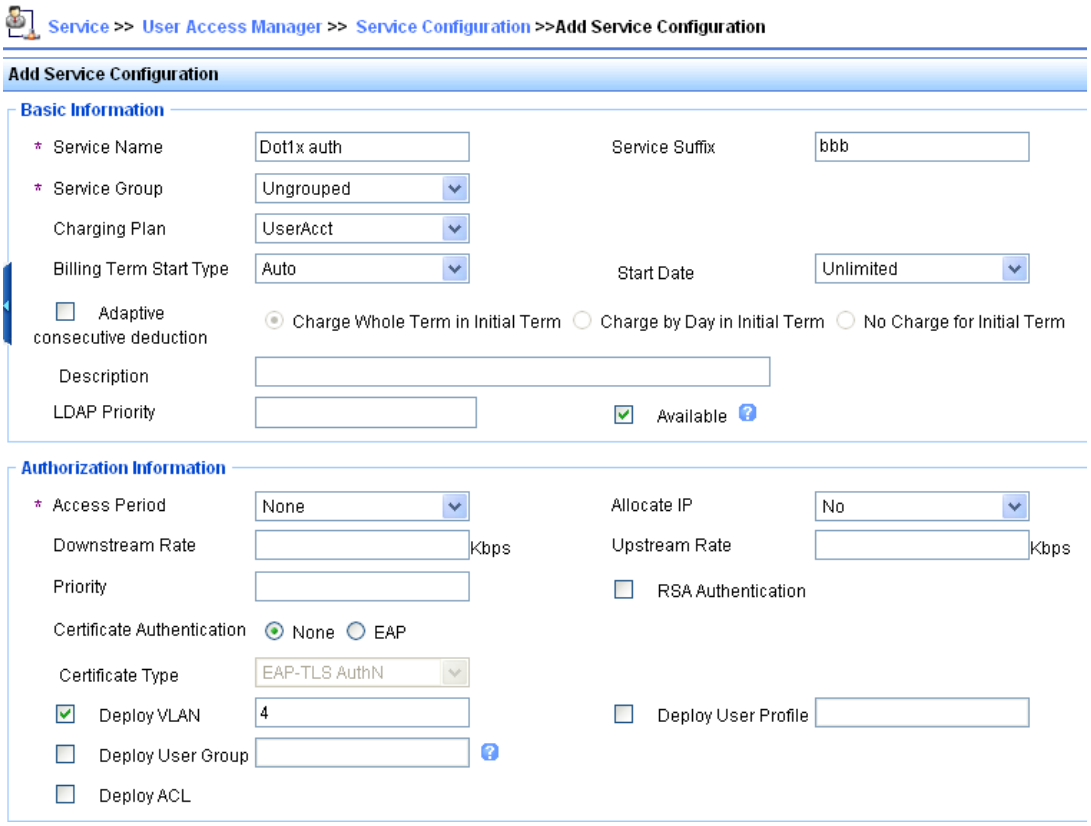
   b. Select **UserAcct** from the **Charging Plan** list.

c. Select **Deploy VLAN** and set the ID of the VLAN to be assigned to **4**.

d. Configure other parameters as needed.

e. Click **OK**.

Figure 24 Adding a service



4. Add a user:

Click the **User** tab, and select **Access User View** > **All Access Users** from the navigation tree to enter the **All Access Users** page. Then, click **Add** to configure a user as follows:

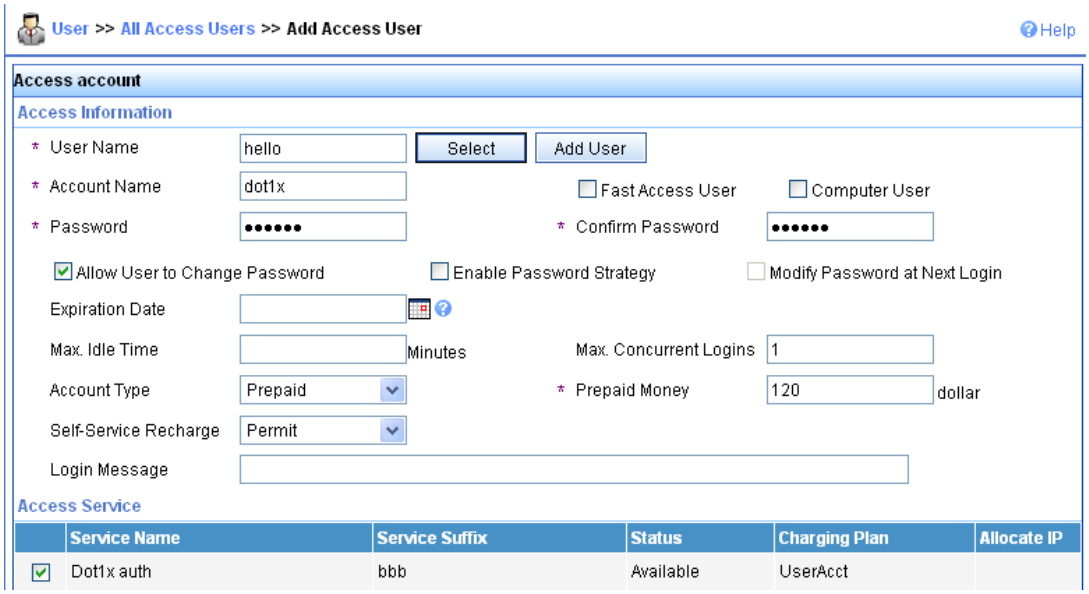
a. Select the user or add a user named **hello**.

b. Specify the account name as **dot1x** and configure the password.

c. Select **Dot1x auth** in the **Access Service** area.

d. Configure other parameters as needed and click **OK**.

Figure 25 Adding an access user account



Configuring the switch

1. Configure a RADIUS scheme:

   # Create a RADIUS scheme named **rad** and enter RADIUS scheme view.

   ```
   <Switch> system-view
   [Switch] radius scheme rad
   ```

   # Specify the primary authentication server and primary accounting server, and configure the keys for communication with the servers.

   ```
   [Switch-radius-rad] primary authentication 10.1.1.1
   [Switch-radius-rad] primary accounting 10.1.1.1
   [Switch-radius-rad] key authentication simple expert
   [Switch-radius-rad] key accounting simple expert
   ```

   # Include domain names in the usernames sent to the RADIUS server.

   ```
   [Switch-radius-rad] user-name-format with-domain
   [Switch-radius-rad] quit
   ```

2. Configure an ISP domain:

   # Create an ISP domain named **bbb** and enter ISP domain view.

   ```
   [Switch] domain bbb
   ```

   # Configure the ISP domain to use RADIUS scheme **rad** for authentication, authorization, and accounting of LAN users.

   ```
   [Switch-isp-bbb] authentication lan-access radius-scheme rad
   [Switch-isp-bbb] authorization lan-access radius-scheme rad
   [Switch-isp-bbb] accounting lan-access radius-scheme rad
   [Switch-isp-bbb] quit
   ```

3. Configure 802.1X authentication:

   # Enable 802.1X globally.

   ```
   [Switch] dot1x
   ```

   # Enable 802.1X for GigabitEthernet 1/0/1.

   ```
   [Switch] interface gigabitethernet 1/0/1
   [Switch-GigabitEthernet1/0/1] dot1x
   ```

Configure the access control method. By default, an 802.1X-enabled port uses the MAC-based access control.

```
[Switch-GigabitEthernet1/0/1] dot1x port-method macbased
```

Verifying the configuration

1. On the host, use account **dot1x@bbb** to pass 802.1X authentication:

   # If the host runs the Windows XP 802.1X client, configure the network connection properties as follows:

   a. Click the **Authentication** tab of the properties window.

   b. Select the **Enable IEEE 802.1X authentication for this network** option.

   c. Select MD5 challenge as the EAP type.

   d. Click **OK**.

   The user passes authentication after entering the correct username and password on the authentication page.

   # If the host runs the iNode client, no advanced authentication options are required. The user can pass authentication after entering username **dot1x@bbb** and the correct password on the client property page.

   IMPORTANT:

   Make sure the client can update its IP address to access the resources in the authorized VLAN after passing authentication.

2. On the switch, verify that the server assigns the port connecting the client to VLAN 4 after the user passes authentication. (Details not shown.)
3. Display 802.1X connection information on the switch.

   ```
   [Switch] display dot1x connection
   ```

Example: Configuring authentication and authorization for 802.1X users by the device as a RADIUS server

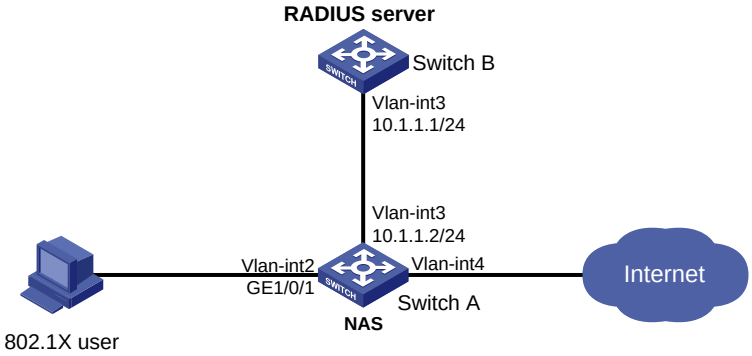
Network configuration

As shown in Figure 26, Switch B acts as the RADIUS server for authentication and authorization of 802.1X users connected to the NAS (Switch A).

Configure the switches to meet the following requirements:

- Perform 802.1X user authentication on GigabitEthernet 1/0/1 of the NAS.
- The shared key is **expert** and the authentication port is 1812.
- Exclude domain names from the usernames sent to the RADIUS server.
- The user name for 802.1X authentication is **dot1x**.
- After the user passes authentication, the RADIUS server authorizes VLAN 4 to the NAS port that the user is connecting to.

Figure 26 Network diagram



Procedure

1. Configure the NAS:
   a. Configure a RADIUS scheme:

      # Configure a RADIUS scheme named **rad** and enter RADIUS scheme view.

      ```
      <SwitchA> system-view
      [SwitchA] radius scheme rad
      ```

      # Specify the primary authentication server with IP address 10.1.1.1 and set the shared key to **expert** in plaintext form.

      ```
      [SwitchA-radius-rad] primary authentication 10.1.1.1 key simple expert
      ```

      # Exclude domain names from the usernames sent to the RADIUS server.

      ```
      [SwitchA-radius-rad] user-name-format without-domain
      [SwitchA-radius-rad] quit
      ```

   b. Configure an ISP domain:

      # Create an ISP domain named **bbb** and enter ISP domain view.

      ```
      [SwitchA] domain bbb
      ```

      # Configure the ISP domain to use RADIUS scheme **rad** for authentication and authorization of LAN users and not to perform accounting for LAN users.

      ```
      [SwitchA-isp-bbb] authentication lan-access radius-scheme rad
      [SwitchA-isp-bbb] authorization lan-access radius-scheme rad
      [SwitchA-isp-bbb] accounting lan-access none
      [SwitchA-isp-bbb] quit
      ```

   c. Configure 802.1X authentication:

      # Enable 802.1X for GigabitEthernet 1/0/1.

      ```
      [SwitchA] interface gigabitethernet 1/0/1
      [SwitchA-GigabitEthernet1/0/1] dot1x
      ```

      # Specify **bbb** as the mandatory authentication domain for 802.1X users on the interface.

      ```
      [SwitchA-GigabitEthernet1/0/1] dot1x mandatory-domain bbb
      [SwitchA-GigabitEthernet1/0/1] quit
      ```

      # Enable 802.1X globally.

      ```
      [SwitchA] dot1x
      ```

2. Configure the RADIUS server:

   # Create a network access user named **dot1x**.

   ```
   <SwitchB> system-view
   [SwitchB] local-user dot1x class network
   ```

   # Configure the password as **123456** in plaintext form.

```
[SwitchB-luser-network-dot1x] password simple 123456
```

Configure VLAN 4 as the authorization VLAN.

```
[SwitchB-luser-network-dot1x] authorization-attribute vlan 4
[SwitchB-luser-network-dot1x] quit
```

Configure the IP address of the RADIUS client as 10.1.1.2 and the shared key as **expert** in plaintext form.

```
[SwitchB] radius-server client ip 10.1.1.2 key simple expert
```

Activate the RADIUS server configuration.

```
[SwitchB] radius-server activate
```

Verifying the configuration

1. On the RADIUS server, display the activated RADIUS clients and users.

```
[SwitchB] display radius-server active-client
Total 1 RADIUS clients.
Client IP: 10.1.1.2
[SwitchB] display radius-server active-user dot1x
Total 1 RADIUS users matched.
Username: dot1x
  Description: Not configured
  Authorization attributes:
    VLAN ID: 4
    ACL number: Not configured
  Validity period:
    Expiration time: Not configured
```

2. On the host, use account **dot1x** for 802.1X authentication.

   If the host runs the Windows built-in 802.1X client, configure the network connection properties as follows:

   a. Click the **Authentication** tab of the properties window.
   b. Select the **Enable IEEE 802.1X authentication for this network** option.
   c. Select MD5 challenge as the EAP type.
   d. Click **OK**.

   If the host runs the iNode client, no advanced authentication options are required. The user passes authentication after entering the correct user name and password on the authentication page or the iNode client.

IMPORTANT:

Make sure the client can update its IP address to access the resources in the authorized VLAN after passing authentication.

3. On the NAS, verify that the RADIUS server assigns the port to VLAN 4 after the user passes authentication. (Details not shown.)
4. On the NAS, display online 802.1X user information.

```
[SwitchA] display dot1x connection
```

Troubleshooting AAA

RADIUS authentication failure

Symptom

User authentication always fails.

Analysis

Possible reasons include:

- A communication failure exists between the NAS and the RADIUS server.
- The username is not in the *userid@isp-name* format, or the ISP domain is not correctly configured on the NAS.
- The user is not configured on the RADIUS server.
- The password entered by the user is incorrect.
- The RADIUS server and the NAS are configured with different shared keys.

Solution

To resolve the problem:

1. Verify the following items:
   - The NAS and the RADIUS server can ping each other.
   - The username is in the *userid@isp-name* format and the ISP domain is correctly configured on the NAS.
   - The user is configured on the RADIUS server.
   - The correct password is entered.
   - The same shared key is configured on both the RADIUS server and the NAS.
2. If the problem persists, contact H3C Support.

RADIUS packet delivery failure

Symptom

RADIUS packets cannot reach the RADIUS server.

Analysis

Possible reasons include:

- A communication failure exists between the NAS and the RADIUS server.
- The NAS is not configured with the IP address of the RADIUS server.
- The authentication and accounting UDP ports configured on the NAS are incorrect.
- The RADIUS server's authentication and accounting port numbers are being used by other applications.

Solution

To resolve the problem:

1. Verify the following items:
   - The link between the NAS and the RADIUS server works well at both the physical and data link layers.
   - The IP address of the RADIUS server is correctly configured on the NAS.

    - The authentication and accounting UDP port numbers configured on the NAS are the same as those of the RADIUS server.
    - The RADIUS server's authentication and accounting port numbers are available.
2. If the problem persists, contact H3C Support.

RADIUS accounting error

Symptom

A user is authenticated and authorized, but accounting for the user is not normal.

Analysis

The accounting server configuration on the NAS is not correct. Possible reasons include:

- The accounting port number configured on the NAS is incorrect.
- The accounting server IP address configured on the NAS is incorrect. For example, the NAS is configured to use a single server to provide authentication, authorization, and accounting services, but in fact the services are provided by different servers.

Solution

To resolve the problem:

1. Verify the following items:
    - The accounting port number is correctly configured.
    - The accounting server IP address is correctly configured on the NAS.
2. If the problem persists, contact H3C Support.

Troubleshooting HWTACACS

Similar to RADIUS troubleshooting. See "RADIUS authentication failure," "RADIUS packet delivery failure," and "RADIUS accounting error."

LDAP authentication failure

Symptom

User authentication fails.

Analysis

Possible reasons include:

- A communication failure exists between the NAS and the LDAP server.
- The LDAP server IP address or port number configured on the NAS is not correct.
- The username is not in the *userid@isp-name* format, or the ISP domain is not correctly configured on the NAS.
- The user is not configured on the LDAP server.
- The password entered by the user is incorrect.
- The administrator DN or password is not configured.
- Some user attributes (for example, the username attribute) configured on the NAS are not consistent with those configured on the server.
- No user search base DN is specified for the LDAP scheme.

Solution

To resolve the problem:

1. Verify the following items:
   - The NAS and the LDAP server can ping each other.
   - The IP address and port number of the LDAP server configured on the NAS match those of the server.
   - The username is in the correct format and the ISP domain for the user authentication is correctly configured on the NAS.
   - The user is configured on the LDAP server.
   - The correct password is entered.
   - The administrator DN and the administrator password are correctly configured.
   - The user attributes (for example, the username attribute) configured on the NAS are consistent with those configured on the LDAP server.
   - The user search base DN for authentication is specified.
2. If the problem persists, contact H3C Support.

Appendixes

Appendix A Commonly used RADIUS attributes

Commonly used RADIUS attributes are defined in RFC 2865, RFC 2866, RFC 2867, and RFC 2868.

Table 4 Commonly used RADIUS attributes

No.	Attribute	No.	Attribute
1	User-Name	45	Acct-Authentic
2	User-Password	46	Acct-Session-Time
3	CHAP-Password	47	Acct-Input-Packets
4	NAS-IP-Address	48	Acct-Output-Packets
5	NAS-Port	49	Acct-Terminate-Cause
6	Service-Type	50	Acct-Multi-Session-Id
7	Framed-Protocol	51	Acct-Link-Count
8	Framed-IP-Address	52	Acct-Input-Gigawords
9	Framed-IP-Netmask	53	Acct-Output-Gigawords
10	Framed-Routing	54	(unassigned)
11	Filter-ID	55	Event-Timestamp
12	Framed-MTU	56-59	(unassigned)
13	Framed-Compression	60	CHAP-Challenge
14	Login-IP-Host	61	NAS-Port-Type
15	Login-Service	62	Port-Limit
16	Login-TCP-Port	63	Login-LAT-Port
17	(unassigned)	64	Tunnel-Type
18	Reply-Message	65	Tunnel-Medium-Type

No.	Attribute	No.	Attribute
19	Callback-Number	66	Tunnel-Client-Endpoint
20	Callback-ID	67	Tunnel-Server-Endpoint
21	(unassigned)	68	Acct-Tunnel-Connection
22	Framed-Route	69	Tunnel-Password
23	Framed-IPX-Network	70	ARAP-Password
24	State	71	ARAP-Features
25	Class	72	ARAP-Zone-Access
26	Vendor-Specific	73	ARAP-Security
27	Session-Timeout	74	ARAP-Security-Data
28	Idle-Timeout	75	Password-Retry
29	Termination-Action	76	Prompt
30	Called-Station-Id	77	Connect-Info
31	Calling-Station-Id	78	Configuration-Token
32	NAS-Identifier	79	EAP-Message
33	Proxy-State	80	Message-Authenticator
34	Login-LAT-Service	81	Tunnel-Private-Group-ID
35	Login-LAT-Node	82	Tunnel-Assignment-id
36	Login-LAT-Group	83	Tunnel-Preference
37	Framed-AppleTalk-Link	84	ARAP-Challenge-Response
38	Framed-AppleTalk-Network	85	Acct-Interim-Interval
39	Framed-AppleTalk-Zone	86	Acct-Tunnel-Packets-Lost
40	Acct-Status-Type	87	NAS-Port-Id
41	Acct-Delay-Time	88	Framed-Pool
42	Acct-Input-Octets	89	(unassigned)
43	Acct-Output-Octets	90	Tunnel-Client-Auth-id
44	Acct-Session-Id	91	Tunnel-Server-Auth-id

Appendix B Descriptions for commonly used standard RADIUS attributes

No.	Attribute	Description
1	User-Name	Name of the user to be authenticated.
2	User-Password	User password for PAP authentication, only present in Access-Request packets when PAP authentication is used.
3	CHAP-Password	Digest of the user password for CHAP authentication, only present in Access-Request packets when CHAP authentication is used.
4	NAS-IP-Address	IP address for the server to use to identify the client. Typically, a client

No.	Attribute	Description
		is identified by the IP address of its access interface. This attribute is only present in Access-Request packets.
5	NAS-Port	Physical port of the NAS that the user accesses.
6	Service-Type	Type of service that the user has requested or type of service to be provided.
7	Framed-Protocol	Encapsulation protocol for framed access.
8	Framed-IP-Address	IP address assigned to the user.
11	Filter-ID	Name of the filter list. This attribute is parsed as follows: • If the name starts with a digit, it indicates an ACL number. • If the name does not start with a digit, it indicates a user profile name.
12	Framed-MTU	MTU for the data link between the user and NAS. For example, this attribute can be used to define the maximum size of EAP packets allowed to be processed in 802.1X EAP authentication.
14	Login-IP-Host	IP address of the NAS interface that the user accesses.
15	Login-Service	Type of service that the user uses for login.
18	Reply-Message	Text to be displayed to the user, which can be used by the server to communicate information, for example, the cause of the authentication failure.
26	Vendor-Specific	Vendor-specific proprietary attribute. A packet can contain one or more proprietary attributes, each of which can contain one or more subattributes.
27	Session-Timeout	Maximum service duration for the user before termination of the session.
28	Idle-Timeout	Maximum idle time permitted for the user before termination of the session.
31	Calling-Station-Id	User identification that the NAS sends to the server. For the LAN access service provided by an H3C device, this attribute includes the MAC address of the user.
32	NAS-Identifier	Identification that the NAS uses to identify itself to the RADIUS server.
40	Acct-Status-Type	Type of the Accounting-Request packet. Possible values include: • **1**—Start. • **2**—Stop. • **3**—Interim-Update. • **4**—Reset-Charge. • **7**—Accounting-On. (Defined in the 3rd Generation Partnership Project.) • **8**—Accounting-Off. (Defined in the 3rd Generation Partnership Project.) • **9 to 14**—Reserved for tunnel accounting. • **15**—Reserved for failed.
45	Acct-Authentic	Authentication method used by the user. Possible values include: • **1**—RADIUS. • **2**—Local. • **3**—Remote.
60	CHAP-Challenge	CHAP challenge generated by the NAS for MD5 calculation during CHAP authentication.

No.	Attribute	Description
61	NAS-Port-Type	Type of the physical port of the NAS that is authenticating the user. Possible values include: • **15**—Ethernet. • **16**—Any type of ADSL. • **17**—Cable. (With cable for cable TV.) • **19**—WLAN-IEEE 802.11. • **201**—VLAN. • **202**—ATM. If the port is an ATM or Ethernet one and VLANs are implemented on it, the value of this attribute is 201.
64	Tunnel-Type	Tunneling protocols used. The value **13** represents VLAN. If the value is 13, the device interprets the Tunnel-Type, Tunnel-Medium-Type, and Tunnel-Private-Group-ID attributes as attributes to assign VLANs.
65	Tunnel-Medium-Type	Transport medium type to use for creating a tunnel. For VLAN assignment, the value must be **6** to indicate the 802 media plus Ethernet.
79	EAP-Message	Used to encapsulate EAP packets to allow RADIUS to support EAP authentication.
80	Message-Authenticator	Used for authentication and verification of authentication packets to prevent spoofing Access-Requests. This attribute is present when EAP authentication is used.
81	Tunnel-Private-Group-ID	Group ID for a tunnel session. To assign VLANs, the NAS conveys VLAN IDs by using this attribute.
87	NAS-Port-Id	String for describing the port of the NAS that is authenticating the user.
168	Framed-IPv6-Address	Server-assigned IPv6 address for the NAS to assign to the host. The address must be unique.

Appendix C RADIUS subattributes (vendor ID 25506)

Table 5 lists all RADIUS subattributes with a vendor ID of 25506. Support for these subattributes depends on the device model.

Table 5 RADIUS subattributes (vendor ID 25506)

No.	Subattribute	Description
1	Input-Peak-Rate	Peak rate in the direction from the user to the NAS, in bps.
2	Input-Average-Rate	Average rate in the direction from the user to the NAS, in bps.
3	Input-Basic-Rate	Basic rate in the direction from the user to the NAS, in bps.
4	Output-Peak-Rate	Peak rate in the direction from the NAS to the user, in bps.
5	Output-Average-Rate	Average rate in the direction from the NAS to the user, in bps.
6	Output-Basic-Rate	Basic rate in the direction from the NAS to the user, in bps.
15	Remanent_Volume	Total amount of data available for the connection, in different units for different server types.
17	ISP-ID	ISP domain where the user obtains authorization information.
20	Command	Operation for the session, used for session control. Possible

No.	Subattribute	Description
		values include: • **1**—Trigger-Request. • **2**—Terminate-Request. • **3**—SetPolicy. • **4**—Result. • **5**—PortalClear.
25	Result_Code	Result of the Trigger-Request or SetPolicy operation, zero for success and any other value for failure.
26	Connect_ID	Index of the user connection.
27	PortalURL	PADM redirect URL assigned to PPPoE users.
28	Ftp_Directory	FTP, SFTP, or SCP user working directory. When the RADIUS client acts as the FTP, SFTP, or SCP server, this attribute is used to set the working directory for an FTP, SFTP, or SCP user on the RADIUS client.
29	Exec_Privilege	EXEC user priority.
32	NAT-IP-Address	Public IP address assigned to the user when the source IP address and port are translated.
33	NAT-Start-Port	Start port number of the port range assigned to the user when the source IP address and port are translated.
34	NAT-End-Port	End port number of the port range assigned to the user when the source IP address and port are translated.
59	NAS_Startup_Timestamp	Startup time of the NAS in seconds, which is represented by the time elapsed after 00:00:00 on Jan. 1, 1970 (UTC).
60	Ip_Host_Addr	User IP address and MAC address included in authentication and accounting requests, in the format A.B.C.D hh:hh:hh:hh:hh:hh. A space is required between the IP address and the MAC address.
61	User_Notify	Information that must be sent from the server to the client transparently.
62	User_HeartBeat	Hash value assigned after an 802.1X user passes authentication, which is a 32-byte string. This attribute is stored in the user list on the NAS and verifies the handshake packets from the 802.1X user. This attribute only exists in Access-Accept and Accounting-Request packets.
98	Multicast_Receive_Group	IP address of the multicast group that the user's host joins as a receiver. This subattribute can appear multiple times in a multicast packet to indicate that the user belongs to multiple multicast groups.
100	IP6_Multicast_Receive_Group	IPv6 address of the multicast group that the user's host joins as a receiver. This subattribute can appear multiple times in a multicast packet to indicate that the user belongs to multiple multicast groups.
101	MLD-Access-Limit	Maximum number of MLD multicast groups that the user can join concurrently.
102	local-name	L2TP local tunnel name.
103	IGMP-Access-Limit	Maximum number of IGMP multicast groups that the user can join concurrently.
104	VPN-Instance	MPLS L3VPN instance to which a user belongs.

No.	Subattribute	Description
105	ANCP-Profile	ANCP profile name.
135	Client-Primary-DNS	IP address of the primary DNS server.
136	Client-Secondary-DNS	IP address of the secondary DNS server.
140	User_Group	User groups assigned after the user passes authentication. Typically, a user can belong to only one user group.
144	Acct_IPv6_Input_Octets	Bytes of IPv6 packets in the inbound direction. The measurement unit depends on the configuration on the device.
145	Acct_IPv6_Output_Octets	Bytes of IPv6 packets in the outbound direction. The measurement unit depends on the configuration on the device.
146	Acct_IPv6_Input_Packets	Number of IPv6 packets in the inbound direction. The measurement unit depends on the configuration on the device.
147	Acct_IPv6_Output_Packets	Number of IPv6 packets in the outbound direction. The measurement unit depends on the configuration on the device.
148	Acct_IPv6_Input_Gigawords	Bytes of IPv6 packets in the inbound direction. The measurement unit is 4G bytes.
149	Acct_IPv6_Output_Gigawords	Bytes of IPv6 packets in the outbound direction. The measurement unit is 4G bytes.
155	User-Roles	List of space-separated user roles.

210	Av-Pair	User-defined attribute pair. Available attribute pairs include:
		• Server-assigned voice VLAN in the format of device-traffic-class=voice.
		• Server-assigned user role in the format of shell:role=xxx.
		• Server-assigned ACL in the format of url-redirect-acl=xxx.
		• Server-assigned Web redirect URL in the format of url-redirect=xxx.
		• Server-deployed command to reboot a port, in the format of subscriber:command=bounce-host-port.
		• Server-assigned port shutdown duration in the format of bounce:seconds=xxx.
		• Server-deployed command to shut down a port, in the format of subscriber:command=disable-host-port.
		• Server-assigned MAC authentication offline detect timer (in seconds) in the format of mac-authentication: offline-detect-time=xxx. Value 0 of xxx indicates that MAC authentication offline detection is disabled.
		• Server-assigned MAC authentication offline detection flag in the format of mac-authentication: offline-detect-check=x. x has the following values:
		  ○ **0**—The device does not search for the ARP snooping entry or ND snooping entry of the MAC address.
		  ○ **1**—The device searches for the ARP snooping entry or ND snooping entry of the MAC address.
		• (Supported only in Release 6309P01 and later.) Server-assigned dynamic ACL. For more information about the format of this attribute, see "Appendix D Format of dynamic authorization ACLs." Support for this attribute in 802.1X authentication and MAC authentication depends on the device model. If the server assigns a user both this attribute and the Filter-ID attribute, the device will ignore this attribute. The device does not support using CoA messages to change the content assigned by this attribute or assign

No.	Subattribute	Description
		another ACL to the user.
230	NAS-Port-Name	Interface through which the user is connected to the NAS.
246	Auth_Detail_Result	Accounting details. The server sends Access-Accept packets with subattributes 246 and 250 in the following situations: • **1**—The subscriber charge is overdue. The subscriber is allowed to access network resources in the whitelist. If the subscriber accesses other network resources, the device redirects it to the URL specified by subattribute 250. • **2**—The broadband lease of the subscriber expires. The device redirects the subscriber to the URL specified by subattribute 250 when the subscriber requests to access webpages for the first time.
247	Input-Committed-Burst-Size	Committed burst size from the user to the NAS, in bits. The total length cannot exceed 4 bytes for this field. This subattribute must be assigned together with the Input-Average-Rate attribute.
248	Output-Committed-Burst-Size	Committed burst size from the NAS to the user, in bits. The total length cannot exceed 4 bytes for this field. This subattribute must be assigned together with the Output-Average-Rate attribute.
249	authentication-type	Authentication type. The value can be: • **1**—Intranet access authentication. • **2**—Internet access authentication. If the packet does not contain this subattribute, common authentication applies.
250	WEB-URL	Redirect URL for users.
251	Subscriber-ID	Family plan ID.
252	Subscriber-Profile	QoS policy name for the family plan of the subscriber.
255	Product_ID	Product name.

Appendix D Format of dynamic authorization ACLs

The server might assign a dynamic authorization ACL that contains multiple rules to a user in different ways:

- Assign only one Av-Pair subattribute to the user. In this subattribute, the dynamic ACL contains multiple rules separated by question marks (?).
- Assign multiple Av-Pair subattributes to the user. All the subattributes contain the same dynamic ACL and a different rule. Support for this method depends on the server model.

The format of a dynamic ACL rule is as follows:

aclrule?same?*acl-name*?*acl-type*?*ver-type*?*rule-id*?protocol=*protocol-type*?counting?dst-ip=*ip-addr*?src-ip=*ip-addr*?dst-port=*port-value*?src-port=*port-value*?action=*action-type*

The fields in the rule are described in Table 6. The following is an example of a dynamic ACL rule:

aclrule?same?test?1?1?1?protocol=3?counting?dst-ip=1.1.1.1/1.1.1.1?src-ip=1.1.1.1/0?dst-port=1.2000?src-port=5.2000-3000?action=1

Table 6 Fields in a dynamic ACL rule

Field	Description	Remarks
aclrule	Indicates that the following part is information about a dynamic ACL rule.	Required.
same	Indicates that the current user will inherit the dynamic ACL rules that have been successfully assigned to another authenticated user. If the server assigns one user the same dynamic ACL as another user but the rules are different for the two users, the device applies the dynamic ACL rules of the user that comes online first to the other user.	Required.
acl-name	ACL name, a case-insensitive string of 1 to 63 characters. The ACL name must begin with a letter and it cannot be **all** or the same as an existing static ACL on the device.	Required.
acl-type	ACL type. **1** indicates an advanced ACL. In the current software version, only advanced ACLs are supported.	Required.
ver-type	IP protocol type: • **1**—IPv4. • **2**—IPv6.	Required.
rule-id	ACL rule number, in the range of 0 to 65534.	Required.
protocol-type	Protocol type: • **1**—IP. • **2**—ICMP. • **3**—TCP. • **4**—UDP. • **5**—ICMPv6. • **6**—IPv6.	Optional.
counting	Indicates that rule match statistics is enabled. If a rule does not include this field, rule match statistics is disabled for the rule.	Optional.
ip-addr	IP address information. For example, 1.1.1.1/1.1.1.1, 1.1.1.1/0, or 3::3/128. If the value is **any**, the rule matches any IP address.	Optional.

port-value	TCP or UDP port information, in the *X*.*YYY* format.
	• ***X***—Operator.
	  ○ **1**—Equal to.
	  ○ **2**—Greater than.
	  ○ **3**—Smaller than.
	  ○ **4**—Not equal to.
	  ○ **5**—In the range of.
	• ***YYY***—Port number information.
	For example, 1.3000 and 5.2000-3000.
		Optional.

action-type	Action type: • **1**—Deny. • **2**—Permit.	Optional.

The following restrictions apply to dynamic authorization ACLs:

- For the former six fields (aclrule?same?*acl-name*?*acl-type*?*ver-type*?*rule-id*) of a dynamic ACL rule, their positions are fixed. The device cannot interpret a dynamic ACL rule if the positions of the six fields are changed. For the other fields, position changes are allowed.

- The settings for all the fields in the rules must meet the configuration logic of ACL rules on the device so the device can correctly interpret the rules.
- All dynamic ACL rules in one authorization must belong to the same ACL name.
- A dynamic ACL must have rules and the format of the rules must be valid.

Contents

802.1X overview

About the 802.1X protocol

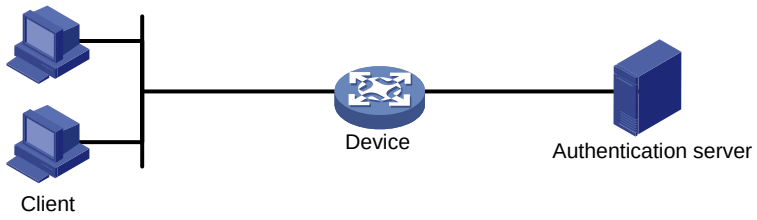
802.1X is a port-based network access control protocol widely used on Ethernet networks. The protocol controls network access by authenticating the devices connected to 802.1X-enabled LAN ports.

802.1X architecture

802.1X operates in the client/server model. As shown in Figure 1, 802.1X authentication includes the following entities:

- **Client (supplicant)**—A user terminal seeking access to the LAN. The terminal must have 802.1X software to authenticate to the access device.
- **Access device (authenticator)**—Authenticates the client to control access to the LAN. In a typical 802.1X environment, the access device uses an authentication server to perform authentication.
- **Authentication server**—Provides authentication services for the access device. The authentication server first authenticates 802.1X clients by using the data sent from the access device. Then, the server returns the authentication results to the access device to make access decisions. The authentication server is typically a RADIUS server. In a small LAN, you can use the access device as the authentication server.

Figure 1 802.1X architecture

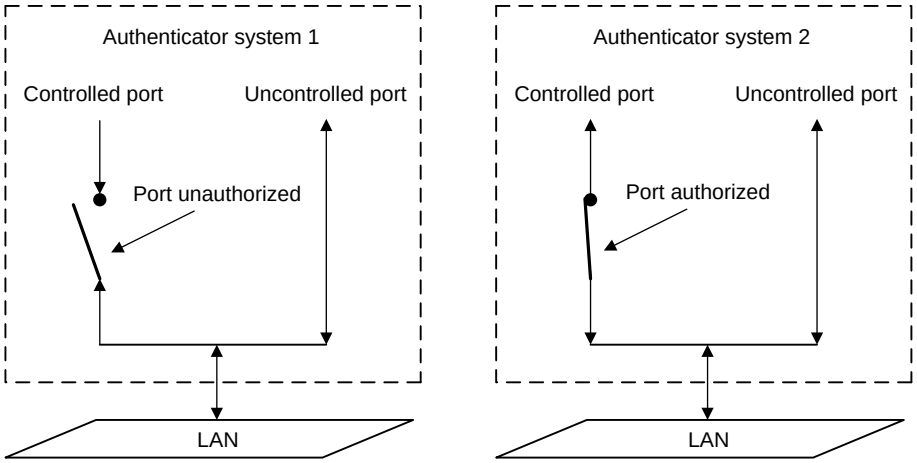


Controlled/uncontrolled port and port authorization status

802.1X defines two logical ports for the network access port: controlled port and uncontrolled port. Any packet arriving at the network access port is visible to both logical ports.

- **Uncontrolled port**—Is always open to receive and transmit authentication packets.
- **Controlled port**—Filters packets depending on the port state.
  - **Authorized state**—The controlled port is in authorized state when the client has passed authentication. The port allows traffic to pass through.
  - **Unauthorized state**—The port is in unauthorized state when the client has failed authentication. The port controls traffic by using one of the following methods:
    - Performs bidirectional traffic control to deny traffic to and from the client.
    - Performs unidirectional traffic control to deny traffic from the client. The device supports only unidirectional traffic control.

Figure 2 Authorization state of a controlled port



Packet exchange methods

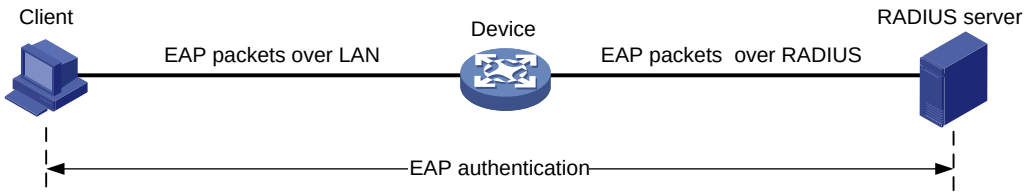
802.1X uses the Extensible Authentication Protocol (EAP) to transport authentication information for the client, the access device, and the authentication server. EAP is an authentication framework that uses the client/server model. The framework supports a variety of authentication methods, including MD5-Challenge, EAP-Transport Layer Security (EAP-TLS), and Protected EAP (PEAP).

802.1X defines EAP over LAN (EAPOL) for passing EAP packets between the client and the access device over a wired or wireless LAN. Between the access device and the authentication server, 802.1X delivers authentication information by either EAP relay or EAP termination.

EAP relay

EAP relay is defined in IEEE 802.1X. In this mode, the network device uses EAP over RADIUS (EAPOR) packets to send authentication information to the RADIUS server, as shown in Figure 3.

Figure 3 EAP relay



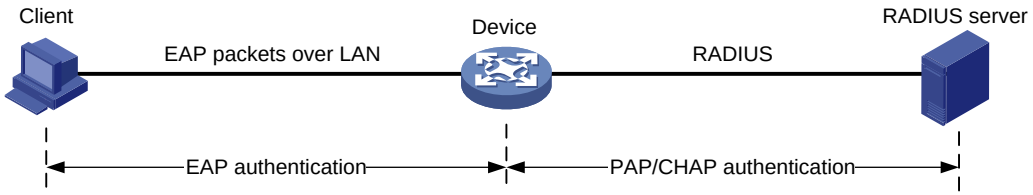
In EAP relay mode, the client must use the same authentication method as the RADIUS server. On the access device, you only need to use the **dot1x authentication-method eap** command to enable EAP relay.

EAP termination

As shown in Figure 4, the access device performs the following operations in EAP termination mode:

1. Terminates the EAP packets received from the client.
2. Encapsulates the client authentication information in standard RADIUS packets.
3. Uses PAP or CHAP to authenticate to the RADIUS server.

Figure 4 EAP termination



Comparing EAP relay and EAP termination

Packet exchange method	Benefits	Limitations
EAP relay	• Supports various EAP authentication methods. • The configuration and processing are simple on the access device.	The RADIUS server must support the EAP-Message and Message-Authenticator attributes, and the EAP authentication method used by the client.

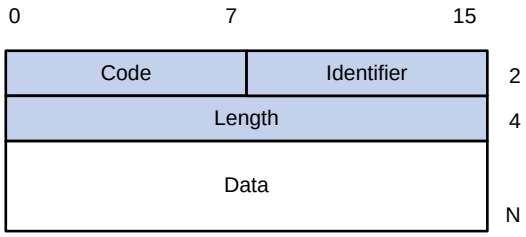
EAP termination	Works with any RADIUS server that supports PAP or CHAP authentication.	• Supports only the following EAP authentication methods:
		  ○ MD5-Challenge EAP authentication.
		  ○ The username and password EAP authentication initiated by an iNode 802.1X client.
		• The processing is complex on the access device.

Packet formats

EAP packet format

Figure 5 shows the EAP packet format.

Figure 5 EAP packet format

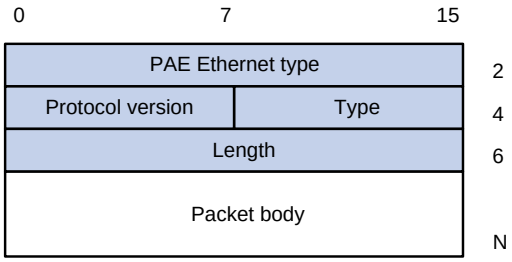


- **Code**—Type of the EAP packet. Options include Request (1), Response (2), Success (3), or Failure (4).
- **Identifier**—Used for matching Responses with Requests.
- **Length**—Length (in bytes) of the EAP packet. The EAP packet length is the sum of the Code, Identifier, Length, and Data fields.
- **Data**—Content of the EAP packet. This field appears only in a Request or Response EAP packet. The **Data** field contains the request type (or the response type) and the type data. Type 1 (Identity) and type 4 (MD5-Challenge) are two examples for the type field.

EAPOL packet format

Figure 6 shows the EAPOL packet format.

Figure 6 EAPOL packet format



- **PAE Ethernet type**—Protocol type. It takes the value 0x888E for EAPOL.
- **Protocol version**—The EAPOL protocol version used by the EAPOL packet sender.
- **Type**—Type of the EAPOL packet. Table 1 lists the types of EAPOL packets supported by the 802.1X implementation of the device.

  Table 1 Types of EAPOL packets

Value	Type	Description
0x00	EAP-Packet	The client and the access device uses EAP-Packets to transport authentication information.
0x01	EAPOL-Start	The client sends an EAPOL-Start message to initiate 802.1X authentication to the access device.
0x02	EAPOL-Logoff	The client sends an EAPOL-Logoff message to tell the access device that the client is logging off.

- **Length**—Data length in bytes, or length of the Packet body. If packet type is EAPOL-Start or EAPOL-Logoff, this field is set to 0, and no Packet body field follows.
- **Packet body**—Content of the packet. When the EAPOL packet type is EAP-Packet, the Packet body field contains an EAP packet.

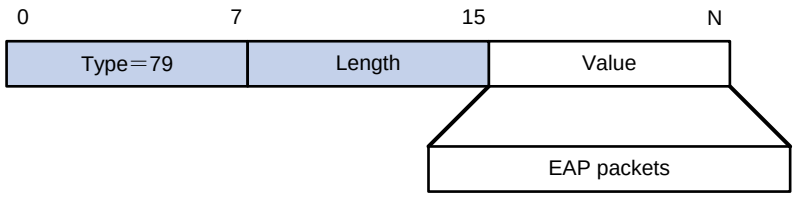
EAP over RADIUS

RADIUS adds two attributes, EAP-Message and Message-Authenticator, for supporting EAP authentication. For the RADIUS packet format, see "Configuring AAA."

- EAP-Message.

  RADIUS encapsulates EAP packets in the EAP-Message attribute, as shown in Figure 7. The Type field takes 79, and the Value field can be up to 253 bytes. If an EAP packet is longer than 253 bytes, RADIUS encapsulates it in multiple EAP-Message attributes.

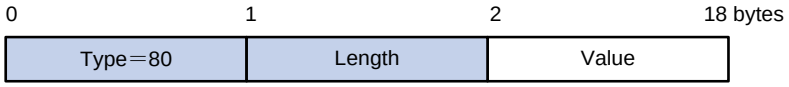
  Figure 7 EAP-Message attribute format



- Message-Authenticator.

  As shown in Figure 8, RADIUS includes the Message-Authenticator attribute in all packets that have an EAP-Message attribute to check their integrity. The packet receiver drops the packet if the calculated packet integrity checksum is different from the Message-Authenticator attribute value. The Message-Authenticator prevents EAP authentication packets from being tampered with during EAP authentication.

Figure 8 Message-Authenticator attribute format



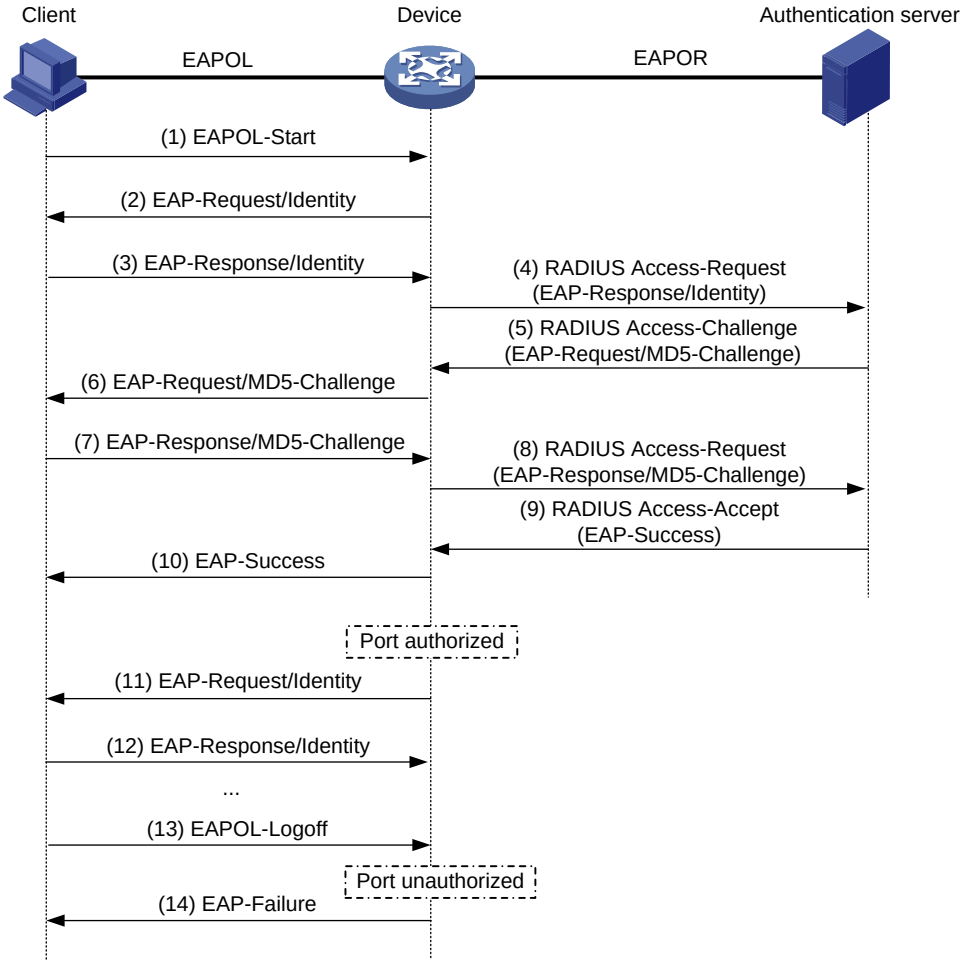
802.1X authentication procedures

802.1X authentication has two methods: EAP relay and EAP termination. You choose either mode depending on support of the RADIUS server for EAP packets and EAP authentication methods.

EAP relay

Figure 9 shows the basic 802.1X authentication procedure in EAP relay mode, assuming that MD5-Challenge EAP authentication is used.

Figure 9 802.1X authentication procedure in EAP relay mode



The following steps describe the 802.1X authentication procedure:

1. When a user launches the 802.1X client and enters a registered username and password, the 802.1X client sends an EAPOL-Start packet to the access device.
2. The access device responds with an EAP-Request/Identity packet to ask for the client username.
3. In response to the EAP-Request/Identity packet, the client sends the username in an EAP-Response/Identity packet to the access device.

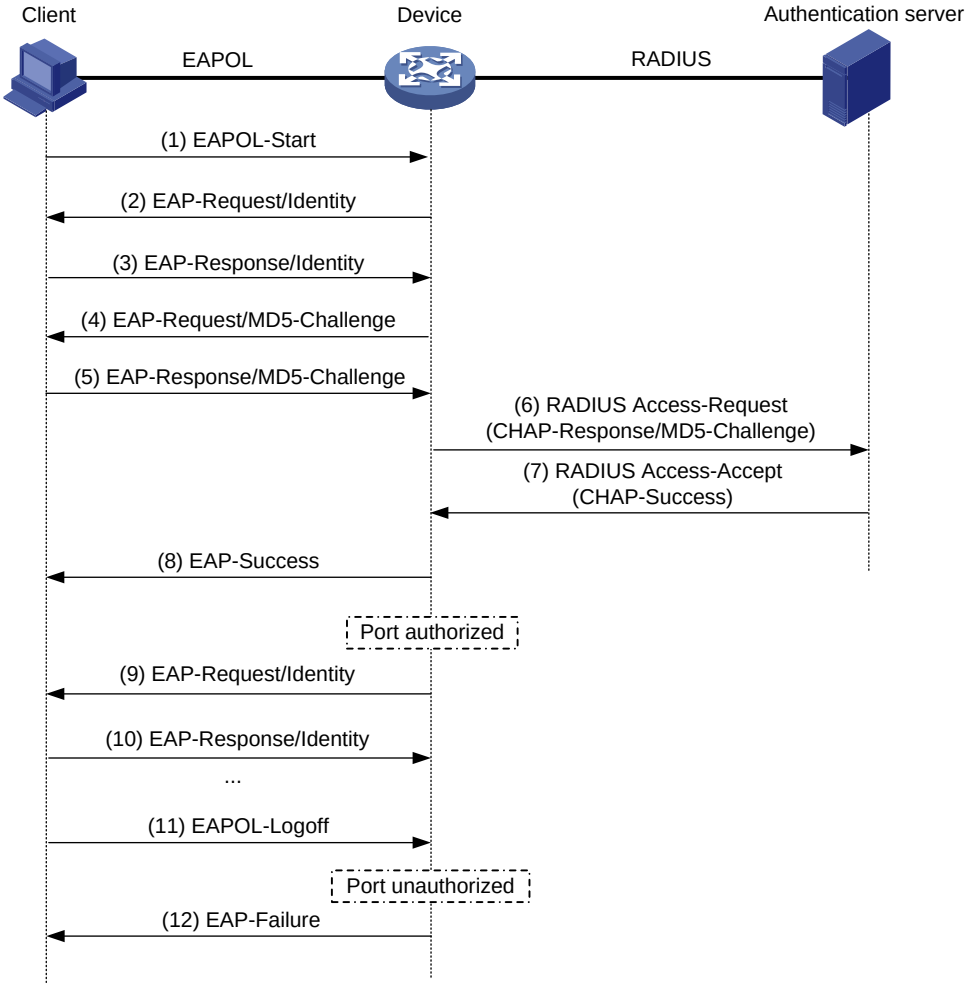
4. The access device relays the EAP-Response/Identity packet in a RADIUS Access-Request packet to the authentication server.
5. The authentication server uses the identity information in the RADIUS Access-Request to search its user database. If a matching entry is found, the server uses a randomly generated challenge (EAP-Request/MD5-Challenge) to encrypt the password in the entry. Then, the server sends the challenge in a RADIUS Access-Challenge packet to the access device.
6. The access device transmits the EAP-Request/MD5-Challenge packet to the client.
7. The client uses the received challenge to encrypt the password, and sends the encrypted password in an EAP-Response/MD5-Challenge packet to the access device.
8. The access device relays the EAP-Response/MD5-Challenge packet in a RADIUS Access-Request packet to the authentication server.
9. The authentication server compares the received encrypted password with the encrypted password it generated at step 5. If the two passwords are identical, the server considers the client valid and sends a RADIUS Access-Accept packet to the access device.
10. Upon receiving the RADIUS Access-Accept packet, the access device performs the following operations:
    a. Sends an EAP-Success packet to the client.
    b. Sets the controlled port in authorized state.

    The client can access the network.
11. After the client comes online, the access device periodically sends handshake requests to check whether the client is still online. By default, if two consecutive handshake attempts fail, the device logs off the client.
12. Upon receiving a handshake request, the client returns a response. If the client fails to return a response after a number of consecutive handshake attempts (two by default), the access device logs off the client. This handshake mechanism enables timely release of the network resources used by 802.1X users that have abnormally gone offline.
13. The client can also send an EAPOL-Logoff packet to ask the access device for a logoff.
14. In response to the EAPOL-Logoff packet, the access device changes the status of the controlled port from authorized to unauthorized. Then, the access device sends an EAP-Failure packet to the client.

EAP termination

Figure 10 shows the basic 802.1X authentication procedure in EAP termination mode, assuming that CHAP authentication is used.

Figure 10 802.1X authentication procedure in EAP termination mode



In EAP termination mode, the access device rather than the authentication server generates an MD5 challenge for password encryption. The access device then sends the MD5 challenge together with the username and encrypted password in a standard RADIUS packet to the RADIUS server.

802.1X authentication initiation

Both the 802.1X client and the access device can initiate 802.1X authentication.

802.1X client as the initiator

The client sends an EAPOL-Start packet to the access device to initiate 802.1X authentication. The destination MAC address of the packet is the IEEE 802.1X specified multicast address 01-80-C2-00-00-03 or the broadcast MAC address. If any intermediate device between the client and the authentication server does not support the multicast address, you must use an 802.1X client that can send broadcast EAPOL-Start packets. For example, you can use the iNode 802.1X client.

Access device as the initiator

If the client cannot send EAPOL-Start packets, configure the access device to initiate authentication. One example is the 802.1X client available with Windows XP.

The access device supports the following modes:

- **Multicast trigger mode**—The access device multicasts EAP-Request/Identity packets to initiate 802.1X authentication at the identity request interval.

- **Unicast trigger mode**—Upon receiving a frame from an unknown MAC address, the access device sends an EAP-Request/Identity packet out of the receiving port to the MAC address. The device retransmits the packet if no response has been received within the identity request timeout interval. This process continues until the maximum number of request attempts set by using the **`dot1x retry`** command is reached.

The username request timeout timer sets both the identity request interval for the multicast trigger and the identity request timeout interval for the unicast trigger.

Access control methods

H3C implements port-based access control as defined in the 802.1X protocol, and extends the protocol to support MAC-based access control.

- **Port-based access control**—Once an 802.1X user passes authentication on a port, any subsequent user can access the network through the port without authentication. When the authenticated user logs off, all other users are logged off.
- **MAC-based access control**—Each user is separately authenticated on a port. When a user logs off, no other online users are affected.

802.1X VLAN manipulation

Authorization VLAN

The authorization VLAN controls the access of an 802.1X user to authorized network resources. The device supports authorization VLANs assigned locally or by a remote server.

IMPORTANT:

Only remote servers can assign tagged authorization VLANs.

Remote VLAN authorization

In remote VLAN authorization, you must configure an authorization VLAN for a user on the remote server. After the user authenticates to the server, the server assigns authorization VLAN information to the device. Then, the device assigns the user access port to the authorization VLAN as a tagged or untagged member.

The device supports assignment of the following authorization VLAN information by the remote server:

- VLAN ID.
- VLAN name, which must be the same as the VLAN description on the access device.
- A string of VLAN IDs and VLAN names.

  In the string, some VLANs are represented by their IDs, and some VLANs are represented by their names.
- VLAN group name.

  For more information about VLAN groups, see *Layer 2—LAN Switching Configuration Guide*.
- VLAN ID with a suffix of **t** or **u**.

  The **t** and **u** suffixes require the device to assign the access port to the VLAN as a tagged or untagged member, respectively. For example, **2u** indicates assigning the port to VLAN 2 as an untagged member.

If a VLAN name or VLAN group name is assigned, the device converts the information into a VLAN ID before VLAN assignment.

IMPORTANT:

For a VLAN represented by its VLAN name to be assigned successfully, you must make sure the VLAN has been created on the device.

To assign VLAN IDs with suffixes, make sure the user access port is a hybrid or trunk port that performs port-based access control.

To ensure a successful assignment, the authorization VLANs assigned by the remote server cannot be any of the following types:

- Dynamically learned VLANs.
- Reserved VLANs.
- Private VLANs.

If the server assigns a group of VLANs, the access device selects a VLAN as described in Table 2.

Table 2 Authorization VLAN selection from a group of VLANs

VLAN information	Authorization VLAN selection

VLAN IDs
VLAN names
VLAN group name
VLAN IDs and VLAN names
	If the 802.1X-enabled port performs MAC-based access control, the device selects an authorization VLAN from the VLAN group for a user according to the following rules:
	• On a hybrid port with MAC-based VLAN enabled:
	  ○ If the port does not have online users, the device selects the VLAN with the lowest ID.
	  ○ If the port has online users, the device selects the VLAN that has the fewest online users. If two VLANs have the same number of online 802.1X users, the device selects the VLAN with the lower ID.
	• On an access, trunk, or MAC-based VLAN disabled hybrid port:
	  ○ If the port does not have online users, the device selects the VLAN with the lowest ID.
	  ○ If the port has online users, the device examines the VLAN group for the VLAN of the online users. If the VLAN is found, the VLAN is assigned to the user as the authorization VLAN. If the VLAN is not found, VLAN authorization fails.
	If the 802.1X-enabled port performs port-based access control, the device selects the VLAN with the lowest ID from the VLAN group. All subsequent 802.1X users are assigned to that VLAN.

VLAN IDs with suffixes	**1.** The device selects the leftmost VLAN ID without a suffix, or the leftmost VLAN ID suffixed by **u** as an untagged VLAN, whichever is more leftmost. **2.** The device assigns the untagged VLAN to the port as the PVID, and it assigns the remaining as tagged VLANs. If no untagged VLAN is assigned, the PVID of the port does not change. The port permits traffic from these tagged and untagged VLANs to pass through. For example, the authentication server sends the string **1u 2t 3** to the access device for a user. The device assigns VLAN 1 as an untagged VLAN and all remaining VLANs (including VLAN 3) as tagged VLANs. VLAN 1 becomes the PVID.

In Release 6318P01 and later, the device includes the User-VLAN-ID attribute in RADIUS accounting requests to inform the RADIUS server of the authorization VLAN assigned to 802.1X users. The RADIUS server can then include user authorization VLAN information in its logs about 802.1X users.

- If the RADIUS server assigns a VLAN ID or VLAN name as the authorization VLAN to a user, the device includes the server-assigned authorization VLAN in the User-VLAN-ID attribute.

- If the RADIUS server assigns a group of VLANs in the authorization VLAN information to a user, the device includes a VLAN in the User-VLAN-ID attribute as described in Table 3.

Table 3 Including a VLAN in the User-VLAN-ID attribute of RADIUS accounting packets

VLAN information	VLAN in the User-VLAN-ID attribute
VLAN IDs VLAN names VLAN group name VLAN IDs and VLAN names	• If the device has selected an authorization VLAN when it starts accounting for the user, it includes the selected VLAN in the User-VLAN-ID attribute. The VLAN will be included in start-accounting, real-time accounting, and stop-accounting request packets. • If the device has not selected an authorization VLAN when it starts accounting for the user, it includes the user's initial VLAN in the User-VLAN-ID attribute in start-accounting request packets. When sending real-time accounting or stop-accounting request packets, the device includes the assigned authorization VLAN in the User-VLAN-ID attribute.
VLAN IDs with suffixes	The device includes the untagged authorization VLAN in the User-VLAN-ID attribute in RADIUS accounting request packets. If no untagged authorization VLAN is available, the device includes the user's initial VLAN in the User-VLAN-ID attribute in RADIUS accounting request packets.

Local VLAN authorization

To perform local VLAN authorization for a user, specify the VLAN ID in the authorization attribute list of the local user account for that user. For each local user, you can specify only one authorization VLAN ID. The user access port is assigned to the VLAN as an untagged member.

IMPORTANT:

Local VLAN authorization does not support assignment of tagged VLANs.

For more information about local user configuration, see "Configuring AAA."

Authorization VLAN manipulation on an 802.1X-enabled port

Table 4 describes how the access device handles VLANs (except for the VLANs specified with suffixes) on an 802.1X-enabled port.

Table 4 VLAN manipulation

Port access control method	VLAN manipulation
Port-based	The device assigns the port to the first authenticated user's authorization VLAN. All subsequent 802.1X users can access the VLAN without authentication. If the authorization VLAN has the untagged attribute, the device assigns the port to the authorization VLAN as an untagged member and sets the VLAN as the PVID. If the authorization VLAN has the tagged attribute, the device assigns the port to the VLAN as a tagged member without changing the PVID. **NOTE:** The tagged attribute is supported only on trunk and hybrid ports.
MAC-based	On a hybrid port with MAC-based VLAN enabled, the device maps the MAC address of each user to its own authorization VLAN. The PVID of the port does not change. On an access, trunk, or MAC-based VLAN disabled hybrid port: • The device assigns the port to the first authenticated user's

Port access control method	VLAN manipulation
	authorization VLAN and sets the VLAN as the PVID if that authorization VLAN has the untagged attribute. • If the authorization VLAN has the tagged attribute, the device assigns the port to the authorization VLAN without changing its PVID.

IMPORTANT:

- If the users are attached to a port whose link type is access, make sure the authorization VLAN assigned by the server has the untagged attribute. VLAN assignment will fail if the server issues a VLAN that has the tagged attribute.
- When you assign VLANs to users attached to a trunk port or a MAC-based VLAN disabled hybrid port, make sure there is only one untagged VLAN. If a different untagged VLAN is assigned to a subsequent user, the user cannot pass authentication.
- As a best practice to enhance network security, do not use the **`port hybrid vlan`** command to assign a hybrid port to an authorization VLAN as a tagged member.

The VLAN assigned by the server to a user as an authorization VLAN might have been configured on the user access port but with a different tagging mode. For example, the server assigns an authorization VLAN with the tagged attribute, but the same VLAN configured on the port has the untagged attribute. In this situation, the VLAN settings that take effect on the user depend on the link type of the port.

- If the link type of the port is access or trunk, the authorization VLAN settings assigned by the server always take effect on the user as long as the user is online. After the user goes offline, the VLAN settings on the port take effect.
- If the link type of the port is hybrid, the VLAN settings configured on the port take effect. For example, the server assigns VLAN 30 with the untagged attribute to a user on the hybrid port. However, VLAN 30 has been configured on the port with the tagged attribute by using the **`port hybrid vlan tagged`** command. Finally, the VLAN has the tagged attribute on the port.

For an 802.1X authenticated user to access the network on a hybrid port when no authorization VLAN is configured for the user, perform one of the following tasks:

- If the port receives tagged authentication packets from the user in a VLAN, use the **`port hybrid vlan`** command to configure the port as a tagged member in the VLAN.
- If the port receives untagged authentication packets from the user in a VLAN, use the **`port hybrid vlan`** command to configure the port as an untagged member in the VLAN.

On a port with periodic online user reauthentication enabled, the MAC-based VLAN feature does not take effect on a user that has been online since before this feature was enabled. The access device creates a MAC-to-VLAN mapping for the user when the following requirements are met:

- The user passes reauthentication.
- The authorization VLAN for the user is changed.

For more information about VLAN configuration and MAC-based VLANs, see *Layer 2—LAN Switching Configuration Guide*.

Guest VLAN

The 802.1X guest VLAN on a port accommodates users that have not performed 802.1X authentication. Users in the guest VLAN can access a limited set of network resources, such as a software server, to download antivirus software and system patches. Once a user in the guest VLAN passes 802.1X authentication, it is removed from the guest VLAN and can access authorized network resources.

The access device handles VLANs on an 802.1X-enabled port based on its 802.1X access control method.

Port-based access control

Authentication status	VLAN manipulation
A user accesses the 802.1X-enabled port when the port is in auto state.	The device assigns the port to the 802.1X guest VLAN. All 802.1X users on this port can access only resources in the guest VLAN. The guest VLAN assignment varies by port link mode. For more information, see Table 4 in "Authorization VLAN."
A user in the 802.1X guest VLAN fails 802.1X authentication.	If an 802.1X Auth-Fail VLAN is available, the device assigns the port to the Auth-Fail VLAN. All users on this port can access only resources in the Auth-Fail VLAN. If no Auth-Fail VLAN is configured, the port is still in the 802.1X guest VLAN. All users on the port are in the guest VLAN. For information about the 802.1X Auth-Fail VLAN, see "Auth-Fail VLAN."
A user in the 802.1X guest VLAN passes 802.1X authentication.	The device removes the port from the 802.1X guest VLAN and assigns the port to the authorization VLAN of the user. If the authentication server does not assign an authorization VLAN, the initial PVID of the port applies. The user and all subsequent 802.1X users are assigned to the initial port VLAN. After the user logs off, the port is assigned to the guest VLAN again. **NOTE:** The initial PVID of an 802.1X-enabled port refers to the PVID used by the port before the port is assigned to any 802.1X VLANs.

IMPORTANT:

When the port receives a packet with a VLAN tag, the packet will be forwarded within the tagged VLAN if the VLAN is not the guest VLAN.

MAC-based access control

Authentication status	VLAN manipulation
A user accesses the 802.1X-enabled port and has not performed 802.1X authentication.	The device creates a mapping between the MAC address of the user and the 802.1X guest VLAN. The user can access only resources in the guest VLAN.
A user in the 802.1X guest VLAN fails 802.1X authentication.	If an 802.1X Auth-Fail VLAN is available, the device remaps the MAC address of the user to the Auth-Fail VLAN. The user can access only resources in the Auth-Fail VLAN. If no 802.1X Auth-Fail VLAN is configured, the user is removed from the guest VLAN and added to the initial PVID.
A user in the 802.1X guest VLAN passes 802.1X authentication.	The device remaps the MAC address of the user to the authorization VLAN. If the authentication server does not assign an authorization VLAN, the device remaps the MAC address of the user to the initial PVID on the port.

Auth-Fail VLAN

The 802.1X Auth-Fail VLAN on a port accommodates users that have failed 802.1X authentication because of the failure to comply with the organization security strategy. For example, the VLAN accommodates users that have entered a wrong password. Users in the Auth-Fail VLAN can access a limited set of network resources, such as a software server, to download antivirus software and system patches.

The access device handles VLANs on an 802.1X-enabled port based on its 802.1X access control method.

Port-based access control

Authentication status	VLAN manipulation
A user accesses the port and fails 802.1X authentication.	The device assigns the port to the Auth-Fail VLAN. All 802.1X users on this port can access only resources in the Auth-Fail VLAN. The Auth-Fail VLAN assignment varies by port link mode. For more information, see Table 4 in "Authorization VLAN."
A user in the 802.1X Auth-Fail VLAN fails 802.1X authentication.	The port is still in the Auth-Fail VLAN, and all 802.1X users on this port are in this VLAN.
A user in the 802.1X Auth-Fail VLAN passes 802.1X authentication.	The device assigns the port to the authorization VLAN of the user, and it removes the port from the Auth-Fail VLAN. If the authentication server does not assign an authorization VLAN, the initial PVID of the port applies. The user and all subsequent 802.1X users are assigned to the initial PVID. After the user logs off, the port is assigned to the guest VLAN. If no guest VLAN is configured, the port is assigned to the initial PVID of the port.

MAC-based access control

Authentication status	VLAN manipulation
A user accesses the port and fails 802.1X authentication.	The device maps the MAC address of the user to the 802.1X Auth-Fail VLAN. The user can access only resources in the Auth-Fail VLAN.
A user in the 802.1X Auth-Fail VLAN fails 802.1X authentication.	The user is still in the Auth-Fail VLAN.
A user in the 802.1X Auth-Fail VLAN passes 802.1X authentication.	The device remaps the MAC address of the user to the authorization VLAN. If the authentication server does not assign an authorization VLAN, the device remaps the MAC address of the user to the initial PVID on the port.

Critical VLAN

The 802.1X critical VLAN on a port accommodates 802.1X users that have failed authentication because none of the RADIUS servers in their ISP domain are reachable. Users in the critical VLAN can access a limited set of network resources depending on the configuration.

The critical VLAN feature takes effect when 802.1X authentication is performed only through RADIUS servers. If an 802.1X user fails local authentication after RADIUS authentication, the user is not assigned to the critical VLAN. For more information about the authentication methods, see "Configuring AAA."

The access device handles VLANs on an 802.1X-enabled port based on its 802.1X access control method.

Port-based access control

Authentication status	VLAN manipulation
A user accesses the port and fails 802.1X authentication because all the RADIUS servers are unreachable.	The device assigns the port to the critical VLAN. The 802.1X user and all subsequent 802.1X users on this port can access only resources in the 802.1X critical VLAN. The critical VLAN assignment varies by port link mode. For more information, see Table 4 in "Authorization VLAN."
A user in the 802.1X critical VLAN fails authentication because all the RADIUS servers are unreachable.	The port is still in the critical VLAN.
A user in the 802.1X critical VLAN fails authentication for any reason other than unreachable servers.	If an 802.1X Auth-Fail VLAN has been configured, the port is assigned to the Auth-Fail VLAN. If no 802.1X Auth-Fail VLAN is configured, the port is assigned to the initial PVID of the port.
A user in the 802.1X critical VLAN passes 802.1X authentication.	The device assigns the port to the authorization VLAN of the user, and it removes the port from the 802.1X critical VLAN. If the authentication server does not assign an authorization VLAN, the initial PVID of the port applies. The user and all subsequent 802.1X users are assigned to this port VLAN. After the user logs off, the port is assigned to the guest VLAN. If no 802.1X guest VLAN is configured, the initial PVID of the port is restored.
A user in the 802.1X guest VLAN fails authentication because all the RADIUS servers are unreachable.	The device assigns the port to the 802.1X critical VLAN, and all 802.1X users on this port are in this VLAN.
A user in the 802.1X Auth-Fail VLAN fails authentication because all the RADIUS servers are unreachable.	The port is still in the 802.1X Auth-Fail VLAN. All 802.1X users on this port can access only resources in the 802.1X Auth-Fail VLAN.
A user that has passed authentication fails reauthentication because all the RADIUS servers are unreachable, and the user is logged out of the device.	The device assigns the port to the 802.1X critical VLAN.

If the port is added to the critical VLAN because no RADIUS servers are reachable, the device performs the following operations after it detects a reachable RADIUS server:

1. Removes the port from the critical VLAN.
2. Sends a multicast EAP-Request/Identity message out of the port to trigger authentication.

MAC-based access control

Authentication status	VLAN manipulation
A user accesses the port and fails 802.1X authentication because all the RADIUS servers are unreachable.	The device maps the MAC address of the user to the 802.1X critical VLAN. The user can access only resources in the 802.1X critical VLAN.
A user in the 802.1X critical VLAN fails authentication because all the RADIUS servers are unreachable.	The user is still in the critical VLAN.
A user in the 802.1X critical VLAN fails 802.1X authentication for any reason other than unreachable servers.	If an 802.1X Auth-Fail VLAN has been configured, the device remaps the MAC address of the user to the Auth-Fail VLAN ID. If no 802.1X Auth-Fail VLAN has been configured, the device remaps the MAC address of the user to the initial PVID.
A user in the 802.1X critical VLAN passes 802.1X authentication.	The device remaps the MAC address of the user to the authorization VLAN. If the authentication server does not assign an authorization VLAN to the user, the device remaps the MAC address of the user to the initial PVID on the port.
A user in the 802.1X guest VLAN fails authentication because all the RADIUS servers are unreachable.	The device remaps the MAC address of the user to the 802.1X critical VLAN. The user can access only resources in the 802.1X critical VLAN.
A user in the 802.1X Auth-Fail VLAN fails authentication because all the RADIUS servers are unreachable.	The user remains in the 802.1X Auth-Fail VLAN.

If a user is added to the critical VLAN because no RADIUS servers are reachable, the device performs the following operations after it detects a reachable RADIUS server:

1. Removes the user from the critical VLAN.
2. Sends a unicast EAP-Request/Identity message out of the port to the user for reauthentication.

Critical voice VLAN

The 802.1X critical voice VLAN on a port accommodates 802.1X voice users that have failed authentication because none of the RADIUS servers in their ISP domain are reachable.

The critical voice VLAN feature takes effect when 802.1X authentication is performed only through RADIUS servers. If an 802.1X voice user fails local authentication after RADIUS authentication, the voice user is not assigned to the critical voice VLAN. For more information about the authentication methods, see "Configuring AAA."

When a reachable RADIUS server is detected, the device performs operations on a port based on its 802.1X access control method.

Port-based access control

When a reachable RADIUS server is detected, the device removes the port from the critical voice VLAN. The port sends a multicast EAP-Request/Identity packet to all 802.1X voice users on the port to trigger authentication.

MAC-based access control

When a reachable RADIUS server is detected, the device removes 802.1X voice users from the critical voice VLAN. The port sends a unicast EAP-Request/Identity packet to each 802.1X voice user that was assigned to the critical voice VLAN to trigger authentication.

ACL assignment

You can specify an ACL for an 802.1X user on the authentication server to control the user's access to network resources. After the user passes 802.1X authentication, the authentication server assigns the ACL to the user access port. Then, the port permits or drops the matching traffic for the user depending on the rules configured in the ACL. This ACL is called an authorization ACL.

The device supports assignment of static and dynamic ACLs as authorization ACLs.

- **Static ACLs**—Static ACLs can be assigned by a RADIUS server or the access device. When the server or access device assigns a static ACL to a user, it assigns only the ACL number. You must manually create the ACL and configure its rules on the access device.

  To change the access permissions of a user, you can use one of the following methods:

  - Modify ACL rules in the authorization ACL on the access device.
  - Assign another ACL to the user from the RADIUS server or the access device.

  Static ACLs and their rules can be manually deleted from the access device.
- **Dynamic ACLs**—Dynamic ACLs and their rules are automatically deployed by a RADIUS server, which are not configurable on the access device. Dynamic ACLs can only be named ACLs. After the device receives a server-deployed dynamic ACL and its rules, it automatically creates the ACL and configures its rules.

  If the dynamic ACL assigned by the server to a user has the same name as a static ACL, the dynamic ACL cannot be issued and the user cannot come online.

  A dynamic ACL and its rules are automatically deleted from the access device after all its users go offline.

  Dynamic ACLs and their rules cannot be manually modified or deleted on the access device. To display information about dynamic ACLs and their rules, use the **`display dot1x connection`** or **`display acl`** command.

IMPORTANT:

Assignment of dynamic ACLs is supported only in Release 6309P01 or later.

The supported authorization ACLs include the following types:

- Basic ACLs, which are numbered in the range of 2000 to 2999.
- Advanced ACLs, which are numbered in the range of 3000 to 3999.
- Layer 2 ACLs, which are numbered in the range of 4000 to 4999.

IMPORTANT:

For an authorization ACL to take effect, make sure the ACL exists with rules and none of the rules contains the **`counting`**, **`established`**, **`fragment`**, **`source-mac`**, or **`logging`** keyword.

For more information about ACLs, see *ACL and QoS Configuration Guide*.

User profile assignment

You can specify a user profile for an 802.1X user on the authentication server to control the user's access to network resources. After the user passes 802.1X authentication, the authentication server assigns the user profile to the user for filtering traffic.

The authentication server can be the local access device or a RADIUS server. In either case, the server only specifies the user profile name. You must configure the user profile on the access device.

To change the user's access permissions, you can use one of the following methods:

- Modify the user profile configuration on the access device.
- Specify another user profile for the user on the authentication server.

For more information about user profiles, see "Configuring user profiles."

Redirect URL assignment

The device supports the URL attribute assigned by a RADIUS server when the 802.1X-enabled port performs MAC-based access control and the port authorization state is **auto**. During authentication, the HTTP or HTTPS requests of an 802.1X user are redirected to the Web interface specified by the server-assigned URL attribute. After the user passes the Web authentication, the RADIUS server records the MAC address of the user and uses a DM (Disconnect Message) to log off the user. When the user initiates 802.1X authentication again, it will pass the authentication and come online successfully.

This feature is mutually exclusive with the EAD assistant feature.

By default, the device listens to port 6654 for HTTPS requests to be redirected. To change the redirect listening port number, see configuring HTTP redirect in *Layer 3—IP Services Configuration Guide*.

Periodic 802.1X reauthentication

Periodic 802.1X reauthentication tracks the connection status of online users and updates the authorization attributes (such as ACL and VLAN) assigned by the server.

The device reauthenticates online 802.1X users at the periodic reauthentication interval when the periodic online user reauthentication feature is enabled. The interval is controlled by a timer and the timer is user configurable. A change to the periodic reauthentication timer applies to online users only after the old timer expires and the users pass authentication.

The server-assigned session timeout timer (Session-Timeout attribute) and termination action (Termination-Action attribute) together can affect the periodic online user reauthentication feature. To display the server-assigned Session-Timeout and Termination-Action attributes, use the **`display dot1x connection`** command (see *Security Command Reference*).

- If the termination action is **Default** (logoff), periodic online user reauthentication on the device takes effect only when the periodic reauthentication timer is shorter than the session timeout timer.
- If the termination action is **Radius-request**, the periodic online user reauthentication settings on the device do not take effect. The device reauthenticates the online 802.1X users after the session timeout timer expires.

If no session timeout timer is assigned by the server, whether the device performs periodic 802.1X reauthentication depends on the periodic reauthentication configuration on the device. Support for the assignment of Session-Timeout and Termination-Action attributes depends on the server model.

With the RADIUS DAS feature enabled, the device immediately reauthenticates a user upon receiving a CoA message that carries the reauthentication attribute from a RADIUS authentication server. In this case, reauthentication will be performed regardless of whether 802.1X periodic reauthentication is enabled on the device. For more information about RADIUS DAS configuration, see "Configuring AAA."

By default, the device logs off online 802.1X users if no server is reachable for 802.1X reauthentication. The keep-online feature keeps authenticated 802.1X users online when no server is reachable for 802.1X reauthentication.

The VLANs assigned to an online user before and after reauthentication can be the same or different.

EAD assistant

Endpoint Admission Defense (EAD) is an H3C integrated endpoint access control solution to improve the threat defensive capability of a network. The solution enables the security client, security policy server, access device, and third-party server to operate together. If a terminal device seeks to access an EAD network, it must have an EAD client, which performs 802.1X authentication.

The EAD assistant feature enables the access device to redirect the HTTP or HTTPS requests of a user to a redirect URL for downloading and installing an EAD client. This feature eliminates the administrative task to deploy EAD clients.

EAD assistant is implemented by the following functionality:

- Free IP.

  A free IP is a freely accessible network segment, which has a limited set of network resources such as software and DHCP servers. To ensure security strategy compliance, an unauthenticated user can access only this segment to perform operations. For example, the user can download EAD client from a software server or obtain a dynamic IP address from a DHCP server.

- Redirect URL.

  If an unauthenticated 802.1X user is using a Web browser to access the network, EAD assistant redirects the network access requests of the user to a specific URL. For example, you can use this feature to redirect the user to the EAD client software download page.

The EAD assistant feature creates an ACL-based EAD rule automatically to open access to the redirect URL for each redirected user.

EAD rules are implemented by using ACL resources. When the EAD rule timer expires or the user passes authentication, the rule is removed. If users fail to download EAD client or fail to pass authentication before the timer expires, they must reconnect to the network to access the free IP.

Configuring 802.1X

Restrictions and guidelines: 802.1X configuration

You can configure the port security feature to perform 802.1X. Port security combines and extends 802.1X and MAC authentication. It applies to a network (a WLAN, for example) that requires different authentication methods for different users on a port. For more information about the port security feature, see "Configuring port security."

When you configure 802.1X settings on an interface, follow these restrictions and guidelines:

- 802.1X is supported only on Layer 2 Ethernet interfaces that do not belong to an aggregation group.
- Do not change the link type of a port when the 802.1X guest VLAN, Auth-Fail VLAN, or critical VLAN on the port has users.
- If multiple authentication methods are configured for the authentication domain and RADIUS remote authentication is the primary method, the device will not add users to the critical VLAN when the RADIUS is unreachable. Instead, it uses a backup authentication method to authentication users. The device adds a user to the critical VLAN only when RADIUS remote authentication is the final authentication method used for the user and the RADIUS server is unreachable.

  To configure multiple authentication methods for an authentication domain, use the **`authentication default`** command.

To ensure a successful HTTPS redirect for users in either of the following situations, make sure VLAN interfaces exist for the VLANs that transport their packets:

- The users are assigned a redirect URL.
- EAD assistant is enabled.

802.1X tasks at a glance

To configure 802.1X authentication, perform the following tasks:

1. Enabling 802.1X
2. Configuring basic 802.1X features
   - Enabling EAP relay or EAP termination
   - Setting the port authorization state
   - Specifying an access control method
   - (Optional.) Specifying a mandatory authentication domain on a port
   - (Optional.) Setting the 802.1X authentication timeout timers
   - (Optional.) Configuring 802.1X reauthentication
   - (Optional.) Setting the quiet timer
3. (Optional.) Configuring 802.1X VLAN assignment
   - Configuring an 802.1X guest VLAN
   - Enabling 802.1X guest VLAN assignment delay
   - Configuring an 802.1X Auth-Fail VLAN
   - Configuring an 802.1X critical VLAN
   - Enabling the 802.1X critical voice VLAN feature
4. (Optional.) Setting the upper limit for 802.1X parameters

- Setting the maximum number of concurrent 802.1X users on a port
- Setting the maximum number of authentication request attempts
- Setting the maximum number of 802.1X authentication attempts for MAC authenticated users

5. (Optional.) Configuring other 802.1X features
   - Configuring 802.1X unauthenticated user aging
   - Sending EAP-Success packets on assignment of users to the 802.1X critical VLAN
   - Enabling 802.1X online user synchronization
   - Configuring the authentication trigger feature

     Perform this task when 802.1X clients cannot initiate authentication.
   - Discarding duplicate 802.1X EAPOL-Start requests
   - Configuring online user handshake
   - Configuring packet detection for 802.1X authentication
   - Specifying supported domain name delimiters
   - Removing the VLAN tags of 802.1X protocol packets sent out of a port
   - Enabling 802.1X user IP freezing
   - Enabling generation of dynamic IPSG binding entries for 802.1X authenticated users
   - Configuring 802.1X MAC address binding
   - Configuring the EAD assistant feature
   - Setting the maximum size of EAP-TLS fragments sent to the server

     Use this feature to reduce the size of authentication packets sent to the server when the device uses EAP-TLS authentication method in EAP relay mode.
   - Logging off 802.1X users
   - Enabling 802.1X user logging

Prerequisites for 802.1X

Before you configure 802.1X, complete the following tasks:

- Configure an ISP domain and AAA scheme (local or RADIUS authentication) for 802.1X users.
- If RADIUS authentication is used, create user accounts on the RADIUS server.
- If local authentication is used, create local user accounts on the access device and set the service type to **lan-access**.

Enabling 802.1X

Restrictions and guidelines

For 802.1X to take effect on a port, you must enable it both globally and on the port.

If the PVID is a voice VLAN, the 802.1X feature cannot take effect on the port. For more information about voice VLANs, see *Layer 2—LAN Switching Configuration Guide*.

Procedure

1. Enter system view.

   `system-view`
2. Enable 802.1X globally.

   `dot1x`

By default, 802.1X is disabled globally.

3. Enter interface view.

   interface *interface-type interface-number*

4. Enable 802.1X on a port.

   dot1x

   By default, 802.1X is disabled on a port.

Enabling EAP relay or EAP termination

About EAP mode selection

Consider the following factors to select a proper EAP mode:

- Support of the RADIUS server for EAP packets.
- Authentication methods supported by the 802.1X client and the RADIUS server.

Restrictions and guidelines

- If EAP relay mode is used, the **user-name-format** command configured in RADIUS scheme view does not take effect. The access device sends the authentication data from the client to the server without any modification. For more information about the **user-name-format** command, see *Security Command Reference*.
- You can use both EAP termination and EAP relay in any of the following situations:
  - The client is using only MD5-Challenge EAP authentication. If EAP termination is used, you must enable CHAP authentication on the access device.
  - The client is an iNode 802.1X client and initiates only the username and password EAP authentication. If EAP termination is used, you can enable either PAP or CHAP authentication on the access device. However, for the purpose of security, you must use CHAP authentication on the access device.
- To use EAP-TLS, PEAP, or any other EAP authentication methods, you must use EAP relay. When you make your decision, see "Comparing EAP relay and EAP termination" for help.

Procedure

1. Enter system view.

   system-view

2. Configure EAP relay or EAP termination.

   dot1x authentication-method { **chap** | **eap** | **pap** }

   By default, the access device performs EAP termination and uses CHAP to communicate with the RADIUS server.

Setting the port authorization state

About port authorization states

The port authorization state determines whether the client is granted access to the network. You can control the following authorization states of a port:

- **Authorized**—Places the port in the authorized state, enabling users on the port to access the network without authentication.
- **Unauthorized**—Places the port in the unauthorized state, denying any access requests from users on the port.

- **Auto**—Places the port initially in unauthorized state to allow only EAPOL packets to pass. After a user passes authentication, sets the port in the authorized state to allow access to the network. You can use this option in most scenarios.

Procedure

1. Enter system view.
   system-view
2. Enter interface view.
   interface *interface-type interface-number*
3. Set the port authorization state.
   dot1x port-control { **authorized-force** | **auto** | **unauthorized-force** }
   By default, the **auto** state applies.

Specifying an access control method

About access control methods

The device supports port-based and MAC-based access control methods.

Restrictions and guidelines

If online 802.1X users are present on a port, changing its access control method will cause the online users to go offline.

Procedure

1. Enter system view.
   system-view
2. Enter interface view.
   interface *interface-type interface-number*
3. Specify an access control method.
   dot1x port-method { **macbased** | **portbased** }
   By default, MAC-based access control applies.

Specifying a mandatory authentication domain on a port

About the mandatory authentication domain

You can place all 802.1X users in a mandatory authentication domain for authentication, authorization, and accounting on a port. No user can use an account in any other domain to access the network through the port. The implementation of a mandatory authentication domain enhances the flexibility of 802.1X access control deployment.

Procedure

1. Enter system view.
   system-view
2. Enter interface view.
   interface *interface-type interface-number*
3. Specify a mandatory 802.1X authentication domain on the port.
   dot1x mandatory-domain *domain-name*

By default, no mandatory 802.1X authentication domain is specified.

Setting the 802.1X authentication timeout timers

About 802.1X authentication timeout timers

The network device uses the following 802.1X authentication timeout timers:

- **Client timeout timer**—Starts when the access device sends an EAP-Request/MD5-Challenge packet to a client. If no response is received when this timer expires, the access device retransmits the request to the client.
- **Server timeout timer**—Starts when the access device sends a RADIUS Access-Request packet to the authentication server. If no response is received when this timer expires, the 802.1X authentication fails.

Restrictions and guidelines

In most cases, the default settings are sufficient. You can edit the timers, depending on the network conditions.

- In a low-speed network, increase the client timeout timer.
- In a network with authentication servers of different performance, adjust the server timeout timer.

To avoid forced logoff before the server timeout timer expires, set the server timeout timer to a value that is lower than or equal to the product of the following values:

- The maximum number of RADIUS packet transmission attempts set by using the **retry** command in RADIUS scheme view.
- The RADIUS server response timeout timer set by using the **timer response-timeout** command in RADIUS scheme view.

For information about setting the maximum number of RADIUS packet transmission attempts and the RADIUS server response timeout timer, see "Configuring AAA."

Procedure

1. Enter system view.
   system-view
2. Set the client timeout timer.
   dot1x timer supp-timeout *supp-timeout-value*
   The default is 30 seconds.
3. Set the server timeout timer.
   dot1x timer server-timeout *server-timeout-value*
   The default is 100 seconds.

Configuring 802.1X reauthentication

Restrictions and guidelines

The device selects a periodic reauthentication timer for 802.1X reauthentication in the following order:

1. Server-assigned reauthentication timer.
2. Port-specific reauthentication timer.
3. Global reauthentication timer.
4. Default reauthentication timer.

After you perform a manual reauthentication, the device reauthenticates all online 802.1X users on a port regardless of the server-assigned reauthentication attribute and the periodic reauthentication feature on the port.

Modification to the mandatory authentication domain or EAP message handling method setting does not affect the reauthentication of online 802.1X users. The modified setting takes effect only on 802.1X users that come online after the modification.

If periodic reauthentication is triggered for a user while that user is waiting for online synchronization, the system performs online synchronization and does not perform reauthentication for the user.

Procedure

1. Enter system view.

   system-view
2. Set the periodic reauthentication timer.
   - Set a global periodic reauthentication timer.

     dot1x timer reauth-period *reauth-period-value*

     The default setting is 3600 seconds.
   - Execute the following commands in sequence to set a port-specific periodic reauthentication timer:

     interface *interface-type interface-number*

     dot1x timer reauth-period *reauth-period-value*

     quit

     By default, no periodic reauthentication timer is set on a port. The port uses the global 802.1X periodic reauthentication timer.
3. Enter interface view.

   interface *interface-type interface-number*
4. Enable periodic online user reauthentication.

   dot1x re-authenticate

   By default, the feature is disabled.
5. (Optional.) Manually reauthenticate all online 802.1X users on the port.

   dot1x re-authenticate manual
6. (Optional.) Enable the keep-online feature for 802.1X users.

   dot1x re-authenticate server-unreachable keep-online

   By default, this feature is disabled. The device logs off online 802.1X users if no authentication server is reachable for 802.1X reauthentication.

   Use the keep-online feature according to the actual network condition. In a fast-recovery network, you can use the keep-online feature to prevent 802.1X users from coming online and going offline frequently.

Setting the quiet timer

About the quiet timer

The quiet timer enables the access device to wait a period of time before it can process any authentication request from a client that has failed an 802.1X authentication.

Restrictions and guidelines

You can edit the quiet timer, depending on the network conditions.

- In a vulnerable network, set the quiet timer to a high value.

- In a high-performance network with quick authentication response, set the quiet timer to a low value.

Procedure

1. Enter system view.

   system-view
2. Enable the quiet timer.

   dot1x quiet-period

   By default, the timer is disabled.
3. Set the quiet timer.

   dot1x timer quiet-period *quiet-period-value*

   The default is 60 seconds.

Configuring an 802.1X guest VLAN

Restrictions and guidelines

- You can configure only one 802.1X guest VLAN on a port. The 802.1X guest VLANs on different ports can be different.
- Assign different IDs to the port VLAN, the voice VLAN, and the 802.1X guest VLAN on a port. The assignment makes sure the port can correctly process incoming VLAN-tagged traffic.
- For the 802.1X guest VLAN feature to work correctly, do not configure this feature together with EAD assistant.
- On a hybrid port, the guest VLAN can only be an untagged VLAN.
- If a voice VLAN and an 802.1X guest VLAN are both configured on a hybrid port, the voice VLAN has higher priority than the 802.1X guest VLAN. A packet is forwarded out of the voice VLAN if it matches the voice VLAN settings. If it does not match the voice VLAN settings, its source MAC address might be added to the 802.1X guest VLAN.
- When you configure multiple security features on a port, follow the guidelines in Table 5.

  Table 5 Relationships of the 802.1X guest VLAN and other security features

Feature	Relationship description	Reference
802.1X Auth-Fail VLAN on a port that performs MAC-based access control	The 802.1X Auth-Fail VLAN has a higher priority than the 802.1X guest VLAN.	See "802.1X VLAN manipulation."
Port intrusion protection actions on a port that performs MAC-based access control	The 802.1X guest VLAN feature has higher priority than the block MAC action. The 802.1X guest VLAN feature has lower priority than the shutdown port action of the port intrusion protection feature.	See "Configuring port security."

Prerequisites

Before you configure an 802.1X guest VLAN, complete the following tasks:

- Create the VLAN to be specified as the 802.1X guest VLAN.
- If the 802.1X-enabled port performs MAC-based access control, perform the following operations for the port:
  - Configure the port as a hybrid port.

    - Enable MAC-based VLAN on the port. For more information about MAC-based VLANs, see *Layer 2—LAN Switching Configuration Guide*.
- If the port type is hybrid, verify that the VLAN to be specified as the guest VLAN is not in the tagged VLAN list on the port.

Procedure

1. Enter system view.
   system-view
2. Enter interface view.
   interface *interface-type interface-number*
3. Configure the 802.1X guest VLAN on the port.
   dot1x guest-vlan *guest-vlan-id*
   By default, no 802.1X guest VLAN exists on a port.

Enabling 802.1X guest VLAN assignment delay

About 802.1X guest VLAN assignment delay

This feature delays assigning an 802.1X-enabled port to the 802.1X guest VLAN when 802.1X authentication is triggered on the port.

This feature applies only to situations where 802.1X authentication is triggered by EAPOL-Start packets from 802.1X clients or packets from unknown MAC addresses.

To use this feature, the 802.1X-enabled port must perform MAC-based access control. To use the new MAC-triggered 802.1X guest VLAN assignment delay, you must also configure 802.1X unicast trigger on the port.

When 802.1X authentication is triggered on a port, the device performs the following operations:

1. Sends a unicast EAP-Request/Identity packet to the MAC address that triggers the authentication.
2. Retransmits the packet if no response is received within the username request timeout interval set by using the **dot1x timer tx-period** command.
3. Assigns the port to the 802.1X guest VLAN after the maximum number of request attempts set by using the **dot1x retry** command is reached.

Procedure

1. Enter system view.
   system-view
2. Enter interface view.
   interface *interface-type interface-number*
3. Enable 802.1X guest VLAN assignment delay on the port.
   dot1x guest-vlan-delay { **eapol** | **new-mac** }
   By default, 802.1X guest VLAN assignment delay is disabled on a port.

Configuring an 802.1X Auth-Fail VLAN

Restrictions and guidelines

- Assign different IDs to the port VLAN, the voice VLAN, and the 802.1X Auth-Fail VLAN on a port. The assignment makes sure the port can correctly process VLAN-tagged incoming traffic.

- You can configure only one 802.1X Auth-Fail VLAN on a port. The 802.1X Auth-Fail VLANs on different ports can be different.
- On a hybrid port, the Auth-Fail VLAN can only be an untagged VLAN.
- When you configure multiple security features on a port, follow the guidelines in Table 6.

Table 6 Relationships of the 802.1X Auth-Fail VLAN with other features

Feature	Relationship description	Reference
MAC authentication guest VLAN on a port that performs MAC-based access control	The 802.1X Auth-Fail VLAN has a high priority.	See "Configuring MAC authentication."
Port intrusion protection actions on a port that performs MAC-based access control	The 802.1X Auth-Fail VLAN feature has higher priority than the block MAC action. The 802.1X Auth-Fail VLAN feature has lower priority than the shutdown port action of the port intrusion protection feature.	See "Configuring port security."

Prerequisites

Before you configure an 802.1X Auth-Fail VLAN, complete the following tasks:

- Create the VLAN to be specified as the 802.1X Auth-Fail VLAN.
- If the 802.1X-enabled port performs MAC-based access control, perform the following operations for the port:
  - Configure the port as a hybrid port.
  - Enable MAC-based VLAN on the port. For more information about MAC-based VLANs, see *Layer 2—LAN Switching Configuration Guide*.
- If the port type is hybrid, verify that the VLAN to be specified as the Auth-Fail VLAN is not in the tagged VLAN list on the port.

Procedure

1. Enter system view.
   `system-view`
2. Enter interface view.
   `interface` *`interface-type interface-number`*
3. Configure the 802.1X Auth-Fail VLAN on the port.
   `dot1x auth-fail vlan` *`authfail-vlan-id`*
   By default, no 802.1X Auth-Fail VLAN exists on a port.

Configuring an 802.1X critical VLAN

Restrictions and guidelines for 802.1X critical VLAN configuration

- Assign different IDs to the PVID, the voice VLAN, and the 802.1X critical VLAN on a port. The assignment makes sure the port can correctly process VLAN-tagged incoming traffic.
- You can configure only one 802.1X critical VLAN on a port. The 802.1X critical VLANs on different ports can be different.
- On a hybrid port, the critical VLAN can only be an untagged VLAN.

Prerequisites

Before you configure an 802.1X critical VLAN, complete the following tasks:

- Create the VLAN to be specified as a critical VLAN.
- If the 802.1X-enabled port performs MAC-based access control, perform the following operations for the port:
  - Configure the port as a hybrid port.
  - Enable MAC-based VLAN on the port. For more information about MAC-based VLANs, see *Layer 2—LAN Switching Configuration Guide*.
- If the port type is hybrid, verify that the VLAN to be specified as the critical VLAN is not in the tagged VLAN list on the port.

Procedure

1. Enter system view.

   system-view
2. Enter interface view.

   interface *interface-type interface-number*
3. Configure the 802.1X critical VLAN on the port.

   dot1x critical vlan *critical-vlan-id*

   By default, no 802.1X critical VLAN exists on a port.

Enabling the 802.1X critical voice VLAN feature

Hardware and feature compatibility

This feature is not supported on the following switch series:

- S5000E-X.
- S5110V2-SI.
- S5000V3-EI.
- S5000V5-EI.
- S5000X-EI.
- WAS6000.

Restrictions and guidelines

The feature does not take effect if the voice user has been in the 802.1X Auth-Fail VLAN.

Prerequisites

Before you enable the 802.1X critical voice VLAN feature on a port, complete the following tasks:

- Enable LLDP both globally and on the port.

  The device uses LLDP to identify voice users. For information about LLDP, see *Layer 2—LAN Switching Configuration Guide*.
- Enable voice VLAN on the port.

  For information about voice VLANs, see *Layer 2—LAN Switching Configuration Guide*.
- Specify an 802.1X critical VLAN on the port. This setting ensures that a voice user is assigned to the critical VLAN if it has failed authentication for unreachability of RADIUS servers before the device recognizes it as a voice user. If an 802.1X critical VLAN is not available, the voice user might be logged off instead.

Procedure

1. Enter system view.
   system-view
2. Enter interface view.
   interface *interface-type interface-number*
3. Enable the 802.1X critical voice VLAN feature on a port.
   dot1x critical-voice-vlan
   By default, the 802.1X critical voice VLAN feature is disabled on a port.

Configuring 802.1X unauthenticated user aging

About 802.1X unauthenticated user aging

802.1X unauthenticated user aging applies to users added to an 802.1X guest, critical, or Auth-Fail VLAN because they have not been authenticated or have failed authentication.

When a user in one of those VLANs ages out, the device removes the user from the VLAN and deletes the MAC address entry for the user from the access port.

For users in one of those VLANs on one port to be authenticated successfully and come online on another port, enable this feature. In any other scenarios, disable this feature as a best practice.

The 802.1X user aging mechanism on a port depends on its access control mode.

- If the port uses port-based access control, a user aging timer starts when the port is assigned to the critical or Auth-Fail VLAN. When the aging timer expires, the port is removed from the VLAN and all MAC address entries for users in the VLAN are also removed.
- If the port uses MAC-based access control, a user aging timer starts for each 802.1X user when they are assigned to the Auth-Fail, critical, or guest VLAN. When the aging timer for a user expires, the device removes that user from the VLAN.

The removed users will be unable to access any network resources until after another authentication is triggered.

Restrictions and guidelines

As a best practice, use this feature on a port only if you want to have its unauthenticated users to be authenticated and come online on a different port.

Procedure

1. Enter system view.
   system-view
2. Set the user aging timer for a type of 802.1X VLAN.
   dot1x timer user-aging { **auth-fail-vlan** | **critical-vlan** | **guest-vlan** } *aging-time-value*
   By default, the user aging timers for all applicable types of 802.1X VLANs are 1000 seconds.
3. Enter interface view.
   interface *interface-type interface-number*
4. Enable 802.1X unauthenticated user aging.
   dot1x unauthenticated-user aging enable
   By default, 802.1X unauthenticated user aging is enabled.

Sending EAP-Success packets on assignment of users to the 802.1X critical VLAN

About this task

By default, the device sends EAP-Failure packets to 802.1X clients when the client users are assigned to the 802.1X critical VLAN. Some 802.1X clients, such as Windows built-in 802.1X clients, cannot respond to the EAP-Request/Identity packet from the device for reauthentication if they have received an EAP-Failure packet. As a result, reauthentication for these clients will fail after the authentication server becomes reachable.

To avoid this situation, enable the device to send EAP-Success packets instead of EAP-Failure packets to 802.1X clients when the client users are assigned to the 802.1X critical VLAN.

Procedure

1. Enter system view.

   system-view

2. Enter interface view.

   interface *interface-type interface-number*

3. Configure the device to send an EAP-Success packet to an 802.1X client when its client user is assigned to the critical VLAN on the port.

   dot1x critical eapol

   By default, the device sends an EAP-Failure packet to an 802.1X client when its client user is assigned to the critical VLAN.

Enabling 802.1X online user synchronization

About 802.1X online user synchronization

IMPORTANT:

This feature takes effect only when the device uses an IMC RADIUS server to authenticate 802.1X users.

To ensure that the RADIUS server maintains the same online 802.1X user information as the device after the server state changes from unreachable to reachable, use this feature.

This feature synchronizes online 802.1X user information between the device and the RADIUS server when the RADIUS server state is detected having changed from unreachable to reachable.

When synchronizing online 802.1X user information on a port with the RADIUS server, the device initiates 802.1X authentication in turn for each authenticated online 802.1X user to the RADIUS server.

If synchronization fails for an online user, the device logs off that user unless the failure occurs because the server has become unreachable again.

Restrictions and guidelines

The amount of time required to complete online user synchronization increases as the number of online users grows. This might result in an increased delay for new 802.1X users and users in the critical VLAN to authenticate or reauthenticate to the RADIUS server and come online.

To have this feature take effect, you must use it in conjunction with the RADIUS server status detection feature, which is configurable with the **radius-server test-profile** command. When you configure this feature, make sure the detection interval is shorter than the RADIUS server quiet timer configured by using the **timer quiet** command in RADIUS scheme view. The server

state changes to active on expiration of the quiet timer regardless of its actual reachability. Setting a shorter detection interval than the quiet timer prevents the RADIUS server status detection feature from falsely reporting the server reachability.

For more information about the RADIUS server status detection feature, see "Configuring AAA."

Procedure

1. Enter system view.
   system-view
2. Enter interface view.
   interface *interface-type interface-number*
3. Enable 802.1X online user synchronization.
   dot1x server-recovery online-user-sync
   By default, 802.1X online user synchronization is disabled.

Configuring the authentication trigger feature

About authentication triggers

The authentication trigger feature enables the access device to initiate 802.1X authentication when 802.1X clients cannot initiate authentication.

This feature provides the multicast trigger and unicast trigger (see 802.1X authentication initiation in "802.1X overview").

Restrictions and guidelines

- Enable the multicast trigger on a port when the clients attached to the port cannot send EAPOL-Start packets to initiate 802.1X authentication.
- Enable the unicast trigger on a port if only a few 802.1X clients are attached to the port and these clients cannot initiate authentication.
- To avoid duplicate authentication packets, do not enable both triggers on a port.
- As a best practice, do not use the unicast trigger on a port that performs port-based access control. If you do so, users on the port might fail to come online correctly.

Procedure

1. Enter system view.
   system-view
2. (Optional.) Set the username request timeout timer.
   dot1x timer tx-period *tx-period-value*
   The default is 30 seconds.
3. Enter interface view.
   interface *interface-type interface-number*
4. Enable an authentication trigger.
   dot1x { **multicast-trigger** | **unicast-trigger** }
   By default, the multicast trigger is enabled, and the unicast trigger is disabled.

Discarding duplicate 802.1X EAPOL-Start requests

About this task

During 802.1X authentication, the device might receive duplicate EAPOL-Start requests from an 802.1X user. By default, the device delivers the duplicate EAPOL-Start requests to the authentication server as long as they are legal. However, this mechanism might result in authentication failure if the authentication server cannot respond to duplicate EAPOL-Start requests. To resolve this issue, perform this task on the user access interface to discard duplicate EAPOL-Start requests.

Restrictions and guidelines

This feature is supported only in Release 6309P01 or later.

As a best practice, perform this task only if the server cannot respond to duplicate EAPOL-Start requests. Do not perform this task in other situations.

Procedure

1. Enter system view.

   system-view
2. Enter Layer 2 Ethernet interface view.

   interface *interface-type interface-number*
3. Discard duplicate EAPOL-Start requests on the interface.

   dot1x duplicate-eapol-start discard

   By default, the device does not discard duplicate EAPOL-Start requests on an interface if the requests are legal.

Setting the maximum number of concurrent 802.1X users on a port

About setting the maximum number of concurrent 802.1X users on a port

Perform this task to prevent the system resources from being overused.

Procedure

1. Enter system view.

   system-view
2. Enter interface view.

   interface *interface-type interface-number*
3. Set the maximum number of concurrent 802.1X users on a port.

   dot1x max-user *max-number*

   The default is 4294967295.

Setting the maximum number of authentication request attempts

About authentication request retransmission

The access device retransmits an authentication request if it does not receive any responses to the request from the client within a period of time. To set the time, use the **dot1x timer tx-period** *tx-period-value* command or the **dot1x timer supp-timeout** *supp-timeout-value* command. The access device stops retransmitting the request if it has made the maximum number of request transmission attempts but still receives no response.

Procedure

1. Enter system view.

   system-view

2. Set the maximum number of attempts for sending an authentication request.

   dot1x retry *retries*

   The default setting is 2.

Configuring online user handshake

About online user handshake

The online user handshake feature checks the connectivity status of online 802.1X users. The access device sends handshake requests (EAP-Request/Identity) to online users at the interval specified by the **dot1x timer handshake-period** command. If the device does not receive any EAP-Response/Identity packets from an online user after it has made the maximum handshake attempts, the device sets the user to offline state. To set the maximum handshake attempts, use the **dot1x retry** command.

Typically, the device does not reply to 802.1X clients' EAP-Response/Identity packets with EAP-Success packets. Some 802.1X clients will go offline if they do not receive the EAP-Success packets for handshake. To avoid this issue, enable the online user handshake reply feature.

If iNode clients are deployed, you can also enable the online user handshake security feature to check authentication information in the handshake packets from clients. This feature can prevent 802.1X users that use illegal client software from bypassing iNode security check, such as dual network interface cards (NICs) detection. If a user fails the handshake security checking, the device sets the user to the offline state.

Restrictions and guidelines

- If the network has 802.1X clients that cannot exchange handshake packets with the access device, disable the online user handshake feature. This operation prevents the 802.1X connections from being incorrectly torn down.
- To use the online user handshake security feature, make sure the online user handshake feature is enabled.
- The online user handshake security feature takes effect only on the network where the iNode client and IMC server are used.
- Enable the online user handshake reply feature only if 802.1X clients will go offline without receiving EAP-Success packets from the device.

Procedure

1. Enter system view.

   system-view

2. (Optional.) Set the handshake timer.

   dot1x timer handshake-period *handshake-period-value*

   The default is 15 seconds.
3. Enter interface view.

   interface *interface-type interface-number*
4. Enable the online user handshake feature.

   dot1x handshake

   By default, the feature is enabled.
5. (Optional.) Enable the online user handshake security feature.

   dot1x handshake secure

   By default, the feature is disabled.
6. (Optional.) Enable the 802.1X online user handshake reply feature.

   dot1x handshake reply enable

   By default, the device does not reply to 802.1X clients' EAP-Response/Identity packets during the online handshake process.

Configuring packet detection for 802.1X authentication

About this task

When packet detection for 802.1X authentication is enabled on a port, the device sends detection packets to 802.1X users connected to that port at offline detection intervals set by using the offline detection timer. If the device does not receive a response from a user after it has made the maximum packet transmission attempts within an offline detection interval, it logs off that user and requests the RADIUS server to stop accounting for the user.

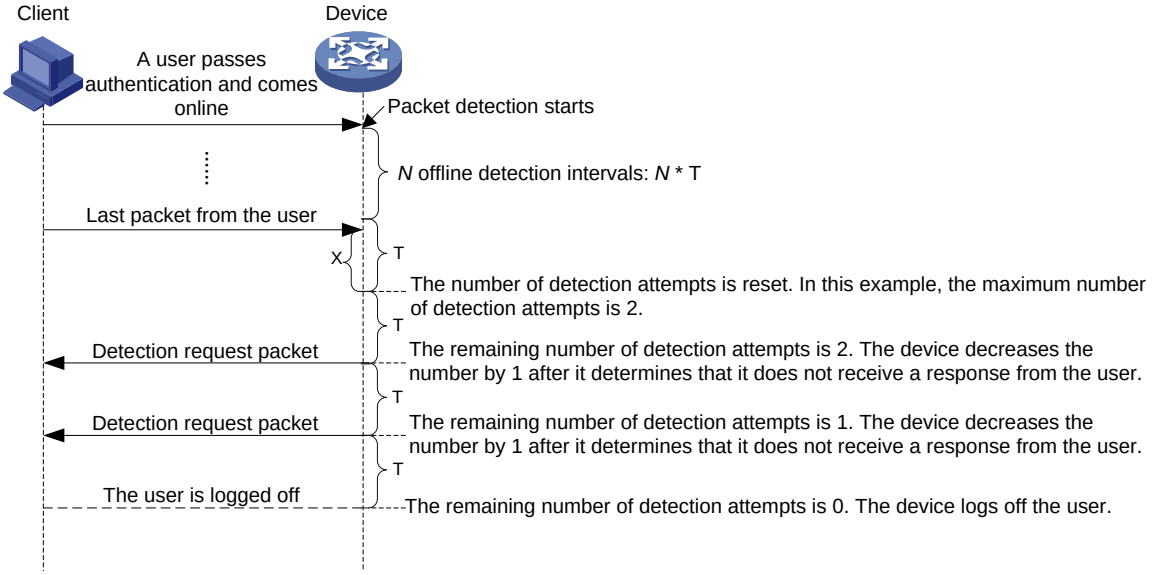
When packet detection for 802.1X authentication and 802.1X offline detection are both enabled, the device processes an 802.1X user as follows:

- If 802.1X offline detection determines that a user is online, the device does not send detection packets to that user.
- If 802.1X offline detection determines that a user is offline, the device does not immediately logs off that user. Instead, the device sends a detection packet to that user. It will log off that user if it does not receive a response from that user after it has made the maximum packet transmission attempts within an offline detection interval.

802.1X uses ARP request packets to detect the online status of IPv4 users and uses NS packets to detect the online status of IPv6 users.

Packet detection adopts the principle of counting prior to judging. The device decreases the detection attempts (packet transmission attempts) by 1 only after it determines that it does not receive a response from a user. The device stops the detection process when the number of detection attempts becomes 0. The duration from the time when the user sends the last packet to the time when the user is logged off is calculated by using the following formula: duration = (*retries* + 1) * T + X. Figure 11 shows the packet detection process. In this example, the device sends a detection packet to an 802.1X user for a maximum of two times.

Figure 11 Network diagram for packet detection process



The duration from the time when the user sends the last packet to the time when the user is logged off equals to 3 * T + X.

Feature and software version compatibility

This feature is supported only in Release 6348P01 and later.

Restrictions and guidelines

To ensure that the device is aware of user IP address changes, enable ARP snooping and ND snooping in conjunction with packet detection for 802.1X authentication. If you do not enable ARP snooping or ND snooping, the device is unaware of user IP address changes. As a result, the device still sends detection packets to the users' original IP addresses and falsely log off these users.

Procedure

1. Enter system view.
   `system-view`
2. Set the offline detection timer.
   `dot1x timer offline-detect` *`offline-detect-value`*
   By default, the offline detection timer expires in 300 seconds.
3. Enter interface view.
   `interface` *`interface-type interface-number`*
4. Enable packet detection for 802.1X authentication.
   `dot1x packet-detect enable`
   By default, packet detection for 802.1X authentication is disabled.
5. Set the maximum number of attempts for sending a detection packet to an 802.1X user.
   `dot1x packet-detect retry` *`retries`*
   By default, the device sends a detection packet to an 802.1X user for a maximum of two times.

Specifying supported domain name delimiters

About supported domain name delimiters

By default, the access device supports the at sign (@) as the delimiter. You can also configure the access device to accommodate 802.1X users that use other domain name delimiters. The

configurable delimiters include the at sign (@), backslash (\), dot (.), and forward slash (/). Usernames that include domain names can use the format of *username@domain-name*, *domain-name******username*, *username***.***domain-name*, or *username***/***domain-name*.

If an 802.1X username string contains multiple configured delimiters, the rightmost delimiter is the domain name delimiter. For example, if you configure the backslash (\), dot (.), and forward slash (/) as delimiters, the domain name delimiter for the username string 121.123/22\@abc is the backslash (\). The username is @**abc** and the domain name is **121.123/22**.

Restrictions and guidelines

If a username string contains none of the delimiters, the access device authenticates the user in the mandatory or default ISP domain.

If you configure the access device to send usernames with domain names to the RADIUS server, make sure the domain delimiter can be recognized by the RADIUS server. For username format configuration, see the **user-name-format** command in *Security Command Reference*.

Procedure

1. Enter system view.

   system-view

2. Specify a set of domain name delimiters for 802.1X users.

   dot1x domain-delimiter *string*

   By default, only the at sign (@) delimiter is supported.

Removing the VLAN tags of 802.1X protocol packets sent out of a port

About removing the VLAN tags of 802.1X protocol packets sent out of a port

This feature operates on a hybrid port to have it send 802.1X protocol packets with their VLAN tags removed, regardless of whether the port is a tagged or untagged member of a VLAN.

Use this feature if the 802.1X-enabled hybrid port is a tagged member of its PVID and the attached 802.1X clients cannot recognize VLAN-tagged 802.1X protocol packets.

Restrictions and guidelines

This feature removes the VLAN tags of all 802.1X protocol packets sent out of the port to 802.1X clients. Do not use this feature if VLAN-aware 802.1X clients are attached to the port. As a best practice, perform this task only in the described applicable scenario.

Prerequisites

Set the link type of the 802.1X-enabled port to hybrid. For more information, see VLAN configuration in *Layer 2 LAN Switching Configuration Guide*.

Procedure

1. Enter system view.

   system-view

2. Enter interface view.

   interface *interface-type interface-number*

3. Remove the VLAN tags of all 802.1X protocol packets sent out of the port to 802.1X clients.

   dot1x eapol untag

   By default, whether the device removes the VLAN tags of all 802.1X protocol packets sent out of a port to 802.1X clients depends on the configuration in the VLAN module.

CAUTION:

This command removes the VLAN tags of all 802.1X protocol packets sent out of the port to 802.1X clients. Do not use this command if VLAN-aware 802.1X clients are attached to the port. As a best practice, use this command only in the described applicable scenario.

Setting the maximum number of 802.1X authentication attempts for MAC authenticated users

About authentication attempts for MAC authenticated users

When a port uses both 802.1X authentication and MAC authentication, the device accepts 802.1X authentication requests from MAC authenticated users. If a MAC authenticated user passes 802.1X authentication, the user will come online as an 802.1X user. If the user fails 802.1X authentication, the user continues to make 802.1X authentication attempts depending on client configuration.

Perform this task to limit the number of 802.1X authentication attempts made by a MAC authenticated user.

Procedure

1. Enter system view.

   system-view

2. Enter interface view.

   interface *interface-type interface-number*

3. Set the maximum number of 802.1X authentication attempts for MAC authenticated users on the port.

   dot1x after-mac-auth max-attempt *max-attempts*

   By default, the number of 802.1X authentication attempts for MAC authenticated users is not limited on a port.

Enabling 802.1X user IP freezing

About 802.1X user IP freezing

This feature works with the IP source guard feature. 802.1X-based IP source guard requires that 802.1X clients support sending user IP addresses to the access device. The device uses information such as user MAC addresses and IP addresses obtained through 802.1X to generate IPSG bindings to filter out IPv4 packets from unauthenticated 802.1X users. For information about IP source guard, see "Configuring IP source guard."

This feature prevents any authenticated 802.1X users on a port from changing their IP addresses. After you enable this feature, the port does not update the IP addresses in dynamic IPSG bindings for 802.1X users. If an 802.1X user uses an IP address different from the IP address in its IPSG binding entry, the port denies the user access.

Procedure

1. Enter system view.

   system-view

2. Enter interface view.

   interface *interface-type interface-number*

3. Enable 802.1X user IP freezing.

   dot1x user-ip freeze

   By default, 802.1X user IP freezing is disabled.

Enabling generation of dynamic IPSG binding entries for 802.1X authenticated users

About this task

IMPORTANT:

This feature must operate in conjunction with the IP source guard (IPSG) feature.

By default, the device generates a dynamic IPv4SG or IPv6SG binding entry for an 802.1X authenticated user after the user obtains a static or DHCP assigned IP address.

To improve security by allowing only 802.1X users with DHCP assigned IP addresses to access the network, perform the following operations:

- Enable IPSG.
- Disable generation of dynamic IPv4SG or IPv6SG binding entries for 802.1X authenticated users.
- Enable DHCP snooping. The device will generate IPv4SG or IPv6SG binding entries for the users based on DHCP snooping.

For more information about IPSG, see IP source guard in *Security Configuration Guide*.

Software version and feature compatibility

This feature is supported only in Release 6340 and later.

Restrictions and guidelines

This feature takes effect only on 802.1X users that come online after the feature is enabled. If the IP address of an online 802.1X user changes, the device updates the dynamic IPv4SG or IPv6SG binding entry for that user.

Disabling this feature does not delete the existing dynamic IPv4SG or IPv6SG binding entries for online 802.1X users. If the IP address of an online 802.1X user changes after the feature is disabled, the device deletes the dynamic IPv4SG or IPv6SG binding entry for that user.

Procedure

1. Enter system view.

   system-view

2. Enter interface view.

   interface *interface-type interface-number*

3. Enable generation of dynamic IPv4SG or IPv6SG binding entries for 802.1X authenticated users.

   dot1x { **ip-verify-source** | **ipv6-verify-source** } **enable**

   By default, generation of dynamic IPv4SG or IPv6SG binding entries for 802.1X authenticated users is enabled.

Configuring 802.1X MAC address binding

About 802.1X MAC address binding

This feature can automatically bind MAC addresses of authenticated 802.1X users to the users' access port and generate 802.1X MAC address binding entries. You can also use the **dot1x mac-binding** *mac-address* command to manually add 802.1X MAC address binding entries.

802.1X MAC address binding entries never age out. They can survive a user logoff or a device reboot. If users in the 802.1X MAC address binding entries perform 802.1X authentication on another port, they cannot pass authentication.

Restrictions and guidelines

The 802.1X MAC address binding feature takes effect only when the port performs MAC-based access control.

To delete an 802.1X MAC address binding entry, use the **undo dot1x mac-binding** *mac-address* command. An 802.1X MAC address binding entry cannot be deleted when the user in the entry is online.

After the number of 802.1X MAC address binding entries reaches the upper limit of concurrent 802.1X users (set by using the **dot1x max-user** command), the following restrictions exist:

- Users not in the binding entries will fail authentication even after users in the binding entries go offline.
- New 802.1X MAC address binding entries are not allowed.

Procedure

1. Enter system view.
   system-view
2. Enter interface view.
   interface *interface-type interface-number*
3. Enable the 802.1X MAC address binding feature.
   dot1x mac-binding enable
   By default, the feature is disabled.
4. (Optional.) Manually add an 802.1X MAC address binding entry.
   dot1x mac-binding *mac-address*
   By default, no 802.1X MAC address binding entries exist on a port.

Configuring the EAD assistant feature

Hardware and feature compatibility

This feature is not supported on the following switch series:

- S5000E-X.
- S5110V2-SI.
- S5000V3-EI.
- S5000V5-EI.
- S5000X-EI.
- WAS6000.

Restrictions and guidelines

When you configure EAD assistant, follow these restrictions and guidelines:

- You must disable MAC authentication and port security globally before you enable the EAD assistant feature.
- To make the EAD assistant feature take effect on an 802.1X-enabled port, you must set the port authorization mode to **auto**.
- When global MAC authentication or port security is enabled, the free IP does not take effect.
- For the 802.1X guest VLAN feature to work correctly, do not enable EAD assistant together with the 802.1X guest VLAN feature.
- As from Release 6331, the **dot1x ead-assistant permit authentication-escape** command is added to remove the 802.1X Auth-Fail VLAN and critical VLAN malfunction issue when EAD assistant is enabled. This command enables the device to remove the EAD entries of users before it assigns the users to 802.1X Auth-Fail and critical VLANs.
- If you use free IP and Auth-Fail VLAN features together, make sure the resources in the Auth-Fail VLAN are on the free IP segments.
- The server that provides the redirect URL must be on the free IP accessible to unauthenticated users.

As from Release 6328, you can use EAD assistant in conjunction with MAC authentication. When you use both EAD assistant and MAC authentication on the device, follow these restrictions and guidelines:

- If both EAD assistant and MAC authentication are configured, the device does not mark the MAC address of a user that has failed MAC authentication as a silent MAC address. If the user has never passed MAC authentication, packets from the user can trigger MAC authentication again only after the user's EAD entry ages out.
- As a best practice, do not configure MAC authentication guest VLANs or critical VLANs. The VLANs might fail to work correctly when both EAD assistant and MAC authentication are configured on the device.
- As a best practice, do not configure the Web authentication or IP source guard feature. These features might fail to work correctly when both EAD assistant and MAC authentication are configured on the device.
- If the MAC address of a user has been marked as a silent MAC address before you enable EAD assistant, packets from the user can trigger 802.1X or MAC authentication only after the quiet timer expires.
- As from Release 6331, the **dot1x ead-assistant permit authentication-escape** command is added to remove the MAC authentication critical VLAN malfunction issue when EAD assistant is enabled. This command enables the device to remove the EAD entries of users before it assigns the users to MAC authentication critical VLANs.

Procedure

1. Enter system view.

   system-view

2. Enable the EAD assistant feature.

   dot1x ead-assistant enable

   By default, this feature is disabled.

3. Configure a free IP.

   dot1x ead-assistant free-ip *ip-address* { *mask-length* | *mask-address* }

   Repeat this command to configure multiple free IPs.

4. (Optional.) Configure the redirect URL if users will use Web browsers to access the network.

   dot1x ead-assistant url *url-string*

By default, no redirect URL exists.

By default, the device listens to port 6654 for HTTPS requests to be redirected. To change the redirect listening port number, see configuring HTTP redirect in *Layer 3—IP Services Configuration Guide*.

5. (Optional.) Set the EAD rule timer.

   dot1x timer ead-timeout *ead-timeout-value*

   The default setting is 30 minutes.

   To avoid using up ACL resources when a large number of EAD users exist, you can shorten the EAD rule timer.

6. (Optional.) Enable support for 802.1X Auth-Fail and critical VLANs and MAC authentication critical VLANs when 802.1X EAD assistant is enabled.

   dot1x ead-assistant permit authentication-escape

   By default, 802.1X Auth-Fail and critical VLANs and MAC authentication critical VLANs cannot take effect when 802.1X EAD assistant is enabled.

   This command is supported only in Release 6331 and later.

Setting the maximum size of EAP-TLS fragments sent to the server

About 802.1X EAP-TLS fragmentation

When the device uses EAP-TLS authentication method in EAP relay mode, the RADIUS packets might exceed the maximum packet size supported by the RADIUS server. This situation typically occurs because long EAP-TLS messages are encapsulated in the EAP-Message attribute of the RADIUS packet sent to the RADIUS server.

To avoid authentication failures caused by oversized packets, fragment the EAP-TLS messages depending on the maximum RADIUS packet size supported by the remote RADIUS server.

For example, the maximum packet length allowed by the server is 1200 bytes and the length of a RADIUS packet (excluding the EAP-Message attribute) is 800 bytes. To make sure the maximum length of a RADIUS packet does not exceed 1200 bytes, you must set the maximum length of an EAP-TLS fragment to a value less than 400 bytes.

Restrictions and guidelines

802.1X EAP-TLS fragmentation takes effect only when EAP relay mode is used. For more information about enabling EAP relay, see "Enabling EAP relay or EAP termination."

Procedure

1. Enter system view.

   system-view

2. Enable 802.1X EAP-TLS fragmentation and set the maximum EAP-TLS fragment size.

   dot1x eap-tls-fragment to-server *eap-tls-max-length*

   By default, EAP-TLS messages are not fragmented.

Logging off 802.1X users

About this task

Perform this task to log off the specified 802.1X users and clear information about these users from the device. These users must perform 802.1X authentication to come online again.

Software version and feature compatibility

This feature is supported only in Release 6318P01 and later.

Procedure

To log off 802.1X users, execute the following command in user view:

reset dot1x access-user [**interface** *interface-type interface-number* | **mac** *mac-address* | **username** *username* | **vlan** *vlan-id*]

Enabling 802.1X user logging

About 802.1X user logging

This feature enables the device to generate logs about 802.1X users and send the logs to the information center. For the logs to be output correctly, you must also configure the information center on the device. For more information about information center configuration, see *Network Management and Monitoring Configuration Guide*.

Restrictions and guidelines

To prevent excessive 802.1X user log entries, use this feature only if you need to analyze abnormal 802.1X user logins or logouts.

Procedure

1. Enter system view.

   system-view

2. Enable 802.1X user logging.

   dot1x access-user log enable [**abnormal-logoff** | **failed-login** | **normal-logoff** | **successful-login**] *

   By default, 802.1X user logging is disabled.

   If you do not specify any parameters, this command enables all types of 802.1X user logs.

Display and maintenance commands for 802.1X

Execute **display** commands in any view and **reset** commands in user view.

Task	Command
Display 802.1X session information, statistics, or configuration information of specified or all ports.	**display dot1x** [**sessions** | **statistics**] [**interface** *interface-type interface-number*]
Display online 802.1X user information.	**display dot1x connection** [**open**] [**interface** *interface-type interface-number* | **slot** *slot-number* | **user-mac** *mac-address* | **user-name** *name-string*]
Display MAC address information of 802.1X users in 802.1X VLANs of a specific type.	**display dot1x mac-address** { **auth-fail-vlan** | **critical-vlan** | **guest-vlan** } [**interface** *interface-type interface-number*]
Remove users from the 802.1X guest VLAN on a port.	**reset dot1x guest-vlan interface** *interface-type interface-number* [**mac-address** *mac-address*]
Clear 802.1X statistics.	**reset dot1x statistics** [**interface**

Task	Command
	interface-type interface-number]

802.1X authentication configuration examples

Example: Configuring basic 802.1X authentication

Network configuration

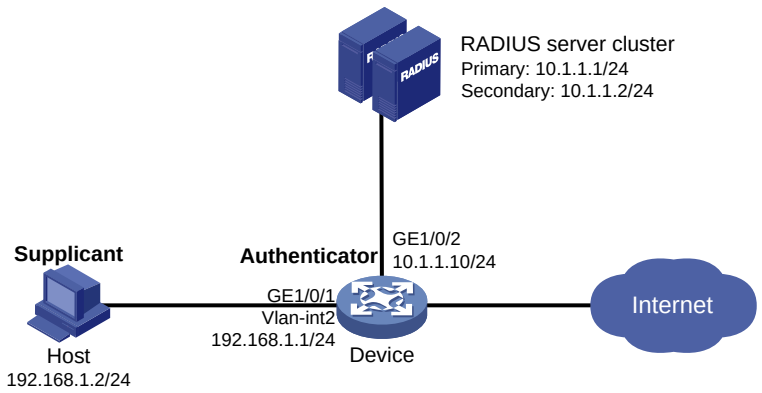
As shown in Figure 12, the access device performs 802.1X authentication for users that connect to GigabitEthernet 1/0/1. Implement MAC-based access control on the port, so the logoff of one user does not affect other online 802.1X users.

Use RADIUS servers to perform authentication, authorization, and accounting for the 802.1X users. If RADIUS authentication fails, perform local authentication on the access device.

Configure the RADIUS server at 10.1.1.1/24 as the primary authentication and accounting server, and the RADIUS server at 10.1.1.2/24 as the secondary authentication and accounting server. Assign all users to ISP domain **bbb**.

Set the shared key to **name** for packets between the access device and the authentication server. Set the shared key to **money** for packets between the access device and the accounting server.

Figure 12 Network diagram



Procedure

For information about the RADIUS commands used on the access device in this example, see *Security Command Reference*.

1. Configure the RADIUS servers and add user accounts for the 802.1X users. Make sure the RADIUS servers can provide authentication, authorization, and accounting services. (Details not shown.)
2. Assign an IP address to each interface. (Details not shown.)
3. Configure user accounts for the 802.1X users on the access device:

   # Add a local network access user with username **localuser** and password **localpass** in plaintext. (Make sure the username and password are the same as those configured on the RADIUS servers.)

   ```
   <Device> system-view
   [Device] local-user localuser class network
   [Device-luser-network-localuser] password simple localpass
   ```

   # Set the service type to **lan-access**.

```
[Device-luser-network-localuser] service-type lan-access
[Device-luser-network-localuser] quit
```

4. Configure a RADIUS scheme on the access device:

   # Create a RADIUS scheme named **radius1** and enter RADIUS scheme view.

   ```
   [Device] radius scheme radius1
   ```

   # Specify the IP addresses of the primary authentication and accounting RADIUS servers.

   ```
   [Device-radius-radius1] primary authentication 10.1.1.1
   [Device-radius-radius1] primary accounting 10.1.1.1
   ```

   # Configure the IP addresses of the secondary authentication and accounting RADIUS servers.

   ```
   [Device-radius-radius1] secondary authentication 10.1.1.2
   [Device-radius-radius1] secondary accounting 10.1.1.2
   ```

   # Specify the shared key between the access device and the authentication server.

   ```
   [Device-radius-radius1] key authentication simple name
   ```

   # Specify the shared key between the access device and the accounting server.

   ```
   [Device-radius-radius1] key accounting simple money
   ```

   # Exclude the ISP domain names from the usernames sent to the RADIUS servers.

   ```
   [Device-radius-radius1] user-name-format without-domain
   [Device-radius-radius1] quit
   ```

   NOTE:

   The access device must use the same username format as the RADIUS server. If the RADIUS server includes the ISP domain name in the username, so must the access device.

5. Configure an ISP domain on the access device:

   # Create an ISP domain named **bbb** and enter ISP domain view.

   ```
   [Device] domain bbb
   ```

   # Apply RADIUS scheme **radius1** to the ISP domain, and specify local authentication as the secondary authentication method.

   ```
   [Device-isp-bbb] authentication lan-access radius-scheme radius1 local
   [Device-isp-bbb] authorization lan-access radius-scheme radius1 local
   [Device-isp-bbb] accounting lan-access radius-scheme radius1 local
   [Device-isp-bbb] quit
   ```

6. Configure 802.1X on the access device:

   # Enable 802.1X on GigabitEthernet 1/0/1.

   ```
   [Device] interface gigabitethernet 1/0/1
   [Device-GigabitEthernet1/0/1] dot1x
   ```

   # Enable MAC-based access control on the port. By default, the port uses MAC-based access control.

   ```
   [Device-GigabitEthernet1/0/1] dot1x port-method macbased
   ```

   # Specify ISP domain **bbb** as the mandatory domain.

   ```
   [Device-GigabitEthernet1/0/1] dot1x mandatory-domain bbb
   [Device-GigabitEthernet1/0/1] quit
   ```

   # Enable 802.1X globally.

   ```
   [Device] dot1x
   ```

7. Configure the 802.1X client. If an iNode client is used, do not select the **Carry version info** option in the client configuration. (Details not shown.)

Verifying the configuration

Verify the 802.1X configuration on GigabitEthernet 1/0/1.

```
[Device] display dot1x interface gigabitethernet 1/0/1
```

Display the user connection information after an 802.1X user passes authentication.

```
[Device] display dot1x connection
```

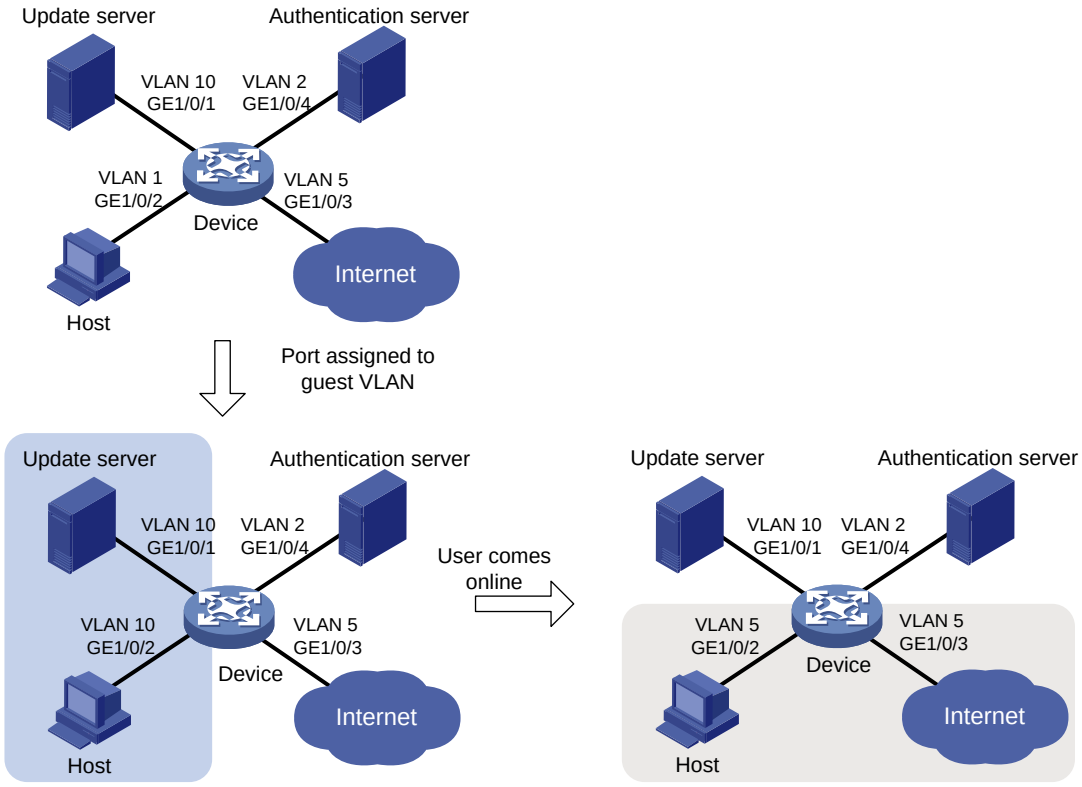
Example: Configuring 802.1X guest VLAN and authorization VLAN

Network configuration

As shown in Figure 13:

- Use RADIUS servers to perform authentication, authorization, and accounting for 802.1X users that connect to GigabitEthernet 1/0/2. Implement port-based access control on the port.
- Configure VLAN 10 as the 802.1X guest VLAN on GigabitEthernet 1/0/2. The host and the update server are both in VLAN 10, and the host can access the update server and download the 802.1X client software.
- Configure a QoS policy to deny packets destined for the Internet (5.1.1.1) and apply the QoS policy to the outbound direction of VLAN 10. The configuration prevents users in the 802.1X guest VLAN from accessing the Internet before they pass 802.1X authentication.
- After the host passes 802.1X authentication, the access device assigns the host to VLAN 5 where GigabitEthernet 1/0/3 is. The host can access the Internet.

Figure 13 Network diagram



Procedure

For information about the RADIUS commands used on the access device in this example, see *Security Command Reference*.

1. Configure the RADIUS server to provide authentication, authorization, and accounting services. Configure user accounts and authorization VLAN (VLAN 5 in this example) for the users. (Details not shown.)
2. Create VLANs, and assign ports to the VLANs on the access device.

   NOTE:

   By default, VLAN 1 exists and all ports belong to the VLAN. You do not need to create the VLAN or assign GigabitEthernet 1/0/2 to the VLAN.

   ```
   <Device> system-view
   [Device] vlan 10
   [Device-vlan10] port gigabitethernet 1/0/1
   [Device-vlan10] quit
   [Device] vlan 2
   [Device-vlan2] port gigabitethernet 1/0/4
   [Device-vlan2] quit
   [Device] vlan 5
   [Device-vlan5] port gigabitethernet 1/0/3
   [Device-vlan5] quit
   ```

3. Configure a QoS policy:

   # Configure advanced ACL 3000 to match packets destined for 5.1.1.1.

   ```
   [Device] acl advanced 3000
   [Device-acl-ipv4-adv-3000] rule permit ip destination 5.1.1.1 0.0.0.255
   [Device-acl-ipv4-adv-3000] quit
   ```

   # Specify advanced ACL 3000 in traffic class **classifier_1** to match traffic.

   ```
   [Device] traffic classifier classifier_1
   [Device-classifier-classifier_1] if-match acl 3000
   [Device-classifier-classifier_1] quit
   ```

   # Configure traffic behavior **behavior_1** to deny matching packets.

   ```
   [Device] traffic behavior behavior_1
   [Device-behavior-behavior_1] filter deny
   [Device-behavior-behavior_1] quit
   ```

   # Configure QoS policy **policy_1** to associate traffic class **classifier_1** with traffic behavior **behavior_1**.

   ```
   [Device] qos policy policy_1
   [Device-qospolicy-policy_1] classifier classifier_1 behavior behavior_1
   [Device-qospolicy-policy_1] quit
   ```

   # Apply QoS policy **policy_1** to the outbound direction of VLAN 10.

   ```
   [Device] qos vlan-policy policy_1 vlan 10 outbound
   ```

4. Configure a RADIUS scheme on the access device:

   # Create RADIUS scheme **2000** and enter RADIUS scheme view.

   ```
   [Device] radius scheme 2000
   ```

   # Specify the server at 10.11.1.1 as the primary authentication server, and set the authentication port to 1812.

   ```
   [Device-radius-2000] primary authentication 10.11.1.1 1812
   ```

Specify the server at 10.11.1.1 as the primary accounting server, and set the accounting port to 1813.

```
[Device-radius-2000] primary accounting 10.11.1.1 1813
```

Set the shared key to **abc** in plain text for secure communication between the authentication server and the device.

```
[Device-radius-2000] key authentication simple abc
```

Set the shared key to **abc** in plain text for secure communication between the accounting server and the device.

```
[Device-radius-2000] key accounting simple abc
```

Exclude the ISP domain names from the usernames sent to the RADIUS server.

```
[Device-radius-2000] user-name-format without-domain
[Device-radius-2000] quit
```

5. Configure an ISP domain on the access device:

Create ISP domain **bbb** and enter ISP domain view.

```
[Device] domain bbb
```

Apply RADIUS scheme 2000 to the ISP domain for authentication, authorization, and accounting.

```
[Device-isp-bbb] authentication lan-access radius-scheme 2000
[Device-isp-bbb] authorization lan-access radius-scheme 2000
[Device-isp-bbb] accounting lan-access radius-scheme 2000
[Device-isp-bbb] quit
```

6. Configure 802.1X on the access device:

Enable 802.1X on GigabitEthernet 1/0/2.

```
[Device] interface gigabitethernet 1/0/2
[Device-GigabitEthernet1/0/2] dot1x
```

Implement port-based access control on the port.

```
[Device-GigabitEthernet1/0/2] dot1x port-method portbased
```

Set the port authorization mode to **auto**. By default, the port uses the auto mode.

```
[Device-GigabitEthernet1/0/2] dot1x port-control auto
```

Specify VLAN 10 as the 802.1X guest VLAN on GigabitEthernet 1/0/2.

```
[Device-GigabitEthernet1/0/2] dot1x guest-vlan 10
[Device-GigabitEthernet1/0/2] quit
```

Enable 802.1X globally.

```
[Device] dot1x
```

7. Configure the 802.1X client. Make sure the 802.1X client can update its IP address after the access port is assigned to the guest VLAN or an authorization VLAN. (Details not shown.)

Verifying the configuration

Verify the 802.1X guest VLAN configuration on GigabitEthernet 1/0/2.

```
[Device] display dot1x interface gigabitethernet 1/0/2
```

Verify that GigabitEthernet 1/0/2 is assigned to VLAN 10 before any user passes authentication on the port.

```
[Device] display vlan 10
```

After a user passes authentication, display information on GigabitEthernet 1/0/2. Verify that GigabitEthernet 1/0/2 is assigned to VLAN 5.

```
[Device] display interface gigabitethernet 1/0/2
```

Example: Configuring 802.1X with ACL assignment

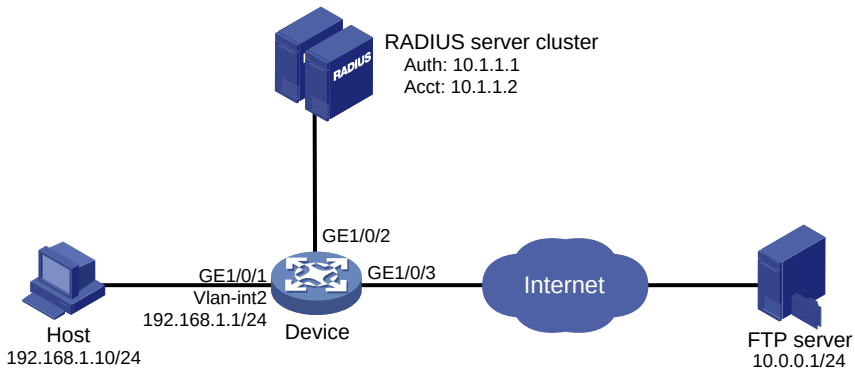
Network configuration

As shown in Figure 14, the host that connects to GigabitEthernet 1/0/1 must pass 802.1X authentication to access the Internet.

Perform 802.1X authentication on GigabitEthernet 1/0/1. Use the RADIUS server at 10.1.1.1 as the authentication and authorization server, and the RADIUS server at 10.1.1.2 as the accounting server.

Configure ACL assignment on GigabitEthernet 1/0/1 to deny access of 802.1X users to the FTP server from 8:00 to 18:00 on weekdays.

Figure 14 Network diagram



Procedure

For information about the RADIUS commands used on the access device in this example, see *Security Command Reference*.

1. Configure the RADIUS servers to provide authentication, authorization, and accounting services. Add user accounts and specify the ACL (ACL 3000 in this example) for the users. (Details not shown.)
2. Assign an IP address to each interface, as shown in Figure 14. (Details not shown.)
3. Configure a RADIUS scheme on the access device:

   # Create RADIUS scheme **2000** and enter RADIUS scheme view.

   ```
   <Device> system-view
   [Device] radius scheme 2000
   ```

   # Specify the server at 10.1.1.1 as the primary authentication server, and set the authentication port to 1812.

   ```
   [Device-radius-2000] primary authentication 10.1.1.1 1812
   ```

   # Specify the server at 10.1.1.2 as the primary accounting server, and set the accounting port to 1813.

   ```
   [Device-radius-2000] primary accounting 10.1.1.2 1813
   ```

   # Set the shared key to **abc** in plain text for secure communication between the authentication server and the device.

   ```
   [Device-radius-2000] key authentication simple abc
   ```

   # Set the shared key to **abc** in plain text for secure communication between the accounting server and the device.

   ```
   [Device-radius-2000] key accounting simple abc
   ```

   # Exclude the ISP domain names from the usernames sent to the RADIUS server.

   ```
   [Device-radius-2000] user-name-format without-domain
   ```

```
[Device-radius-2000] quit
```

4. Configure an ISP domain on the access device:

   # Create ISP domain **bbb** and enter ISP domain view.

   ```
   [Device] domain bbb
   ```

   # Apply RADIUS scheme 2000 to the ISP domain for authentication, authorization, and accounting.

   ```
   [Device-isp-bbb] authentication lan-access radius-scheme 2000
   [Device-isp-bbb] authorization lan-access radius-scheme 2000
   [Device-isp-bbb] accounting lan-access radius-scheme 2000
   [Device-isp-bbb] quit
   ```

5. Configure a time range named **ftp** from 8:00 to 18:00 on weekdays on the access device.

   ```
   [Device] time-range ftp 8:00 to 18:00 working-day
   ```

6. Configure ACL 3000 to deny packets destined for the FTP server at 10.0.0.1 during the specified time range on the access device.

   ```
   [Device] acl advanced 3000
   [Device-acl-ipv4-adv-3000] rule 0 deny ip destination 10.0.0.1 0 time-range ftp
   [Device-acl-ipv4-adv-3000] quit
   ```

7. Configure 802.1X on the access device:

   # Enable 802.1X on GigabitEthernet 1/0/1.

   ```
   [Device] interface gigabitethernet 1/0/1
   [Device-GigabitEthernet1/0/1] dot1x
   [Device-GigabitEthernet1/0/1] quit
   ```

   # Enable 802.1X globally.

   ```
   [Device] dot1x
   ```

8. Configure the 802.1X client. Make sure the client is able to update its IP address after the access port is assigned to the 802.1X guest VLAN or an authorization VLAN. (Details not shown.)

Verifying the configuration

Use the user account to pass authentication. (Details not shown.)

Verify that the user cannot ping the FTP server at any time from 8:00 to 18:00 on any weekday.

```
C:\>ping 10.0.0.1

Pinging 10.0.0.1 with 32 bytes of data:

Request timed out.
Request timed out.
Request timed out.
Request timed out.

Ping statistics for 10.0.0.1:
    Packets: Sent = 4, Received = 0, Lost = 4 (100% loss),
```

The output shows that ACL 3000 is active on the user, and the user cannot access the FTP server.

Example: Configuring 802.1X with EAD assistant (with DHCP relay agent)

Network configuration

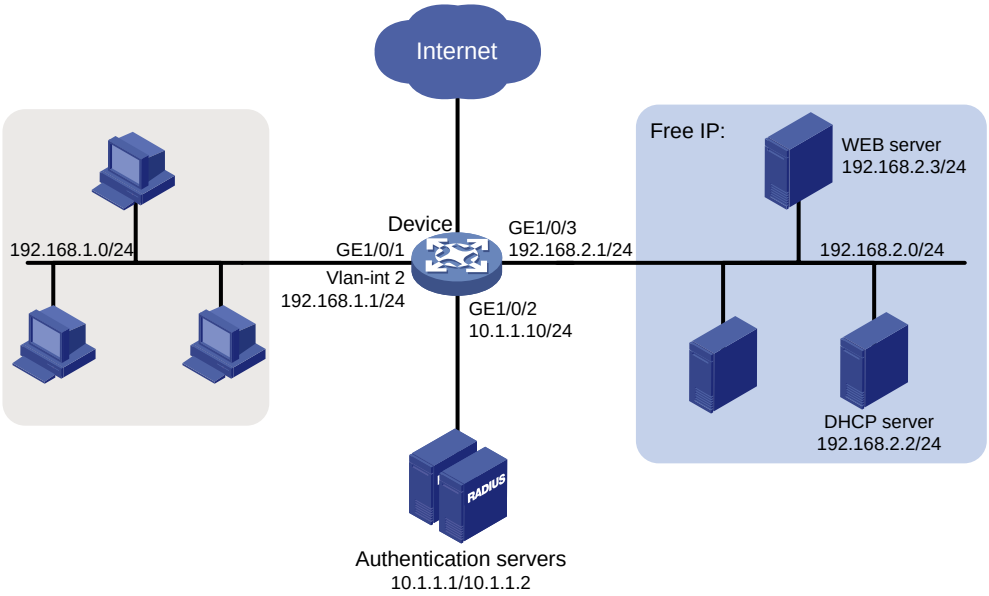
As shown in Figure 15:

- The intranet 192.168.1.0/24 is attached to GigabitEthernet 1/0/1 of the access device.
- The hosts use DHCP to obtain IP addresses.
- A DHCP server and a Web server are deployed on the 192.168.2.0/24 subnet for users to obtain IP addresses and download client software.

Deploy an EAD solution for the intranet to meet the following requirements:

- Allow unauthenticated users and users that have failed 802.1X authentication to access 192.168.2.0/24. The users can obtain IP addresses and download software.
- If these users use a Web browser to access a network other than 192.168.2.0/24, redirect them to the Web server for 802.1X client downloading.
- Allow authenticated 802.1X users to access the network.

Figure 15 Network diagram



Procedure

1. Make sure the DHCP server, the Web server, and the authentication servers have been configured correctly. (Details not shown.)
2. Configure an IP address for each interface. (Details not shown.)
3. Configure DHCP relay:

   # Enable DHCP.

   ```
   <Device> system-view
   [Device] dhcp enable
   ```

   # Enable the DHCP relay agent on VLAN-interface 2.

   ```
   [Device] interface vlan-interface 2
   [Device-Vlan-interface2] dhcp select relay
   ```

   # Specify the DHCP server 192.168.2.2 on the relay agent interface VLAN-interface 2.

```
[Device-Vlan-interface2] dhcp relay server-address 192.168.2.2
[Device-Vlan-interface2] quit
```

4. Configure a RADIUS scheme:

Create RADIUS scheme **2000** and enter RADIUS scheme view.

```
[Device] radius scheme 2000
```

Specify the server at 10.1.1.1 as the primary authentication server, and set the authentication port to 1812.

```
[Device-radius-2000] primary authentication 10.1.1.1 1812
```

Specify the server at 10.1.1.2 as the primary accounting server, and set the accounting port to 1813.

```
[Device-radius-2000] primary accounting 10.1.1.2 1813
```

Set the shared key to **abc** in plain text for secure communication between the authentication server and the device.

```
[Device-radius-2000] key authentication simple abc
```

Set the shared key to **abc** in plain text for secure communication between the accounting server and the device.

```
[Device-radius-2000] key accounting simple abc
```

Exclude the ISP domain names from the usernames sent to the RADIUS server.

```
[Device-radius-2000] user-name-format without-domain
[Device-radius-2000] quit
```

5. Configure an ISP domain:

Create ISP domain **bbb** and enter ISP domain view.

```
[Device] domain bbb
```

Apply RADIUS scheme 2000 to the ISP domain for authentication, authorization, and accounting.

```
[Device-isp-bbb] authentication lan-access radius-scheme 2000
[Device-isp-bbb] authorization lan-access radius-scheme 2000
[Device-isp-bbb] accounting lan-access radius-scheme 2000
[Device-isp-bbb] quit
```

6. Configure 802.1X:

Configure the free IP.

```
[Device] dot1x ead-assistant free-ip 192.168.2.0 24
```

Configure the redirect URL for client software download.

```
[Device] dot1x ead-assistant url http://192.168.2.3
```

Enable the EAD assistant feature.

```
[Device] dot1x ead-assistant enable
```

Enable 802.1X on GigabitEthernet 1/0/1.

```
[Device] interface gigabitethernet 1/0/1
[Device-GigabitEthernet1/0/1] dot1x
[Device-GigabitEthernet1/0/1] quit
```

Enable 802.1X globally.

```
[Device] dot1x
```

Verifying the configuration

Verify the 802.1X configuration.

```
[Device] display dot1x
```

Verify that you can ping an IP address on the free IP subnet from a host.

```
C:\>ping 192.168.2.3
```

```
Pinging 192.168.2.3 with 32 bytes of data:

Reply from 192.168.2.3: bytes=32 time<1ms TTL=128
Reply from 192.168.2.3: bytes=32 time<1ms TTL=128
Reply from 192.168.2.3: bytes=32 time<1ms TTL=128
Reply from 192.168.2.3: bytes=32 time<1ms TTL=128

Ping statistics for 192.168.2.3:
    Packets: Sent = 4, Received = 4, Lost = 0 (0% loss),
Approximate round trip times in milli-seconds:
    Minimum = 0ms, Maximum = 0ms, Average = 0ms
```

The output shows that you can access the free IP subnet before passing 802.1X authentication.

Verify that you are redirected to the Web server when you enter in your Web browser an IP address not on the free IP. (Details not shown.)

Example: Configuring 802.1X with EAD assistant (with DHCP server)

Network configuration

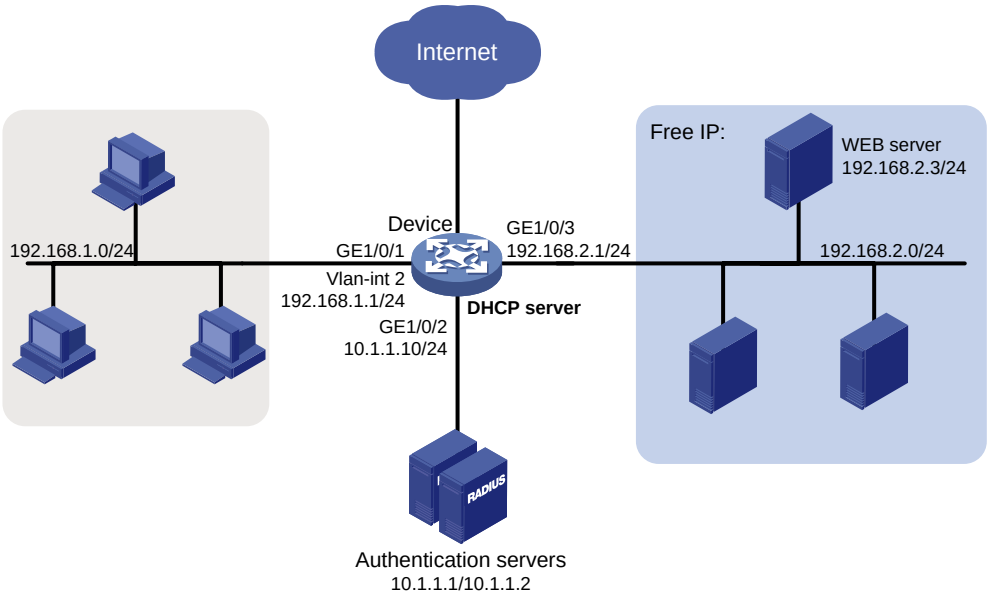
As shown in Figure 16:

- The intranet 192.168.1.0/24 is attached to GigabitEthernet 1/0/1 of the access device.
- The hosts use DHCP to obtain IP addresses.
- A Web server is deployed on the 192.168.2.0/24 subnet for users to download client software.

Deploy an EAD solution for the intranet to meet the following requirements:

- Allow unauthenticated users and users that have failed 802.1X authentication to access 192.168.2.0/24. The users can download software.
- If these users use a Web browser to access a network other than 192.168.2.0/24, redirect them to the Web server for 802.1X client downloading.
- Allow authenticated 802.1X users to access the network.

Figure 16 Network diagram



Procedure

1. Make sure the Web server and the authentication servers have been configured correctly. (Details not shown.)
2. Configure an IP address for each interface. (Details not shown.)
3. Configure the DHCP server:

   # Enable DHCP.

   ```
   <Device> system-view
   [Device] dhcp enable
   ```

   # Enable the DHCP server on VLAN-interface 2.

   ```
   [Device] interface vlan-interface 2
   [Device-Vlan-interface2] dhcp select server
   [Device-Vlan-interface2] quit
   ```

   # Create DHCP address pool **0**.

   ```
   [Device] dhcp server ip-pool 0
   ```

   # Specify subnet 192.168.1.0/24 in DHCP address pool 0.

   ```
   [Device-dhcp-pool-0] network 192.168.1.0 mask 255.255.255.0
   ```

   # Specify the gateway address 192.168.1.1 in DHCP address pool 0.

   ```
   [Device-dhcp-pool-0] gateway-list 192.168.1.1
   [Device-dhcp-pool-0] quit
   ```

4. Configure a RADIUS scheme:

   # Create RADIUS scheme **2000** and enter RADIUS scheme view.

   ```
   [Device] radius scheme 2000
   ```

   # Specify the server at 10.1.1.1 as the primary authentication server, and set the authentication port to 1812.

   ```
   [Device-radius-2000] primary authentication 10.1.1.1 1812
   ```

   # Specify the server at 10.1.1.2 as the primary accounting server, and set the accounting port to 1813.

   ```
   [Device-radius-2000] primary accounting 10.1.1.2 1813
   ```

Set the shared key to **abc** in plain text for secure communication between the authentication server and the device.

```
[Device-radius-2000] key authentication simple abc
```

Set the shared key to **abc** in plain text for secure communication between the accounting server and the device.

```
[Device-radius-2000] key accounting simple abc
```

Exclude the ISP domain names from the usernames sent to the RADIUS server.

```
[Device-radius-2000] user-name-format without-domain
[Device-radius-2000] quit
```

5. Configure an ISP domain:

Create ISP domain **bbb** and enter ISP domain view.

```
[Device] domain bbb
```

Apply RADIUS scheme 2000 to the ISP domain for authentication, authorization, and accounting.

```
[Device-isp-bbb] authentication lan-access radius-scheme 2000
[Device-isp-bbb] authorization lan-access radius-scheme 2000
[Device-isp-bbb] accounting lan-access radius-scheme 2000
[Device-isp-bbb] quit
```

6. Configure 802.1X:

Configure the free IP.

```
[Device] dot1x ead-assistant free-ip 192.168.2.0 24
```

Configure the redirect URL for client software download.

```
[Device] dot1x ead-assistant url http://192.168.2.3
```

Enable the EAD assistant feature.

```
[Device] dot1x ead-assistant enable
```

Enable 802.1X on GigabitEthernet 1/0/1.

```
[Device] interface gigabitethernet 1/0/1
[Device-GigabitEthernet1/0/1] dot1x
[Device-GigabitEthernet1/0/1] quit
```

Enable 802.1X globally.

```
[Device] dot1x
```

Verifying the configuration

Verify the 802.1X configuration.

```
[Device] display dot1x
```

Verify that you can ping an IP address on the free IP subnet from a host.

```
C:\>ping 192.168.2.3

Pinging 192.168.2.3 with 32 bytes of data:

Reply from 192.168.2.3: bytes=32 time<1ms TTL=128
Reply from 192.168.2.3: bytes=32 time<1ms TTL=128
Reply from 192.168.2.3: bytes=32 time<1ms TTL=128
Reply from 192.168.2.3: bytes=32 time<1ms TTL=128

Ping statistics for 192.168.2.3:
    Packets: Sent = 4, Received = 4, Lost = 0 (0% loss),
Approximate round trip times in milli-seconds:
```

```
    Minimum = 0ms, Maximum = 0ms, Average = 0ms
```

The output shows that you can access the free IP subnet before passing 802.1X authentication.

Verify that you are redirected to the Web server when you enter in your Web browser an IP address not on the free IP. (Details not shown.)

Troubleshooting 802.1X

EAD assistant URL redirection failure

Symptom

Unauthenticated users are not redirected to the specified redirect URL after they enter external website addresses in their Web browsers.

Analysis

Redirection will not happen for one of the following reasons:

- The address is in the string format. The operating system of the host regards the string as a website name and tries to resolve the string. If the resolution fails, the operating system sends an ARP request, but the target address is not in the dotted decimal notation. The redirection feature does redirect this kind of ARP request.
- The address is within a free IP segment. No redirection will take place, even if no host is present with the address.
- The redirect URL is not in a free IP segment.
- No server is using the redirect URL, or the server with the URL does not provide Web services.

Solution

To resolve the issue:

1. Enter a dotted decimal IP address that is not in any free IP segments.
2. Verify that the access device and the server are configured correctly.
3. If the issue persists, contact H3C Support.

Contents

Configuring MAC authentication

About MAC authentication

MAC authentication controls network access by authenticating source MAC addresses on a port. The feature does not require client software, and users do not have to enter a username and password for network access. The device initiates a MAC authentication process when it detects an unknown source MAC address on a MAC authentication-enabled port. If the MAC address passes authentication, the user can access authorized network resources. If the authentication fails, the device marks the MAC address as a silent MAC address, drops the packet, and starts a quiet timer. The device drops all subsequent packets from the MAC address within the quiet time. The quiet mechanism avoids repeated authentication during a short time.

User account policies

MAC authentication supports the following user account policies:

- **Global user account policy**—It can be either of the following options:
  - **MAC-based user account policy**—One MAC-based user account for each user. As shown in Figure 1, the access device uses the source MAC addresses in packets as the usernames and passwords of users for MAC authentication. This policy is suitable for an insecure environment.

    NOTE:

    MAC-based user account policy also supports configuring a password shared by all MAC-based user accounts.

  - **Shared user account policy**—One shared user account for all users. You specify one username and password, which are not necessarily a MAC address, for all MAC authentication users on the access device, as shown in Figure 2. This policy is suitable for a secure environment.
- **MAC range-specific user account policy**—One shared user account for users in a specific MAC address range. You specify one username and password (which are not necessarily a MAC address) for users in a specific MAC address range on the access device, as shown in Figure 3. For example, you can specify a username and password for users with a specific OUI for MAC authentication.

IMPORTANT:

- You can use global and MAC range-specific user account policies together. For users in a MAC address range, the MAC range-specific user account settings have higher priority than the global user account settings.
- If a RADIUS server is used for MAC authentication, you must create the user accounts on the RADIUS server based on the user account policy on the access device.

Figure 1 MAC-based user account policy

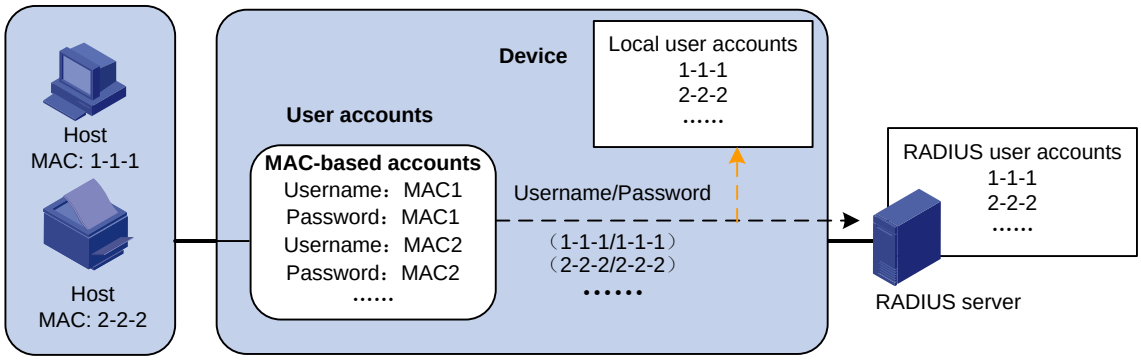


Figure 2 Shared user account policy (global)

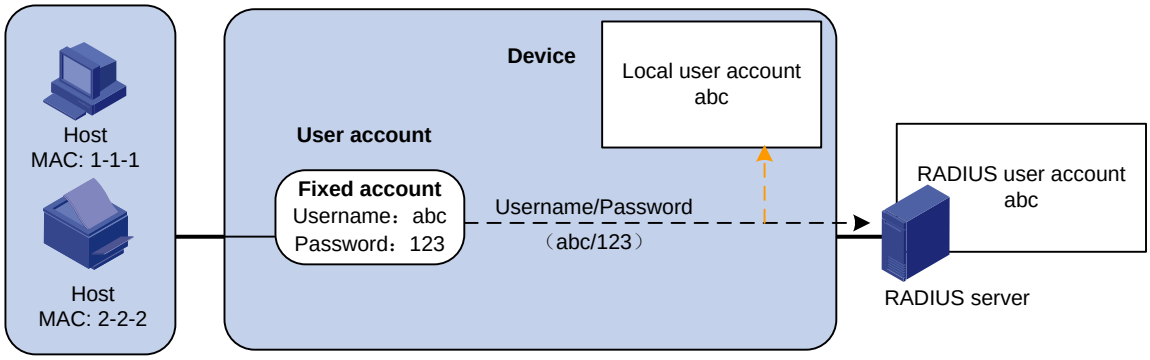
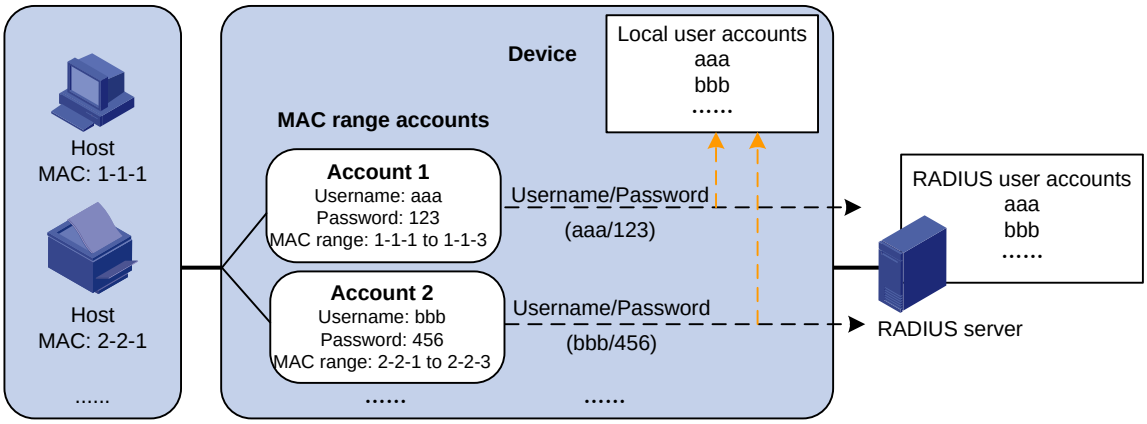


Figure 3 Shared user account policy (specific to MAC address ranges)



Authentication methods

You can perform MAC authentication on the access device (local authentication) or through a RADIUS server.

For more information about configuring local authentication and RADIUS authentication, see "Configuring AAA."

RADIUS authentication

If MAC-based accounts are used, the access device by default sends the source MAC address of a packet as the username and password to the RADIUS server for authentication. If a password is

configured for MAC-based accounts, the access device sends the configured password as the password to the RADIUS server.

If a shared account is used, the access device sends the shared account username and password to the RADIUS server for authentication.

The access device and the RADIUS server use Password Authentication Protocol (PAP) or Challenge Handshake Authentication Protocol (CHAP) for communication.

Local authentication

If MAC-based accounts are used, the access device by default uses the source MAC address of a packet as the username and password to search the local account database for a match. If a password is configured for MAC-based accounts, the device uses the configured password to search the local account database for a match.

If a shared account is used, the access device uses the shared account username and password to search the local account database for a match.

VLAN assignment

Authorization VLAN

The authorization VLAN controls the access of a MAC authentication user to authorized network resources. The device supports authorization VLANs assigned locally or by a remote server.

IMPORTANT:

Only remote servers can assign tagged authorization VLANs.

Remote VLAN authorization

In remote VLAN authorization, you must configure an authorization VLAN for a user on the remote server. After the user authenticates to the server, the server assigns authorization VLAN information to the device. Then, the device assigns the user access port to the authorization VLAN as a tagged or untagged member.

The device supports assignment of the following authorization VLAN information by the remote server:

- VLAN ID.
- VLAN name, which must be the same as the VLAN description on the access device.
- A string of VLAN IDs and VLAN names.

  In the string, some VLANs are represented by their IDs, and some VLANs are represented by their names.
- VLAN group name.

  For more information about VLAN groups, see *Layer 2—LAN Switching Configuration Guide*.
- VLAN ID with a suffix of **t** or **u**.

  The **t** and **u** suffixes require the device to assign the access port to the VLAN as a tagged or untagged member, respectively. For example, **2u** indicates assigning the port to VLAN 2 as an untagged member.

If a VLAN name or VLAN group name is assigned, the device converts the information into a VLAN ID before VLAN assignment.

IMPORTANT:

For a VLAN represented by its VLAN name to be assigned successfully, you must make sure the VLAN has been created on the device.

To assign VLAN IDs with suffixes, make sure the user access port is a hybrid or trunk port.

IMPORTANT:

To ensure a successful assignment, the authorization VLANs assigned by the remote server cannot be any of the following types:

- Dynamically learned VLANs.
- Reserved VLANs.
- Private VLANs.

If the server assigns a group of VLANs, the access device selects a VLAN as described in Table 1.

Table 1 Authorization VLAN selection from a group of VLANs

VLAN information	Authorization VLAN selection

VLAN IDs
VLAN names
VLAN group name
VLAN IDs and VLAN names
	The device selects an authorization VLAN from the VLAN group for a user according to the following rules:
	• On a hybrid port with MAC-based VLAN enabled:
	  ○ If the port does not have online users, the device selects the VLAN with the lowest ID.
	  ○ If the port has online users, the device selects the VLAN that has the fewest online users. If two VLANs have the same number of online 802.1X users, the device selects the VLAN with the lower ID.
	• On an access, trunk, or MAC-based VLAN disabled hybrid port:
	  ○ If the port does not have online users, the device selects the VLAN with the lowest ID.
	  ○ If the port has online users, the device examines the VLAN group for the VLAN of the online users. If the VLAN is found, the VLAN is assigned to the user as the authorization VLAN. If the VLAN is not found, VLAN authorization fails.

VLAN IDs with suffixes	**1.** The device selects the leftmost VLAN ID without a suffix, or the leftmost VLAN ID suffixed by **u** as an untagged VLAN, whichever is more leftmost. **2.** The device assigns the untagged VLAN to the port as the PVID, and it assigns the remaining as tagged VLANs. If no untagged VLAN is assigned, the PVID of the port does not change. The port permits traffic from these tagged and untagged VLANs to pass through. For example, the authentication server sends the string **1u 2t 3** to the access device for a user. The device assigns VLAN 1 as an untagged VLAN and all remaining VLANs (including VLAN 3) as tagged VLANs. VLAN 1 becomes the PVID.

In Release 6318P01 and later, the device includes the User-VLAN-ID attribute in RADIUS accounting requests to inform the RADIUS server of the authorization VLAN assigned to MAC authentication users. The RADIUS server can then include user authorization VLAN information in its logs about MAC authentication users.

- If the RADIUS server assigns a VLAN ID or VLAN name as the authorization VLAN to a user, the device includes the server-assigned authorization VLAN in the User-VLAN-ID attribute.
- If the RADIUS server assigns a group of VLANs in the authorization VLAN information to a user, the device includes a VLAN in the User-VLAN-ID attribute as described in Table 2.

Table 2 Including a VLAN in the User-VLAN-ID attribute of RADIUS accounting packets

VLAN information	VLAN in the User-VLAN-ID attribute
VLAN IDs VLAN names VLAN group name	• If the device has selected an authorization VLAN when it starts accounting for the user, it includes the selected VLAN in the User-VLAN-ID attribute. The VLAN will be included in start-accounting, real-time accounting, and stop-accounting

VLAN information	VLAN in the User-VLAN-ID attribute
VLAN IDs and VLAN names	request packets. • If the device has not selected an authorization VLAN when it starts accounting for the user, it includes the user's initial VLAN in the User-VLAN-ID attribute in start-accounting request packets. When sending real-time accounting or stop-accounting request packets, the device includes the assigned authorization VLAN in the User-VLAN-ID attribute.
VLAN IDs with suffixes	The device includes the untagged authorization VLAN in the User-VLAN-ID attribute in RADIUS accounting request packets. If no untagged authorization VLAN is available, the device includes the user's initial VLAN in the User-VLAN-ID attribute in RADIUS accounting request packets.

Local VLAN authorization

To perform local VLAN authorization for a user, specify the VLAN ID in the authorization attribute list of the local user account for that user. For each local user, you can specify only one authorization VLAN ID. The user access port is assigned to the VLAN as an untagged member.

IMPORTANT:

Local VLAN authorization does not support assignment of tagged VLANs.

For more information about local user configuration, see "Configuring AAA."

Authorization VLAN manipulation on a MAC authentication-enabled port

Table 3 describes the way the network access device handles authorization VLANs (except for the VLANs specified with suffixes) for MAC authenticated users on a port.

Table 3 VLAN manipulation

Port type	VLAN manipulation
• Access port • Trunk port • Hybrid port with MAC-based VLAN disabled	• The device assigns the port to the first authenticated user's authorization VLAN and sets the VLAN as the PVID if that authorization VLAN has the untagged attribute. • If the authorization VLAN has the tagged attribute, the device assigns the port to the authorization VLAN without changing its PVID. **NOTE:** The tagged attribute is supported only on trunk and hybrid ports.
Hybrid port with MAC-based VLAN enabled	The device maps the MAC address of each user to its own authorization VLAN regardless of whether the port is a tagged member. The PVID of the port does not change.

IMPORTANT:

- If the users are attached to a port whose link type is access, make sure the authorization VLAN assigned by the server has the untagged attribute. VLAN assignment will fail if the server issues a VLAN that has the tagged attribute.
- When you assign VLANs to users attached to a trunk port or a MAC-based VLAN disabled hybrid port, make sure there is only one untagged VLAN. If a different untagged VLAN is assigned to a subsequent user, the user cannot pass authentication.
- As a best practice to enhance network security, do not use the **`port hybrid vlan`** command to assign a hybrid port to an authorization VLAN as a tagged member.

The VLAN assigned by the server to a user as an authorization VLAN might have been configured on the user access port but with a different tagging mode. For example, the server assigns an authorization VLAN with the tagged attribute, but the same VLAN configured on the port has the untagged attribute. In this situation, the VLAN settings that take effect on the user depend on the link type of the port.

- If the link type of the port is access or trunk, the authorization VLAN settings assigned by the server always take effect on the user as long as the user is online. After the user goes offline, the VLAN settings on the port take effect.
- If the link type of the port is hybrid, the VLAN settings configured on the port take effect. For example, the server assigns VLAN 30 with the untagged attribute to a user on the hybrid port. However, VLAN 30 has been configured on the port with the tagged attribute by using the **`port hybrid vlan tagged`** command. Finally, the VLAN has the tagged attribute on the port.

For a MAC authenticated user to access the network on a hybrid port when no authorization VLAN is configured for the user, perform one of the following tasks:

- If the port receives tagged authentication packets from the user in a VLAN, use the **`port hybrid vlan`** command to configure the port as a tagged member in the VLAN.
- If the port receives untagged authentication packets from the user in a VLAN, use the **`port hybrid vlan`** command to configure the port as an untagged member in the VLAN.

Guest VLAN

The MAC authentication guest VLAN on a port accommodates users that have failed MAC authentication for any reason other than server unreachable. For example, the VLAN accommodates users with invalid passwords entered.

You can deploy a limited set of network resources in the MAC authentication guest VLAN. For example, a software server for downloading software and system patches.

A hybrid port is always assigned to a MAC authentication guest VLAN as an untagged member. After the assignment, do not reconfigure the port as a tagged member in the VLAN.

The device reauthenticates users in the MAC authentication guest VLAN at a specific interval. Table 4 shows the way that the network access device handles guest VLANs for MAC authentication users.

Table 4 VLAN manipulation

Authentication status	VLAN manipulation
A user in the MAC authentication guest VLAN fails MAC authentication.	The user is still in the MAC authentication guest VLAN.
A user in the MAC authentication guest VLAN passes MAC authentication.	The device remaps the MAC address of the user to the authorization VLAN assigned by the authentication server. If no authorization VLAN is configured for the user on the authentication server, the device remaps the MAC address of the user to the PVID of the port.

Critical VLAN

The MAC authentication critical VLAN on a port accommodates users that have failed MAC authentication because no RADIUS authentication servers are reachable. Users in a MAC authentication critical VLAN can access only network resources in the critical VLAN.

The critical VLAN feature takes effect when MAC authentication is performed only through RADIUS servers. If a MAC authentication user fails local authentication after RADIUS authentication, the user is not assigned to the critical VLAN. For more information about the authentication methods, see "Configuring AAA."

Table 5 shows the way that the network access device handles critical VLANs for MAC authentication users.

Table 5 VLAN manipulation

Authentication status	VLAN manipulation
A user fails MAC authentication because all the RADIUS servers are unreachable.	The device maps the MAC address of the user to the MAC authentication critical VLAN. The user is still in the MAC authentication critical VLAN if the user fails MAC reauthentication because all the RADIUS servers are unreachable. If no MAC authentication critical VLAN is configured, the device maps the MAC address of the user to the PVID of the port.
A user in the MAC authentication guest VLAN fails authentication because all the RADIUS servers are unreachable.	The user remains in the MAC authentication guest VLAN.
A user in the MAC authentication critical VLAN fails MAC authentication for any reason other than server unreachable.	If a guest VLAN has been configured, the device maps the MAC address of the user to the guest VLAN. If no guest VLAN is configured, the device maps the MAC address of the user to the PVID of the port.
A user in the MAC authentication critical VLAN passes MAC authentication.	The device remaps the MAC address of the user to the authorization VLAN assigned by the authentication server. If no authorization VLAN is configured for the user on the authentication server, the device remaps the MAC address of the user to the PVID of the access port.

Critical voice VLAN

The MAC authentication critical voice VLAN on a port accommodates MAC authentication voice users that have failed authentication because none of the RADIUS servers in their ISP domain are reachable.

The critical voice VLAN feature takes effect when MAC authentication is performed only through RADIUS servers. If a MAC authentication voice user fails local authentication after RADIUS authentication, the user is not assigned to the critical voice VLAN. For more information about the authentication methods, see "Configuring AAA."

Table 6 shows the way that the network access device handles critical voice VLANs for MAC authentication voice users.

Table 6 VLAN manipulation

Authentication status	VLAN manipulation
A voice user fails MAC authentication because all the RADIUS servers are unreachable.	The device maps the MAC address of the voice user to the MAC authentication critical voice VLAN. The voice user is still in the MAC authentication critical voice VLAN if the voice user fails MAC reauthentication because all the RADIUS servers are unreachable. If no MAC authentication critical voice VLAN is configured, the device maps the MAC address of the voice user to the PVID of the port.
A voice user in the MAC authentication critical voice VLAN fails MAC authentication for any reason other than server unreachable.	If a guest VLAN has been configured, the device maps the MAC address of the voice user to the guest VLAN. If no guest VLAN is configured, the device maps the MAC address of the voice user to the PVID of the port.

Authentication status	VLAN manipulation
A voice user in the MAC authentication critical voice VLAN passes MAC authentication.	The device remaps the MAC address of the voice user to the authorization VLAN assigned by the authentication server. If no authorization VLAN is configured for the voice user on the authentication server, the device remaps the MAC address of the voice user to the PVID of the access port.

ACL assignment

You can specify an authorization ACL in the user account for a MAC authentication user on the authentication server to control the user's access to network resources. After the user passes MAC authentication, the authentication server assigns the authorization ACL to the user access port. Then, the port permits or drops the matching traffic for the user depending on the rules configured in the ACL. This ACL is called an authorization ACL.

The device supports assignment of static and dynamic ACLs as authorization ACLs.

- **Static ACLs**—Static ACLs can be assigned by a RADIUS server or the access device. When the server or access device assigns a static ACL to a user, it assigns only the ACL number. You must manually create the ACL and configure its rules on the access device.

  To change the access permissions of a user, you can use one of the following methods:

  - Modify ACL rules in the authorization ACL on the access device.
  - Assign another ACL to the user from the RADIUS server or the access device.

  Static ACLs and their rules can be manually deleted from the access device.
- **Dynamic ACLs**—Dynamic ACLs and their rules are automatically deployed by a RADIUS server, which are not configurable on the access device. Dynamic ACLs can only be named ACLs. After the device receives a server-deployed dynamic ACL and its rules, it automatically creates the ACL and configures its rules.

  If the dynamic ACL assigned by the server to a user has the same name as a static ACL, the dynamic ACL cannot be issued and the user cannot come online.

  A dynamic ACL and its rules are automatically deleted from the access device after all its users go offline.

  Dynamic ACLs and their rules cannot be manually modified or deleted on the access device. To display information about dynamic ACLs and their rules, use the **`display mac-authentication connection`** or **`display acl`** command.

IMPORTANT:

Assignment of dynamic ACLs is supported only in Release 6309P01 or later.

The supported authorization ACLs include the following types:

- Basic ACLs, which are numbered in the range of 2000 to 2999.
- Advanced ACLs, which are numbered in the range of 3000 to 3999.
- Layer 2 ACLs, which are numbered in the range of 4000 to 4999.

IMPORTANT:

For an authorization ACL to take effect, make sure the ACL exists with rules and none of the rules contains the **`counting`**, **`established`**, **`fragment`**, **`source-mac`**, **`cos`**, **`dest-mac`**, **`lsap`**, **`vxlan`**, or **`logging`** keyword.

For more information about ACLs, see *ACL and QoS Configuration Guide*.

User profile assignment

You can specify a user profile in the user account for a MAC authentication user on the authentication server to control the user's access to network resources. After the user passes MAC authentication, the authentication server assigns the user profile to the user to filter traffic for this user.

The authentication server can be the local access device or a RADIUS server. In either case, the server only specifies the user profile name. You must configure the user profile on the access device.

To change the user's access permissions, you can use one of the following methods:

- Modify the user profile configuration on the access device.
- Specify another user profile for the user on the authentication server.

For more information about user profiles, see "Configuring user profiles."

Redirect URL assignment

The device supports the URL attribute assigned by a RADIUS server. During MAC authentication, the HTTP or HTTPS requests of a user are redirected to the Web interface specified by the server-assigned URL attribute. After the user passes the Web authentication, the RADIUS server records the MAC address of the user and uses a DM (Disconnect Message) to log off the user. When the user initiates MAC authentication again, it will pass the authentication and come online successfully.

By default, the device listens to port 6654 for HTTPS requests to be redirected. To change the redirect listening port number, see configuring HTTP redirect in *Layer 3—IP Services Configuration Guide*.

Periodic MAC reauthentication

Periodic MAC reauthentication tracks the connection status of online users, and updates the authorization attributes assigned by the RADIUS server. The attributes include the ACL and VLAN.

The device reauthenticates online MAC authentication users at the periodic reauthentication interval when the periodic MAC reauthentication feature is enabled. The interval is controlled by a timer and the timer is user configurable. A change to the periodic reauthentication timer applies to online MAC authentication users only after the old timer expires and the MAC authentication users pass authentication.

The server-assigned RADIUS Session-Timeout (attribute 27) and Termination-Action (attribute 29) attributes together can affect the periodic MAC reauthentication feature. To display the server-assigned Session-Timeout and Termination-Action attributes, use the **display mac-authentication connection** command.

- If the termination action is to log off users, periodic MAC reauthentication takes effect only when the periodic reauthentication timer is shorter than the session timeout timer. If the session timeout timer is shorter, the device logs off online authenticated users when the session timeout timer expires.
- If the termination action is to reauthenticate users, the periodic MAC reauthentication configuration on the device cannot take effect. The device reauthenticates online MAC authentication users after the server-assigned session timeout timer expires.

If no session timeout timer is assigned by the server, whether the device performs periodic MAC reauthentication depends on the periodic MAC reauthentication configuration on the device. Support for the assignment of Session-Timeout and Termination-Action attributes depends on the server model.

With the RADIUS DAS feature enabled, the device immediately reauthenticates a user upon receiving a CoA message that carries the reauthentication attribute from a RADIUS authentication server. In this case, reauthentication will be performed regardless of whether periodic MAC reauthentication is enabled on the device. For more information about RADIUS DAS configuration, see "Configuring AAA."

By default, the device logs off online MAC authentication users if no server is reachable for MAC reauthentication. The keep-online feature keeps authenticated MAC authentication users online when no server is reachable for MAC reauthentication.

The VLANs assigned to an online user before and after reauthentication can be the same or different.

Restrictions and guidelines: MAC authentication configuration

When you configure MAC authentication on an interface, follow these restrictions and guidelines:

- MAC authentication is supported only on Layer 2 Ethernet interfaces that do not belong to an aggregation group.
- Do not change the link type of a port when the MAC authentication guest VLAN or critical VLAN on the port has users.

If the MAC address that has failed authentication is a static MAC address or a MAC address that has passed any security authentication, the device does not mark the MAC address as a silent address.

To ensure a successful HTTPS redirect for users who are assigned a redirect URL, make sure VLAN interfaces exist for the VLANs that transport their packets.

MAC authentication tasks at a glance

To configure MAC authentication, perform the following tasks:

1. Enabling MAC authentication
2. Configure basic MAC authentication features
   - Specifying a MAC authentication method
   - Specifying a MAC authentication domain
   - Configuring user account policy
   - (Optional.) Configuring MAC authentication timers
   - (Optional.) Configuring periodic MAC reauthentication
3. (Optional.) Configuring MAC authentication VLAN assignment
   - Configuring a MAC authentication guest VLAN
   - Configuring a MAC authentication critical VLAN
   - Enabling the MAC authentication critical voice VLAN feature
4. (Optional.) Configuring other MAC authentication features
   - Configuring unauthenticated MAC authentication user aging
   - Configuring MAC authentication offline detection
   - Configuring packet detection for MAC authentication
   - Enabling online user synchronization for MAC authentication
   - Setting the maximum number of concurrent MAC authentication users on a port
   - Enabling MAC authentication multi-VLAN mode on a port

     Perform this task to not reauthenticate online users when VLAN changes occur on a port.

Prerequisites for MAC authentication

Before you configure MAC authentication, complete the following tasks:

1. Make sure the port security feature is disabled. For more information about port security, see "Configuring port security."
2. Configure an ISP domain and specify an AAA method. For more information, see "Configuring AAA."
   - For local authentication, you must also create local user accounts (including usernames and passwords) and specify the **lan-access** service for local users.
   - For RADIUS authentication, make sure the device and the RADIUS server can reach each other and create user accounts on the RADIUS server. If you are using MAC-based accounts, make sure the username and password for each account are the same as the MAC address of each MAC authentication user.

Enabling MAC authentication

Restrictions and guidelines

For MAC authentication to take effect on a port, you must enable this feature globally and on the port.

MAC authentication cannnot take effect on a port if the device has run out of ACL resources when you perform either of the following operations:

- Enable MAC authentication on the port while MAC authentication has been enabled globally.
- Enable MAC authentication globally in system while MAC authentication has been enabled on the port.

Procedure

1. Enter system view.
   `system-view`
2. Enable MAC authentication globally.
   `mac-authentication`
   By default, MAC authentication is disabled globally.
3. Enter interface view.
   `interface` *`interface-type interface-number`*
4. Enable MAC authentication on the port.
   `mac-authentication`
   By default, MAC authentication is disabled on a port.

Specifying a MAC authentication method

About MAC authentication methods

RADIUS-based MAC authentication supports the following authentication methods:

- **PAP**—Transports usernames and passwords in plain text. The authentication method applies to scenarios that do not require high security.
- **CHAP**—Transports usernames in plain text and passwords in encrypted form over the network. CHAP is more secure than PAP.

Restrictions and guidelines

The device must use the same authentication method as the RADIUS server.

Procedure

1. Enter system view.
   system-view
2. Specify an authentication method for MAC authentication.
   mac-authentication authentication-method { **chap** | **pap** }
   By default, the device uses PAP for MAC authentication.

Specifying a MAC authentication domain

About authentication domains for MAC authentication

By default, MAC authentication users are in the system default authentication domain. To implement different access policies for users, you can use one of the following methods to specify authentication domains for MAC authentication users:

- Specify a global authentication domain in system view. This domain setting applies to all ports enabled with MAC authentication.
- Specify an authentication domain for an individual port in interface view.

MAC authentication chooses an authentication domain for users on a port in this order: the port-specific domain, the global domain, and the default domain. For more information about authentication domains, see "Configuring AAA."

Procedure

1. Enter system view.
   system-view
2. Specify an authentication domain for MAC authentication users.
   - In system view:
     mac-authentication domain *domain-name*
   - In interface view:
     interface *interface-type interface-number*
     mac-authentication domain *domain-name*

   By default, the system default authentication domain is used for MAC authentication users.

Configuring user account policy

Restrictions and guidelines

IMPORTANT:
MAC range-specific user accounts are supported only in Release 6310 or later.

For users in a MAC address range, the MAC address range-specific user account has higher priority than the global user account settings.

You can configure a maximum of 16 MAC address ranges and must make sure the MAC address ranges do not overlap.

If you configure user account settings multiple times for the same MAC address range, the most recent configuration overwrites the previous configuration.

The MAC range-specific accounts apply only to unicast MAC addresses.

- If you specify a MAC address range that contains only multicast MAC addresses, execution of this command will fail.
- If you specify a MAC address range that contains both unicast and multicast MAC addresses, the command takes effect only on unicast MAC addresses.

The all-zero MAC address is invalid for MAC authentication. Users with the all-zero MAC address cannot pass MAC authentication.

Procedure

1. Enter system view.

   system-view

2. Configure the global MAC authentication user account policy.
   - Use one MAC-based user account for each user.

     mac-authentication user-name-format mac-address [{ **with-hyphen** [**separator colon**] | **without-hyphen** } [**lowercase** | **uppercase**]] [**password** { **cipher** | **simple** } *string*]

     The **separator colon** keywords are available only in Release 6340 and later.
   - Use one shared user account for all users.

     mac-authentication user-name-format fixed [**account** *name*] [**password** { **cipher** | **simple** } *string*]

   By default, the device uses the MAC address of each user as both the username and password for MAC authentication. The MAC addresses are in hexadecimal notation without hyphens, and letters are in lower case.
3. Specify one shared user account specific to a MAC address range.

   mac-authentication mac-range-account mac-address *mac-address* **mask** { *mask* | *mask-length* } **account** *name* **password** { **cipher** | **simple** } *string*

   By default, no username or password is configured specific to a MAC address range. The global user account policy applies to the users.

Configuring MAC authentication timers

About MAC authentication timers

MAC authentication uses the following timers:

- **Offline detection timer**—Sets the interval that the device must wait for traffic from a user before the device determines that the user is idle. If the device has not received traffic from a user before the timer expires, the device logs off that user and requests the accounting server to stop accounting for the user. This timer takes effect only when the MAC authentication offline detection feature is enabled.

  As a best practice, set the MAC address aging timer to the same value as the offline detection timer. This operation prevents a MAC authenticated user from being logged off within the offline detect interval because of MAC address entry expiration.
- **Quiet timer**—Sets the interval that the device must wait before the device can perform MAC authentication for a user that has failed MAC authentication. All packets from the MAC address are dropped during the quiet time. This quiet mechanism prevents repeated authentication from affecting system performance.

- **Server timeout timer**—Sets the interval that the device waits for a response from a RADIUS server before the device determines that the RADIUS server is unavailable. If the timer expires during MAC authentication, the user fails MAC authentication.

Restrictions and guidelines

To avoid forced logoff before the server timeout timer expires, set the server timeout timer to a value that is lower than or equal to the product of the following values:

- The maximum number of RADIUS packet transmission attempts set by using the **retry** command in RADIUS scheme view.
- The RADIUS server response timeout timer set by using the **timer response-timeout** command in RADIUS scheme view.

For information about setting the maximum number of RADIUS packet transmission attempts and the RADIUS server response timeout timer, see "Configuring AAA."

Procedure

1. Enter system view.

   system-view
2. Configure MAC authentication timers.

   mac-authentication timer { **offline-detect** *offline-detect-value* | **quiet** *quiet-value* | **server-timeout** *server-timeout-value* }

   By default, the offline detection timer is 300 seconds, the quiet timer is 60 seconds, and the server timeout timer is 100 seconds.

Configuring periodic MAC reauthentication

Restrictions and guidelines

The device selects a periodic reauthentication timer for MAC reauthentication in the following order:

1. Server-assigned reauthentication timer.
2. Port-specific reauthentication timer.
3. Global reauthentication timer.
4. Default reauthentication timer.

Modification to the MAC authentication domain, MAC authentication method, or user account format setting does not affect the reauthentication of online MAC authentication users. The modified setting takes effect only on MAC authentication users that come online after the modification.

If periodic reauthentication is triggered for a user while that user is waiting for online synchronization, the system performs online synchronization and does not perform reauthentication for the user.

Procedure

1. Enter system view.

   system-view
2. Set the periodic MAC reauthentication timer.
   - Set a global periodic reauthentication timer.

     mac-authentication timer reauth-period *reauth-period-value*

     The default setting is 3600 seconds.
   - Execute the following commands in sequence to set a port-specific periodic reauthentication timer:

     interface *interface-type interface-number*

     mac-authentication timer reauth-period *reauth-period-value*

quit

By default, no periodic MAC reauthentication timer is set on a port. The port uses the global periodic MAC reauthentication timer.

3. Enter interface view.
   interface *interface-type interface-number*
4. Enable periodic MAC reauthentication.
   mac-authentication re-authenticate

   By default, periodic MAC reauthentication is disabled on a port.
5. (Optional.) Enable the keep-online feature for MAC authenticated users on the port.
   mac-authentication re-authenticate server-unreachable keep-online

   By default, the keep-online feature is disabled. The device logs off online MAC authentication users if no server is reachable for MAC reauthentication.

   In a fast-recovery network, you can use the keep-online feature to prevent MAC authentication users from coming online and going offline frequently.

Configuring a MAC authentication guest VLAN

Restrictions and guidelines

When you configure the MAC authentication guest VLAN on a port, follow the guidelines in Table 7.

Table 7 Relationships of the MAC authentication guest VLAN with other security features

Feature	Relationship description	Reference
Quiet feature of MAC authentication	The MAC authentication guest VLAN feature has higher priority. When a user fails MAC authentication, the user can access the resources in the guest VLAN. The user's MAC address is not marked as a silent MAC address.	See "Configuring MAC authentication timers."
Port intrusion protection	The guest VLAN feature has higher priority than the block MAC action but lower priority than the shutdown port action of the port intrusion protection feature.	See "Configuring port security."

Prerequisites

Before you configure the MAC authentication guest VLAN on a port, complete the following tasks:

- Create the VLAN to be specified as the MAC authentication guest VLAN.
- Configure the port as a hybrid port, and configure the VLAN as an untagged member on the port.
- Enable MAC-based VLAN on the port.

For information about VLAN configuration, see *Layer 2—LAN Switching Configuration Guide*.

Procedure

1. Enter system view.
   system-view
2. Enter interface view.
   interface *interface-type interface-number*
3. Specify the MAC authentication guest VLAN on the port.
   mac-authentication guest-vlan *guest-vlan-id*

By default, no MAC authentication guest VLAN is specified on a port.

You can configure only one MAC authentication guest VLAN on a port. The MAC authentication guest VLANs on different ports can be different.

4. Set the authentication interval for users in the MAC authentication guest VLAN.

   mac-authentication guest-vlan auth-period *period-value*

   The default setting is 30 seconds.

Configuring a MAC authentication critical VLAN

Restrictions and guidelines

When you configure the MAC authentication critical VLAN on a port, follow the guidelines in Table 8.

Table 8 Relationships of the MAC authentication critical VLAN with other security features

Feature	Relationship description	Reference
Quiet feature of MAC authentication	The MAC authentication critical VLAN feature has higher priority. When a user fails MAC authentication because no RADIUS authentication server is reachable, the user can access the resources in the critical VLAN. The user's MAC address is not marked as a silent MAC address.	See "Configuring MAC authentication timers."
Port intrusion protection	The critical VLAN feature has higher priority than the block MAC action but lower priority than the shutdown port action of the port intrusion protection feature.	See "Configuring port security."

Prerequisites

Before you configure the MAC authentication critical VLAN on a port, complete the following tasks:

- Create the VLAN to be specified as the MAC authentication critical VLAN.
- Configure the port as a hybrid port, and configure the VLAN as an untagged member on the port.
- Enable MAC-based VLAN on the port.

For information about VLAN configuration, see *Layer 2—LAN Switching Configuration Guide*.

Procedure

1. Enter system view.

   system-view

2. Enter interface view.

   interface *interface-type interface-number*

3. Specify the MAC authentication critical VLAN on the port.

   mac-authentication critical vlan *critical-vlan-id*

   By default, no MAC authentication critical VLAN is specified on a port.

   You can configure only one MAC authentication critical VLAN on a port. The MAC authentication critical VLANs on different ports can be different.

Enabling the MAC authentication critical voice VLAN feature

Hardware and feature compatibility

This feature is not supported on the following switch series:

- S5000E-X.
- S5110V2-SI.
- S5000V3-EI.
- S5000V5-EI.
- S5000X-EI.
- WAS6000.

Prerequisites

Before you enable the MAC authentication critical voice VLAN feature on a port, complete the following tasks:

- Enable LLDP both globally and on the port.

  The device uses LLDP to identify voice users. For information about LLDP, see *Layer 2—LAN Switching Configuration Guide*.
- Enable voice VLAN on the port.

  For information about voice VLANs, see *Layer 2—LAN Switching Configuration Guide*.
- Specify a MAC authentication critical VLAN on the port. This setting ensures that a voice user is assigned to the critical VLAN if it has failed authentication for unreachability of RADIUS servers before the device recognizes it as a voice user. If a MAC authentication critical VLAN is not available, the voice user might be logged off instead.

Procedure

1. Enter system view.

   `system-view`
2. Enter interface view.

   `interface` *`interface-type interface-number`*
3. Enable the MAC authentication critical voice VLAN feature on a port.

   `mac-authentication critical-voice-vlan`

   By default, the MAC authentication critical voice VLAN feature is disabled on a port.

Configuring unauthenticated MAC authentication user aging

About unauthenticated MAC authentication user aging

Unauthenticated MAC authentication user aging applies to users added to a MAC authentication guest or critical VLAN because they have not been authenticated or have failed authentication.

When a user in one of those VLANs ages out, the device removes the user from the VLAN and deletes the MAC address entry for the user from the access port.

For users in one of those VLANs on one port to be authenticated successfully and come online on another port, enable this feature. In any other scenarios, disable this feature as a best practice.

Restrictions and guidelines

As a best practice, use this feature on a port only if you want to have its unauthenticated users to be authenticated and come online on a different port.

Procedure

1. Enter system view.

   system-view

2. Set the user aging timer for a type of MAC authentication VLAN.

   mac-authentication timer user-aging { **critical-vlan** | **guest-vlan** } *aging-time-value*

   By default, the user aging timer is 1000 seconds for all applicable types of MAC authentication VLANs.

3. Enter interface view.

   interface *interface-type interface-number*

4. Enable unauthenticated MAC authentication user aging.

   mac-authentication unauthenticated-user aging enable

   By default, unauthenticated MAC authentication user aging is enabled.

Configuring MAC authentication offline detection

About MAC authentication offline detection

Enable MAC authentication offline detection to detect idle users on a port. If the port has not received traffic from a user when the offline detection timer expires, the device logs off that user and requests the accounting server to stop accounting for the users. For information about setting the offline detection timer in system view, see "Configuring MAC authentication timers."

Disabling this feature disables the device from inspecting the online user status.

In addition to port-based MAC authentication offline detection, you can configure offline detection parameters on a per-user basis, as follows:

- Set an offline detection timer specific to a user and control whether to use the ARP snooping or ND snooping table to determine the offline state of the user.
  - If the ARP snooping or ND snooping table is used, the device searches the ARP snooping or ND snooping table before it checks for traffic from the user within the detection interval. If a matching ARP snooping or ND snooping entry is found, the device resets the offline detection timer and the user stays online. If the offline detection timer expires because the device has not found a matching snooping entry for the user or received traffic from the user, the device disconnects the user.
  - If the ARP or ND snooping table is not used, the device disconnects the user if it has not received traffic from that user before the offline detection timer expires.

  When disconnecting the user, the device also notifies the RADIUS server (if any) to stop user accounting.
- Skip offline detection for the user. You can choose this option if the user is a dumb terminal. A dumb terminal might fail to come online again after it is logged off by the offline detection feature.

The device uses the offline detection settings for a user in the following sequence:

1. User-specific offline detection settings.
2. Offline detection settings assigned to the user by the RADIUS server. The settings include the offline detection timer, use of the ARP or ND snooping table in offline detection, and whether to ignore offline detection.

3. Port-based offline detection settings.

Restrictions and guidelines

When MAC authentication offline detection is used, make sure the aging timer value for dynamic MAC address entries is less than or equal to the default offline detection timer value (300 seconds) for MAC authentication users. The aging timer for dynamic MAC address entries is configurable with the **mac-address timer aging** *seconds* command.

For the user-specific offline detection feature to take effect on a user, make sure the MAC authentication offline detection feature is enabled on the user's access port.

The user-specific offline detection settings take effect on the online users immediately after they are configured.

Procedure

1. Enter system view.

   system-view

2. (Optional.) Configure MAC authentication offline detection for a user.

   mac-authentication offline-detect mac-address *mac-address* { **ignore** | **timer** *offline-detect-value* [**check-arp-or-nd-snooping**] }

   By default, offline detection settings configured on access ports take effect and the offline detection timer set in system view is used.

3. Enter interface view.

   interface *interface-type interface-number*

4. Enable MAC authentication offline detection.

   mac-authentication offline-detect enable

   By default, MAC authentication offline detection is enabled on a port.

Configuring packet detection for MAC authentication

About this task

When packet detection for MAC authentication is enabled on a port, the device sends detection packets to MAC authentication users connected to that port at offline detection intervals set by using the offline detection timer. If the device does not receive a response from a user after it has made the maximum packet transmission attempts within an offline detection interval, it logs off that user and requests the RADIUS server to stop accounting for the user.

When packet detection for MAC authentication and MAC authentication offline detection are both enabled, the device processes a MAC authentication user as follows:

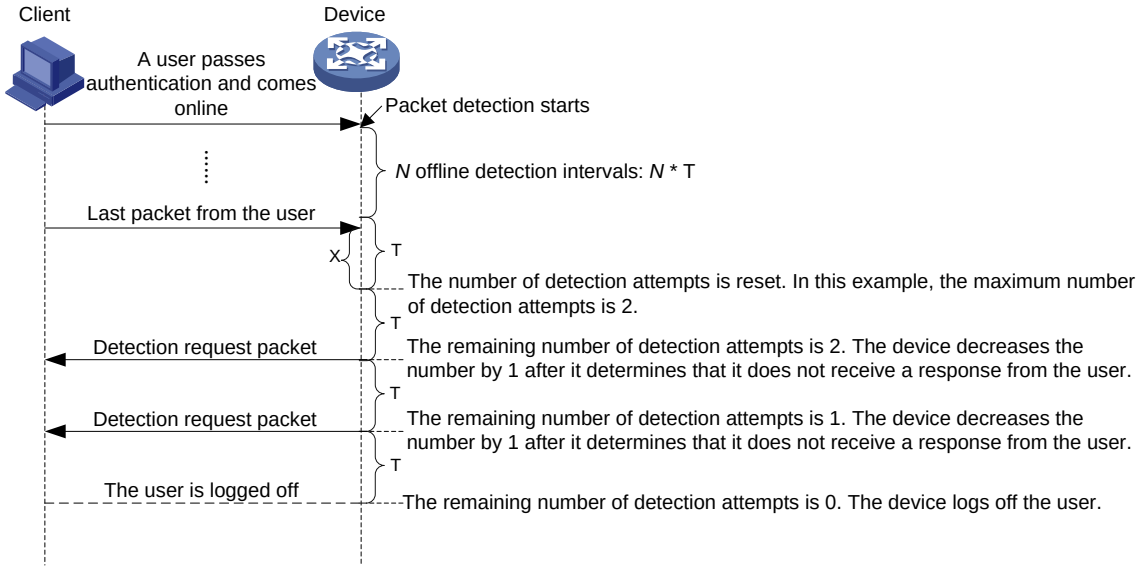
- If MAC authentication offline detection determines that a user is online, the device does not send detection packets to that user.
- If MAC authentication offline detection determines that a user is offline, the device does not immediately logs off that user. Instead, the device sends a detection packet to that user. It will log off that user if it does not receive a response from that user after it has made the maximum packet transmission attempts within an offline detection interval.

MAC authentication uses ARP request packets to detect the online status of IPv4 users and uses NS packets to detect the online status of IPv6 users.

Packet detection adopts the principle of counting prior to judging. The device decreases the detection attempts (packet transmission attempts) by 1 only after it determines that it does not receive a response from a user. The device stops the detection process when the number of detection attempts becomes 0. The duration from the time when the user sends the last packet to the

time when the user is logged off is calculated by using the following formula: duration = (*retries* + 1) * T + X. Figure 4 shows the packet detection process. In this example, the device sends a detection packet to a MAC authentication user for a maximum of two times.

Figure 4 Network diagram for packet detection process



The duration from the time when the user sends the last packet to the time when the user is logged off equals to 3 * T + X.

Feature and software version comaptibiltiy

This feature is supported only in Release 6348P01 and later.

Restrictions and guidelines

To ensure that the device is aware of user IP address changes, enable ARP snooping and ND snooping in conjunction with packet detection for MAC authentication. If you do not enable ARP snooping or ND snooping, the device is unaware of user IP address changes. As a result, the device still sends detection packets to the users' original IP addresses and falsely log off these users.

Procedure

1. Enter system view.

   system-view

2. Set the offline detection timer.

   mac-authentication timer offline-detect *offline-detect-value*

   By default, the offline detection timer expires in 300 seconds.

3. Enter interface view.

   interface *interface-type interface-number*

4. Enable packet detection for MAC authentication.

   mac-authentication packet-detect enable

   By default, packet detection for MAC authentication is disabled.

5. Set the maximum number of attempts for sending a detection packet to a MAC authentication user.

   mac-authentication packet-detect retry *retries*

   By default, the device sends a detection packet to a MAC authentication user for a maximum of two times.

Enabling online user synchronization for MAC authentication

About online user synchronization for MAC authentication

IMPORTANT:

This feature takes effect only when the device uses an IMC RADIUS server to authenticate MAC authentication users.

To ensure that the RADIUS server maintains the same online MAC authentication user information as the device after the server state changes from unreachable to reachable, use this feature.

This feature synchronizes online MAC authentication user information between the device and the RADIUS server when the RADIUS server state is detected having changed from unreachable to reachable.

When synchronizing online MAC authentication user information on a port with the RADIUS server, the device initiates MAC authentication in turn for each authenticated online MAC authentication user to the RADIUS server.

If synchronization fails for an online user, the device logs off that user unless the failure occurs because the server has become unreachable again.

Restrictions and guidelines

The amount of time required to complete online user synchronization increases as the number of online users grows. This might result in an increased delay for new MAC authentication users and users in the critical VLAN to authenticate or reauthenticate to the RADIUS server and come online.

To have this feature take effect, you must use it in conjunction with the RADIUS server status detection feature, which is configurable with the **`radius-server test-profile`** command. For more information about the RADIUS server status detection feature, see "Configuring AAA."

Procedure

1. Enter system view.
   `system-view`
2. Enter interface view.
   `interface` *`interface-type interface-number`*
3. Enable online user synchronization for MAC authentication.
   `mac-authentication server-recovery online-user-sync`
   By default, online user synchronization for MAC authentication is disabled.

Setting the maximum number of concurrent MAC authentication users on a port

About limiting the number of concurrent MAC authentication users on a port

Perform this task to prevent the system resources from being overused.

Procedure

1. Enter system view.
   `system-view`
2. Enter interface view.

interface *interface-type interface-number*

3. Set the maximum number of concurrent MAC authentication users on the port.

   mac-authentication max-user *max-number*

   The default setting is 4294967295.

Enabling MAC authentication multi-VLAN mode on a port

About VLAN modes of MAC authentication

By default, MAC authentication single-VLAN mode applies on a port. In this mode, traffic from an online user cannot be sent in different VLANs on a port without service interruption. To accommodate applications that are sensitive to delay or service interruption in a multi-VLAN environment, for example, IP phones, enable MAC authentication multi-VLAN mode.

In multi-VLAN mode, the port forwards traffic from a user in different VLANs without reauthentication if the user has been authenticated and come online in any VLAN on the port. Free of reauthentication, traffic from an online user can be sent in different VLANs without delay or service interruption.

In single-VLAN mode, the port reauthenticates an online user when traffic received from that user contains a VLAN tag different from the VLAN in which the user was authenticated. The authentication process differs depending on the MAC move setting in port security and the authorization VLAN assignment status, as follows:

- If no authorization VLAN has been assigned to the online user, the device first logs off the user and then reauthenticates the user in the new VLAN.
- If the online user has been assigned an authorization VLAN, the device handles the user depending on the MAC move setting in port security.
  - If MAC move is disabled in port security, the user cannot pass authentication and come online from the new VLAN until after it goes offline from the port.
  - If MAC move is enabled in port security, the user can pass authentication on the new VLAN and come online without having to first go offline from the port. After the user passes authentication on the new VLAN, the original authentication session of the user is deleted from the port.

To enable the port security MAC move feature, use the **port-security mac-move permit** command.

Procedure

1. Enter system view.

   system-view

2. Enter interface view.

   interface *interface-type interface-number*

3. Enable MAC authentication multi-VLAN mode.

   mac-authentication host-mode multi-vlan

   By default, MAC authentication operates in single-VLAN mode on a port.

Configuring MAC authentication delay

About MAC authentication delay

When both 802.1X authentication and MAC authentication are enabled on a port, you can delay MAC authentication so that 802.1X authentication is preferentially triggered.

If no 802.1X authentication is triggered or 802.1X authentication fails within the delay period, the port continues to process MAC authentication.

Restrictions and guidelines

Do not set the port security mode to **mac-else-userlogin-secure** or **mac-else-userlogin-secure-ext** when you use MAC authentication delay. The delay does not take effect on a port in either of the two modes. For more information about port security modes, see "Configuring port security."

Procedure

1. Enter system view.
   system-view
2. Enter interface view.
   interface *interface-type interface-number*
3. Enable MAC authentication delay and set the delay timer.
   mac-authentication timer auth-delay *time*
   By default, MAC authentication delay is disabled.

Including user IP addresses in MAC authentication requests

About the feature of including user IP addresses in MAC authentication requests

IMPORTANT:
This feature can only operate in conjunction with an IMC server.

To avoid IP conflicts that result from changes to static IP addresses, use this feature on a port that has MAC authentication users with static IP addresses.

This feature adds user IP addresses to the MAC authentication requests sent to the authentication server. When MAC authentication is triggered for a user, the device checks the user's IP address for invalidity.

- If the IP address is valid, the device sends a MAC authentication request with the IP address included.
- If the IP address is not a valid host IP address or the triggering packet does not contain an IP address, the device does not initiate MAC authentication.
- If the packet is a DHCP packet with a source IP address of 0.0.0.0, the device sends a MAC authentication request without including the IP address. In this case, the IMC server does not examine the user IP address when it performs authentication.

Upon receipt of the authentication request that includes a user's IP address, the IMC server compares the user's IP and MAC addresses with its local IP-MAC mappings.

- If an exact match is found or if no match is found, the user passes MAC authentication. In the latter case, the server creates an IP-MAC mapping for the user.
- If a mapping is found for the MAC address but the IP addresses do not match, the user fails the MAC authentication.

Restrictions and guidelines

Do not use this feature in conjunction with the MAC authentication guest VLAN on a port. If both features are used, the device cannot perform MAC authentication for a user once that user is added to the MAC authentication guest VLAN.

You can specify an ACL to identify source IP addresses that can or cannot trigger MAC authentication. When you configure the ACL, follow these guidelines:

- The specified ACL number represents an IPv4 ACL and an IPv6 ACL with the same number. For example, if the ACL number is 2000, you specify both IPv4 ACL 2000 and IPv6 ACL 2000. The IPv4 ACL and the IPv6 ACL will be used to process IPv4 packets and IPv6 packets, respectively.
- Use permit rules to identify source IP addresses that are valid for MAC authentication. Use deny rules to identify source IP addresses that cannot trigger MAC authentication.
- In the rules, only the action keyword (permit or deny) and the source IP match criterion can take effect.
- As a best practice, configure a deny rule to exclude the IPv6 IP addresses that start with fe80 from triggering MAC authentication.
- If you configure permit rules, add a **`deny all`** rule at the bottom of the ACL.

IMPORTANT:

If the user host is configured with IPv6, the device might receive packets that contain an IPv6 link-local address, which starts with fe80. MAC authentication failure or incorrect MAC-IP binding will occur if this address is used in MAC authentication. To avoid these issues, configure a basic ACL to exclude the IPv6 IP addresses that start with fe80.

Procedure

1. Enter system view.

   `system-view`
2. Enter interface view.

   `interface` *`interface-type interface-number`*
3. Include user IP addresses in MAC authentication requests.

   `mac-authentication carry user-ip` [**`exclude-ip acl`** *`acl-number`*]

   By default, a MAC authentication request does not include the user IP address.

Enabling parallel processing of MAC authentication and 802.1X authentication

About parallel processing of MAC authentication and 802.1X authentication

This feature enables a port that processes MAC authentication after 802.1X authentication is finished to process MAC authentication in parallel with 802.1X authentication.

Make sure the port meets the following requirements:

- The port is configured with both 802.1X authentication and MAC authentication and performs MAC-based access control for 802.1X authentication.
- The port is enabled with the 802.1X unicast trigger.

When the port receives a packet from an unknown MAC address, it sends a unicast EAP-Request/Identity packet to the MAC address. After that, the port immediately processes MAC authentication without waiting for the 802.1X authentication result.

After MAC authentication succeeds, the port is assigned to the MAC authentication authorization VLAN.

- If 802.1X authentication fails, the MAC authentication result takes effect.
- If 802.1X authentication succeeds, the device handles the port and the MAC address based on the 802.1X authentication result.

The process sequence of 802.1X authentication and MAC authentication is configurable in other ways. For the port to perform MAC authentication before it is assigned to the 802.1X guest VLAN, enable new MAC-triggered 802.1X guest VLAN assignment delay. For information about new MAC-triggered 802.1X guest VLAN assignment delay, see "Configuring 802.1X."

Restrictions and guidelines

To configure both 802.1X authentication and MAC authentication on the port, use one of the following methods:

- Enable the 802.1X and MAC authentication features separately on the port.
- Enable port security on the port. The port security mode must be **userlogin-secure-or-mac** or **userlogin-secure-or-mac-ext**.

  For information about port security mode configuration, see "Configuring port security."

For the parallel processing feature to work correctly, do not enable MAC authentication delay on the port. This operation will delay MAC authentication after 802.1X authentication is triggered.

Procedure

1. Enter system view.

   system-view
2. Enter interface view.

   interface *interface-type interface-number*
3. Enable parallel processing of MAC authentication and 802.1X authentication on the port.

   mac-authentication parallel-with-dot1x

   By default, this feature is disabled.

Logging off MAC authentication users

About this task

Perform this task to log off the specified MAC authentication users and clear information about these users from the device. These users must perform MAC authentication to come online again.

Software version and feature compatibility

This feature is supported only in Release 6318P01 and later.

Procedure

To log off MAC authentication users, execute the following command in user view:

reset mac-authentication access-user [**interface** *interface-type interface-number* | **mac** *mac-address* | **username** *username* | **vlan** *vlan-id*]

Enabling MAC authentication user logging

About MAC authentication user logging

This feature enables the device to generate logs about MAC authentication users and send the logs to the information center. For the logs to be output correctly, you must also configure the information center on the device. For more information about information center configuration, see *Network Management and Monitoring Configuration Guide*.

Restrictions and guidelines

To prevent excessive MAC authentication user log entries, use this feature only if you need to analyze abnormal MAC authentication user logins or logouts.

Procedure

1. Enter system view.

   system-view

2. Enable MAC authentication user logging.

   mac-authentication access-user log enable [**failed-login** | **logoff** | **successful-login**] *

   By default, MAC authentication user logging is disabled.

   If you do not specify any parameters, this command enables all types of MAC authentication user logs.

Display and maintenance commands for MAC authentication

Execute **display** commands in any view and **reset** commands in user view.

Task	Command
Display MAC authentication information.	**display mac-authentication** [**interface** *interface-type interface-number*]
Display MAC authentication connections.	**display mac-authentication connection** [**open**] [**interface** *interface-type interface-number* | **slot** *slot-number* | **user-mac** *mac-address* | **user-name** *user-name*]
Display the MAC addresses of MAC authentication users in a type of MAC authentication VLAN.	**display mac-authentication mac-address** { **critical-vlan** | **guest-vlan** } [**interface** *interface-type interface-number*]
Clear MAC authentication statistics.	**reset mac-authentication statistics** [**interface** *interface-type interface-number*]
Remove users from the MAC authentication critical VLAN on a port.	**reset mac-authentication critical vlan interface** *interface-type interface-number* [**mac-address** *mac-address*]
Remove users from the MAC authentication critical voice VLAN on a port.	**reset mac-authentication critical-voice-vlan interface** *interface-type interface-number* [**mac-address** *mac-address*]
Remove users from the MAC authentication guest VLAN on a port.	**reset mac-authentication guest-vlan interface** *interface-type interface-number* [**mac-address** *mac-address*]

MAC authentication configuration examples

Example: Configuring local MAC authentication

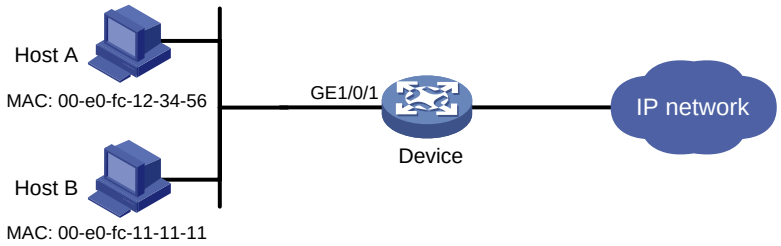
Network configuration

As shown in Figure 5, the device performs local MAC authentication on GigabitEthernet 1/0/1 to control Internet access of users.

Configure the device to meet the following requirements:

- Detect whether a user has gone offline every 180 seconds.
- Deny a user for 180 seconds if the user fails MAC authentication.
- Authenticate all users in ISP domain **bbb**.
- Use the MAC address of each user as both the username and password for authentication. The MAC addresses are in hexadecimal notation with hyphens, and letters are in lower case.

Figure 5 Network diagram



Procedure

Add a network access local user. In this example, configure both the username and password as Host A's MAC address 00-e0-fc-12-34-56.

```
<Device> system-view
[Device] local-user 00-e0-fc-12-34-56 class network
[Device-luser-network-00-e0-fc-12-34-56] password simple 00-e0-fc-12-34-56
```

Specify the LAN access service for the user.

```
[Device-luser-network-00-e0-fc-12-34-56] service-type lan-access
[Device-luser-network-00-e0-fc-12-34-56] quit
```

Configure ISP domain **bbb** to perform local authentication for LAN users.

```
[Device] domain bbb
[Device-isp-bbb] authentication lan-access local
[Device-isp-bbb] quit
```

Enable MAC authentication on GigabitEthernet 1/0/1.

```
[Device] interface gigabitethernet 1/0/1
[Device-GigabitEthernet1/0/1] mac-authentication
[Device-GigabitEthernet1/0/1] quit
```

Specify ISP domain **bbb** as the MAC authentication domain.

```
[Device] mac-authentication domain bbb
```

Configure MAC authentication timers.

```
[Device] mac-authentication timer offline-detect 180
[Device] mac-authentication timer quiet 180
```

Use the MAC address of each user as both the username and password for MAC authentication. The MAC addresses are in hexadecimal notation with hyphens, and letters are in lower case.

```
[Device] mac-authentication user-name-format mac-address with-hyphen lowercase
```

Enable MAC authentication globally.

```
[Device] mac-authentication
```

Verifying the configuration

Display MAC authentication settings and statistics to verify your configuration.

```
[Device] display mac-authentication
 Global MAC authentication parameters:
   MAC authentication                  : Enabled
   Authentication method               : PAP
   User name format                    : MAC address in lowercase(xx-xx-xx-xx-xx-xx)
           Username                    : mac
           Password                    : Not configured
   Offline detect period               : 180 s
   Quiet period                        : 180 s
   Server timeout                      : 100 s
   Reauth period                       : 3600 s
   User aging period for critical VLAN : 1000 s
   User aging period for guest VLAN    : 1000 s
   Authentication domain               : bbb
 Online MAC-auth wired users           : 1

 Silent MAC users:
          MAC address       VLAN ID  From port               Port index
          00e0-fc11-1111    8        GE1/0/1                 1

 GigabitEthernet1/0/1 is link-up
   MAC authentication               : Enabled
   Carry User-IP                    : Disabled
   Authentication domain            : Not configured
   Auth-delay timer                 : Disabled
   Periodic reauth                  : Disabled
   Re-auth server-unreachable       : Logoff
   Guest VLAN                       : Not configured
   Guest VLAN reauthentication      : Enabled
     Guest VLAN auth-period         : 30 s
   Critical VLAN                    : Not configured
   Critical voice VLAN              : Disabled
   Host mode                        : Single VLAN
   Offline detection                : Enabled
   Authentication order             : Default
   User aging                       : Enabled
   Server-recovery online-user-sync : Enabled

   Auto-tag feature                 : Disabled
   VLAN tag configuration ignoring  : Disabled
   Max online users                 : 4294967295
```

```
Authentication attempts          : successful 1, failed 0
Current online users             : 1
       MAC address       Auth state
       00e0-fc12-3456    Authenticated
```

The output shows that Host A has passed MAC authentication and has come online. Host B failed MAC authentication and its MAC address is marked as a silent MAC address.

Example: Configuring RADIUS-based MAC authentication

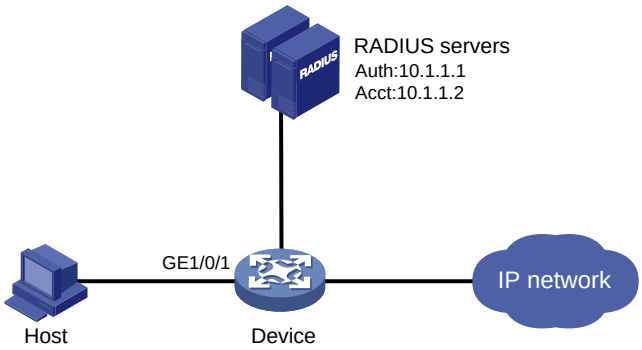
Network configuration

As shown in Figure 6, the device uses RADIUS servers to perform authentication, authorization, and accounting for users. The RADIUS servers use the CHAP authentication method.

To control user access to the Internet by MAC authentication, perform the following tasks:

- Enable MAC authentication globally and on GigabitEthernet 1/0/1.
- Configure the device to use CHAP for MAC authentication.
- Configure the device to detect whether a user has gone offline every 180 seconds.
- Configure the device to deny a user for 180 seconds if the user fails MAC authentication.
- Configure all users to belong to ISP domain **bbb**.
- Use a shared user account for all users, with username **aaa** and password **123456**.

Figure 6 Network diagram



Procedure

Make sure the RADIUS servers and the access device can reach each other.

1. Configure the RADIUS servers to provide authentication, authorization, and accounting services. Create a shared account with username **aaa** and password **123456** for MAC authentication users. (Details not shown.)
2. Configure RADIUS-based MAC authentication on the device:

   # Configure a RADIUS scheme.

```
<Device> system-view
[Device] radius scheme 2000
[Device-radius-2000] primary authentication 10.1.1.1 1812
[Device-radius-2000] primary accounting 10.1.1.2 1813
[Device-radius-2000] key authentication simple abc
[Device-radius-2000] key accounting simple abc
[Device-radius-2000] user-name-format without-domain
[Device-radius-2000] quit
```

Specify CHAP as the authentication method for MAC authentication.

```
[Device] mac-authentication authentication-method chap
```

Apply the RADIUS scheme to ISP domain **bbb** for authentication, authorization, and accounting.

```
[Device] domain bbb
[Device-isp-bbb] authentication default radius-scheme 2000
[Device-isp-bbb] authorization default radius-scheme 2000
[Device-isp-bbb] accounting default radius-scheme 2000
[Device-isp-bbb] quit
```

Enable MAC authentication on GigabitEthernet 1/0/1.

```
[Device] interface gigabitethernet 1/0/1
[Device-GigabitEthernet1/0/1] mac-authentication
[Device-GigabitEthernet1/0/1] quit
```

Specify the MAC authentication domain as ISP domain **bbb**.

```
[Device] mac-authentication domain bbb
```

Set MAC authentication timers.

```
[Device] mac-authentication timer offline-detect 180
[Device] mac-authentication timer quiet 180
```

Specify username **aaa** and password **123456** in plain text for the account shared by MAC authentication users.

```
[Device] mac-authentication user-name-format fixed account aaa password simple 123456
```

Enable MAC authentication globally.

```
[Device] mac-authentication
```

Verifying the configuration

Verify the MAC authentication configuration.

```
[Device] display mac-authentication
 Global MAC authentication parameters:
   MAC authentication                  : Enabled
   Authentication method               : CHAP
   Username format                     : Fixed account
           Username                    : aaa
           Password                    : ******
   Offline detect period               : 180 s
   Quiet period                        : 180 s
   Server timeout                      : 100 s
   Reauth period                       : 3600 s
   User aging period for critical VLAN : 1000 s
   User aging period for guest VLAN    : 1000 s
   Authentication domain               : bbb
 Online MAC-auth wired users           : 1

 Silent MAC users:
          MAC address       VLAN ID  From port               Port index

 GigabitEthernet1/0/1  is link-up
   MAC authentication               : Enabled
   Carry User-IP                    : Disabled
   Authentication domain            : Not configured
```

```
Auth-delay timer                 : Disabled
Periodic reauth                  : Disabled
Re-auth server-unreachable       : Logoff
Guest VLAN                       : Not configured
Guest VLAN reauthentication      : Enabled
  Guest VLAN auth-period         : 30 s
Critical VLAN                    : Not configured
Critical voice VLAN              : Disabled
Host mode                        : Single VLAN
Offline detection                : Enabled
Authentication order             : Default
User aging                       : Enabled
Server-recovery online-user-sync : Enabled

Auto-tag feature                 : Disabled
VLAN tag configuration ignoring  : Disabled
Max online users                 : 4294967295
Authentication attempts          : successful 1, failed 0
Current online users             : 1
       MAC address       Auth state
       00e0-fc12-3456    Authenticated
```

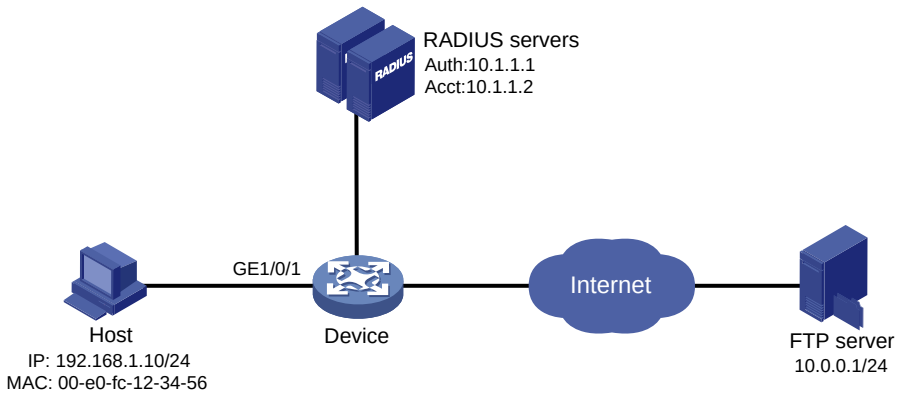
Example: Configuring ACL assignment for MAC authentication

Network configuration

As shown in Figure 7, configure the device to meet the following requirements:

- Use RADIUS servers to perform authentication, authorization, and accounting for users.
- Perform MAC authentication on GigabitEthernet 1/0/1 to control Internet access.
- Use the MAC address of each user as both the username and password for MAC authentication. The MAC addresses are in hexadecimal notation with hyphens, and letters are in lower case.
- Use an ACL to deny authenticated users to access the FTP server at 10.0.0.1.

Figure 7 Network diagram



Procedure

Make sure the RADIUS servers and the access device can reach each other.

1. Configure the RADIUS servers:

Configure the RADIUS servers to provide authentication, authorization, and accounting services. (Details not shown.)

Add a user account with **00-e0-fc-12-34-56** as both the username and password on each RADIUS server. (Details not shown.)

Specify ACL 3000 as the authorization ACL for the user account. (Details not shown.)

2. Configure ACL 3000 to deny packets destined for 10.0.0.1 on the device.

```
<Device> system-view
[Device] acl advanced 3000
[Device-acl-ipv4-adv-3000] rule 0 deny ip destination 10.0.0.1 0
[Device-acl-ipv4-adv-3000] quit
```

3. Configure RADIUS-based MAC authentication on the device:

Configure a RADIUS scheme.

```
[Device] radius scheme 2000
[Device-radius-2000] primary authentication 10.1.1.1 1812
[Device-radius-2000] primary accounting 10.1.1.2 1813
[Device-radius-2000] key authentication simple abc
[Device-radius-2000] key accounting simple abc
[Device-radius-2000] user-name-format without-domain
[Device-radius-2000] quit
```

Apply the RADIUS scheme to an ISP domain for authentication, authorization, and accounting.

```
[Device] domain bbb
[Device-isp-bbb] authentication default radius-scheme 2000
[Device-isp-bbb] authorization default radius-scheme 2000
[Device-isp-bbb] accounting default radius-scheme 2000
[Device-isp-bbb] quit
```

Specify the ISP domain for MAC authentication.

```
[Device] mac-authentication domain bbb
```

Use the MAC address of each user as both the username and password for MAC authentication. The MAC addresses are in hexadecimal notation with hyphens, and letters are in lower case.

```
[Device] mac-authentication user-name-format mac-address with-hyphen lowercase
```

Enable MAC authentication on GigabitEthernet 1/0/1.

```
[Device] interface gigabitethernet 1/0/1
[Device-GigabitEthernet1/0/1] mac-authentication
[Device-GigabitEthernet1/0/1] quit
```

Enable MAC authentication globally.

```
[Device] mac-authentication
```

Verifying the configuration

Verify the MAC authentication configuration.

```
[Device] display mac-authentication
 Global MAC authentication parameters:
   MAC authentication                 : Enable
   Authentication method              : PAP
```

```
  Username format                    : MAC address in lowercase(xx-xx-xx-xx-xx-xx)
          Username                   : mac
          Password                   : Not configured
  Offline detect period              : 300 s
  Quiet period                       : 60 s
  Server timeout                     : 100 s
  Reauth period                      : 3600 s
  User aging period for critical VLAN : 1000 s
  User aging period for guest VLAN    : 1000 s
  Authentication domain              : bbb
Online MAC-auth wired users          : 1

Silent MAC users:
         MAC address       VLAN ID  From port               Port index

GigabitEthernet1/0/1  is link-up
  MAC authentication               : Enabled
  Carry User-IP                    : Disabled
  Authentication domain            : Not configured
  Auth-delay timer                 : Disabled
  Periodic reauth                  : Disabled
  Re-auth server-unreachable       : Logoff
  Guest VLAN                       : Not configured
  Guest VLAN reauthentication      : Enabled
    Guest VLAN auth-period         : 30 s
  Critical VLAN                    : Not configured
  Critical voice VLAN              : Disabled
  Host mode                        : Single VLAN
  Offline detection                : Enabled
  Authentication order             : Default
  User aging                       : Enabled
  Server-recovery online-user-sync : Enabled

  Auto-tag feature                 : Disabled
  VLAN tag configuration ignoring  : Disabled
  Max online users                 : 4294967295
  Authentication attempts          : successful 1, failed 0
  Current online users             : 1
         MAC address       Auth state
         00e0-fc12-3456    Authenticated
```

Verify that you cannot ping the FTP server from the host.

```
C:\>ping 10.0.0.1

Pinging 10.0.0.1 with 32 bytes of data:

Request timed out.
Request timed out.
Request timed out.
```

```
Request timed out.

Ping statistics for 10.0.0.1:
   Packets: Sent = 4, Received = 0, Lost = 4 (100% loss),
```

The output shows that ACL 3000 has been assigned to GigabitEthernet 1/0/1 to deny access to the FTP server.

Contents

Configuring portal authentication

About portal authentication

Portal authentication controls user access to networks. Portal authenticates a user by the username and password the user enters on a portal authentication page. Typically, portal authentication is deployed on the access layer and vital data entries.

In a portal-enabled network, users can actively initiate portal authentication by visiting the authentication website provided by the portal Web server. Or, they are redirected to the portal authentication page for authentication when they visit other websites.

The device supports Portal 1.0, Portal 2.0, and Portal 3.0.

Advantages of portal authentication

Portal authentication has the following advantages:

- Allows users to perform authentication through a Web browser without installing client software.
- Provides ISPs with diversified management choices and extended functions. For example, the ISPs can place advertisements, provide community services, and publish information on the authentication page.
- Supports multiple authentication modes. For example, re-DHCP authentication implements a flexible address assignment scheme and saves public IP addresses. Cross-subnet authentication can authenticate users who reside in a different subnet than the access device.

Extended portal functions

By forcing patching and anti-virus policies, extended portal functions help hosts to defend against viruses. Portal supports the following extended functions:

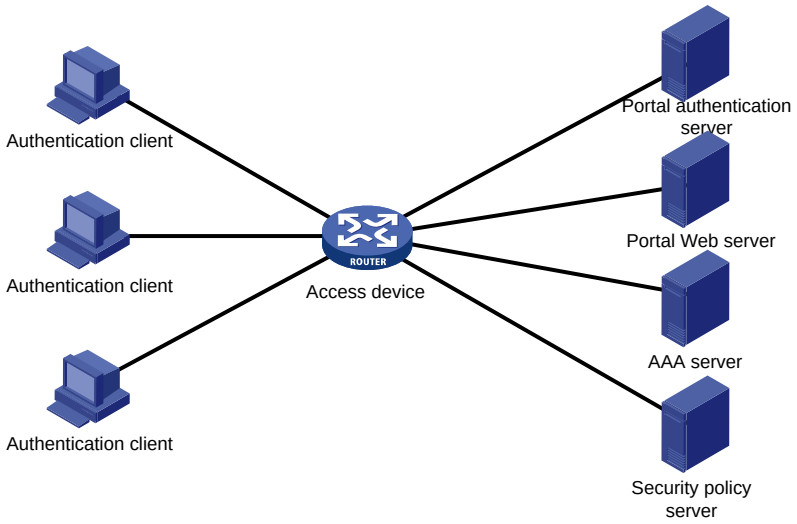
- **Security check**—Detects after authentication whether or not a user host installs anti-virus software, virus definition file, unauthorized software, and operating system patches.
- **Resource access restriction**—Allows an authenticated user to access certain network resources such as the virus server and the patch server. Users can access more network resources after passing security check.

Security check must cooperate with the H3C IMC security policy server and the iNode client.

Portal system

A typical portal system consists of these basic components: authentication client, access device, portal authentication server, portal Web server, AAA server, and security policy server.

Figure 1 Portal system



Authentication client

An authentication client is a Web browser that runs HTTP/HTTPS or a user host that runs a portal client. Security check for the user host is implemented through the interaction between the portal client and the security policy server. Only the H3C iNode client is supported.

Access device

An access device provides access services. It has the following functions:

- Redirects all HTTP or HTTPS requests of unauthenticated users to the portal Web server.
- Interacts with the portal authentication server and the AAA server to complete authentication, authorization, and accounting.
- Allows users that pass portal authentication to access authorized network resources.

Portal server

A portal server collectively refers to a portal authentication server and portal Web server.

The portal Web server pushes the Web authentication page to authentication clients and forwards user authentication information (username and password) to the portal authentication server. The portal authentication server receives authentication requests from authentication clients and interacts with the access device to authenticate users. The portal Web server is typically integrated with the portal authentication server and it can also be an independent server.

AAA server

The AAA server interacts with the access device to implement authentication, authorization, accounting for portal users. In a portal system, a RADIUS server can perform authentication, authorization, accounting for portal users, and an LDAP server can perform authentication for portal users.

Security policy server

The security policy server interacts with the portal client and the access device for security check and authorization for users. Only hosts that run portal clients can interact with the security policy server.

Portal authentication using a remote portal server

The components of a portal system interact as follows:

1. An unauthenticated user initiates authentication by accessing an Internet website through a Web browser. When receiving the HTTP or HTTPS request, the access device redirects it to the

Web authentication page provided by the portal Web server. The user can also visit the authentication website to log in. The user must log in through the H3C iNode client for extended portal functions.

2. The user enters the authentication information on the authentication page/dialog box and submits the information. The portal Web server forwards the information to the portal authentication server. The portal authentication server processes the information and forwards it to the access device.
3. The access device interacts with the AAA server to implement authentication, authorization, accounting for the user.
4. If security policies are not imposed on the user, the access device allows the authenticated user to access networks.

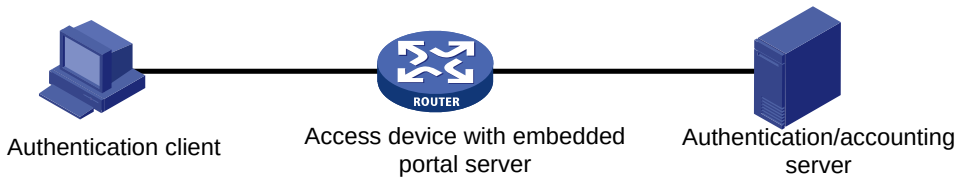
   If security policies are imposed on the user, the portal client, the access device, and the security policy server interact to check the user host. If the user passes the security check, the security policy server authorizes the user to access resources based on the check result.

Local portal service

System components

As shown in Figure 2, a local portal system consists of an authentication client, access device, and AAA server. The access device acts as both the portal Web server and the portal authentication server to provide the local portal Web service for the authentication client. The authentication client can only be a Web browser, and it cannot be a user host that runs a portal client. Therefore, extended portal functions are not supported and no security policy server is required.

Figure 2 System components



Portal page customization

To provide the local portal web service, you must customize a set of authentication pages that the device will push to users. You can customize multiple sets of authentication pages, compress each set of the pages to a .zip file, and upload the compressed files to the storage medium of the device. On the device, you must specify one of the files as the default authentication page file by using the **default-logon-page** command.

For more information about authentication page customization, see "Customizing authentication pages."

Portal authentication modes

Portal authentication has three modes: direct authentication, re-DHCP authentication, and cross-subnet authentication. In direct authentication and re-DHCP authentication, no Layer 3 forwarding devices exist between the authentication client and the access device. In cross-subnet authentication, Layer 3 forwarding devices can exist between the authentication client and the access device.

Direct authentication

A user manually configures a public IP address or obtains a public IP address through DHCP. Before authentication, the user can access only the portal Web server and predefined authentication-free

websites. After passing authentication, the user can access other network resources. The process of direct authentication is simpler than that of re-DHCP authentication.

Re-DHCP authentication

Before a user passes authentication, DHCP allocates an IP address (a private IP address) to the user. The user can access only the portal Web server and predefined authentication-free websites. After the user passes authentication, DHCP reallocates an IP address (a public IP address) to the user. The user then can access other network resources. No public IP address is allocated to users who fail authentication. Re-DHCP authentication saves public IP addresses. For example, an ISP can allocate public IP addresses to broadband users only when they access networks beyond the residential community network.

Only the H3C iNode client supports re-DHCP authentication. IPv6 portal authentication does not support the re-DHCP authentication mode.

Cross-subnet authentication

Cross-subnet authentication is similar to direct authentication, except it allows Layer 3 forwarding devices to exist between the authentication client and the access device.

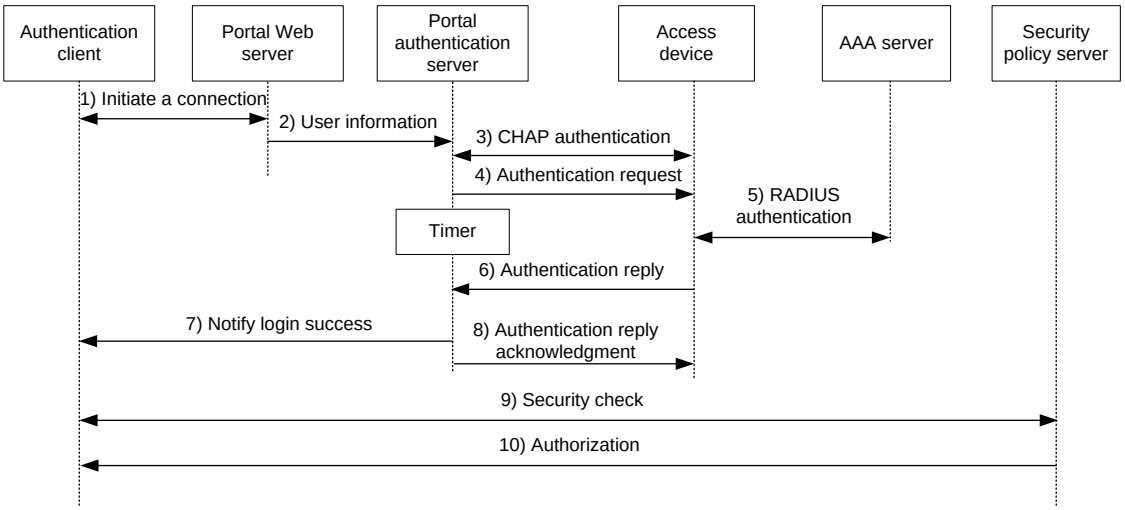
In direct authentication, re-DHCP authentication, and cross-subnet authentication, a user's IP address uniquely identifies the user. After a user passes authentication, the access device generates an ACL for the user based on the user's IP address to control forwarding of the packets from the user. Because no Layer 3 forwarding device exists between authentication clients and the access device in direct authentication and re-DHCP authentication, the access device can learn the user MAC addresses. The access device can enhance its capability of controlling packet forwarding by using the learned MAC addresses.

Portal authentication process

Direct authentication and cross-subnet authentication share the same authentication process. Re-DHCP authentication has a different process as it has two address allocation procedures.

Direct authentication/cross-subnet authentication process (with CHAP/PAP authentication)

Figure 3 Direct authentication/cross-subnet authentication process



The direct/cross-subnet authentication process is as follows:

1. A portal user access the Internet through HTTP or HTTPS, and the HTTP or HTTPS packet arrives at the access device.
   - If the packet matches a portal free rule, the access device allows the packet to pass.

- If the packet does not match any portal-free rule, the access device redirects the packet to the portal Web server. The portal Web server pushes the Web authentication page to the user for him to enter his username and password.

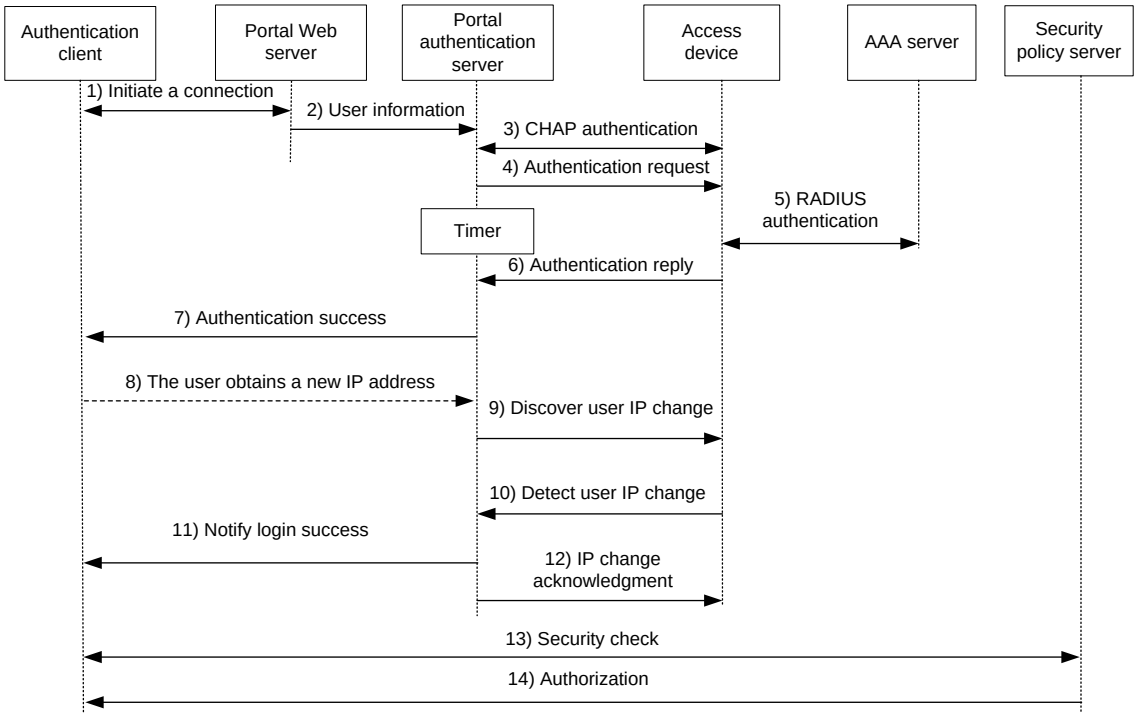
2. The portal Web server submits the user authentication information to the portal authentication server.
3. The portal authentication server and the access device exchange CHAP messages. This step is skipped for PAP authentication. The portal authentication server decides the method (CHAP or PAP) to use.
4. The portal authentication server adds the username and password into an authentication request packet and sends it to the access device. Meanwhile, the portal authentication server starts a timer to wait for an authentication reply packet.
5. The access device and the RADIUS server exchange RADIUS packets.
6. The access device sends an authentication reply packet to the portal authentication server to notify authentication success or failure.
7. The portal authentication server sends an authentication success or failure packet to the client.
8. If the authentication is successful, the portal authentication server sends an authentication reply acknowledgment packet to the access device.

If the client is an iNode client, the authentication process includes step 9 and step 10 for extended portal functions. Otherwise the authentication process is complete.

9. The client and the security policy server exchange security check information. The security policy server detects whether or not the user host installs anti-virus software, virus definition files, unauthorized software, and operating system patches.
10. The security policy server authorizes the user to access certain network resources based on the check result. The access device saves the authorization information and uses it to control access of the user.

Re-DHCP authentication process (with CHAP/PAP authentication)

Figure 4 Re-DHCP authentication process



The re-DHCP authentication process is as follows:

Step 1 through step 7 are the same as those in the direct authentication/cross-subnet authentication process.

8. After receiving the authentication success packet, the client obtains a public IP address through DHCP. The client then notifies the portal authentication server that it has a public IP address.
9. The portal authentication server notifies the access device that the client has obtained a public IP address.
10. The access device detects the IP change of the client through DHCP and then notifies the portal authentication server that it has detected an IP change of the client IP.
11. After receiving the IP change notification packets sent by the client and the access device, the portal authentication server notifies the client of login success.
12. The portal authentication server sends an IP change acknowledgment packet to the access device.

Step 13 and step 14 are for extended portal functions.

13. The client and the security policy server exchanges security check information. The security policy server detects whether or not the user host installs anti-virus software, virus definition files, unauthorized software, and operating system patches.
14. The security policy server authorizes the user to access certain network resources based on the check result. The access device saves the authorization information and uses it to control access of the user.

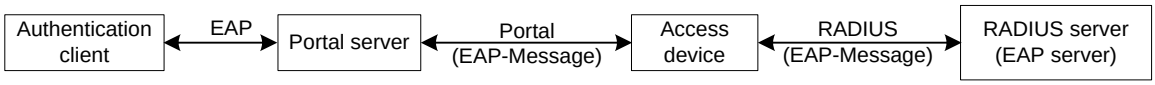
Portal support for EAP

To use portal authentication that supports EAP, the portal authentication server and client must be the H3C IMC portal server and the H3C iNode portal client. Local portal authentication does not support EAP authentication.

Compared with username and password based authentication, digital certificate-based authentication ensures higher security.

The Extensible Authentication Protocol (EAP) supports several digital certificate-based authentication methods, for example, EAP-TLS. Working together with EAP, portal authentication can implement digital certificate-based user authentication.

Figure 5 Portal support for EAP working flow diagram



As shown in Figure 5, the authentication client and the portal authentication server exchange EAP authentication packets. The portal authentication server and the access device exchange portal authentication packets that carry the EAP-Message attributes. The access device and the RADIUS server exchange RADIUS packets that carry the EAP-Message attributes. The RADIUS server that supports the EAP server function processes the EAP packets encapsulated in the EAP-Message attributes, and provides the EAP authentication result.

The access device does not process but only transports EAP-Message attributes between the portal authentication server and the RADIUS server. Therefore, the access device requires no additional configuration to support EAP authentication.

Portal filtering rules

The access device uses portal filtering rules to control user traffic forwarding.

Based on the configuration and authentication status of portal users, the device generates the following categories of portal filtering rules:

- **Category 1**—The rule permits user packets that are destined for the portal Web server and packets that match the portal-free rules to pass through.
- **Category 2**—For an authenticated user with no ACL authorized, the rule allows the user to access any destination network resources. For an authenticated user with an ACL authorized, the rule allows users to access resources permitted by the ACL. The device adds the rule when a user comes online and deletes the rule when the user goes offline.

  The device supports the following types of authorization ACLs:

  - Basic ACLs (ACL 2000 to ACL 2999).
  - Advanced ACLs (ACL 3000 to ACL 3999).
  - Layer 2 ACLs (ACL 4000 to ACL 4999).

  For an authorization ACL to take effect, make sure the ACL exists and has ACL rules excluding rules configured with the **`counting`**, **`established`**, **`fragment`**, **`source-mac`**, or **`logging`** keyword. For more information about ACL rules, see ACL commands in *ACL and QoS Command Reference*.
- **Category 3**—The rule redirects all HTTP or HTTPS requests from unauthenticated users to the portal Web server.
- **Category 4**—For direct authentication and cross-subnet authentication, the rule forbids any user packets to pass through. For re-DHCP authentication, the device forbids user packets with private source addresses to pass.

After receiving a user packet, the device compares the packet against the filtering rules from category 1 to category 4. Once the packet matches a rule, the matching process completes.

Restrictions and guidelines: Portal configuration

Portal authentication through Web does not support security check for users. To implement security check, the client must be the H3C iNode client.

Portal authentication supports NAT traversal whether it is initiated by a Web client or an H3C iNode client. NAT traversal must be configured when the portal client is on a private network and the portal server is on a public network.

Portal authentication tasks at a glance

To configure portal authentication, perform the following tasks:

1. Configuring a remote portal service

   Perform this task if a remote portal server is used.

   - Configuring a remote portal authentication server
   - Configuring a portal Web server
2. Configuring a local portal service

   Perform this task if the access device acts as a portal authentication server and portal Web server.

   - Configuring local portal service features
   - Configuring a portal Web server
3. Enabling portal authentication and specifying a portal Web server
   - Enabling portal authentication on an interface
   - Specifying a portal Web server on an interface
4. (Optional.) Specifying a preauthentication IP address pool
5. (Optional.) Specifying a portal authentication domain

6. (Optional.) Controlling portal user access
   - Configuring a portal-free rule
   - Configuring an authentication source subnet
   - Configuring an authentication destination subnet
   - Configuring support of Web proxy for portal authentication
   - Checking the issuing of category-2 portal filtering rules
   - Setting the maximum number of portal users
   - Enabling strict-checking on portal authorization information
   - Allowing only users with DHCP-assigned IP addresses to pass portal authentication
   - Enabling portal roaming
   - Configuring the portal fail-permit feature
7. (Optional.) Configuring portal detection features
   - Configuring online detection of portal users
   - Configuring portal authentication server detection
   - Configuring portal Web server detection
   - Configuring portal user synchronization
8. (Optional.) Configuring attributes for portal packets and RADIUS packets
   - Configuring portal packet attributes

     You can configure the BAS-IP or BAS-IPv6 attribute for portal packets and specify the device ID.
   - Configuring attributes for RADIUS packets

     You can configure the NAS-Port-Id and NAS-Port-Type attributes and apply a NAS-ID profile to an interface.
9. (Optional.) Configuring online and offline related features for portal users
   - Logging out online portal users
   - Enabling portal user login/logout logging
10. (Optional.) Configuring extended portal authentication features
    - Disabling the Rule ARP or ND entry feature for portal clients
    - Configuring Web redirect

Prerequisites for portal authentication

The portal feature provides a solution for user identity authentication and security check. To complete user identity authentication, portal must cooperate with RADIUS.

Before you configure portal, you must complete the following tasks:

- The portal authentication server, portal Web server, and RADIUS server have been installed and configured correctly.
- To use the re-DHCP portal authentication mode, make sure the DHCP relay agent is enabled on the access device, and the DHCP server is installed and configured correctly.
- The portal client, access device, and servers can reach each other.
- To use the remote RADIUS server, configure usernames and passwords on the RADIUS server, and configure the RADIUS client on the access device. For information about RADIUS client configuration, see "Configuring AAA."
- To implement extended portal functions, install and configure CAMS EAD or IMC EAD. Make sure the ACLs configured on the access device correspond to the isolation ACL and the security ACL on the security policy server. For installation and configuration about the security

policy server, see *CAMS EAD Security Policy Component User Manual* or *IMC EAD Security Policy Help*.

Configuring a remote portal authentication server

About configuring the remote portal authentication server

With portal authentication enabled, the device searches for a portal authentication server for a received portal request packet according to the source IP address of the packet.

- If a matching portal authentication server is found, the device regards the packet valid and sends an authentication response packet to the portal authentication server. After a user logs in to the device, the user interacts with the portal authentication server as needed.
- If no matching portal authentication server is found, the device drops the packet.

Restrictions and guidelines

Do not delete a portal authentication server in use. Otherwise, users authenticated by that server cannot log out correctly.

Procedure

1. Enter system view.

   system-view

2. Create a portal authentication server and enter its view.

   portal server *server-name*

   You can create multiple portal authentication servers.

3. Specify the IP address of the portal authentication server.

   IPv4:

   ip *ipv4-address* [**key** { **cipher** | **simple** } *string*]

   IPv6:

   ipv6 *ipv6-address* [**key** { **cipher** | **simple** } *string*]

4. (Optional.) Set the destination UDP port number used by the device to send unsolicited portal packets to the portal authentication server.

   port *port-number*

   By default, the UDP port number is 50100.

   This port number must be the same as the listening port number specified on the portal authentication server.

5. (Optional.) Specify the portal authentication server type.

   server-type { **cmcc** | **imc** }

   By default, the portal authentication server type is IMC.

   The specified server type must be the same as the type of the portal authentication server actually used.

6. (Optional.) Configure the device to periodically register with the portal authentication server.

   server-register [**interval** *interval-value*]

   By default, the device does not register with a portal authentication server.

Configuring a portal Web server

Portal Web server tasks at a glance

To configure a portal Web server, perform the following tasks:

1. Configure basic parameters for a portal Web server
2. (Optional.) Enabling the captive-bypass feature
3. (Optional.) Configuring a match rule for URL redirection

Configure basic parameters for a portal Web server

1. Enter system view.
   system-view
2. Create a portal Web server and enter its view.
   portal web-server *server-name*
   You can create multiple portal Web servers.
3. Specify the URL of the portal Web server.
   url *url-string*
   By default, no URL is specified for a portal Web server.
4. Configure the parameters to be carried in the URL when the device redirects it to users.
   url-parameter *param-name* { **original-url** | **source-address** | **source-mac** [**encryption** { **aes** | **des** } **key** { **cipher** | **simple** } *string*] | **value** *expression* }
   By default, no redirection URL parameters are configured.
5. (Optional.) Specify the portal Web server type.
   server-type { **cmcc** | **imc** }
   By default, the portal Web server type is IMC.
   This configuration is applicable to only to the remote portal service.
   The specified server type must be the same as the type of the portal Web server actually used.

Enabling the captive-bypass feature

About the captive-bypass feature

By default, the device automatically pushes the portal authentication page to iOS devices and some Android devices when they are connected to the network. The captive-bypass feature enables the device to push the portal authentication page to iOS devices and some Android devices only when they access the Internet by using browsers.

Procedure

1. Enter system view.
   system-view
2. Enter portal Web server view.
   portal web-server *server-name*
3. Enable the captive-pass feature.
   captive-bypass enable
   By default, the captive-bypass feature is disabled.

Configuring a match rule for URL redirection

About match rules for URL redirection

A URL redirection match rule matches HTTP or HTTPS requests by user-requested URL or User-Agent information, and redirects the matching requests to the specified redirection URL. Therefore, URL redirection match rules allow for more flexible URL redirection than the **url** command. The **url** command is only used to redirect HTTP or HTTPS requests from unauthenticated users to the portal Web server for authentication.

Restrictions and guidelines

For a user to successfully access a redirection URL, configure a portal-free rule to allow HTTP or HTTPS requests destined for the redirection URL to pass. For information about configuring portal-free rules, see the **portal free-rule** command.

If both the **url** and **if-match** commands are executed, the **if-match** command takes priority to perform URL redirection.

Procedure

1. Enter system view.

   system-view
2. Enter portal Web server view.

   portal web-server *server-name*
3. Configure a match rule for URL redirection.

   if-match { **original-url** *url-string* **redirect-url** *url-string* [**url-param-encryption** { **aes** | **des** } **key** { **cipher** | **simple** } *string*] | **user-agent** *string* **redirect-url** *url-string* }

Configuring local portal service features

About the local portal service

After a local portal service is configured, the device acts as the portal Web server and portal authentication server to perform portal authentication on users. The portal authentication page file is saved in the root directory of the device.

Restrictions and guidelines for configuring local portal service features

For an interface to use the local portal service, the URL of the portal Web server specified for the interface must meet the following requirements:

- The IP address in the URL must be the IP address of a Layer 3 interface (except 127.0.0.1) on the device, and the IP address must be reachable to portal clients.
- The URL must be ended with **/portal/**. For example: **http://1.1.1.1/portal/**.

As a best practice for the correct operation of the local portal Web service, use the default authentication page file in the root directory of the device storage medium. To use custom authentication pages, you must strictly follow the related restrictions and guidelines when customizing your own authentication pages. For more information about the restrictions and guidelines, see "Customizing authentication pages."

Customizing authentication pages

About customizing authentication pages

Authentication pages are HTML files. Local portal authentication requires the following authentication pages:

- Logon page
- Logon success page
- Logon failure page
- Online page
- System busy page
- Logoff success page

You must customize the authentication pages, including the page elements that the authentication pages will use, for example, **back.jpg** for authentication page **Logon.htm**.

Follow the authentication page customization rules when you edit the authentication page files.

File name rules

The names of the main authentication page files are fixed (see Table 1). You can define the names of the files other than the main authentication page files. File names and directory names are case insensitive.

Table 1 Main authentication page file names

Main authentication page	File name
Logon page	logon.htm
Logon success page	logonSuccess.htm
Logon failure page	logonFail.htm
Online page Pushed after the user gets online for online notification	online.htm
System busy page Pushed when the system is busy or the user is in the logon process	busy.htm
Logoff success page	logoffSuccess.htm

Page request rules

The local portal Web server supports only Get and Post requests.

- **Get requests**—Used to get the static files in the authentication pages and allow no recursion. For example, if file **Logon.htm** includes contents that perform Get action on file **ca.htm**, file **ca.htm** cannot include any reference to file **Logon.htm**.
- **Post requests**—Used when users submit username and password pairs, log in, and log out.

Post request attribute rules

1. Observe the following requirements when editing a form of an authentication page:
   - An authentication page can have multiple forms, but there must be one and only one form whose action is **logon.cgi**. Otherwise, user information cannot be sent to the access device.
   - The username attribute is fixed as **PtUser**. The password attribute is fixed as **PtPwd**.
   - The value of the **PtButton** attribute is either **Logon** or **Logoff**, which indicates the action that the user requests.

- A logon Post request must contain **PtUser**, **PtPwd**, and **PtButton** attributes.
- A logoff Post request must contain the **PtButton** attribute.

2. Authentication pages **logon.htm** and **logonFail.htm** must contain the logon Post request.

   The following example shows part of the script in page **logon.htm**.

```
<form action=logon.cgi method = post >
<p>User name:<input type="text" name = "PtUser" style="width:160px;height:22px"
maxlength=64>
<p>Password :<input type="password" name = "PtPwd" style="width:160px;height:22px"
maxlength=32>
<p><input type=SUBMIT value="Logon" name = "PtButton" style="width:60px;"
onclick="form.action=form.action+location.search;">
</form>
```

3. Authentication pages **logonSuccess.htm** and **online.htm** must contain the logoff Post request.

   The following example shows part of the script in page **online.htm**.

```
<form action=logon.cgi method = post >
<p><input type=SUBMIT value="Logoff" name="PtButton" style="width:60px;">
</form>
```

Page file compression and saving rules

You must compress the authentication pages and their page elements into a standard zip file.

- The name of a zip file can contain only letters, numbers, and underscores.
- The authentication pages must be placed in the root directory of the zip file.
- Zip files can be transferred to the device through FTP or TFTP and must be saved in the root directory of the device.

  Examples of zip files on the device:

```
<Sysname> dir
Directory of flash:
   1     -rw-      1405  Feb 28 2008 15:53:20   ssid1.zip
   0     -rw-      1405  Feb 28 2008 15:53:31   ssid2.zip
   2     -rw-      1405  Feb 28 2008 15:53:39   ssid3.zip
   3     -rw-      1405  Feb 28 2008 15:53:44   ssid4.zip
2540 KB total (1319 KB free)
```

Redirecting authenticated users to a specific webpage

To make the device automatically redirect authenticated users to a specific webpage, do the following in logon.htm and logonSuccess.htm:

1. In logon.htm, set the target attribute of Form to _**blank**.

   See the contents in gray:

```
<form method=post action=logon.cgi target="_blank">
```

2. Add the function for page loading pt_init() to LogonSuccess.htm.

   See the contents in gray:

```
<html>
<head>
<title>LogonSuccess</title>
<script type="text/javascript" language="javascript"
src="pt_private.js"></script>
</head>
<body onload="pt_init();" onbeforeunload="return pt_unload();">
```

```
    ... ...
    </body>
</html>
```

Configuring a local portal Web service

Prerequisites

Before you configure an HTTPS-based local portal Web service, you must complete the following tasks:

- Configure a PKI policy, obtain the CA certificate, and request a local certificate. For more information, see "Configuring PKI."
- Configure an SSL server policy, and specify the PKI domain configured in the PKI policy.

  During SSL connection establishment, the user browser might display a message that it cannot verify server identity by certificate. For users to perform portal authentication without checking such a message, configure an SSL server policy to request a client-trusted certificate on the device. The name of the policy must be **https_redirect**. For more information about SSL server policy configuration, see "Configuring SSL."

Procedure

1. Enter system view.

   system-view
2. Enable HTTP- or HTTPS-based local portal Web service and enter its view.

   portal local-web-server { **http** | **https ssl-server-policy** *policy-name* [**tcp-port** *port-number*] }
3. Specify the default authentication page file for the local portal Web service.

   default-logon-page *filename*

   By default, the default authentication page file for a local portal Web service is file **defaultfile.zip**.
4. (Optional.) Configure the HTTP or HTTPS listening TCP port for the local portal Web service.

   tcp-port *port-number*

   By default, the HTTP service listening port number is 80 and the HTTPS service listening port number is the TCP port number set by the **portal local-web-server** command.

Enabling portal authentication on an interface

Restrictions and guidelines

When you enable portal authentication on an interface, follow these restrictions and guidelines:

- Cross-subnet authentication mode (**layer3**) does not require Layer 3 forwarding devices between the access device and the portal authentication clients. However, if a Layer 3 forwarding device exists between the authentication client and the access device, you must use the cross-subnet portal authentication mode.
- You can enable both IPv4 portal authentication and IPv6 portal authentication on an interface.

When you configure re-DHCP portal authentication on an interface, follow these restrictions and guidelines:

- Make sure the interface has a valid IP address before you enable re-DHCP portal authentication on the interface.
- With re-DHCP portal authentication, configure authorized ARP on the interface as a best practice to make sure only valid users can access the network. With authorized ARP configured

on the interface, the interface learns ARP entries only from the users who have obtained a public address from DHCP.

- For successful re-DHCP portal authentication, make sure the BAS-IP or BAS-IPv6 attribute value is the same as the device IP address specified on the portal authentication server. To configure the attribute, use the **portal** { **bas-ip** | **bas-ipv6** } command.
- An IPv6 portal server does not support re-DHCP portal authentication.

Portal authentication supports HTTP and HTTPS redirect. To redirect portal users' HTTPS packets, make sure the specified HTTPS redirect listening port number (the default is 6654) is available. For more information about how to change the HTTPS redirect listening port number, see HTTPS redirect configuration in *Layer 3—IP Services Configuration Guide*.

Procedure

1. Enter system view.

   system-view
2. Enter Layer 3 interface view.

   interface *interface-type interface-number*
3. Enable portal authentication.

   IPv4:

   portal enable method { **direct** | **layer3** | **redhcp** }

   IPv6:

   portal ipv6 enable method { **direct** | **layer3** }

   By default, portal authentication is disabled.

Specifying a portal Web server on an interface

About specifying a portal Web server on an interface

With a portal Web server specified on an interface, the device redirects the HTTP requests of portal users on the interface to the portal Web server.

You can specify both an IPv4 portal Web server and an IPv6 portal Web server on an interface.

Procedure

1. Enter system view.

   system-view
2. Enter Layer 3 interface view.

   interface *interface-type interface-number*
3. Specify a portal Web server on the interface.

   portal [**ipv6**] **apply web-server** *server-name* [**fail-permit** | **secondary**]

   By default, no portal Web servers are specified on an interface.

   The **secondary** keyword is supported only in Release 6348P01 and later.

Specifying a preauthentication IP address pool

About preauthentication IP address pools

You must specify a preauthentication IP address pool on a portal-enabled interface in the following situation:

- Portal users access the network through a subinterface of the portal-enabled interface.

- The subinterface does not have an IP address.
- Portal users need to obtain IP addresses through DHCP.

After a user connects to a portal-enabled interface, the user uses an IP address for portal authentication according to the following rules:

- If the interface is configured with a preauthentication IP address pool, the user uses the following IP address:
  - If the client is configured to obtain an IP address automatically through DHCP, the user obtains an address from the specified IP address pool.
  - If the client is configured with a static IP address, the user uses the static IP address.
- If the interface has an IP address but no preauthentication IP pool specified, the user uses the static IP address or the IP address obtained from a DHCP server.
- If the interface has no IP address or preauthentication IP pool specified, the user cannot perform portal authentication.

After the user passes portal authentication, the AAA server authorizes an IP address pool for re-assigning an IP address to the user. If no authorized IP address pool is deployed, the user continues using the previous IP address.

Restrictions and guidelines

This configuration takes effect only when the direct IPv4 portal authentication is enabled on the interface.

Make sure the specified IP address pool exists and is complete. Otherwise, the user cannot obtain the IP address and cannot perform portal authentication.

If the portal user does not perform authentication or fails to pass authentication, the assigned IP address is still retained.

Procedure

1. Enter system view.
   system-view
2. Enter Layer 3 interface view.
   interface *interface-type interface-number*
3. Specify a preauthentication IP address pool on the interface.
   portal [**ipv6**] **pre-auth ip-pool** *pool-name*
   By default, no preauthentication IP address pool is specified on an interface.

Specifying a portal authentication domain

About portal authentication domains

An authentication domain defines a set of authentication, authorization, and accounting policies. Each portal user belongs to an authentication domain and is authenticated, authorized, and accounted in the domain.

With an authentication domain specified on an interface, the device uses the authentication domain for AAA of portal users. This allows for flexible portal access control.

Restrictions and guidelines for specifying a portal authentication domain

The device selects the authentication domain for a portal user in this order:

1. ISP domain specified for the interface.
2. ISP domain carried in the username.
3. System default ISP domain.

If the chosen domain does not exist on the device, the device searches for the ISP domain configured to accommodate users assigned to nonexistent domains. If no such ISP domain is configured, user authentication fails. For information about ISP domains, see "Configuring AAA."

For the authorization ACL in the authentication domain, the following rules apply:

- If the user traffic matches a rule in the ACL, the device processes the traffic based on the permit or deny statement of the rule.
- If the user traffic does not match any rule in the ACL, the device permits the traffic. To deny such traffic, configure the last rule in the ACL to deny all packets by using the **rule deny ip** command.
- If the ACL contains rules that specify a source address, users might not be able to get online. Do not specify a source IPv4, IPv6, or MAC address when you configure a rule in the ACL.

Specifying a portal authentication domain on an interface

1. Enter system view.

   system-view
2. Enter Layer 3 interface view.

   interface *interface-type interface-number*
3. Specify an portal authentication domain on the interface.

   portal [**ipv6**] **domain** *domain-name*

   By default, no portal authentication domain is specified on an interface.

   You can specify both an IPv4 portal authentication domain and an IPv6 portal authentication domain on an interface.

Controlling portal user access

Configuring a portal-free rule

About portal-free rules

A portal-free rule allows specified users to access specified external websites without portal authentication.

The matching items for a portal-free rule include the host name, source/destination IP address, TCP/UDP port number, source MAC address, access interface, and VLAN. Packets matching a portal-free rule will not trigger portal authentication, so users sending the packets can directly access the specified external websites.

Restrictions and guidelines for configuring a portal-free rule

If you specify both a VLAN and an interface, the interface must belong to the VLAN. If the interface does not belong to the VLAN, the portal-free rule does not take effect.

You cannot configure two or more portal-free rules with the same filtering criteria. Otherwise, the system prompts that the rule already exists.

Regardless of whether portal authentication is enabled or not, you can only add or remove a portal-free rule. You cannot modify it.

Configuring an IP-based portal-free rule

1. Enter system view.

   system-view

2. Configure an IP-based portal-free rule.

   IPv4:

   portal free-rule *rule-number* { **destination ip** { *ipv4-address* { *mask-length* | *mask* } | **any** } [**tcp** *tcp-port-numbe*r | **udp** *udp-port-number*] | **source ip** { *ipv4-address* { *mask-length* | *mask* } | **any** } [**tcp** *tcp-port-number* | **udp** *udp-port-number*] } * [**interface** *interface-type interface-number*]

   IPv6:

   portal free-rule *rule-number* { **destination ipv6** { *ipv6-address prefix-length* | **any** } [**tcp** *tcp-port-numbe*r | **udp** *udp-port-number*] | **source ipv6** { *ipv6-address prefix-length* | **any** } [**tcp** *tcp-port-number* | **udp** *udp-port-number*] } * [**interface** *interface-type interface-number*]

Configuring a source-based portal-free rule

1. Enter system view.

   system-view

2. Configure a source-based portal-free rule.

   portal free-rule *rule-number* **source** { **interface** *interface-type interface-number* | **mac** *mac-address* | **vlan** *vlan-id* } *

   The **vlan** *vlan-id* option takes effect only on portal users that access the network through VLAN interfaces.

Configuring a destination-based portal-free rule

1. Enter system view.

   system-view

2. Configure a destination-based portal-free rule.

   portal free-rule *rule-number* **destination** *host-name*

   Before you configure destination-based portal-free rules, make sure a DNS server is deployed on the network.

Configuring an authentication source subnet

About authentication source subnets

By configuring authentication source subnets, you specify that only HTTP or HTTPS packets from users on the authentication source subnets can trigger portal authentication. If an unauthenticated user is not on any authentication source subnet, the access device discards all the user's HTTP or HTTPS packets that do not match any portal-free rule.

Restrictions and guidelines

Authentication source subnets apply only to cross-subnet portal authentication.

In direct or re-DHCP portal authentication mode, a portal user and its access interface (portal-enabled) are on the same subnet. It is not necessary to specify the subnet as the authentication source subnet.

- In direct mode, the access device regards the authentication source subnet as any source IP address.

- In re-DHCP mode, the access device regards the authentication source subnet on an interface as the subnet to which the private IP address of the interface belongs.

If both authentication source subnets and destination subnets are configured on an interface, only the authentication destination subnets take effect.

You can configure multiple authentication source subnets. If the source subnets overlap, the subnet with the largest address scope (with the smallest mask or prefix) takes effect.

Procedure

1. Enter system view.
   system-view
2. Enter Layer 3 interface view.
   interface *interface-type interface-number*
3. Configure a portal authentication source subnet.
   IPv4:
   portal layer3 source *ipv4-network-address* { *mask-length* | *mask* }
   By default, users from any subnets must pass portal authentication.
   IPv6:
   portal ipv6 layer3 source *ipv6-network-address prefix-length*
   By default, users from any subnets must pass portal authentication.

Configuring an authentication destination subnet

About authentication destination subnets

By configuring authentication destination subnets, you specify that users trigger portal authentication only when they accessing the specified subnets (excluding the destination IP addresses and subnets specified in portal-free rules). Users can access other subnets without portal authentication.

Restrictions and guidelines

If both authentication source subnets and destination subnets are configured on an interface, only the authentication destination subnets take effect.

You can configure multiple authentication destination subnets. If the destination subnets overlap, the subnet with the largest address scope (with the smallest mask or prefix) takes effect.

Procedure

1. Enter system view.
   system-view
2. Enter Layer 3 interface view.
   interface *interface-type interface-number*
3. Configure a portal authentication destination subnet.
   IPv4:
   portal free-all except destination *ipv4-network-address* { *mask-length* | *mask* }
   IPv6:
   portal ipv6 free-all except destination *ipv6-network-address prefix-length*
   By default, users accessing any subnets must pass portal authentication.

Configuring support of Web proxy for portal authentication

About the support of Web proxy for portal authentication

To allow HTTP requests proxied by a Web proxy server to trigger portal authentication, specify the port number of the Web proxy server on the device. If a Web proxy server port is not specified on the device, HTTP requests proxied by the Web proxy server are dropped, and portal authentication cannot be triggered.

Restrictions and guidelines

If a user's browser uses the Web Proxy Auto-Discovery (WPAD) protocol to discover Web proxy servers, you must perform the following tasks on the device:

- Specify port numbers of the Web proxy servers.
- Configure portal-free rules to allow user packets destined for the WPAD server to pass without authentication.

If portal users enable Web proxy in their browsers, the users must add the IP address of the portal authentication server as a proxy exception in their browsers. Thus, HTTP packets that the users send to the portal authentication server will not be sent to Web proxy servers.

You cannot specify Web proxy server port 443 on the device.

You can execute this command multiple times to specify multiple port numbers of Web proxy servers.

Procedure

1. Enter system view.

   system-view

2. Specify the port number of a Web proxy server.

   portal web-proxy port *port-number*

   By default, no port numbers of Web proxy servers are specified. Proxied HTTP requests are dropped.

Checking the issuing of category-2 portal filtering rules

About checking the issuing of category-2 portal filtering rules

Category-2 portal filtering rules permit authenticated users to access authorized network resources. By default, the device allows an authenticated user to come online as long as a member device has issued a category-2 portal filtering rule for the user. Users coming online from global interfaces might fail to access network resources because some member ports might not have category-2 rules for the users. To resolve this issue, enable the device to check the issuing of category-2 portal filtering rules. Then, the device allows users to come online only when all member devices have issued category-2 portal filtering rules for the users.

As a best practice, perform this task when portal authentication is enabled on a global interface.

Procedure

1. Enter system view.

   system-view

2. Enable the device to check the issuing of category-2 portal filtering rules.

   portal user-rule assign-check enable

   By default, the device does not check the issuing of category-2 portal filtering rules.

Setting the maximum number of portal users

About setting the maximum number of portal users

Perform this task to control the total number of portal users in the system, and the maximum number of IPv4 or IPv6 portal users on an interface.

Restrictions and guidelines for setting the maximum number of portal users

Make sure the maximum combined number of IPv4 and IPv6 portal users specified on all interfaces does not exceed the system-allowed maximum number. Otherwise, the exceeding number of portal users will not be able to log in to the device.

Setting the global maximum number of portal users

1. Enter system view.

   system-view

2. Set the global maximum number of portal users.

   portal max-user *max-number*

   By default, no limit is set on the global number of portal users.

   If you set the global maximum number smaller than the number of current online portal users on the device, this configuration still takes effect. The online users are not affected but the system forbids new portal users to log in.

Setting the maximum number of portal users on an interface

1. Enter system view.

   system-view

2. Enter Layer 3 interface view.

   interface *interface-type interface-number*

3. Set the maximum number of portal users.

   portal { **ipv4-max-user** | **ipv6-max-user** } *max-number*

   By default, no limit is set on the number of portal users on an interface.

   If you set the maximum number smaller than the current number of portal users on an interface, this configuration still takes effect. The online users are not affected but the system forbids new portal users to log in from the interface.

Enabling strict-checking on portal authorization information

About strict-checking on portal authorization information

The strict checking feature allows a portal user to stay online only when the authorization information for the user is successfully deployed.

Enabling strict checking on portal authentication information on an interface

1. Enter system view.

   system-view

2. Enter Layer 3 interface view.

   interface *interface-type interface-number*

3. Enable strict checking on portal authorization information.

   portal authorization { **acl** | **user-profile** } **strict-checking**

CAUTION:

- The strict checking fails if the authorized ACL or user profile does not exist on the device or the device fails to deploy the user profile.
- You can enable strict checking on the authorized ACL, authorized user profile, or both. If you enable both ACL checking and user profile checking, the user will be logged out if either checking fails.

By default, strict checking on portal authorization information is disabled on an interface. Portal users stay online even when the authorized ACL or user profile does not exist or the device fails to deploy the user profile.

Allowing only users with DHCP-assigned IP addresses to pass portal authentication

About allowing only users with DHCP-assigned IP addresses to pass portal authentication

This feature allows only users with DHCP-assigned IP addresses to pass portal authentication. Use this feature to ensure that only users with valid IP addresses can access the network.

Restrictions and guidelines

This feature takes effect only when the device acts as both the access device and the DHCP server.

Configuration of this feature does not affect the online portal users.

Allowing only users with DHCP-assigned IP addresses to pass portal authentication on an interface

1. Enter system view.
   `system-view`
2. Enter Layer 3 interface view.
   `interface` *`interface-type interface-number`*
3. Allow only users with DHCP-assigned IP addresses to pass portal authentication.
   `portal` [**`ipv6`**] **`user-dhcp-only`**

CAUTION:

- After this feature is configured, users with static IP addresses cannot pass portal authentication to come online.
- When this feature is configured in an IPv6 network, disable the temporary IPv6 address feature. Otherwise, IPv6 users will use temporary IPv6 addresses to access the IPv6 network and will fail portal authentication.

By default, both users with IP addresses obtained through DHCP and users with static IP addresses can pass authentication to come online.

Enabling portal roaming

About portal roaming

If portal roaming is enabled on a VLAN interface, an online portal user can access resources from any Layer 2 port in the VLAN without re-authentication.

If portal roaming is disabled, to access external network resources from a Layer 2 port different from the current access port in the VLAN, the user must do the following:

1. Logs out from the current port.
2. Re-authenticates on the new Layer 2 port.

Restrictions and guidelines

Portal roaming takes effect only on portal users logging in from VLAN interfaces. It does not take effect on portal users logging in from common Layer 3 interface.

You cannot enable portal roaming when online portal users exist on the device.

For portal roaming to take effect, you must disable the Rule ARP or ND entry feature by using the **undo portal refresh** { **arp** | **nd** } **enable** command.

Procedure

1. Enter system view.
   system-view
2. Enable portal roaming.
   portal roaming enable
   By default, portal roaming is disabled.

Configuring the portal fail-permit feature

About the portal fail-permit feature

Perform this task to configure the portal fail-permit feature on an interface. When the access device detects that the portal authentication server or portal Web server is unreachable, it allows users on the interface to have network access without portal authentication.

If you enable fail-permit for both a portal authentication server and a portal Web server on an interface, the interface does the following:

- Disables portal authentication when either server is unreachable.
- Resumes portal authentication when both servers are reachable.

After portal authentication resumes, unauthenticated users must pass portal authentication to access the network. Users who have passed portal authentication before the fail-permit event can continue accessing the network.

Procedure

1. Enter system view.
   system-view
2. Enter Layer 3 interface view.
   interface *interface-type interface-number*
3. Enable portal fail-permit for a portal authentication server.
   portal [**ipv6**] **fail-permit server** *server-name*
   By default, portal fail-permit is disabled for a portal authentication server.
4. Enable portal fail-permit for a portal Web server.
   portal [**ipv6**] **fail-permit web-server**
   By default, portal fail-permit is disabled for a portal Web server.
   This feature is is supported only in Release 6348P01 and later.

Configuring portal detection features

Configuring online detection of portal users

About online detection for portal users

Use the online detection feature to quickly detect abnormal logouts of portal users. Configure ARP or ICMP detection for IPv4 portal users. Configure ND or ICMPv6 detection for IPv6 portal users.

If the device receives no packets from a portal user within the idle time, the device detects the user's online status as follows:

- **ICMP or ICMPv6 detection**—Sends ICMP or ICMPv6 requests to the user at configurable intervals to detect the user status.
  - If the device receives a reply within the maximum number of detection attempts, it considers that the user is online and stops sending detection packets. Then the device resets the idle timer and repeats the detection process when the timer expires.
  - If the device receives no reply after the maximum number of detection attempts, the device logs out the user.
- **ARP or ND detection**—Sends ARP or ND requests to the user and detects the ARP or ND entry status of the user at configurable intervals.
  - If the ARP or ND entry of the user is refreshed within the maximum number of detection attempts, the device considers that the user is online and stops detection. Then the device resets the idle timer and repeats the detection process when the timer expires.
  - If the ARP or ND entry of the user is not refreshed after the maximum number of detection attempts, the device logs out the user.

Restrictions and guidelines

ARP detection and ND detection apply only to direct and re-DHCP portal authentication. ICMP detection applies to all portal authentication modes.

Procedure

1. Enter system view.

   system-view

2. Enter Layer 3 interface view.

   interface *interface-type interface-number*

3. Configure online detection of portal users.

   IPv4:

   portal user-detect type { **arp** | **icmp** } [**retry** *retries*] [**interval** *interval*] [**idle** *time*]

   IPv6:

   portal ipv6 user-detect type { **icmpv6** | **nd** } [**retry** *retries*] [**interval** *interval*] [**idle** *time*]

   By default, online detection is disabled for portal users on an interface.

Configuring portal authentication server detection

About portal authentication server detection

During portal authentication, if the communication between the access device and portal authentication server is broken, new portal users are not able to log in. Online portal users are not able to log out normally.

To address this problem, the access device needs to be able to detect the reachability changes of the portal server quickly and take corresponding actions to deal with the changes.

The portal authentication server detection feature enables the device to periodically detect portal packets sent by a portal authentication server to determine the reachability of the server. If the device receives a portal packet within a detection timeout (**timeout** *timeout*) and the portal packet is valid, the device considers the portal authentication server to be reachable. Otherwise, the device considers the portal authentication server to be unreachable.

Portal packets include user login packets, user logout packets, and heartbeat packets. Heartbeat packets are periodically sent by a server. By detecting heartbeat packets, the device can detect the server's actual status more quickly than by detecting other portal packets.

Restrictions and guidelines

The portal authentication server detection feature takes effect only when the device has a portal-enabled interface.

Only the IMC portal authentication server supports sending heartbeat packets. To test server reachability by detecting heartbeat packets, you must enable the server heartbeat feature on the IMC portal authentication server.

You can configure the device to take one or more of the following actions when the server reachability status changes:

- Sending a log message, which contains the name, the current state, and the original state of the portal authentication server.
- Enabling portal fail-permit. When the portal authentication server is unreachable, the portal fail-permit feature on an interface allows users on the interface to have network access. When the server recovers, it resumes portal authentication on the interface. For more information, see "Configuring the portal fail-permit feature."
- Make sure the detection timeout configured on the device is greater than the server heartbeat interval configured on the portal authentication server.

Procedure

1. Enter system view.

   system-view
2. Enter portal authentication server view.

   portal server *server-name*
3. Configure portal authentication server detection.

   server-detect [**timeout** *timeout*] **log**

   By default, portal authentication server detection is disabled.

Configuring portal Web server detection

About portal Web server detection

A portal authentication process cannot complete if the communication between the access device and the portal Web server is broken. To address this problem, you can enable portal Web server detection on the access device.

With the portal Web server detection feature, the access device simulates a Web access process to initiate a TCP connection to the portal Web server. If the TCP connection can be established successfully, the access device considers the detection successful, and the portal Web server is reachable. Otherwise, it considers the detection to have failed. Portal authentication status on interfaces of the access device does not affect the portal Web server detection feature.

You can configure the following detection parameters:

- **Detection interval**—Interval at which the device detects the server reachability.

- **Maximum number of consecutive failures**—If the number of consecutive detection failures reaches this value, the access device considers that the portal Web server is unreachable.

You can configure the device to take one or more of the following actions when the server reachability status changes:

- Sending a log message, which contains the name, the current state, and the original state of the portal Web server.
- Enabling portal fail-permit. When the portal Web server is unreachable, the portal fail-permit feature on an interface allows users on the interface to have network access. When the server recovers, it resumes portal authentication on the interface. For more information, see "Configuring the portal fail-permit feature."

Restrictions and guidelines

The portal Web server detection feature takes effect only when the URL of the portal Web server is specified and the device has a portal-enabled interface.

Procedure

1. Enter system view.

   system-view

2. Enter portal Web server view.

   portal web-server *server-name*

3. Configure portal Web server detection.

   server-detect [**interval** *interval*] [**retry** *retries*] **log**

   By default, portal Web server detection is disabled.

Configuring portal user synchronization

About portal user synchronization

Once the access device loses communication with a portal authentication server, the portal user information on the access device and that on the portal authentication server might be inconsistent after the communication resumes. To address this problem, the device provides the portal user synchronization feature. This feature is implemented by sending and detecting portal synchronization packets, as follows:

1. The portal authentication server sends the online user information to the access device in a synchronization packet at the user heartbeat interval.

   The user heartbeat interval is set on the portal authentication server.

2. Upon receiving the synchronization packet, the access device compares the users carried in the packet with its own user list and performs the following operations:
   - If a user contained in the packet does not exist on the access device, the access device informs the portal authentication server to delete the user. The access device starts the synchronization detection timer (**timeout** *timeout*) immediately when a user logs in.
   - If the user does not appear in any synchronization packet within a synchronization detection interval, the access device considers the user does not exist on the portal authentication server and logs the user out.

Restrictions and guidelines

Portal user synchronization requires a portal authentication server to support the portal user heartbeat function. Only the IMC portal authentication server supports the portal user heartbeat function. To implement the portal user synchronization feature, you also need to configure the user heartbeat function on the portal authentication server. Make sure the user heartbeat interval configured on the portal authentication server is not greater than the synchronization detection timeout configured on the access device.

Deleting a portal authentication server on the access device also deletes the user synchronization configuration for the portal authentication server.

Procedure

1. Enter system view.
   system-view
2. Enter portal authentication server view.
   portal server *server-name*
3. Configure portal user synchronization.
   user-sync timeout *timeout*
   By default, portal user synchronization is disabled.

Configuring portal packet attributes

Configuring the BAS-IP or BAS-IPv6 attribute

About this task

If the device runs Portal 2.0, the unsolicited packets sent to the portal authentication server must carry the BAS-IP attribute. If the device runs Portal 3.0, the unsolicited packets sent to the portal authentication server must carry the BAS-IP or BAS-IPv6 attribute.

After this attribute is configured, the source IP address for unsolicited notification portal packets the device sends to the portal authentication server is the configured BAS-IP or BAS-IPv6 address. If the attribute is not configured, the source IP address of the portal packets is the IP address of the packet output interface.

Restrictions and guidelines

During a re-DHCP portal authentication or mandatory user logout process, the device sends portal notification packets to the portal authentication server. For the authentication or logout process to complete, make sure the BAS-IP/BAS-IPv6 attribute is the same as the device IP address specified on the portal authentication server.

You must configure the BAS-IP or BAS-IPv6 attribute on a portal authentication-enabled interface if the following conditions are met:

- The portal authentication server is an H3C IMC server.
- The portal device IP address specified on the portal authentication server is not the IP address of the portal packet output interface.

Configuring the BAS-IP or BAS-IPv6 attribute on an interface

1. Enter system view.
   system-view
2. Enter Layer 3 interface view.
   interface *interface-type interface-number*
3. Configure the BAS-IP or BAS-IPv6 attribute.
   IPv4:
   portal bas-ip *ipv4-address*
   By default, the BAS-IP attribute of an IPv4 portal reply packet is the source IPv4 address of the packet. The BAS-IP attribute of an IPv4 portal notification packet is the IPv4 address of the packet's output interface.
   IPv6:

portal bas-ipv6 *ipv6-address*

By default, the BAS-IPv6 attribute of an IPv6 portal reply packet is the source IPv6 address of the packet. The BAS-IPv6 attribute of an IPv6 portal notification packet is the IPv6 address of the packet's output interface.

Specifying the device ID

About specifying the device ID

The portal authentication server uses device IDs to identify the devices that send protocol packets to the portal server.

Restrictions and guidelines

Make sure the configured device ID is different than any other access devices communicating with the same portal authentication server.

Procedure

1. Enter system view.
   system-view
2. Specify the device ID.
   portal device-id *device-id*
   By default, a device is not configured with a device ID.

Configuring attributes for RADIUS packets

Specifying a format for the NAS-Port-Id attribute

About specifying a format for the NAS-Port-Id attribute

RADIUS servers from different vendors might require different formats of the NAS-Port-Id attribute in the RADIUS packets. You can specify the NAS-Port-Id attribute format as required.

The device supports predefined formats (format 1, 2, 3, and 4). For more information about the formats, see portal commands in *Security Command Reference*.

Procedure

1. Enter system view.
   system-view
2. Specify the format for the NAS-Port-Id attribute.
   portal nas-port-id format { **1** | **2** | **3** | **4** }
   By default, the format for the NAS-Port-Id attribute is format 2.

Configuring the NAS-Port-Type attribute

About the NAS-Port-Type attribute

The NAS-Port-Type attribute in a RADIUS request represents the type of a user's access interface.

The access device might not be able to correctly obtain the type of users' access interfaces when multiple network devices exist between the access device and the portal client. For the access device to send the correct access interface type to the RADIUS server, perform this task to configure the NAS-Port-Type attribute.

Restrictions and guidelines

This configuration takes effect only on portal users that newly come online.

Procedure

1. Enter system view.

   system-view

2. Enter interface view.

   interface *interface-type interface-number*

3. Configure the NAS-Port-Type attribute carried in outgoing RADIUS requests on the interface.

   portal nas-port-type { **802.11** | **adsl-cap** | **adsl-dmt** | **async** | **cable** | **ethernet** | **g.3-fax** | **hdlc** | **idsl** | **isdn-async-v110** | **isdn-async-v120** | **isdn-sync** | **piafs** | **sdsl** | **sync** | **virtual** | **wireless-other** | **x.25** | **x.75** | **xdsl** }

   By default, the NAS-Port-Type carried in outgoing RADIUS requests is Ethernet (attribute value 15).

Applying a NAS-ID profile to an interface

About applying a NAS-ID profile to an interface

By default, the device sends its device name in the NAS-Identifier attribute of all RADIUS requests.

A NAS-ID profile enables you to send different NAS-Identifier attribute strings in RADIUS requests from different VLANs. The strings can be organization names, service names, or any user categorization criteria, depending on the administrative requirements.

For example, map the NAS-ID **companyA** to all VLANs of company A. The device will send **companyA** in the NAS-Identifier attribute for the RADIUS server to identify requests from any Company A users.

Restrictions and guidelines

You can apply a NAS-ID profile to a portal-enabled interface. If no NAS-ID profile is specified on the interface or no matching NAS-ID is found in the specified profile, the device uses the device name as the interface NAS-ID.

Procedure

1. Enter system view.

   system-view

2. Create a NAS-ID profile and enter NAS-ID profile view.

   aaa nas-id profile *profile-name*

   For more information about this command, see *Security Command Reference*.

3. Configure a NAS ID and VLAN binding in the profile.

   nas-id *nas-identifier* **bind vlan** *vlan-id*

   For more information about this command, see AAA commands in *Security Command Reference*. Portal access matches only the inner VLAN ID of QinQ packets. For more information about QinQ, see *Layer 2—LAN Switching Configuration Guide*.

4. Execute the following commands in sequence to specify the NAS-ID profile on the interface.

   a. Return to system view.

      quit

   b. Enter Layer 3 interface view.

      interface *interface-type interface-number*

c. Specify the NAS-ID profile on the interface.
portal nas-id-profile *profile-name*

Logging out online portal users

About logging out online portal users

This feature deletes users that have passed portal authentication and terminates ongoing portal authentications.

Restrictions and guidelines

When the number of online users exceeds 2000, executing the **portal delete-user** command takes a few minutes.

To ensure successful logout of online users, do not disable portal authentication or perform master/subordinate device switchover on the portal-enabled interface during the command execution.

Procedure

1. Enter system view.
   system-view
2. Log out online portal users.
   portal delete-user { *ipv4-address* | **all** | **interface** *interface-type interface-number* | **ipv6** *ipv6-address* }

Enabling portal user login/logout logging

About enabling portal user login/logout logging

This feature logs information about user login and logout events. The information includes the username, user IP address and MAC address, user access interface, VLAN, and login result. The logs are sent to the information center of the device. For the logs to be output correctly, you must also configure the information center on the device. For more information about information center configuration, see *Network Management and Monitoring Configuration Guide*.

Procedure

1. Enter system view.
   system-view
2. Enable portal user login/logout logging.
   portal log enable
   By default, portal user login/logout logging is disabled.

Disabling the Rule ARP or ND entry feature for portal clients

About this task

When the Rule ARP or ND entry feature is enabled for portal clients, ARP or ND entries for portal clients are Rule entries after the clients come online. The Rule entries will not age out and will be deleted immediately after the portal clients go offline. If a portal client goes offline and then tries to get online before the ARP or ND entry is relearned for the client, the client will fail the authentication.

To avoid such authentication failure, disable this feature. Then, ARP or ND entries for portal clients are dynamic entries after the clients come online and are deleted only when they age out.

Restrictions and guidelines

Enabling or disabling of this feature does not affect existing Rule/dynamic ARP or ND entries.

Procedure

1. Enter system view.
   system-view
2. Disable the Rule ARP or ND entry feature for portal clients.
   undo portal refresh { **arp** | **nd** } **enable**
   By default, the Rule ARP or ND entry feature is enabled for portal clients.

Configuring Web redirect

About Web redirect

Web redirect is a simplified portal feature. With Web redirect, a user does not perform portal authentication but is directly redirected to the specified URL on the first Web access attempt in a browser. After the specified redirect interval, the user is redirected from the visiting website to the specified URL again.

Web redirect can provide ISPs with extended services. For example, the ISPs can place advertisements and publish information on the redirected webpage.

Restrictions and guidelines

The Web redirect feature takes effect only on HTTP packets that use the default port number 80.

Web redirect does not work when both Web redirect and portal authentication are enabled.

Procedure

1. Enter system view.
   system-view
2. Enter Layer 3 interface view.
   interface *interface-type interface-number*
3. Configure Web redirect.
   web-redirect [**ipv6**] **url** *url-string* [**interval** *interval*]
   By default, Web redirect is disabled.

Display and maintenance commands for portal

Execute **display** commands in any view and the **reset** command in user view.

Task	Command
Display portal configuration and portal running state.	**display portal interface** *interface-type interface-number*
Display packet statistics for portal authentication servers.	**display portal packet statistics** [**server** *server-name*]
Display portal rules.	**display portal rule** { **all** | **dynamic** | **static** } **interface** *interface-type interface-number* [**slot** *slot-number*]

Task	Command
Display portal authentication server information.	**display portal server** [*server-name*]
Display portal user information.	**display portal user** { **all** | **interface** *interface-type interface-number* | **ip** *ipv4-address* | **ipv6** *ipv6-address* } [**verbose**]
Display portal Web server information.	**display portal web-server** [*server-name*]
Display Web redirect rule information.	**display web-redirect rule interface** *interface-type interface-number* [**slot** *slot-number*]
Clear packet statistics for portal authentication servers.	**reset portal packet statistics** [**server** *server-name*]

Portal configuration examples

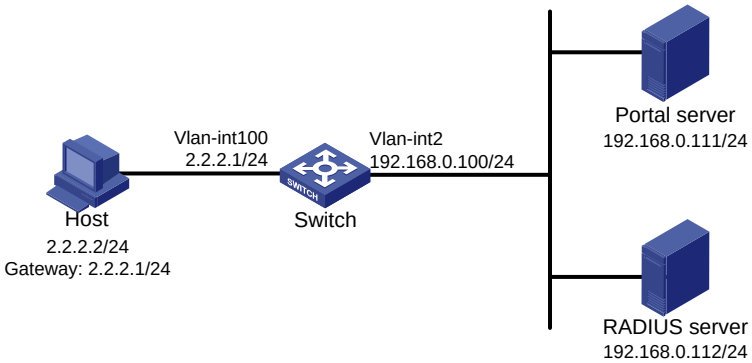
Example: Configuring direct portal authentication

Network configuration

As shown in Figure 6, the host is directly connected to the switch (the access device). The host is assigned a public IP address either manually or through DHCP. A portal server acts as both a portal authentication server and a portal Web server. A RADIUS server acts as the authentication/accounting server.

Configure direct portal authentication, so the host can access only the portal server before passing the authentication and access other network resources after passing the authentication.

Figure 6 Network diagram



Prerequisites

- Configure IP addresses for the host, switch, and servers as shown in Figure 6 and make sure they can reach each other.
- Configure the RADIUS server correctly to provide authentication and accounting functions.

Configuring the portal authentication server on IMC PLAT 5.0

In this example, the portal server runs on IMC PLAT 5.0(E0101) and IMC UAM 5.0(E0101).

1. Configure the portal authentication server:

a. Log in to IMC and click the **Service** tab.

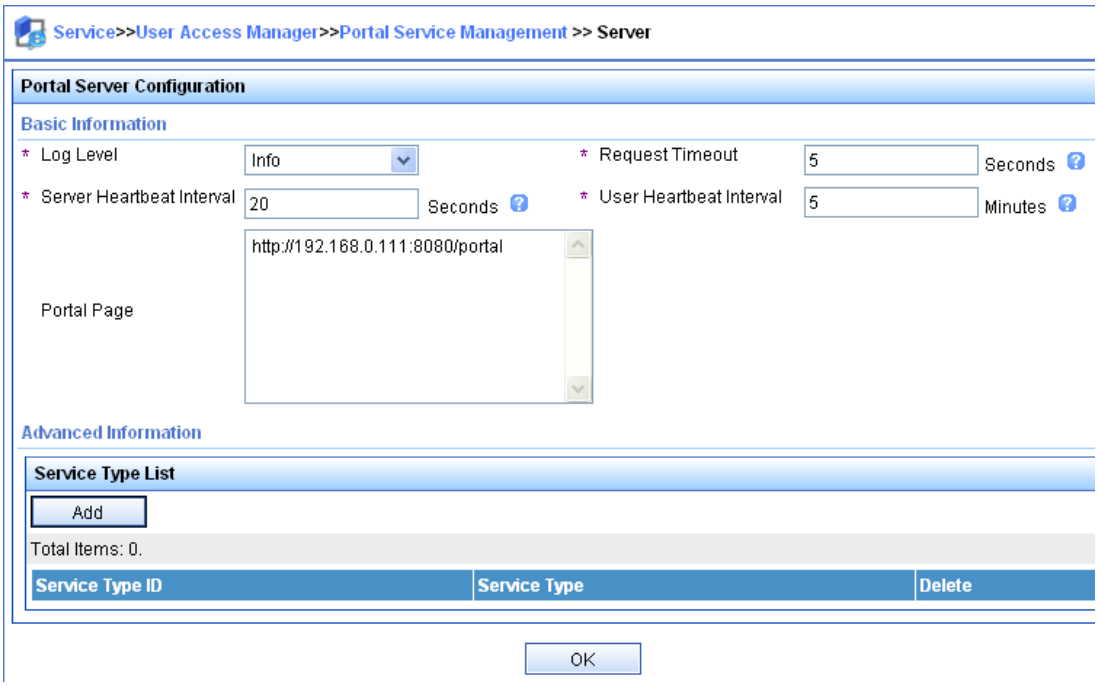
b. Select **User Access Manager** > **Portal Service Management** > **Server** from the navigation tree to open the portal server configuration page, as shown in Figure 7.

c. Configure the portal server parameters as needed.

   This example uses the default settings.

d. Click **OK**.

Figure 7 Portal server configuration



2. Configure the IP address group:

   a. Select **User Access Manager** > **Portal Service Management** > **IP Group** from the navigation tree to open the portal IP address group configuration page.

   b. Click **Add** to open the page as shown in Figure 8.

   c. Enter the IP group name.

   d. Enter the start IP address and end IP address of the IP group.

      Make sure the host IP address is in the IP group.

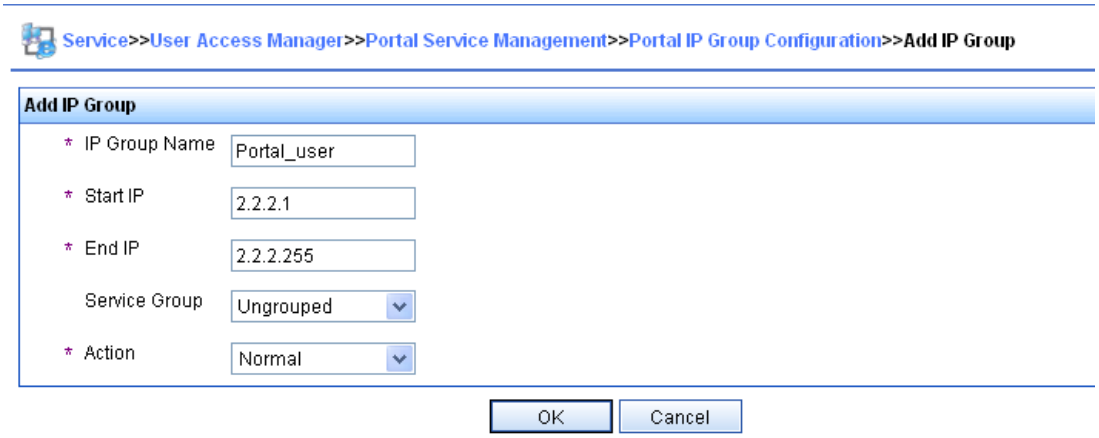
   e. Select a service group.

      This example uses the default group **Ungrouped**.

   f. Select the action **Normal**.

   g. Click **OK**.

Figure 8 Adding an IP address group

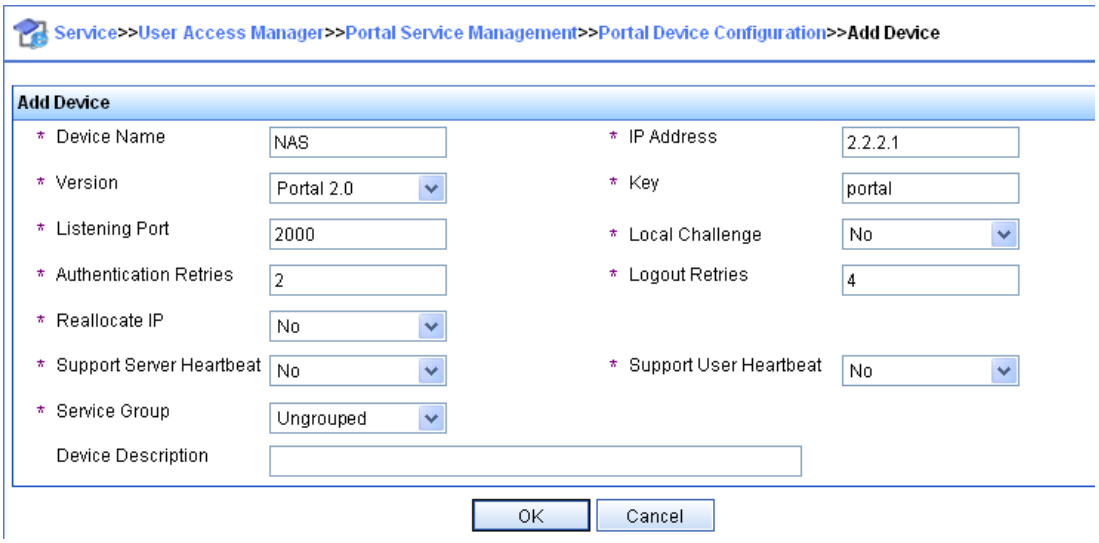


3. Add a portal device:
   a. Select **User Access Manager** > **Portal Service Management** > **Device** from the navigation tree to open the portal device configuration page.
   b. Click **Add** to open the page as shown in Figure 9.
   c. Enter the device name **NAS**.
   d. Enter the IP address of the switch's interface connected to the host.
   e. Enter the key, which must be the same as that configured on the switch.
   f. Set whether to enable IP address reallocation.

      This example uses direct portal authentication, and therefore select **No** from the **Reallocate IP** list.
   g. Select whether to support server heartbeat and user heartbeat functions.

      In this example, select **No** for both **Support Server Heartbeat** and **Support User Heartbeat**.
   h. Click **OK**.

Figure 9 Adding a portal device



4. Associate the portal device with the IP address group:
   a. As shown in Figure 10, click the icon in the **Port Group Information Management** column of device **NAS** to open the port group configuration page.

b. Click **Add** to open the page as shown in Figure 11.

c. Enter the port group name.

d. Select the configured IP address group.

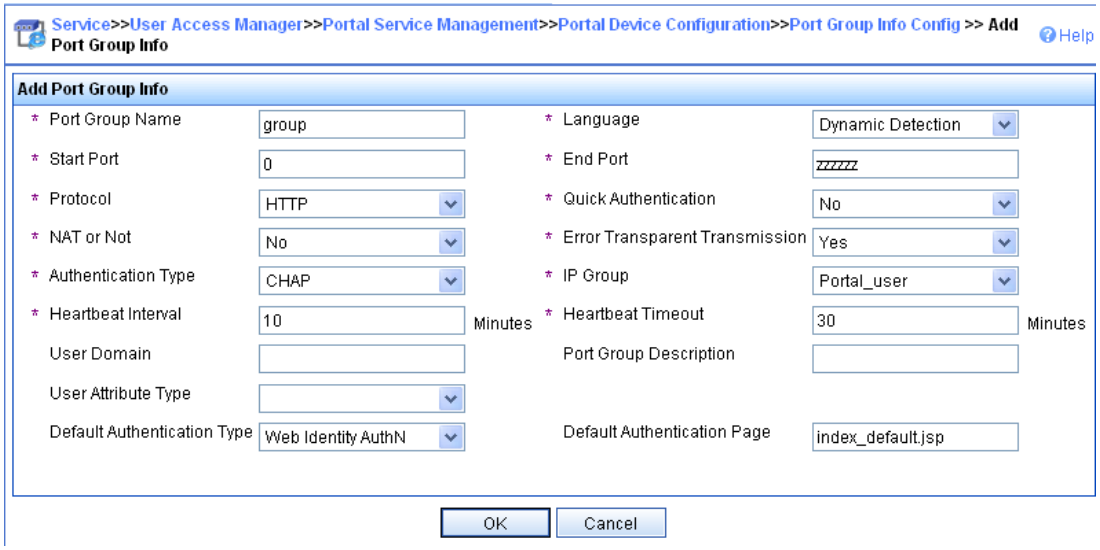
The IP address used by the user to access the network must be within this IP address group.

e. Use the default settings for other parameters.

f. Click **OK**.

Figure 10 Device list

Figure 11 Adding a port group



5. Select **User Access Manager** > **Service Parameters** > **Validate System Configuration** from the navigation tree to make the configurations take effect.

Configuring the switch

1. Configure a RADIUS scheme:

Create a RADIUS scheme named **rs1** and enter its view.

```
<Switch> system-view
[Switch] radius scheme rs1
```

Specify the primary authentication server and primary accounting server, and configure the keys for communication with the servers.

```
[Switch-radius-rs1] primary authentication 192.168.0.112
[Switch-radius-rs1] primary accounting 192.168.0.112
[Switch-radius-rs1] key authentication simple radius
[Switch-radius-rs1] key accounting simple radius
```

Exclude the ISP domain name from the username sent to the RADIUS server.

```
[Switch-radius-rs1] user-name-format without-domain
[Switch-radius-rs1] quit
```

Enable RADIUS session control.

```
[Switch] radius session-control enable
```

2. Configure an authentication domain:

Create an ISP domain named **dm1** and enter its view.

```
[Switch] domain dm1
```

Configure AAA methods for the ISP domain.

```
[Switch-isp-dm1] authentication portal radius-scheme rs1
[Switch-isp-dm1] authorization portal radius-scheme rs1
[Switch-isp-dm1] accounting portal radius-scheme rs1
[Switch-isp-dm1] quit
```

Configure domain **dm1** as the default ISP domain. If a user enters the username without the ISP domain name at login, the authentication and accounting methods of the default domain are used for the user.

```
[Switch] domain default enable dm1
```

3. Configure portal authentication:

Configure a portal authentication server.

```
[Switch] portal server newpt
[Switch-portal-server-newpt] ip 192.168.0.111 key simple portal
[Switch-portal-server-newpt] port 50100
[Switch-portal-server-newpt] quit
```

Configure a portal Web server.

```
[Switch] portal web-server newpt
[Switch-portal-websvr-newpt] url http://192.168.0.111:8080/portal
[Switch-portal-websvr-newpt] quit
```

Enable direct portal authentication on VLAN-interface 100.

```
[Switch] interface vlan-interface 100
[Switch–Vlan-interface100] portal enable method direct
```

Specify portal Web server **newpt** on VLAN-interface 100.

```
[Switch–Vlan-interface100] portal apply web-server newpt
```

Configure the BAS-IP as 2.2.2.1 for portal packets sent from VLAN-interface 100 to the portal authentication server.

```
[Switch–Vlan-interface100] portal bas-ip 2.2.2.1
[Switch–Vlan-interface100] quit
```

Verifying the configuration

Verify that the portal configuration has taken effect.

```
[Switch] display portal interface vlan-interface 100
 Portal information of Vlan-interface100
     NAS-ID profile: Not configured
     Authorization : Strict checking
     ACL           : Disabled
     User profile  : Disabled
 IPv4:
     Portal status: Enabled
     Portal authentication method: Direct
     Portal web server: newpt
     Secondary portal Web server: Not configured
     Portal mac-trigger-server: Not configured
```

```
     Authentication domain: Not configured
     User-dhcp-only: Disabled
     Pre-auth IP pool: Not configured
     Max Portal users: Not configured
     Bas-ip: 2.2.2.1
     User detection:  Not configured
     Action for server detection:
         Server type    Server name                         Action
         --             --                                  --
     Layer3 source network:
         IP address              Mask

     Destination authenticate subnet:
         IP address              Mask
IPv6:
     Portal status: Disabled
     Portal authentication method: Disabled
     Portal web server: Not configured
     Secondary portal Web server: Not configured
     Portal mac-trigger-server: Not configured
     Authentication domain: Not configured
     User-dhcp-only: Disabled
     Pre-auth IP pool: Not configured
     Max Portal users: Not configured
     Bas-ipv6: Not configured
     User detection: Not configured
     Action for server detection:
         Server type    Server name                         Action
         --             --                                  --
     Layer3 source network:
         IP address                                         Prefix length

     Destination authenticate subnet:
         IP address                                         Prefix length
```

A user can perform portal authentication by using the H3C iNode client or through a Web browser. Before passing the authentication, the user can access only the authentication page **http://192.168.0.111:8080/portal**. All Web requests from the user will be redirected to the authentication page. After passing the authentication, the user can access other network resources.

After the user passes authentication, use the following command to display information about the portal user.

```
[Switch] display portal user interface vlan-interface 100
 Total portal users: 1
  Username: abc
  Portal server: newpt
  State: Online
  VPN instance: N/A
  MAC               IP                VLAN   Interface
  0015-e9a6-7cfe    2.2.2.2           100    Vlan-interface100
  Authorization information:
```

```
DHCP IP pool: N/A
User profile: N/A
Session group profile: N/A
ACL number: N/A
Inbound CAR: N/A
Outbound CAR: N/A
```

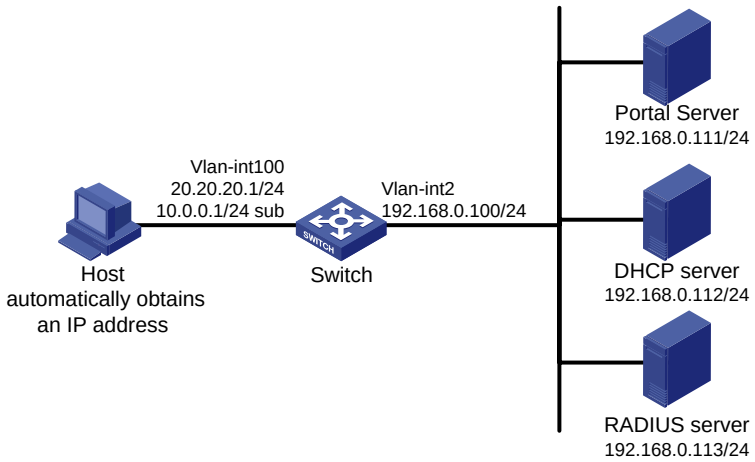
Example: Configuring re-DHCP portal authentication

Network configuration

As shown in Figure 12, the host is directly connected to the switch (the access device). The host obtains an IP address through the DHCP server. A portal server acts as both a portal authentication server and a portal Web server. A RADIUS server acts as the authentication/accounting server.

Configure re-DHCP portal authentication. Before passing the authentication, the host is assigned a private IP address. After passing the authentication, the host gets a public IP address and can access network resources.

Figure 12 Network diagram



Restrictions and guidelines

- For re-DHCP portal authentication, configure a public address pool (20.20.20.0/24) and a private address pool (10.0.0.0/24) on the DHCP server. (Details not shown.)
- For re-DHCP portal authentication:
  - The switch must be configured as a DHCP relay agent.
  - The portal-enabled interface must be configured with a primary IP address (a public IP address) and a secondary IP address (a private IP address).

  For information about DHCP relay agent configuration, see *Layer 3—IP Services Configuration Guide*.
- Make sure the IP address of the portal device added on the portal server is the public IP address (20.20.20.1) of the switch's interface connecting the host. The private IP address range for the IP address group associated with the portal device is the private subnet 10.0.0.0/24 where the host resides. The public IP address range for the IP address group is the public subnet 20.20.20.0/24.

Prerequisites

- Configure IP addresses for the switch and servers as shown in Figure 12 and make sure the host, switch, and servers can reach each other.

- Configure the RADIUS server correctly to provide authentication and accounting functions.

Procedure

1. Configure a RADIUS scheme:

Create a RADIUS scheme named **rs1** and enter its view.

```
<Switch> system-view
[Switch] radius scheme rs1
```

Specify the primary authentication server and primary accounting server, and configure the keys for communication with the servers.

```
[Switch-radius-rs1] primary authentication 192.168.0.113
[Switch-radius-rs1] primary accounting 192.168.0.113
[Switch-radius-rs1] key authentication simple radius
[Switch-radius-rs1] key accounting simple radius
```

Exclude the ISP domain name from the username sent to the RADIUS server.

```
[Switch-radius-rs1] user-name-format without-domain
[Switch-radius-rs1] quit
```

Enable RADIUS session control.

```
[Switch] radius session-control enable
```

2. Configure an authentication domain:

Create an ISP domain named **dm1** and enter its view.

```
[Switch] domain dm1
```

Configure AAA methods for the ISP domain.

```
[Switch-isp-dm1] authentication portal radius-scheme rs1
[Switch-isp-dm1] authorization portal radius-scheme rs1
[Switch-isp-dm1] accounting portal radius-scheme rs1
[Switch-isp-dm1] quit
```

Configure domain **dm1** as the default ISP domain. If a user enters the username without the ISP domain name at login, the authentication and accounting methods of the default domain are used for the user.

```
[Switch] domain default enable dm1
```

3. Configure DHCP relay and authorized ARP:

Configure DHCP relay.

```
[Switch] dhcp enable
[Switch] dhcp relay client-information record
[Switch] interface vlan-interface 100
[Switch–Vlan-interface100] ip address 20.20.20.1 255.255.255.0
[Switch–Vlan-interface100] ip address 10.0.0.1 255.255.255.0 sub
[Switch-Vlan-interface100] dhcp select relay
[Switch-Vlan-interface100] dhcp relay server-address 192.168.0.112
```

Enable authorized ARP.

```
[Switch-Vlan-interface100] arp authorized enable
[Switch-Vlan-interface100] quit
```

4. Configure portal authentication:

Configure a portal authentication server.

```
[Switch] portal server newpt
[Switch-portal-server-newpt] ip 192.168.0.111 key simple portal
[Switch-portal-server-newpt] port 50100
[Switch-portal-server-newpt] quit
```

Configure a portal Web server.

```
[Switch] portal web-server newpt
[Switch-portal-websvr-newpt] url http://192.168.0.111:8080/portal
[Switch-portal-websvr-newpt] quit
```

Enable re-DHCP portal authentication on VLAN-interface 100.

```
[Switch] interface vlan-interface 100
[Switch–Vlan-interface100] portal enable method redhcp
```

Specify portal Web server **newpt** on VLAN-interface 100.

```
[Switch–Vlan-interface100] portal apply web-server newpt
```

Configure the BAS-IP as 20.20.20.1 for portal packets sent from VLAN-interface 100 to the portal authentication server.

```
[Switch–Vlan-interface100] portal bas-ip 20.20.20.1
[Switch–Vlan-interface100] quit
```

Verifying the configuration

Verify that the portal configuration has taken effect.

```
[Switch] display portal interface vlan-interface 100
 Portal information of Vlan-interface100
     NAS-ID profile: Not configured
     Authorization : Strict checking
     ACL           : Disabled
     User profile  : Disabled
 IPv4:
     Portal status: Enabled
     Portal authentication method: Redhcp
     Portal web server: newpt
     Secondary portal Web server: Not configured
     Portal mac-trigger-server: Not configured
     Authentication domain: Not configured
     User-dhcp-only: Disabled
     Pre-auth IP pool: Not configured
     Max Portal users: Not configured
     Bas-ip: 20.20.20.1
     User detection:  Not configured
     Action for server detection:
         Server type    Server name                        Action
         --             --                                 --
     Layer3 source network:
         IP address              Mask

     Destination authenticate subnet:
         IP address              Mask
IPv6:
     Portal status: Disabled
     Portal authentication method: Disabled
     Portal web server: Not configured
     Secondary portal Web server: Not configured
     Portal mac-trigger-server: Not configured
     Authentication domain: Not configured
```

```
    User-dhcp-only: Disabled
    Pre-auth IP pool: Not configured
    Max Portal users: Not configured
    Bas-ipv6: Not configured
    User detection: Not configured
    Action for server detection:
        Server type    Server name                     Action
        --             --                              --
    Layer3 source network:
        IP address                                     Prefix length

    Destination authenticate subnet:
        IP address                                     Prefix length
```

Before passing the authentication, a user that uses the H3C iNode client can access only the authentication page **http://192.168.0.111:8080/portal**. All Web requests from the user will be redirected to the authentication page. After passing the authentication, the user can access other network resources.

After the user passes authentication, use the following command to display information about the portal user.

```
[Switch] display portal user interface vlan-interface 100
Total portal users: 1
Username: abc
  Portal server: newpt
  State: Online
  VPN instance: N/A
  MAC               IP                VLAN   Interface
  0015-e9a6-7cfe    20.20.20.2        100    Vlan-interface100
  Authorization information:
    DHCP IP pool: N/A
    User profile: N/A
    Session group profile: N/A
    ACL number: N/A
    Inbound CAR: N/A
    Outbound CAR: N/A
```

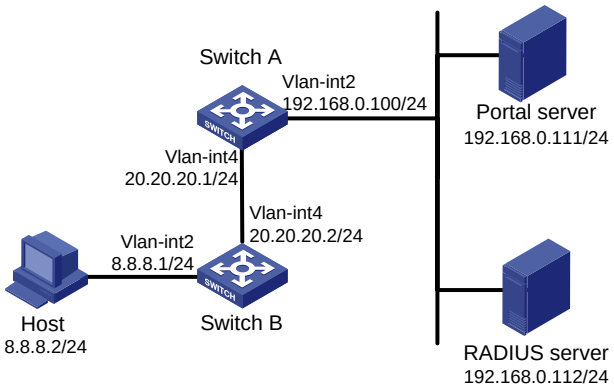
Example: Configuring cross-subnet portal authentication

Network configuration

As shown in Figure 13, Switch A supports portal authentication. The host accesses Switch A through Switch B. A portal server acts as both a portal authentication server and a portal Web server. A RADIUS server acts as the authentication/accounting server.

Configure Switch A for cross-subnet portal authentication. Before passing the authentication, the host can access only the portal Web server. After passing the authentication, the user can access other network resources.

Figure 13 Network diagram



Restrictions and guidelines

Make sure the IP address of the portal device added on the portal authentication server is the IP address (20.20.20.1) of the switch's interface connecting the host. The IP address group associated with the portal device is the subnet of the host (8.8.8.0/24).

Prerequisites

- Configure IP addresses for the switch and servers as shown in Figure 13 and make sure the host, switch, and servers can reach each other.
- Configure the RADIUS server correctly to provide authentication and accounting functions.

Procedure

1. Configure a RADIUS scheme:

   # Create a RADIUS scheme named **rs1** and enter its view.

   ```
   <SwitchA> system-view
   [SwitchA] radius scheme rs1
   ```

   # Specify the primary authentication server and primary accounting server, and configure the keys for communication with the servers.

   ```
   [SwitchA-radius-rs1] primary authentication 192.168.0.112
   [SwitchA-radius-rs1] primary accounting 192.168.0.112
   [SwitchA-radius-rs1] key authentication simple radius
   [SwitchA-radius-rs1] key accounting simple radius
   ```

   # Exclude the ISP domain name from the username sent to the RADIUS server.

   ```
   [SwitchA-radius-rs1] user-name-format without-domain
   [SwitchA-radius-rs1] quit
   ```

   # Enable RADIUS session control.

   ```
   [SwitchA] radius session-control enable
   ```

2. Configure an authentication domain:

   # Create an ISP domain named **dm1** and enter its view.

   ```
   [SwitchA] domain dm1
   ```

   # Configure AAA methods for the ISP domain.

   ```
   [SwitchA-isp-dm1] authentication portal radius-scheme rs1
   [SwitchA-isp-dm1] authorization portal radius-scheme rs1
   [SwitchA-isp-dm1] accounting portal radius-scheme rs1
   [SwitchA-isp-dm1] quit
   ```

Configure domain **dm1** as the default ISP domain. If a user enters the username without the ISP domain name at login, the authentication and accounting methods of the default domain are used for the user.

```
[SwitchA] domain default enable dm1
```

3. Configure portal authentication:

Configure a portal authentication server.

```
[SwitchA] portal server newpt
[SwitchA-portal-server-newpt] ip 192.168.0.111 key simple portal
[SwitchA-portal-server-newpt] port 50100
[SwitchA-portal-server-newpt] quit
```

Configure a portal Web server.

```
[SwitchA] portal web-server newpt
[SwitchA-portal-websvr-newpt] url http://192.168.0.111:8080/portal
[SwitchA-portal-websvr-newpt] quit
```

Enable cross-subnet portal authentication on VLAN-interface 4.

```
[SwitchA] interface vlan-interface 4
[SwitchA–Vlan-interface4] portal enable method layer3
```

Specify portal Web server **newpt** on VLAN-interface 4.

```
[SwitchA–Vlan-interface4] portal apply web-server newpt
```

Configure the BAS-IP as 20.20.20.1 for portal packets sent from VLAN-interface 4 to the portal authentication server.

```
[SwitchA–Vlan-interface4] portal bas-ip 20.20.20.1
[SwitchA–Vlan-interface4] quit
```

Verifying the configuration

Verify that the portal configuration has taken effect.

```
[SwitchA] display portal interface vlan-interface 4
 Portal information of Vlan-interface4
     NAS-ID profile: Not configured
     Authorization : Strict checking
     ACL           : Disabled
     User profile  : Disabled
 IPv4:
     Portal status: Enabled
     Portal authentication method: Layer3
     Portal web server: newpt
     Secondary portal Web server: Not configured
     Portal mac-trigger-server: Not configured
     Authentication domain: Not configured
     User-dhcp-only: Disabled
     Pre-auth IP pool: Not configured
     Max Portal users: Not configured
     Bas-ip: 20.20.20.1
     User detection:  Not configured
     Action for server detection:
         Server type    Server name                       Action
         --             --                                --
     Layer3 source network:
         IP address              Mask
```

```
     Destination authenticate subnet:
         IP address              Mask
IPv6:
     Portal status: Disabled
     Portal authentication method: Disabled
     Portal web server: Not configured
     Secondary portal Web server: Not configured
     Portal mac-trigger-server: Not configured
     Authentication domain: Not configured
     User-dhcp-only: Disabled
     Pre-auth IP pool: Not configured
     Max Portal users: Not configured
     Bas-ipv6: Not configured
     User detection: Not configured
     Action for server detection:
         Server type    Server name                     Action
         --             --                              --
     Layer3 source network:
         IP address                                     Prefix length

     Destination authenticate subnet:
         IP address                                     Prefix length
```

A user can perform portal authentication by using the H3C iNode client or through a Web browser. Before passing the authentication, the user can access only the authentication page **http://192.168.0.111:8080/portal**. All Web requests from the user will be redirected to the authentication page. After passing the authentication, the user can access other network resources.

After the user passes authentication, use the following command to display information about the portal user.

```
[SwitchA] display portal user interface vlan-interface 4
Total portal users: 1
Username: abc
  Portal server: newpt
  State: Online
  VPN instance: N/A
  MAC               IP                VLAN   Interface
  0000-0000-0000    8.8.8.2           4      Vlan-interface4
  Authorization information:
    DHCP IP pool: N/A
    User profile: N/A
    Session group profile: N/A
    ACL number: N/A
    Inbound CAR: N/A
    Outbound CAR: N/A
```

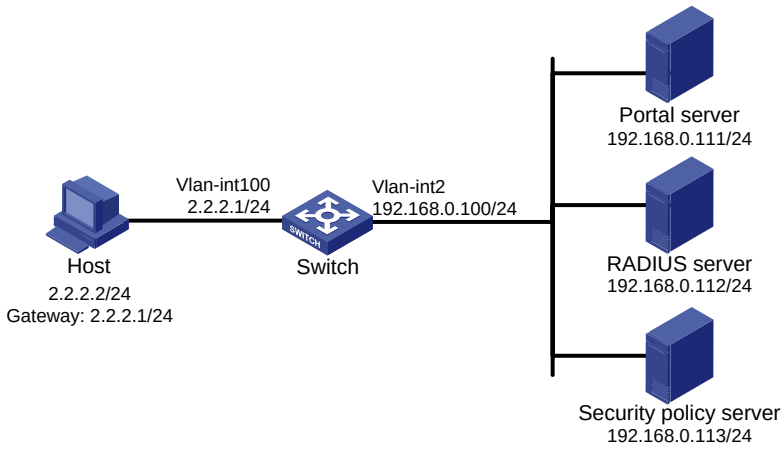
Example: Configuring extended direct portal authentication

Network configuration

As shown in Figure 14, the host is directly connected to the switch (the access device). The host is assigned a public IP address either manually or through DHCP. A portal server acts as both a portal authentication server and a portal Web server. A RADIUS server acts as the authentication/accounting server.

Configure extended direct portal authentication. If the host fails security check after passing identity authentication, it can access only subnet 192.168.0.0/24. After passing security check, the host can access other network resources.

Figure 14 Network diagram



Prerequisites

- Configure IP addresses for the host, switch, and servers as shown in Figure 14 and make sure they can reach each other.
- Configure the RADIUS server correctly to provide authentication and accounting functions.

Procedure

1. Configure a RADIUS scheme:

   # Create a RADIUS scheme named **rs1** and enter its view.

   ```
   <Switch> system-view
   [Switch] radius scheme rs1
   ```

   # Specify the primary authentication server and primary accounting server, and configure the keys for communication with the servers.

   ```
   [Switch-radius-rs1] primary authentication 192.168.0.112
   [Switch-radius-rs1] primary accounting 192.168.0.112
   [Switch-radius-rs1] key accounting simple radius
   [Switch-radius-rs1] key authentication simple radius
   [Switch-radius-rs1] user-name-format without-domain
   ```

   # Enable RADIUS session control.

   ```
   [Switch] radius session-control enable
   ```

   # Specify a session-control client with IP address 192.168.0.112 and shared key 12345 in plaintext form.

   ```
   [Switch] radius session-control client ip 192.168.0.112 key simple 12345
   ```

2. Configure an authentication domain:

Create an ISP domain named dm1 and enter its view.

```
[Switch] domain dm1
```

Configure AAA methods for the ISP domain.

```
[Switch-isp-dm1] authentication portal radius-scheme rs1
[Switch-isp-dm1] authorization portal radius-scheme rs1
[Switch-isp-dm1] accounting portal radius-scheme rs1
[Switch-isp-dm1] quit
```

Configure domain dm1 as the default ISP domain. If a user enters the username without the ISP domain name at login, the authentication and accounting methods of the default domain are used for the user.

```
[Switch] domain default enable dm1
```

3. Configure ACL 3000 as the isolation ACL and ACL 3001 as the security ACL.

```
[Switch] acl advanced 3000
[Switch-acl-ipv4-adv-3000] rule permit ip destination 192.168.0.0 0.0.0.255
[Switch-acl-ipv4-adv-3000] rule deny ip
[Switch-acl-ipv4-adv-3000] quit
[Switch] acl advanced 3001
[Switch-acl-ipv4-adv-3001] rule permit ip
[Switch-acl-ipv4-adv-3001] quit
```

NOTE:

Make sure you specify ACL 3000 as the isolation ACL and ACL 3001 as the security ACL on the security policy server.

4. Configure portal authentication:

Configure a portal authentication server.

```
[Switch] portal server newpt
[Switch-portal-server-newpt] ip 192.168.0.111 key simple portal
[Switch-portal-server-newpt] port 50100
[Switch-portal-server-newpt] quit
```

Configure a portal Web server.

```
[Switch] portal web-server newpt
[Switch-portal-websvr-newpt] url http://192.168.0.111:8080/portal
[Switch-portal-websvr-newpt] quit
```

Enable direct portal authentication on VLAN-interface 100.

```
[Switch] interface vlan-interface 100
[Switch–Vlan-interface100] portal enable method direct
```

Specify portal Web server **newpt** on VLAN-interface 100.

```
[Switch–Vlan-interface100] portal apply web-server newpt
```

Configure the BAS-IP as 2.2.2.1 for portal packets sent from VLAN-interface 100 to the portal authentication server.

```
[Switch–Vlan-interface100] portal bas-ip 2.2.2.1
[Switch–Vlan-interface100] quit
```

Verifying the configuration

Verify that the portal configuration has taken effect.

```
[Switch] display portal interface vlan-interface 100
 Portal information of Vlan-interface100
     NAS-ID profile: Not configured
```

```
    Authorization : Strict checking
    ACL           : Disabled
    User profile  : Disabled
 IPv4:
    Portal status: Enabled
    Portal authentication method: Direct
    Portal web server: newpt
    Secondary portal Web server: Not configured
    Portal mac-trigger-server: Not configured
    Authentication domain: Not configured
    User-dhcp-only: Disabled
    Pre-auth IP pool: Not configured
    Max Portal users: Not configured
    Bas-ip: 2.2.2.1
    User detection:  Not configured
    Action for server detection:
        Server type    Server name                     Action
        --             --                              --
    Layer3 source network:
        IP address              Mask

    Destination authenticate subnet:
        IP address              Mask
IPv6:
    Portal status: Disabled
    Portal authentication method: Disabled
    Portal web server: Not configured
    Secondary portal Web server: Not configured
    Portal mac-trigger-server: Not configured
    Authentication domain: Not configured
    User-dhcp-only: Disabled
    Pre-auth IP pool: Not configured
    Max Portal users: Not configured
    Bas-ipv6: Not configured
    User detection: Not configured
    Action for server detection:
        Server type    Server name                     Action
        --             --                              --
    Layer3 source network:
        IP address                                     Prefix length

    Destination authenticate subnet:
        IP address                                     Prefix length
```

Before passing portal authentication, a user that uses the H3C iNode client can access only the authentication page **http://192.168.0.111:8080/portal**. All Web requests from the user will be redirected to the authentication page.

- The user can access the resources permitted by ACL 3000 after passing only identity authentication.

- The user can access network resources permitted by ACL 3001 after passing both identity authentication and security check.

After the user passes identity authentication and security check, use the following command to display information about the portal user.

```
[Switch] display portal user interface vlan-interface 100
Total portal users: 1
Username: abc
  Portal server: newpt
  State: Online
  VPN instance: N/A
  MAC                IP                VLAN   Interface
  0015-e9a6-7cfe     2.2.2.2           100    Vlan-interface100
  Authorization information:
    DHCP IP pool: N/A
    User profile: N/A
    Session group profile: N/A
    ACL number: 3001 (active)
    Inbound CAR: N/A
    Outbound CAR: N/A
```

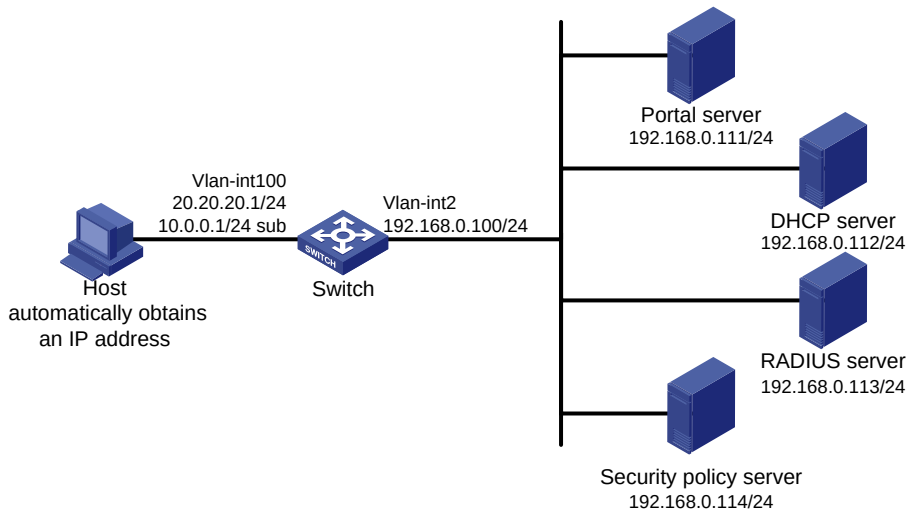
Example: Configuring extended re-DHCP portal authentication

Network configuration

As shown in Figure 15, the host is directly connected to the switch (the access device). The host obtains an IP address through the DHCP server. A portal server acts as both a portal authentication server and a portal Web server. A RADIUS server acts as the authentication/accounting server.

Configure extended re-DHCP portal authentication. Before passing portal authentication, the host is assigned a private IP address. After passing portal identity authentication, the host obtains a public IP address and accepts security check. If the host fails the security check, it can access only subnet 192.168.0.0/24. After passing the security check, the host can access other network resources.

Figure 15 Network diagram



Restrictions and guidelines

- For re-DHCP portal authentication, configure a public address pool (20.20.20.0/24) and a private address pool (10.0.0.0/24) on the DHCP server. (Details not shown.)
- For re-DHCP portal authentication:
  - The switch must be configured as a DHCP relay agent.
  - The portal-enabled interface must be configured with a primary IP address (a public IP address) and a secondary IP address (a private IP address).

  For information about DHCP relay agent configuration, see *Layer 3—IP Services Configuration Guide*.
- Make sure the IP address of the portal device added on the portal server is the public IP address (20.20.20.1) of the switch's interface connecting the host. The private IP address range for the IP address group associated with the portal device is the private subnet 10.0.0.0/24 where the host resides. The public IP address range for the IP address group is the public subnet 20.20.20.0/24.

Prerequisites

- Configure IP addresses for the switch and servers as shown in Figure 15 and make sure the host, switch, and servers can reach each other.
- Configure the RADIUS server correctly to provide authentication and accounting functions.

Procedure

1. Configure a RADIUS scheme:

Create a RADIUS scheme named **rs1** and enter its view.

```
<Switch> system-view
[Switch] radius scheme rs1
```

Specify the primary authentication server and primary accounting server, and configure the keys for communication with the servers.

```
[Switch-radius-rs1] primary authentication 192.168.0.113
[Switch-radius-rs1] primary accounting 192.168.0.113
[Switch-radius-rs1] key accounting simple radius
[Switch-radius-rs1] key authentication simple radius
[Switch-radius-rs1] user-name-format without-domain
```

Enable RADIUS session control.

```
[Switch] radius session-control enable
```

Specify a session-control client with IP address 192.168.0.113 and shared key 12345 in plaintext form.

```
[Switch] radius session-control client ip 192.168.0.113 key simple 12345
```

2. Configure an authentication domain:

Create an ISP domain named **dm1** and enter its view.

```
[Switch] domain dm1
```

Configure AAA methods for the ISP domain.

```
[Switch-isp-dm1] authentication portal radius-scheme rs1
[Switch-isp-dm1] authorization portal radius-scheme rs1
[Switch-isp-dm1] accounting portal radius-scheme rs1
[Switch-isp-dm1] quit
```

Configure domain **dm1** as the default ISP domain. If a user enters the username without the ISP domain name at login, the authentication and accounting methods of the default domain are used for the user.

```
[Switch] domain default enable dm1
```

3. Configure ACL 3000 as the isolation ACL and ACL 3001 as the security ACL.

```
[Switch] acl advanced 3000
[Switch-acl-ipv4-adv-3000] rule permit ip destination 192.168.0.0 0.0.0.255
[Switch-acl-ipv4-adv-3000] rule deny ip
[Switch-acl-ipv4-adv-3000] quit
[Switch] acl advanced 3001
[Switch-acl-ipv4-adv-3001] rule permit ip
[Switch-acl-ipv4-adv-3001] quit
```

NOTE:

Make sure you specify ACL 3000 as the isolation ACL and ACL 3001 as the security ACL on the security policy server.

4. Configure DHCP relay and authorized ARP:

Configure DHCP relay.

```
[Switch] dhcp enable
[Switch] dhcp relay client-information record
[Switch] interface vlan-interface 100
[Switch–Vlan-interface100] ip address 20.20.20.1 255.255.255.0
[Switch–Vlan-interface100] ip address 10.0.0.1 255.255.255.0 sub
[Switch-Vlan-interface100] dhcp select relay
[Switch-Vlan-interface100] dhcp relay server-address 192.168.0.112
```

Enable authorized ARP.

```
[Switch-Vlan-interface100] arp authorized enable
[Switch-Vlan-interface100] quit
```

5. Configure portal authentication:

Configure a portal authentication server.

```
[Switch] portal server newpt
[Switch-portal-server-newpt] ip 192.168.0.111 key simple portal
[Switch-portal-server-newpt] port 50100
[Switch-portal-server-newpt] quit
```

Configure a portal Web server.

```
[Switch] portal web-server newpt
[Switch-portal-websvr-newpt] url http://192.168.0.111:8080/portal
[Switch-portal-websvr-newpt] quit
```

Enable re-DHCP portal authentication on VLAN-interface 100.

```
[Switch] interface vlan-interface 100
[Switch–Vlan-interface100] portal enable method redhcp
```

Specify portal Web server **newpt** on VLAN-interface 100.

```
[Switch–Vlan-interface100] portal apply web-server newpt
```

Configure the BAS-IP as 20.20.20.1 for portal packets sent from VLAN-interface 100 to the portal authentication server.

```
[Switch–Vlan-interface100] portal bas-ip 20.20.20.1
[Switch–Vlan-interface100] quit
```

Verifying the configuration

Verify that the portal configuration has taken effect.

```
[Switch] display portal interface vlan-interface 100
 Portal information of Vlan-interface100
```

```
    NAS-ID profile: Not configured
    Authorization : Strict checking
    ACL           : Disabled
    User profile  : Disabled
 IPv4:
    Portal status: Enabled
    Portal authentication method: Redhcp
    Portal web server: newpt
    Secondary portal Web server: Not configured
    Portal mac-trigger-server: Not configured
    Authentication domain: Not configured
    User-dhcp-only: Disabled
    Pre-auth IP pool: Not configured
    Max Portal users: Not configured
    Bas-ip: 20.20.20.1
    User detection:  Not configured
    Action for server detection:
        Server type    Server name                      Action
        --             --                               --
    Layer3 source network:
        IP address              Mask

    Destination authenticate subnet:
        IP address              Mask
IPv6:
    Portal status: Disabled
    Portal authentication method: Disabled
    Portal web server: Not configured
    Secondary portal Web server: Not configured
    Portal mac-trigger-server: Not configured
    Authentication domain: Not configured
    User-dhcp-only: Disabled
    Pre-auth IP pool: Not configured
    Max Portal users: Not configured
    Bas-ipv6: Not configured
    User detection: Not configured
    Action for server detection:
        Server type    Server name                      Action
        --             --                               --
    Layer3 source network:
        IP address                                      Prefix length

    Destination authenticate subnet:
        IP address                                      Prefix length
```

Before passing portal authentication, a user that uses the H3C iNode client can access only the authentication page **http://192.168.0.111:8080/portal**. All Web requests from the user will be redirected to the authentication page.

- The user can access the resources permitted by ACL 3000 after passing only identity authentication.

- The user can access network resources permitted by ACL 3001 after passing both identity authentication and security check.

After the user passes identity authentication and security check, use the following command to display information about the portal user.

```
[Switch] display portal user interface vlan-interface 100
Total portal users: 1
Username: abc
  Portal server: newpt
  State: Online
  VPN instance: N/A
  MAC                IP                 VLAN   Interface
  0015-e9a6-7cfe     20.20.20.2         100    Vlan-interface100
  Authorization information:
    DHCP IP pool: N/A
    User profile: N/A
    Session group profile: N/A
    ACL number: 3001 (active)
    Inbound CAR: N/A
    Outbound CAR: N/A
```

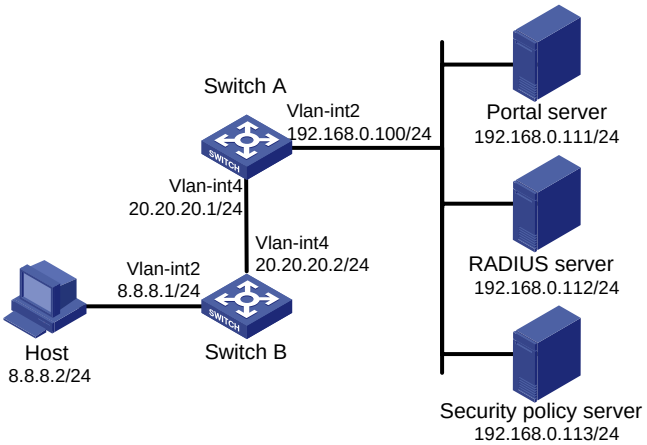
Example: Configuring extended cross-subnet portal authentication

Network configuration

As shown in Figure 16, Switch A supports portal authentication. The host accesses Switch A through Switch B. A portal server acts as both a portal authentication server and a portal Web server. A RADIUS server acts as the authentication/accounting server.

Configure Switch A for extended cross-subnet portal authentication. Before passing portal authentication, the host can access only the portal server. After passing portal identity authentication, the host accepts security check. If the host fails the security check it can access only the subnet 192.168.0.0/24. After passing the security check, the host can access other network resources.

Figure 16 Network diagram



Restrictions and guidelines

Make sure the IP address of the portal device added on the portal server is the IP address (20.20.20.1) of the switch's interface connecting the host. The IP address group associated with the portal device is the subnet of the host (8.8.8.0/24).

Prerequisites

- Configure IP addresses for the switch and servers as shown in Figure 16 and make sure the host, switch, and servers can reach each other.
- Configure the RADIUS server correctly to provide authentication and accounting functions.

Procedure

1. Configure a RADIUS scheme:

Create a RADIUS scheme named **rs1** and enter its view.

```
<SwitchA> system-view
[SwitchA] radius scheme rs1
```

Specify the primary authentication server and primary accounting server, and configure the keys for communication with the servers.

```
[SwitchA-radius-rs1] primary authentication 192.168.0.112
[SwitchA-radius-rs1] primary accounting 192.168.0.112
[SwitchA-radius-rs1] key accounting simple radius
[SwitchA-radius-rs1] key authentication simple radius
[SwitchA-radius-rs1] user-name-format without-domain
```

Enable RADIUS session control.

```
[SwitchA] radius session-control enable
```

Specify a session-control client with IP address 192.168.0.112 and shared key 12345 in plaintext form.

```
[SwitchA] radius session-control client ip 192.168.0.112 key simple 12345
```

2. Configure an authentication domain:

Create an ISP domain named **dm1** and enter its view.

```
[SwitchA] domain dm1
```

Configure AAA methods for the ISP domain.

```
[SwitchA-isp-dm1] authentication portal radius-scheme rs1
[SwitchA-isp-dm1] authorization portal radius-scheme rs1
[SwitchA-isp-dm1] accounting portal radius-scheme rs1
[SwitchA-isp-dm1] quit
```

Configure domain **dm1** as the default ISP domain. If a user enters the username without the ISP domain name at login, the authentication and accounting methods of the default domain are used for the user.

```
[SwitchA] domain default enable dm1
```

3. Configure ACL 3000 as the isolation ACL and ACL 3001 as the security ACL.

```
[SwitchA] acl advanced 3000
[SwitchA-acl-ipv4-adv-3000] rule permit ip destination 192.168.0.0 0.0.0.255
[SwitchA-acl-ipv4-adv-3000] rule deny ip
[SwitchA-acl-ipv4-adv-3000] quit
[SwitchA] acl advanced 3001
[SwitchA-acl-ipv4-adv-3001] rule permit ip
[SwitchA-acl-ipv4-adv-3001] quit
```

NOTE:

Make sure you specify ACL 3000 as the isolation ACL and ACL 3001 as the security ACL on the security policy server.

4. Configure portal authentication:

Configure a portal authentication server.

```
[SwitchA] portal server newpt
[SwitchA-portal-server-newpt] ip 192.168.0.111 key simple portal
[SwitchA-portal-server-newpt] port 50100
[SwitchA-portal-server-newpt] quit
```

Configure a portal Web server.

```
[SwitchA] portal web-server newpt
[SwitchA-portal-websvr-newpt] url http://192.168.0.111:8080/portal
[SwitchA-portal-websvr-newpt] quit
```

Enable cross-subnet portal authentication on VLAN-interface 4.

```
[SwitchA] interface vlan-interface 4
[SwitchA–Vlan-interface4] portal enable method layer3
```

Specify portal Web server **newpt** on VLAN-interface 4.

```
[SwitchA–Vlan-interface4] portal apply web-server newpt
```

Configure the BAS-IP as 20.20.20.1 for portal packets sent from VLAN-interface 4 to the portal authentication server.

```
[SwitchA–Vlan-interface4] portal bas-ip 20.20.20.1
[SwitchA–Vlan-interface4] quit
```

Verifying the configuration

Verify that the portal configuration has taken effect.

```
[SwitchA] display portal interface vlan-interface 4
 Portal information of Vlan-interface4
     NAS-ID profile: Not configured
     Authorization : Strict checking
     ACL           : Disabled
     User profile  : Disabled
 IPv4:
     Portal status: Enabled
     Portal authentication method: Layer3
     Portal web server: newpt
     Secondary portal Web server: Not configured
     Portal mac-trigger-server: Not configured
     Authentication domain: Not configured
     User-dhcp-only: Disabled
     Pre-auth IP pool: Not configured
     Max Portal users: Not configured
     Bas-ip: 20.20.20.1
     User detection:  Not configured
     Action for server detection:
         Server type    Server name                       Action
         --             --                                --
     Layer3 source network:
         IP address              Mask
```

```
     Destination authenticate subnet:
         IP address              Mask
IPv6:
     Portal status: Disabled
     Portal authentication method: Disabled
     Portal web server: Not configured
     Secondary portal Web server: Not configured
     Portal mac-trigger-server: Not configured
     Authentication domain: Not configured
     User-dhcp-only: Disabled
     Pre-auth IP pool: Not configured
     Max Portal users: Not configured
     Bas-ip: Not configured
     User detection: Not configured
     Action for server detection:
         Server type    Server name                        Action
         --             --                                 --
     Layer3 source network:
         IP address                                        Prefix length

     Destination authenticate subnet:
         IP address                                        Prefix length
```

Before passing portal authentication, a user that uses the H3C iNode client can access only the authentication page **http://192.168.0.111:8080/portal**. All Web requests from the user will be redirected to the authentication page.

- The user can access the resources permitted by ACL 3000 after passing only identity authentication.
- The user can access network resources permitted by ACL 3001 after passing both identity authentication and security check.

After the user passes identity authentication and security check, use the following command to display information about the portal user.

```
[SwitchA] display portal user interface vlan-interface 4
Total portal users: 1
Username: abc
  Portal server: newpt
  State: Online
  VPN instance: N/A
  MAC               IP                VLAN   Interface
  0015-e9a6-7cfe    8.8.8.2           4    Vlan-interface4
  Authorization information:
    DHCP IP pool: N/A
    User profile: N/A
    Session group profile: N/A
    ACL number: 3001 (active)
    Inbound CAR: N/A
    Outbound CAR: N/A
```

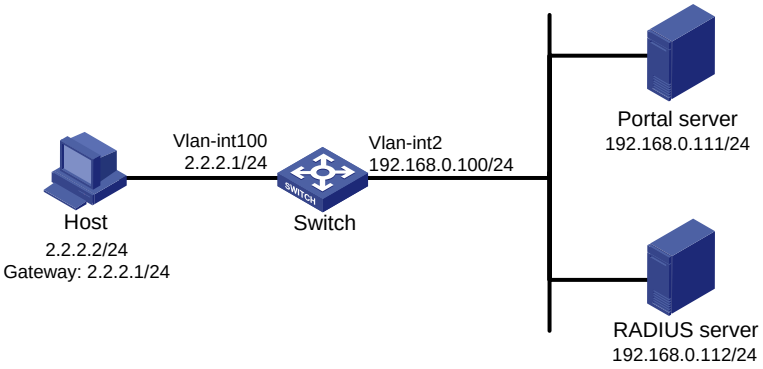
Example: Configuring portal server detection and portal user synchronization

Network configuration

As shown in Figure 17, the host is directly connected to the switch (the access device). The host is assigned a public IP address either manually or through DHCP. A portal server acts as both a portal authentication server and a portal Web server. A RADIUS server acts as the authentication/accounting server.

- Configure direct portal authentication on the switch, so the host can access only the portal server before passing the authentication and access other network resources after passing the authentication.
- Configure the switch to detect the reachability state of the portal authentication server, send log messages upon state changes, and disable portal authentication when the authentication server is unreachable.
- Configure the switch to synchronize portal user information with the portal server periodically.

Figure 17 Network diagram



Prerequisites

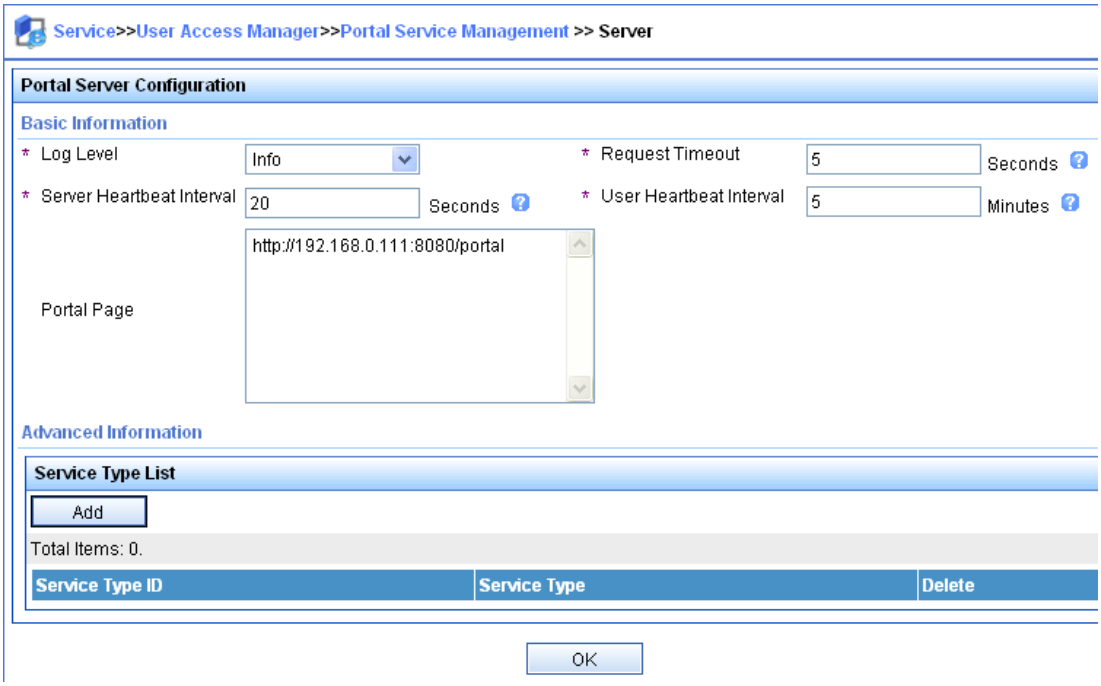
- Configure IP addresses for the switch and servers as shown in Figure 17 and make sure the host, switch, and servers can reach each other.
- Configure the RADIUS server correctly to provide authentication and accounting functions.

Configuring the portal authentication server on IMC PLAT 5.0

In this example, the portal server runs on IMC PLAT 5.0(E0101) and IMC UAM 5.0(E0101).

1. Configure the portal authentication server:
   a. Log in to IMC and click the **Service** tab.
   b. Select **User Access Manager** > **Portal Service Management** > **Server** from the navigation tree to open the portal server configuration page, as shown in Figure 18.
   c. Configure the portal server heartbeat interval and user heartbeat interval.
   d. Use the default settings for other parameters.
   e. Click **OK**.

Figure 18 Portal authentication server configuration

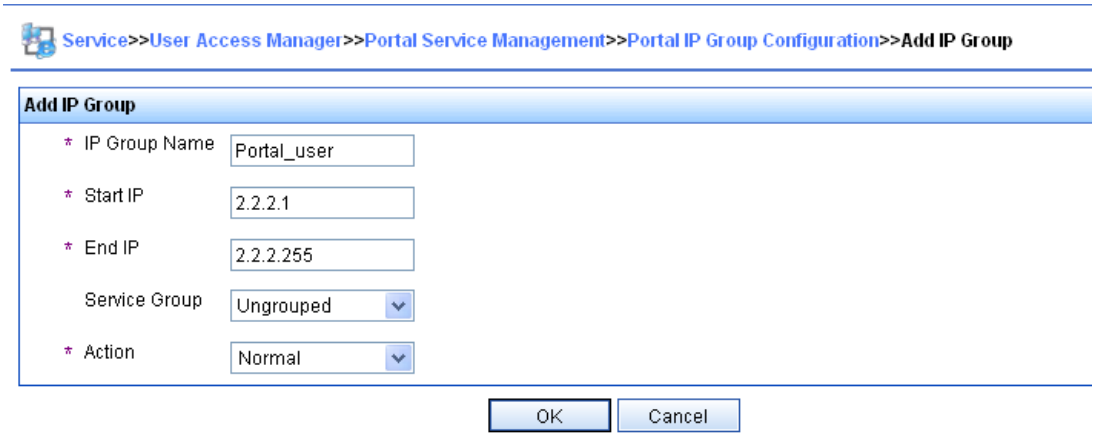


2. Configure the IP address group:
   a. Select **User Access Manager** > **Portal Service Management** > **IP Group** from the navigation tree to open the portal IP address group configuration page.
   b. Click **Add** to open the page as shown in Figure 19.
   c. Enter the IP group name.
   d. Enter the start IP address and end IP address of the IP group.

      Make sure the host IP address is in the IP group.
   e. Select a service group.

      This example uses the default group **Ungrouped**.
   f. Select the action **Normal**.
   g. Click **OK**.

Figure 19 Adding an IP address group



3. Add a portal device:

a. Select **User Access Manager** > **Portal Service Management** > **Device** from the navigation tree to open the portal device configuration page.

b. Click **Add** to open the page as shown in Figure 20.

c. Enter the device name **NAS**.

d. Enter the IP address of the switch's interface connected to the host.

e. Enter the key, which must be the same as that configured on the switch.

f. Set whether to enable IP address reallocation.

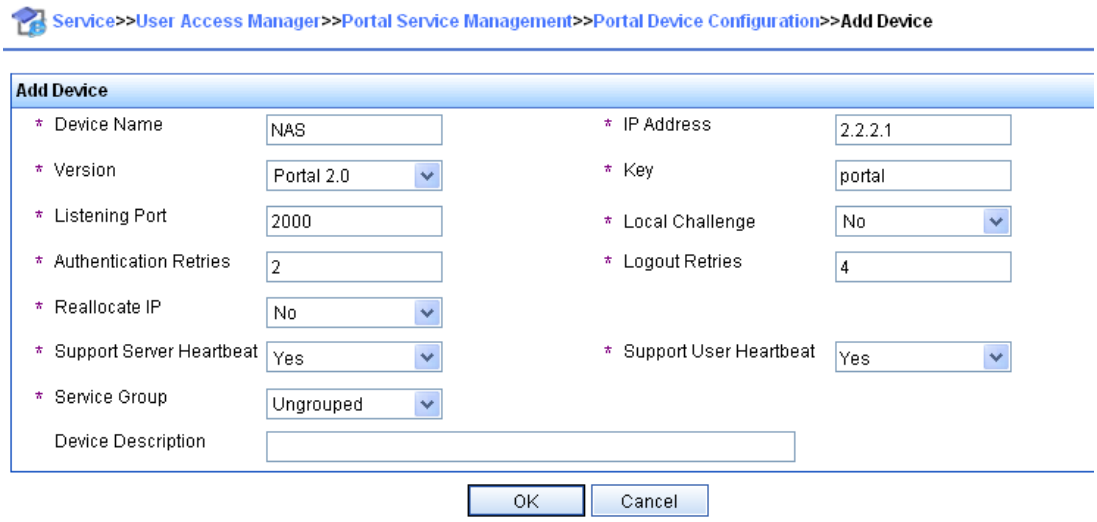
This example uses direct portal authentication, and therefore select **No** from the **Reallocate IP** list.

g. Select whether to support server heartbeat and user heartbeat functions.

In this example, select **Yes** for both **Support Server Heartbeat** and **Support User Heartbeat**.

h. Click **OK**.

Figure 20 Adding a portal device



4. Associate the portal device with the IP address group:

a. As shown in Figure 21, click the icon in the **Port Group Information Management** column of device **NAS** to open the port group configuration page.

b. Click **Add** to open the page as shown in Figure 22.

c. Enter the port group name.

d. Select the configured IP address group.

The IP address used by the user to access the network must be within this IP address group.

e. Use the default settings for other parameters.

f. Click **OK**.

Figure 21 Device list

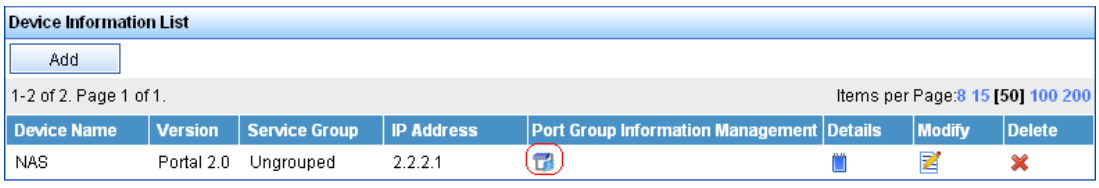
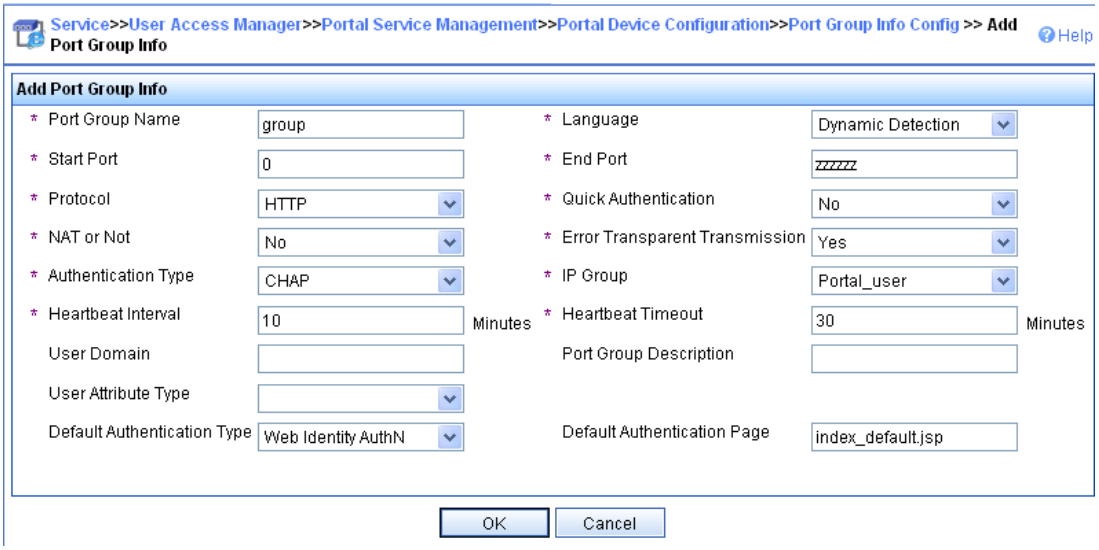


Figure 22 Adding a port group



5. Select **User Access Manager** > **Service Parameters** > **Validate System Configuration** from the navigation tree to make the configurations take effect.

Configuring the switch

1. Configure a RADIUS scheme:

   # Create a RADIUS scheme named **rs1** and enter its view.

   ```
   <Switch> system-view
   [Switch] radius scheme rs1
   ```

   # Specify the primary authentication server and primary accounting server, and configure the keys for communication with the servers.

   ```
   [Switch-radius-rs1] primary authentication 192.168.0.112
   [Switch-radius-rs1] primary accounting 192.168.0.112
   [Switch-radius-rs1] key authentication simple radius
   [Switch-radius-rs1] key accounting simple radius
   ```

   # Exclude the ISP domain name from the username sent to the RADIUS server.

   ```
   [Switch-radius-rs1] user-name-format without-domain
   [Switch-radius-rs1] quit
   ```

   # Enable RADIUS session control.

   ```
   [Switch] radius session-control enable
   ```

2. Configure an authentication domain:

   # Create an ISP domain named **dm1** and enter its view.

   ```
   [Switch] domain dm1
   ```

   # Configure AAA methods for the ISP domain.

   ```
   [Switch-isp-dm1] authentication portal radius-scheme rs1
   [Switch-isp-dm1] authorization portal radius-scheme rs1
   [Switch-isp-dm1] accounting portal radius-scheme rs1
   [Switch-isp-dm1] quit
   ```

   # Configure domain **dm1** as the default ISP domain. If a user enters the username without the ISP domain name at login, the authentication and accounting methods of the default domain are used for the user.

   ```
   [Switch] domain default enable dm1
   ```

3. Configure portal authentication:

Configure a portal authentication server.

```
[Switch] portal server newpt
[Switch-portal-server-newpt] ip 192.168.0.111 key simple portal
[Switch-portal-server-newpt] port 50100
```

Configure reachability detection of the portal authentication server: set the server detection interval to 40 seconds, and send log messages upon reachability status changes.

```
[Switch-portal-server-newpt] server-detect timeout 40 log
```

NOTE:

The value of **timeout** must be greater than or equal to the portal server heartbeat interval.

Configure portal user synchronization with the portal authentication server, and set the synchronization detection interval to 600 seconds.

```
[Switch-portal-server-newpt] user-sync timeout 600
[Switch-portal-server-newpt] quit
```

NOTE:

The value of **timeout** must be greater than or equal to the portal user heartbeat interval.

Configure a portal Web server.

```
[Switch] portal web-server newpt
[Switch-portal-websvr-newpt] url http://192.168.0.111:8080/portal
[Switch-portal-websvr-newpt] quit
```

Enable direct portal authentication on VLAN-interface 100.

```
[Switch] interface vlan-interface 100
[Switch–Vlan-interface100] portal enable method direct
```

Enable portal fail-permit for the portal authentication server **newpt**.

```
[Switch–Vlan-interface100] portal fail-permit server newpt
```

Specify portal Web server **newpt** on VLAN-interface 100.

```
[Switch–Vlan-interface100] portal apply web-server newpt
```

Configure the BAS-IP as 2.2.2.1 for portal packets sent from VLAN-interface 100 to the portal authentication server.

```
[Switch–Vlan-interface100] portal bas-ip 2.2.2.1
[Switch–Vlan-interface100] quit
```

Verifying the configuration

Use the following command to display information about the portal authentication server.

```
[Switch] display portal server newpt
Portal server: newpt
  Type                 : IMC
  IP                   : 192.168.0.111
  VPN instance         : Not configured
  Port                 : 50100
  Server Detection     : Timeout 40s  Action: log
  User synchronization : Timeout 600s
  Status               : Up
```

The **Up** status of the portal authentication server indicates that the portal authentication server is reachable. If the access device detects that the portal authentication server is unreachable, the **Status** field in the command output displays **Down**. The access device generates a server

unreachable log "Portal server newpt turns down from up." and disables portal authentication on the access interface, so the host can access the external network without authentication.

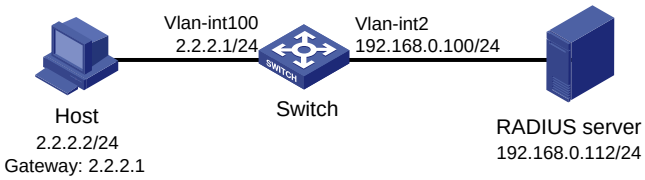
Example: Configuring direct portal authentication using a local portal Web service

Network configuration

As shown in Figure 23, the host is directly connected to the switch (the access device). The host is assigned a public IP address either manually or through DHCP. The switch acts as both a portal authentication server and a portal Web server. A RADIUS server acts as the authentication/accounting server.

Configure direct portal authentication on the switch. Before a user passes portal authentication, the user can access only the portal Web server. After passing portal authentication, the user can access other network resources.

Figure 23 Network diagram



Prerequisites

- Configure IP addresses for the host, switch, and server as shown in Figure 23 and make sure they can reach each other.
- Configure the RADIUS server correctly to provide authentication and accounting functions.

Procedure

1. Configure a RADIUS scheme:

   # Create a RADIUS scheme named **rs1** and enter its view.

   ```
   <Switch> system-view
   [Switch] radius scheme rs1
   ```

   # Specify the primary authentication server and primary accounting server, and configure the keys for communication with the servers.

   ```
   [Switch-radius-rs1] primary authentication 192.168.0.112
   [Switch-radius-rs1] primary accounting 192.168.0.112
   [Switch-radius-rs1] key authentication simple radius
   [Switch-radius-rs1] key accounting simple radius
   ```

   # Exclude the ISP domain name from the username sent to the RADIUS server.

   ```
   [Switch-radius-rs1] user-name-format without-domain
   [Switch-radius-rs1] quit
   ```

   # Enable RADIUS session control.

   ```
   [Switch] radius session-control enable
   ```

2. Configure an authentication domain:

   # Create an ISP domain named **dm1** and enter its view.

   ```
   [Switch] domain dm1
   ```

   # Configure AAA methods for the ISP domain.

   ```
   [Switch-isp-dm1] authentication portal radius-scheme rs1
   ```

```
[Switch-isp-dm1] authorization portal radius-scheme rs1
[Switch-isp-dm1] accounting portal radius-scheme rs1
[Switch-isp-dm1] quit
```

Configure domain **dm1** as the default ISP domain. If a user enters the username without the ISP domain name at login, the authentication and accounting methods of the default domain are used for the user.

```
[Switch] domain default enable dm1
```

3. Configure portal authentication:

Configure a portal Web server named **newpt** and specify **http://2.2.2.1:2331/portal** as the URL of the portal Web server. The IP address in the URL must be the IP address of a Layer 3 interface reachable to portal clients or a loopback interface (except 127.0.0.1) on the device.

```
[Switch] portal web-server newpt
[Switch-portal-websvr-newpt] url http://2.2.2.1:2331/portal
[Switch-portal-websvr-newpt] quit
```

Enable direct portal authentication on VLAN-interface 100.

```
[Switch] interface vlan-interface 100
[Switch–Vlan-interface100] portal enable method direct
```

Specify portal Web server **newpt** on VLAN-interface 100.

```
[Switch–Vlan-interface100] portal apply web-server newpt
[Switch–Vlan-interface100] quit
```

Create an HTTP-based local portal Web service and enter its view.

```
[Switch] portal local-web-server http
```

Specify file **defaultfile.zip** as the default authentication page file for the local portal Web service. (Make sure the file exist under the root directory of the switch.)

```
[Switch–portal-local-websvr-http] default-logon-page defaultfile.zip
```

Set the HTTP listening port number to 2331 for the local portal Web service.

```
[Switch–portal-local-webserver-http] tcp-port 2331
[Switch–portal-local-websvr-http] quit
```

Verifying the configuration

Verify that the portal configuration has taken effect.

```
[Switch] display portal interface vlan-interface 100
 Portal information of Vlan-interface 100
     Authorization                   Strict checking
     ACL                             Disabled
     User profile                    Disabled
 IPv4:
     Portal status: Enabled
     Portal authentication method: Direct
     Portal web server: newpt
     Secondary portal Web server: Not configured
     Portal mac-trigger-server: Not configured
     Authentication domain: Not configured
     User-dhcp-only: Disabled
     Pre-auth IP pool: Not configured
     Max Portal users: Not configured
     Bas-ip: Not configured
     User detection:  Not configured
     Action for server detection:
```

```
        Server type    Server name                          Action
        --             --                                   --
    Layer3 source network:
        IP address              Mask

    Destination authenticate subnet:
        IP address              Mask
IPv6:
    Portal status: Disabled
    Portal authentication method: Disabled
    Portal web server: Not configured
    Secondary portal Web server: Not configured
    Portal mac-trigger-server: Not configured
    Authentication domain: Not configured
    User-dhcp-only: Disabled
    Pre-auth IP pool: Not configured
    Max Portal users: Not configured
    Bas-ipv6: Not configured
    User detection: Not configured
    Action for server detection:
        Server type    Server name                          Action
        --             --                                   --
    Layer3 source network:
        IP address                                          Prefix length

    Destination authenticate subnet:
        IP address                                          Prefix length
```

A user can perform portal authentication through a Web page. Before passing the authentication, the user can access only the authentication page **http://2.2.2.1:2331/portal** and all Web requests will be redirected to the authentication page. After passing the authentication, the user can access other network resources.

After the user passes authentication, use the following command to display information about the portal user.

```
[Switch] display portal user interface vlan-interface 100
Total portal users: 1
Username: abc
  Portal server: newpt
  State: Online
  VPN instance: N/A
  MAC               IP                VLAN   Interface
  0015-e9a6-7cfe    2.2.2.2           100     Vlan-interface100
  Authorization information:
    DHCP IP pool: N/A
    User profile: N/A
    Session group profile: N/A
    ACL number: N/A
    Inbound CAR: N/A
    Outbound CAR: N/A
```

Troubleshooting portal

No portal authentication page is pushed for users

Symptom

When a user is redirected to the IMC portal authentication server, no portal authentication page or error message is prompted for the user. The login page is blank.

Analysis

The key configured on the portal access device and that configured on the portal authentication server are inconsistent. As a result, packet verification fails, and the portal authentication server refuses to push the authentication page.

Solution

Use the **display this** command in portal authentication server view on the access device to check whether a key is configured for the portal authentication server.

- If no key is configured, configure the right key.
- If a key is configured, use the **ip** or **ipv6** command in the portal authentication server view to correct the key, or correct the key configured for the access device on the portal authentication server.

Cannot log out portal users on the access device

Symptom

You cannot use the **portal delete-user** command on the access device to log out a portal user, but the portal user can log out by clicking the **Disconnect** button on the portal authentication client.

Analysis

When you execute the **portal delete-user** command on the access device to log out a user, the access device sends an unsolicited logout notification message to the portal authentication server. The destination port number in the logout notification is the listening port number of the portal authentication server configured on the access device. If this listening port number is not the actual listening port number configured on the server, the server cannot receive the notification. As a result, the server does not log out the user.

When a user uses the **Disconnect** button on the authentication client to log out, the portal authentication server sends an unsolicited logout request message to the access device. The access device uses the source port in the logout request as the destination port in the logout ACK message. As a result, the portal authentication server can definitely receive the logout ACK message and log out the user.

Solution

1. Use the **display portal server** command to display the listening port of the portal authentication server configured on the access device.
2. Use the **portal server** command in system view to change the listening port number to the actual listening port of the portal authentication server.

Cannot log out portal users on the RADIUS server

Symptom

The access device uses the H3C IMC server as the RADIUS server to perform identity authentication for portal users. You cannot log out the portal users on the RADIUS server.

Analysis

The H3C IMC server uses session control packets to send disconnection requests to the access device. On the access device, the listening UDP port for session control packets is disabled by default. Therefore, the access device cannot receive the portal user logout requests from the RADIUS server.

Solution

On the access device, execute the **`radius session-control enable`** command in system view to enable the RADIUS session control function.

Users logged out by the access device still exist on the portal authentication server

Symptom

After you log out a portal user on the access device, the user still exists on the portal authentication server.

Analysis

When you execute the **`portal delete-user`** command on the access device to log out a user, the access device sends an unsolicited logout notification to the portal authentication server. If the BAS-IP or BAS-IPv6 address carried in the logout notification is different from the portal device IP address specified on the portal authentication server, the portal authentication server discards the logout notification. When sending of the logout notifications times out, the access device logs out the user. However, the portal authentication server does not receive the logout notification successfully, and therefore it regards the user is still online.

Solution

Configure the BAS-IP or BAS-IPv6 attribute on the interface enabled with portal authentication. Make sure the attribute value is the same as the portal device IP address specified on the portal authentication server.

Re-DHCP portal authenticated users cannot log in successfully

Symptom

The device performs re-DHCP portal authentication for users. A user enters the correct username and password, and the client successfully obtains the private and public IP addresses. However, the authentication result for the user is failure.

Analysis

When the access device detects that the client IP address is changed, it sends an unsolicited portal packet to notify of the IP change to the portal authentication server. The portal authentication server notifies of the authentication success only after it receives the IP change notification from both the access device and the client.

If the BAS-IP or BAS-IPv6 address carried in the portal notification packet is different from the portal device IP address specified on the portal authentication server, the portal authentication server discards the portal notification packet. As a result, the portal authentication server considers that the user has failed the authentication.

Solution

Configure the BAS-IP or BAS-IPv6 attribute on the interface enabled with portal authentication. Make sure the attribute value is the same as the portal device IP address specified on the portal authentication server.

Contents

Configuring Web authentication

About Web authentication

Web authentication is deployed on Layer 2 Ethernet interfaces of the access device to control user access to networks. The access device redirects unauthenticated users to the specified website. The users can access the resources on the website without authentication. If the users want to access other network resources, they must pass authentication.

Advantages of Web authentication

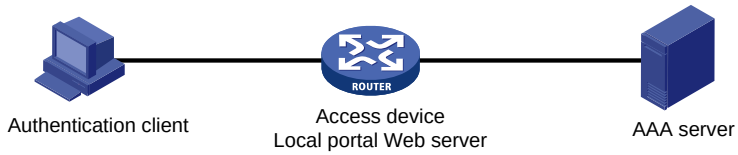
Web authentication has the following advantages:

- Allows users to perform authentication through webpages without installing client software.
- Provides ISPs with diversified management choices and extended functions. For example, the ISPs can place advertisements, provide community services, and publish information on the authentication page.

Web authentication system

A typical Web authentication system consists of four basic components: authentication client, access device, local portal Web server, and AAA server.

Figure 1 Web authentication system using the local portal server



Authentication client

An authentication client is a Web browser that runs HTTP or HTTPS.

Access device

An access device has the following functions:

- Redirects all user HTTP or HTTPS requests that do not match authentication-free rules to the Web authentication page before authentication.
- Interacts with the AAA server to complete authentication, authorization, and accounting. For more information about AAA, see "Configuring AAA."
- Allows users that pass authentication to access authorized network resources.

Local portal Web server

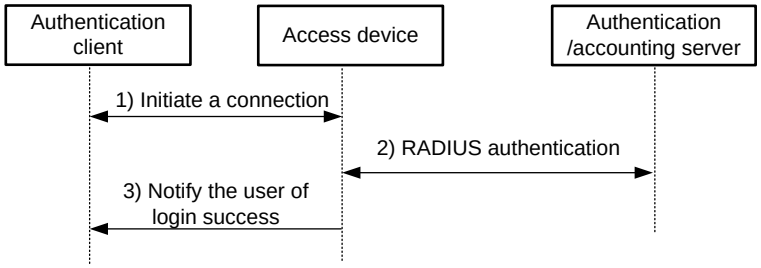
The access device acts as the local portal Web server. The local portal Web server pushes the Web authentication page to authentication clients and obtains user authentication information (username and password).

AAA server

An AAA server interacts with the access device to implement user authentication, authorization, and accounting. A RADIUS server can perform authentication, authorization, and accounting for Web authentication users. An LDAP server can perform authentication for Web authentication users.

Web authentication process

Figure 2 Web authentication process



The Web authentication process is as follows:

1. An unauthenticated user sends an HTTP or HTTPS request. When the access device receives the HTTP or HTTPS request on a Layer 2 Ethernet interface enabled with Web authentication, it redirects the request to the Web authentication page. The user enters the username and password on the Web authentication page.

   If the user requests the Web authentication page or free Web resources, the access device permits the request. No Web authentication is performed.
2. The access device and the AAA server exchange RADIUS packets to authenticate the user.
3. If the user passes RADIUS authentication, the local portal Web server pushes a login success page to the authentication client.

   If the user fails RADIUS authentication, the local portal Web server pushes a login failure page to the authentication client.

Web authentication support for VLAN assignment

Authorization VLAN

Web authentication uses VLANs authorized by the AAA server or the access device to control network resource access of authenticated users.

After a user passes Web authentication, the AAA server or the access device authorizes the user to access a VLAN. If the authorization VLAN does not exist, the access device first creates the VLAN and then assigns the user access interface as an untagged member to the VLAN. If the authorization VLAN already exists, the access device directly assigns the user access interface as an untagged member to the VLAN. Then, the user can access resources in the authorization VLAN.

Table 1 describes the way the access device handles authorization VLANs for Web authenticated users.

Table 1 VLAN manipulation

Port type	VLAN manipulation
• Access port • Trunk port • Hybrid port with MAC-based-VLAN disabled	The device assigns the port to the first authenticated user's authorization VLAN. The authorization VLAN becomes the PVID. All Web authentication users on the port must be assigned the same authorization VLAN. If a different authorization VLAN is assigned to a subsequent user, the user cannot pass Web authentication.
Hybrid port with MAC-based VLAN enabled	The device maps the MAC address of each user to its own authorization VLAN regardless of whether the port is a tagged member. The PVID of the port does not change.

Auth-Fail VLAN

An Auth-Fail VLAN is a VLAN assigned to users who fail authentication. The Auth-Fail VLAN provides network resources such as the patch server, virus definitions server, client software server, and anti-virus software server to the users. The users can use these resources to upgrade their client software or other programs.

Web authentication supports Auth-Fail VLAN on an interface that performs MAC-based access control. If a user on the interface fails authentication, the access devices creates a MAC VLAN entry based on the MAC address of the user and adds the user to the Auth-Fail VLAN. Then, the user can access the portal-free IP resources in the Auth-Fail VLAN. All HTTP or HTTPS requests to non-portal-free IP resources will be redirected to the authentication page. If the user still fails authentication, the interface remains in the Auth-Fail VLAN. If the user passes authentication, the access device removes the interface from the Auth-Fail VLAN and assigns the interface to a VLAN as follows:

- If the authentication server assigns an authorization VLAN to the user, the access device assigns the interface to the authorization VLAN.
- If the authentication server does not assign an authorization VLAN to the user, the access device assigns the interface to the default VLAN.

Web authentication support for authorization ACLs

Web authentication uses ACLs authorized by the AAA server or the access device to control user access to network resources and limit user access rights. When a user passes authentication, the AAA server and the access device assigns an authorization ACL to the access interface of the user. The access device filters traffic from the user on the access interface according to the authorized ACL.

You must configure the authorization ACLs on the access device if you specify authorization ACLs on the authentication server.

To change the access control criteria for the user, you can specify a different authorization ACL on the authentication server or change rules in the authorization ACL on the access device.

The device supports the following types of authorization ACLs:

- Basic ACLs (ACL 2000 to ACL 2999).
- Advanced ACLs (ACL 3000 to ACL 3999).
- Layer 2 ACLs (ACL 4000 to ACL 4999).

For an authorization ACL to take effect, make sure the ACL exists and has ACL rules excluding rules configured with the **`counting`**, **`established`**, **`fragment`**, **`source-mac`**, or **`logging`** keyword. For more information about ACL rules, see ACL commands in *ACL and QoS Command Reference*.

Restrictions and guidelines: Web authentication configuration

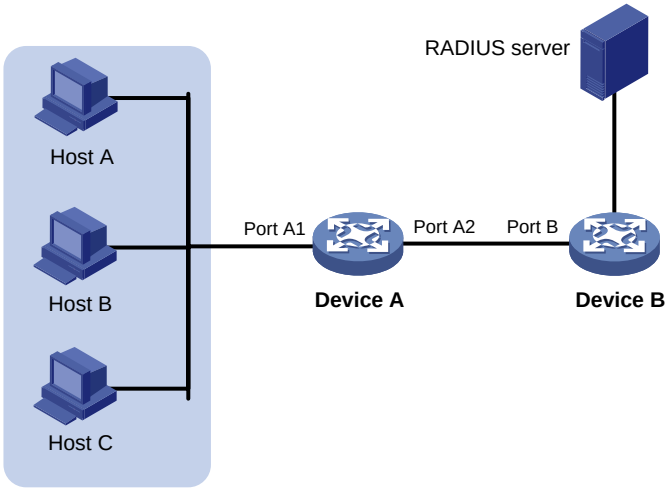
To redirect HTTPS requests for unauthenticated users correctly, make sure the packet incoming VLANs have Layer 3 interfaces (VLAN interfaces) configured.

To access the resources in the authorization or Auth-Fail VLAN, a user must update the IP address of the client after being assigned to the authorization or Auth-Fail VLAN.

As a best practice, perform Web authentication on users directly connected to the device. As shown in Figure 3, if you enable Web authentication on Port B to authenticate non-directly connected users (the hosts), you must follow these restrictions and guidelines:

- If the RADIUS server assigns an authorization VLAN to the users, make sure the following conditions are met:
  - The link between Device A and Device B is a trunk link.
  - The PVIDs of Port A1 and Port B are the same as the authorization VLAN ID.
- If the RADIUS server does not assign an authorization VLAN to the users, make sure the PVIDs of Port A1 and Port B are the same.

Figure 3 Web authentication for non-directly connected users



Web authentication tasks at a glance

To configure Web authentication, perform the following tasks:

1. Configuring a Web authentication server
2. Configuring a local portal service
3. Enabling Web authentication
4. (Optional.) Specifying a Web authentication domain
5. (Optional.) Setting the redirection wait time
6. (Optional.) Configuring the aging timer for temporary MAC address entries for Web authentication
7. (Optional.) Configuring a Web authentication-free subnet
8. (Optional.) Setting the maximum number of Web authentication users
9. (Optional.) Configuring online Web authentication user detection
10. (Optional.) Configuring an Auth-Fail VLAN
11. (Optional.) Configuring Web authentication to support Web proxy

Prerequisites for Web authentication

The device supports two methods for Web authentication, which are local authentication and RADIUS authentication.

To use the RADIUS authentication method, you must complete the following tasks:

- Install a RADIUS server and configure the RADIUS server properly.
- Make sure the authentication client, the access device, and the RADIUS server can reach each other.

- Configure user accounts on the RADIUS server and configure the RADIUS client information on the access device.

To use the local authentication method, you must configure local users on the access device.

For more information about RADIUS clients and local users, see "Configuring AAA."

Configuring a Web authentication server

Restrictions and guidelines

Specify the IP address of a Layer 3 interface on the device that is routable to the Web client as the listening IP address of the Web authentication server. As a best practice, use the IP address of a loopback interface rather than that of a Layer 3 interface. A loopback interface has the following advantages:

- The status of a loopback interface is stable. There will be no authentication page access failures caused by interface failures.
- A loopback interface does not forward received packets to any networks, avoiding impact on system performances when there are many network access requests.

Procedure

1. Enter system view.

   system-view
2. Create a Web authentication server and enter its view.

   web-auth server *server-name*
3. Specify the IP address and port number of the Web authentication server.

   ip *ipv4-address* **port** *port-number*

   The port number of the Web authentication server must be the same as the listening port of the local portal Web service.
4. Specify the redirection URL for the Web authentication server.

   url *url-string*

   The IP address and port number in the specified redirection URL must be the same as those of the Web authentication server.
5. (Optional.) Add parameters to the redirection URL of the Web authentication server.

   url-parameter *parameter-name* { **original-url** | **source-address** | **source-mac** | **value** *expression* }

   By default, no parameters are added to the redirection URL of a Web authentication server.

Configuring a local portal service

For information about the local portal service configuration, see "Configuring portal authentication."

Enabling Web authentication

Restrictions and guidelines

For Web authentication to operate correctly, do not enable port security or configure the port security mode on the Layer 2 Ethernet interface enabled with Web authentication. For more information about port security, see "Configuring port security."

To redirect Web authentication users' HTTPS packets, make sure the specified HTTPS redirect listening port number (the default is 6654) is available. For more information about how to change

the HTTPS redirect listening port number, see HTTPS redirect configuration in *Layer 3—IP Services Configuration Guide*.

Procedure

1. Enter system view.
   system-view
2. Enter interface view.
   interface *interface-type interface-number*
3. Enable Web authentication and specify the Web authentication server.
   web-auth enable apply server *server-name*
   By default, Web authentication is disabled.

Specifying a Web authentication domain

About the Web authentication domain

You can specify different authentication domains for Web authentication users on different interfaces. After you specify a Web authentication domain on an interface, the device uses the authentication domain for AAA of all Web authentication users on the interface, ignoring the domain names carried in the usernames.

The device selects the authentication domain for a Web authentication user on an interface in this order:

1. The authentication domain specified for the interface.
2. The authentication domain carried in the username.
3. The system default authentication domain.
4. The ISP domain configured to accommodate users assigned to nonexistent domains.

If the selected domain does not exist on the device, user authentication fails. For information about ISP domains, see "Configuring AAA."

Procedure

1. Enter system view.
   system-view
2. Enter interface view.
   interface *interface-type interface-number*
3. Specify an authentication domain for Web authentication users on the interface.
   web-auth domain *domain-name*
   By default, no authentication domain is specified for Web authentication users.

Setting the redirection wait time

About the redirection wait time

The redirection wait time determines the length of time that the device waits to redirect a user to the specified webpage after the user passes Web authentication.

You need to change the redirection wait time in some scenarios, for example, when a user needs to update the client IP address after passing Web authentication. To ensure that the specified webpage can be successfully opened, set the redirection wait time to be greater than the time that the user takes to update the IP address of the client.

Procedure

1. Enter system view.
   system-view
2. Enter Web authentication server view.
   web-auth server *server-name*
3. Set the redirection wait time.
   redirect-wait-time *period*
   By default, the redirection wait time for authenticated users is 5 seconds.

Configuring the aging timer for temporary MAC address entries for Web authentication

About the aging timer

If Web authentication is enabled, the device generates a temporary MAC address entry when it detects traffic from a user for the first time. The entry records the MAC address, access interface, and VLAN ID of the user, as well as the aging time of the entry.

The aging timer works as follows:

- If the user does not initiate authentication when the aging timer expires, the device deletes the temporary entry.
- If the user passes authentication before the aging timer expires, the device deletes the aging timer and records online information for the Web authentication user.
- If the user fails authentication before the aging timer expires and an Auth-Fail VLAN is specified for Web authentication, the device binds the MAC address of the user to the Auth-Fail VLAN and reset the aging timer. If the user still fails authentication when the aging timer expires, the device deletes the temporary entry for the user.

Feature and software version comaptibiltiy

This feature is supported only in Release 6343P08 and later.

Restrictions and guidelines

As a best practice, change the aging timer to a bigger value in the following cases:

- Web authentication users without access rights frequently send traffic in a short time. As a result, the access device continuously initiates the web authentication process, increasing the load on the device.
- When a user fails authentication, the user does not have enough time to obtain resources from the Auth-Fail VLAN, for example, it failed to download the virus patches.

Procedure

1. Enter system view.
   system-view
2. Configure the aging timer for temporary MAC address entries.
   web-auth timer temp-entry-aging *aging-time-value*
   By default, the aging timer for temporary MAC address entries is 60 seconds.

Configuring a Web authentication-free subnet

About Web authentication-free subnets

You can configure a Web authentication-free subnet so that users can freely access the network resources in the subnet without being authenticated.

Restrictions and guidelines

As a best practice, do not configure the same address value for a Web authentication-free subnet and a 802.1X free IP. Otherwise, when you cancel one of the configuration, the other configuration does not take effect, either.

Procedure

1. Enter system view.
   system-view
2. Configure a Web authentication-free subnet.
   web-auth free-ip *ip-address* { *mask-length* | *mask* }

Setting the maximum number of Web authentication users

Restrictions and guidelines

If the maximum number of online Web authentication users you set is less than that of the current online Web authentication users, the limit can be set successfully and does not impact the online Web authentication users. However, the system does not allow new Web authentication users to log in until the number drops down below the limit.

Procedure

1. Enter system view.
   system-view
2. Enter interface view.
   interface *interface-type interface-number*
3. Set the maximum number of Web authentication users on the interface.
   web-auth max-user *max-number*

   By default, the maximum number of Web authentication users is 1024.

Configuring online Web authentication user detection

About online Web authentication user detection

This feature enables the device to detect packets of an online user at the specified detection interval. If no packet from the user is received within the interval, the device logs out the user and notifies the RADIUS server to stop accounting for the user.

Restrictions and guidelines

To prevent the device from mistakenly logging out users, set the detection interval to be the same as the aging time of MAC address entries.

Procedure

1. Enter system view.
   system-view
2. Enter interface view.
   interface *interface-type interface-number*
3. Enable online Web authentication user detection.
   web-auth offline-detect interval *interval*
   By default, online Web authentication user detection is disabled.

Configuring an Auth-Fail VLAN

Restrictions and guidelines

To make the Auth-Fail VLAN take effect, you must also enable MAC-based VLAN on the interface, and set the subnet of the Auth-Fail VLAN as the Web authentication-free subnet.

Because MAC-based VLAN takes effect only on Hybrid ports, Auth-Fail VLAN also takes effect only on Hybrid ports.

Do not delete the VLAN that has been configured as an Auth-Fail VLAN. To delete this VLAN, first cancel the Auth-Fail VLAN configuration by using **undo web-auth auth-fail vlan** command.

Procedure

1. Enter system view.
   system-view
2. Enter interface view.
   interface *interface-type interface-number*
3. Configure an Auth-Fail VLAN.
   web-auth auth-fail vlan *authfail-vlan-id*
   By default, no Auth-Fail VLAN is configured on an interface.

Configuring Web authentication to support Web proxy

About support of Web proxy for Web authentication

By default, proxied HTTP requests cannot trigger Web authentication but are silently dropped. To allow such HTTP requests to trigger Web authentication, specify the port numbers of the Web proxy servers on the device.

Restrictions and guidelines

If a user's browser uses the Web Proxy Auto-Discovery (WPAD) protocol to discover Web proxy servers, you must perform the following tasks:

- Add the port numbers of the Web proxy servers on the device.
- Configure authentication-free rules to allow user packets destined for the IP address of the WPAD server to pass without authentication.

For Web authentication to support Web proxy:

- You must add the port numbers of the Web proxy servers on the device.

- Users must make sure their browsers that use a Web proxy server do not use the proxy server for the listening IP address of the local portal Web server. Thus, HTTP packets that the Web authentication user sends to the local portal Web server are not sent to the Web proxy server.

Procedure

1. Enter system view.

   system-view

2. Add a Web proxy server port number.

   web-auth proxy port *port-number*

   You can execute this command multiple times to specify multiple port numbers of Web proxy servers.

Display and maintenance commands for Web authentication

Execute **display** commands in any view.

Task	Command
Display Web authentication configuration information on interfaces.	**display web-auth** [**interface** *interface-type interface-number*]
Display Web authentication-free subnets.	**display web-auth free-ip**
Display Web authentication server information.	**display web-auth server** [*server-name*]
Display Web authentication user information.	**display web-auth user** [**interface** *interface-type interface-number* | **slot** *slot-number*]

Web authentication configuration examples

Example: Configuring Web authentication by using the local authentication method

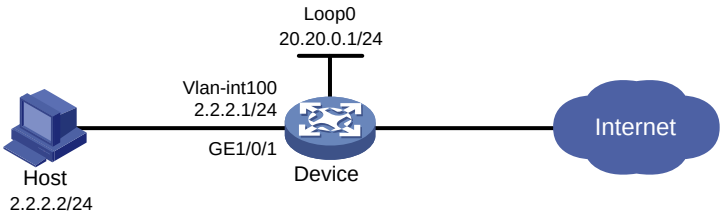
Network configuration

As shown in Figure 4, the host is directly connected to the device through GigabitEthernet 1/0/1.

Configure Web authentication on GigabitEthernet 1/0/1, and use local authentication and authorization for the users.

Configure the device to push customized Web authentication pages to users and use HTTP to transfer the authentication data.

Figure 4 Network diagram



Procedure

1. Customize the authentication pages, compress them to a file, and upload the file to the root directory of the storage medium of the device. In this example, the file is **abc.zip**. (Details not shown.)
2. Assign IP addresses to the host and the device as shown in Figure 4, and make sure the host and the device can reach each other.
3. Configure a local user:

   # Create a local network access user named **localuser**.

   ```
   <Device>system-view
   [Device] local-user localuser class network
   ```

   # Set the password to **localpass** in plaintext form for user **localuser.**

   ```
   [Device-luser-network-localuser] password simple localpass
   ```

   # Authorize the user to use LAN access services.

   ```
   [Device-luser-network-localuser] service-type lan-access
   [Device-luser-network-localuser] quit
   ```

4. Configure an ISP domain:

   # Create an ISP domain named **local**.

   ```
   [Device] domain local
   ```

   # Configure the ISP domain to perform local authentication, authorization, and accounting for LAN access users.

   ```
   [Device-isp-local] authentication lan-access local
   [Device-isp-local] authorization lan-access local
   [Device-isp-local] accounting lan-access local
   [Device-isp-local] quit
   ```

5. Configure a local portal Web service:

   # Create an HTTP-based local portal Web service and enter its view.

   ```
   [Device] portal local-web-server http
   ```

   # Specify file **abc.zip** as the default authentication page file for the local portal Web service. (This file must exist in the root directory of the device.)

   ```
   [Device-portal-local-websvr-http] default-logon-page abc.zip
   ```

   # Specify the HTTP listening port number as 80 for the portal Web service.

   ```
   [Device–portal-local-websvr-http] tcp-port 80
   [Device-portal-local-websvr-http] quit
   ```

6. Configure Web authentication:

   # Create a Web authentication server named **user**.

   ```
   [Device] web-auth server user
   ```

   # Configure the redirection URL for the Web authentication server as **http://20.20.0.1/portal/**.

   ```
   [Device-web-auth-server-user] url http://20.20.0.1/portal/
   ```

Specify 20.20.0.1 as the IP address and 80 as the port number for the Web authentication server.

```
[Device-web-auth-server-user] ip 20.20.0.1 port 80
[Device-web-auth-server-user] quit
```

Specify ISP domain **local** as the Web authentication domain.

```
[Device] interface gigabitethernet 1/0/1
[Device-GigabitEthernet1/0/1] web-auth domain local
```

Enable Web authentication by using Web authentication server **user**.

```
[Device-GigabitEthernet1/0/1] web-auth enable apply server user
[Device-GigabitEthernet1/0/1] quit
```

Verifying the configuration

Display online Web authentication user information after user **localuser** passes Web authentication.

```
<Device> display web-auth user
  Total online web-auth users: 1

User Name: localuser
  MAC address: acf1-df6c-f9ad
  Access interface: GigabitEthernet1/0/1
  Initial VLAN: 100
  Authorization VLAN: N/A
  Authorization ACL ID: N/A
  Authorization user profile: N/A
```

Example: Configuring Web authentication by using the RADIUS authentication method

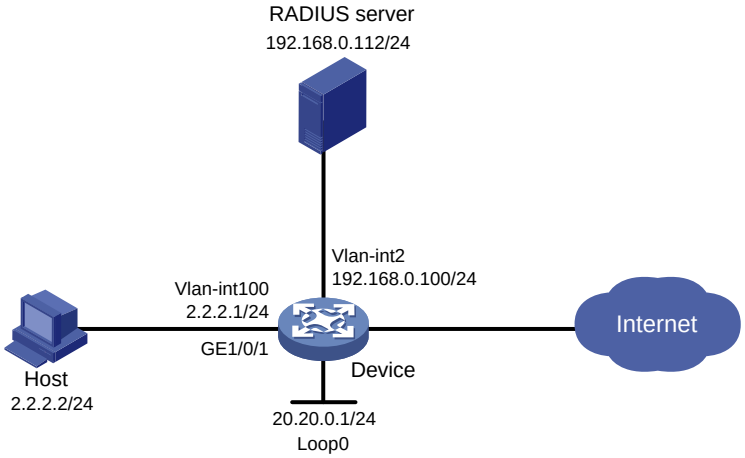
Network configuration

As shown in Figure 5, the host is directly connected to the device through GigabitEthernet 1/0/1.

Configure Web authentication on GigabitEthernet 1/0/1, and use a RADIUS server to perform authentication and authorization for the users.

Configure the device to push customized Web authentication pages to users and use HTTP to transfer the authentication data.

Figure 5 Network diagram



Procedure

1. Configure the RADIUS server properly to provide authentication and accounting functions for users. In this example, the username is configured as **user1** on the RADIUS server. (Details not shown.)
2. Customize the authentication pages, compress them to a file, and upload the file to the root directory of the storage medium of the switch. In this example, the file is **abc.zip**.
3. Create VLANs, assign IP addresses to the VLAN interfaces, and assign interfaces to the VLANs. Make sure the host, the RADIUS server, and the device can reach each other. (Details not shown.)
4. Configure a RADIUS scheme:

   # Create a RADIUS scheme named **rs1**.

   ```
   <Device> system-view
   [Device] radius scheme rs1
   ```

   # Specify the primary authentication server and primary accounting server, and configure the keys for communication with the servers.

   ```
   [Device-radius-rs1] primary authentication 192.168.0.112
   [Device-radius-rs1] primary accounting 192.168.0.112
   [Device-radius-rs1] key authentication simple radius
   [Device-radius-rs1] key accounting simple radius
   ```

   # Exclude the ISP domain name from the username sent to the RADIUS server.

   ```
   [Device-radius-rs1] user-name-format without-domain
   [Device-radius-rs1] quit
   ```
5. Configure an authentication domain:

   # Create an ISP domain named **dm1**.

   ```
   [Device] domain dm1
   ```

   # Configure AAA methods for the ISP domain

   ```
   [Device-isp-dm1] authentication lan-access radius-scheme rs1
   [Device-isp-dm1] authorization lan-access radius-scheme rs1
   [Device-isp-dm1] accounting lan-access radius-scheme rs1
   [Device-isp-dm1] quit
   ```
6. Configure a local portal Web service:

   # Create an HTTP-based local portal Web service.

   ```
   [Device] portal local-web-server http
   ```

Specify the file **abc.zip** as the default authentication page file for the local portal Web service. (This file must exist in the directly root directory of the storage medium.)

```
[Device-portal-local-websvr-http] default-logon-page abc.zip
```

Specify 80 as the port number listened by the local portal Web service.

```
[Device–portal-local-websvr-http] tcp-port 80
[Device-portal-local-websvr-http] quit
```

7. Configure Web authentication:

Create Web authentication server named **user**.

```
[Device] web-auth server user
```

Specify **http://20.20.0.1/portal/** as the redirection URL for the Web authentication server.

```
[Device-web-auth-server-user] url http://20.20.0.1/portal/
```

Specify the IP address of the Web authentication server as 20.20.0.1 (the IP address of Loopback 0) and the port number as 80.

```
[Device-web-auth-server-user] ip 20.20.0.1 port 80
[Device-web-auth-server-user] quit
```

Specify domain **dml** as the Web authentication domain.

```
[Device] interface gigabitethernet 1/0/1
[Device-GigabitEthernet1/0/1] web-auth domain dm1
```

Enable Web authentication by using Web authentication server **user**.

```
[Device-GigabitEthernet1/0/1] web-auth enable apply server user
[Device-GigabitEthernet1/0/1] quit
```

Verifying the configuration

Display Web authentication user information after user **user1** passes Web authentication.

```
<Device> display web-auth user
  Total online web-auth users: 1

User Name: user1
  MAC address: acf1-df6c-f9ad
  Access interface: GigabitEthernet1/0/1
  Initial VLAN: 100
  Authorization VLAN: N/A
  Authorization ACL ID: N/A
  Authorization user profile: N/A
```

Troubleshooting Web authentication

Failure to come online (local authentication interface using the default ISP domain

Symptom

No authentication domain is specified for the local authentication interface. A user fails to pass Web authentication to come online.

Analysis

If no Web authentication domain is specified, the system default ISP domain (domain **system**) is used for Web authentication. The system default domain uses the local authentication method by

default. Using these default domain settings, the local authentication should have operated correctly.

The local authentication fails might because that the authentication method of the system default domain is changed or the system default domain is changed.

Solution

To resolve the problem, perform the following tasks:

1. Use the **`display domain`** command to identify whether the AAA methods for Web users in the system default domain are local.
2. If the AAA methods for Web users in the system default domain are not local, reconfigure the AAA methods as local.

Contents

Configuring triple authentication

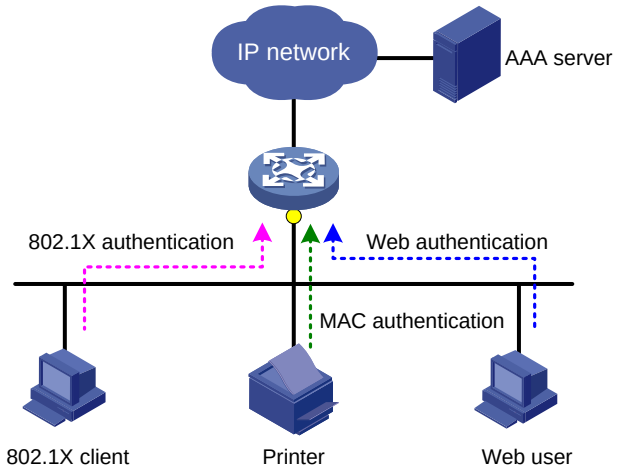
About triple authentication

Triple authentication enables an access port to perform Web, MAC, and 802.1X authentication. A terminal can access the network if it passes one type of authentication. For more information about 802.1X authentication, MAC authentication, and Web authentication, see "Configuring 802.1X authentication", "Configuring MAC authentication", and "Configuring Web authentication."

Typical network of triple authentication

Triple authentication is suitable for a LAN that comprises terminals that require different authentication services, as shown in Figure 1. The triple authentication-enabled access port can perform MAC authentication for the printer, 802.1X authentication for the PC installed with the 802.1X client, and Web authentication for the Web user.

Figure 1 Triple authentication network diagram



Triple authentication mechanism

The three types of authentication are triggered by different packets:

- The access port performs MAC authentication for a terminal when it receives an ARP or DHCP broadcast packet from the terminal for the first time. If the terminal passes MAC authentication, the terminal can access the network. If the MAC authentication fails, the access port performs 802.1X or Web authentication.
- The access port performs 802.1X authentication when it receives an EAP packet from an 802.1X client or a third-party client. If the unicast trigger feature of 802.1X is enabled on the access port, any packet from the client can trigger an 802.1X authentication.
- The access port performs Web authentication when it receives an HTTP packet from a terminal.

If a terminal triggers different types of authentication, the authentications are processed at the same time. The failure of one type of authentication does not affect the others. When a terminal passes one type of authentication, the other types of authentication are processed as follows:

- If the terminal first passes MAC authentication, Web authentication is terminated immediately, but 802.1X authentication will proceed. If the terminal also passes 802.1X authentication, the 802.1X authentication information will overwrite the MAC authentication information for the

terminal. If the terminal fails 802.1X authentication, the user stays online as a MAC authentication user, and only 802.1X authentication can be triggered again.

- If the terminal first passes 802.1X or Web authentication, the other types of authentication are terminated immediately and cannot be triggered again.

Triple authentication support for VLAN assignment

Authorization VLAN

After a user passes authentication, the authentication server assigns an authorization VLAN to the access port for the user. The user can then access the network resources in the authorized VLAN.

Authentication failure VLAN

The access port adds a user to an authentication failure VLAN configured on the port after the user fails authentication.

- For an 802.1X authentication user—Adds the user to the Auth-Fail VLAN configured for 802.1X authentication.
- For a Web authentication user—Adds the user to the Auth-Fail VLAN configured for Web authentication.
- For a MAC authentication user—Adds the user to the guest VLAN configured for MAC authentication.

The access port supports configuring all types of authentication failure VLANs at the same time. If a user fails more than one type of authentication, the authentication failure VLAN of the user changes as follows:

- If a user in the Web Auth-Fail VLAN fails MAC authentication, the user is moved to the MAC authentication guest VLAN.
- If a user in the Web Auth-Fail VLAN or MAC authentication guest VLAN fails 802.1X authentication, the user is moved to the 802.1X Auth-Fail VLAN.
- If a user in the 802.1X Auth-Fail VLAN fails MAC authentication or Web authentication, the user is still in the 802.1X Auth-Fail VLAN.

Server-unreachable VLAN

If a user fails authentication due to the unreachable server, the access port adds the user to an server-unreachable VLAN.

- For an 802.1X authentication user—Adds the user to the critical VLAN configured for 802.1X authentication.
- For a Web authentication user—Adds the user to the Auth-Fail VLAN configured for Web authentication.
- For a MAC authentication user—Adds the user to the critical VLAN configured for MAC authentication.

The access port supports configuring all types of server-unreachable VLANs at the same time. A user is added to the server-unreachable VLAN as follows:

- If the user does not undergo 802.1X authentication, the user is added to the server-unreachable VLAN configured for the last authentication.
- If the user in the Web Auth-Fail VLAN or the MAC authentication critical VLAN also fails 802.1X authentication, the user is added to the 802.1X authentication critical VLAN.

Triple authentication support for ACL authorization

After a user passes authentication, the authentication server assigns an authorization ACL to the access port for the user. The access port uses the ACL to filter traffic for the user.

To use ACL authorization, you must specify authorization ACLs on the authentication server and configure the ACLs on the access device. You can change the user's access authorization by changing the authorization ACL on the authentication server or changing rules of the authorization ACL on the access device.

Triple authentication support for online user detection

You can configure the following features to detect the online status of users:

- Enable online user detection for Web authentication users.
- Enable the online user handshake or periodic online user reauthentication feature for 802.1X users.
- Enable offline detection for MAC authentication users.

Restrictions and guidelines: Triple authentication

In triple authentication, 802.1X authentication must use the MAC-based access control method.

If Web authentication is enabled on a port, configure the subnets of the authentication failure VLANs and server-unreachable VLANs of the port as Web authentication-free subnets. This ensures that an authentication-failed user can access the authentication failure VLAN or server-unreachable VLAN.

Do not configure both Web authentication-free IPs and 802.1X free IPs. If you do so, only 802.1X free IPs take effect.

Triple authentication tasks at a glance

Choose the following tasks as needed:

- Configure 802.1X authentication

  For more information, see "Configuring 802.1X."
- Configure MAC authentication

  For more information, see "Configuring MAC authentication."
- Configure Web authentication

  For more information, see "Configuring Web authentication."

Triple authentication configuration examples

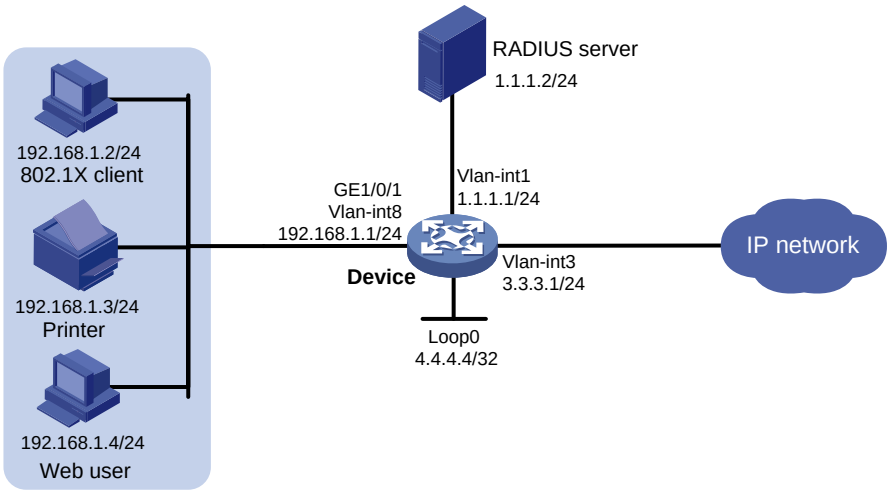
Example: Configuring basic triple authentication

Network configuration

As shown in Figure 2, the terminals are connected to the device to access the IP network. Configure triple authentication on the device's Layer 2 interface that connects to the terminals. A terminal passing one of the three authentication methods, 802.1X authentication, Web authentication, and MAC authentication, can access the IP network.

- Assign IP addresses on subnet 192.168.1.0/24 to the terminals.
- Use the remote RADIUS server to perform authentication, authorization, and accounting. Configure the device to send usernames carrying no ISP domain names to the RADIUS server.
- Configure the local Web authentication server on the device to use listening IP address 4.4.4.4. Configure the device to send a default authentication page to the Web user and forward authentication data by using HTTP.

Figure 2 Network diagram



Procedure

1. Make sure that the terminals, the server, and the device can reach each other. (Details not shown.)
2. Configure the RADIUS server to provide normal authentication, authorization, and accounting for users. In this example, configure the following on the RADIUS server:
   - An 802.1X user with username **userdot**.
   - A Web authentication user with username **userpt**.
   - A MAC authentication user with a username and password both being the MAC address of the printer **f07d6870725f**.
3. Configure Web authentication:

   # Configure VLANs and IP addresses for the VLAN interfaces, and add ports to specific VLANs. (Details not shown.)

   # Edit authentication pages, compress the pages to a .zip file named **abc**, and upload the .zip file to the device by FTP. (Details not shown.)

   # Create an HTTP-based local portal Web service, and specify file **abc.zip** as the default authentication page file of the local portal Web service.

   ```
   <Device> system-view
   [Device] portal local-web-server http
   [Device-portal-local-websvr-http] default-logon-page abc.zip
   [Device-portal-local-websvr-http] quit
   ```

   # Assign IP address 4.4.4.4 to Loopback 0.

   ```
   [Device] interface loopback 0
   [Device-LoopBack0] ip address 4.4.4.4 32
   [Device-LoopBack0] quit
   ```

   # Create a Web authentication server named **webserver** and enter its view.

   ```
   [Device] web-auth server webserver
   ```

   # Configure the redirection URL for the Web authentication server as **http://4.4.4.4/portal/**.

   ```
   [Device-web-auth-server-webserver] url http://4.4.4.4/portal/
   ```

   # Specify 4.4.4.4 as the IP address and 80 as the port number of the Web authentication server.

   ```
   [Device-web-auth-server-webserver] ip 4.4.4.4 port 80
   [Device-web-auth-server-webserver] quit
   ```

Enable Web authentication on GigabitEthernet 1/0/1 and specify Web authentication server **webserver** on the interface.

```
[Device] interface gigabitethernet 1/0/1
[Device–GigabitEthernet1/0/1] web-auth enable apply server webserver
[Device–GigabitEthernet1/0/1] quit
```

4. Configure 802.1X authentication:

Enable 802.1X authentication globally.

```
[Device] dot1x
```

Enable 802.1X authentication (MAC-based access control required) on GigabitEthernet 1/0/1.

```
[Device] interface gigabitethernet 1/0/1
[Device–GigabitEthernet1/0/1] dot1x port-method macbased
[Device–GigabitEthernet1/0/1] dot1x
[Device–GigabitEthernet1/0/1] quit
```

5. Configure MAC authentication:

Enable MAC authentication globally.

```
[Device] mac-authentication
```

Enable MAC authentication on GigabitEthernet 1/0/1.

```
[Device] interface gigabitethernet 1/0/1
[Device–GigabitEthernet1/0/1] mac-authentication
[Device–GigabitEthernet1/0/1] quit
```

6. Configure a RADIUS scheme:

Create a RADIUS scheme named **rs1**.

```
[Device] radius scheme rs1
```

Specify the primary authentication and accounting servers and keys.

```
[Device-radius-rs1] primary authentication 1.1.1.2
[Device-radius-rs1] primary accounting 1.1.1.2
[Device-radius-rs1] key authentication simple radius
[Device-radius-rs1] key accounting simple radius
```

Specify usernames sent to the RADIUS server to carry no domain names.

```
[Device-radius-rs1] user-name-format without-domain
[Device-radius-rs1] quit
```

7. Configure an ISP domain:

Create an ISP domain named **triple**.

```
[Device] domain triple
```

Configure the domain to use RADIUS scheme **rs1** for authentication, authorization and accounting of LAN access users.

```
[Device-isp-triple] authentication lan-access radius-scheme rs1
[Device-isp-triple] authorization lan-access radius-scheme rs1
[Device-isp-triple] accounting lan-access radius-scheme rs1
[Device-isp-triple] quit
```

Configure domain **triple** as the default domain. If a username entered by a user includes no ISP domain name, the AAA method of the default domain is used.

```
[Device] domain default enable triple
```

Verifying the configuration

1. Verify that the Web user can pass Web authentication.

On the Web user terminal, use a Web browser to access an external network and then enter the correct username and password on the authentication page **http://4.4.4.4/portal/logon.html**. (Details not shown.)

Display information about online Web authentication users.

```
[Device] display web-auth user
  Total online web-auth users: 1
User Name: localuser
  MAC address: acf1-df6c-f9ad
  Access interface: GigabitEthernet1/0/1
  Initial VLAN: 8
  Authorization VLAN: N/A
  Authorization ACL ID: N/A
  Authorization user profile: N/A
```

2. Verify that the printer can pass MAC authentication.

Connect the printer to the network. (Details not shown.)

Display information about online MAC authentication users.

```
[Device] display mac-authentication connection
Total connections: 1
Slot ID: 1
User MAC address: f07d-6870-725f
Access interface: GigabitEthernet1/0/1
Username: f07d6870725f
User access state: Successful
Authentication domain: triple
Initial VLAN: 8
Authorization untagged VLAN: N/A
Authorization tagged VLAN: N/A
Authorization VSI: N/A
Authorization ACL ID: N/A
Authorization user profile: N/A
Authorization CAR: N/A
Authorization URL: N/A
Termination action: Default
Session timeout period: N/A
Online from: 2015/01/04 18:01:43
Online duration: 0h 0m 2s
```

3. Verify that the 802.1X client can pass 802.1X authentication.

On the 802.1X client, initiate 802.1X authentication and then enter the correct username and password. (Details not shown.)

Display information about online 802.1X users.

```
[Device] display dot1x connection
Total connections: 1
Slot ID: 1
User MAC address: 7446-a091-84fe
Access interface: GigabitEthernet1/0/1
Username: userdot
User access state: Successful
Authentication domain: triple
```

```
IPv4 address: 192.168.1.2
Authentication method: CHAP
Initial VLAN: 8
Authorization untagged VLAN: N/A
Authorization tagged VLAN list: N/A
Authorization VSI: N/A
Authorization ACL ID: N/A
Authorization user profile: N/A
Authorization CAR: N/A
Authorization URL: N/A
Termination action: Default
Session timeout period: N/A
Online from: 2015/01/04 18:13:01
Online duration: 0h 0m 14s
```

Example: Configuring triple authentication to support authorization VLAN and authentication failure VLAN

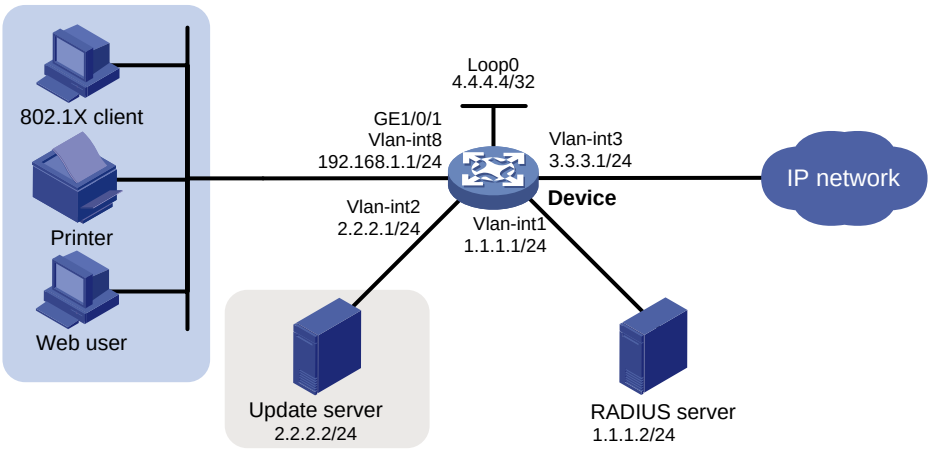
Network configuration

As shown in Figure 3, the terminals are connected to the device to access the IP network. Configure triple authentication on the device's Layer 2 interface connected to the terminals. A terminal passing one of the three authentication methods, 802.1X authentication, Web authentication, and MAC authentication, can access the IP network.

- The Web authentication terminal uses DHCP to get an IP address in 192.168.1.0/24 before authentication and in 3.3.3.0/24 after passing authentication. If the terminal fails authentication, it requests IP addresses in 2.2.2.0/24 through DHCP.

  You can use the access device or an attached device as the DHCP server. In this example, the access device (the device) provides the DHCP service.
- The 802.1X terminal uses DHCP to get an IP address in 192.168.1.0/24 before authentication and in 3.3.3.0/24 after passing authentication. If the terminal fails authentication, it requests IP addresses in 2.2.2.0/24 through DHCP.
- After passing authentication, the printer obtains IP address 3.3.3.111/24 that is bound with its MAC address through DHCP.
- Use the remote RADIUS server to perform authentication, authorization, and accounting. Configure the device to remove the ISP domain names from usernames sent to the RADIUS server.
- Configure the local Web authentication server on the device to use listening IP address 4.4.4.4. Configure the device to send a default authentication page to the Web user and forward authentication data by using HTTP.
- Configure VLAN 3 as the authorization VLAN. Users passing authentication are added to this VLAN.
- Configure VLAN 2 as the authentication failure VLAN. Users failing authentication are added to this VLAN.

Figure 3 Network diagram



Procedure

1. Make sure the terminals, the servers, and the device can reach each other. (Details not shown.)
2. Configure the RADIUS server to provide normal authentication, authorization, and accounting for users. In this example, configure the following on the RADIUS server:
   - An 802.1X user with username **userdot**.
   - A Web authentication user with username **userpt**.
   - A MAC authentication user with a username and password both being the MAC address of the printer **f07d6870725f**.
   - An authorization VLAN (VLAN 3).
3. Configure the IP address of the update server as an authentication-free IP address.

   ```
   <Device> system-view
   [Device] web-auth free-ip 2.2.2.2 24
   ```
4. Edit authentication pages, compress the pages to a .zip file named **defaultfile** and upload the .zip file to the device by FTP. (Details not shown.)
5. Configure DHCP:

   # Configure VLANs and IP addresses for the VLAN interfaces, and add ports to specific VLANs. (Details not shown.)

   # Enable DHCP.

   ```
   [Device] dhcp enable
   ```

   # Exclude the IP address of the update server from dynamic address assignment.

   ```
   [Device] dhcp server forbidden-ip 2.2.2.2
   ```

   # Configure DHCP address pool 1 to assign IP addresses and other configuration parameters to clients on subnet 192.168.1.0.

   ```
   [Device] dhcp server ip-pool 1
   [Device-dhcp-pool-1] network 192.168.1.0 mask 255.255.255.0
   [Device-dhcp-pool-1] expired day 0 hour 0 minute 1
   [Device-dhcp-pool-1] gateway-list 192.168.1.1
   [Device-dhcp-pool-1] quit
   ```

   # Configure DHCP address pool 2 to assign IP address and other configuration parameters to clients on subnet 2.2.2.0.

   ```
   [Device] dhcp server ip-pool 2
   [Device-dhcp-pool-2] network 2.2.2.0 mask 255.255.255.0
   [Device-dhcp-pool-2] expired day 0 hour 0 minute 1
   ```

```
[Device-dhcp-pool-2] gateway-list 2.2.2.1
[Device-dhcp-pool-2] quit
```

Configure DHCP address pool 3 to assign IP address and other configuration parameters to clients on subnet 3.3.3.0.

```
[Device] dhcp server ip-pool 3
[Device-dhcp-pool-3] network 3.3.3.0 mask 255.255.255.0
[Device-dhcp-pool-3] expired day 0 hour 0 minute 1
[Device-dhcp-pool-3] gateway-list 3.3.3.1
[Device-dhcp-pool-3] quit
```

Configure DHCP address pool 4, and bind the printer's MAC address f07d-6870-725f to IP address 3.3.3.111/24 in this address pool.

```
[Device] dhcp server ip-pool 4
[Device-dhcp-pool-4] static-bind ip-address 3.3.3.111 mask 255.255.255.0
client-identifier f07d-6870-725f
[Device-dhcp-pool-4] quit
```

6. Configure Web authentication:

Create an HTTP-based local portal Web service, and specify file **defaultfile.zip** as the default authentication page file of the local portal Web service.

```
[Device] portal local-web-server http
[Device-portal-local-websvr-http] default-logon-page defaultfile.zip
[Device-portal-local-websvr-http] quit
```

Assign IP address 4.4.4.4 to Loopback 0.

```
[Device] interface loopback 0
[Device-LoopBack0] ip address 4.4.4.4 32
[Device-LoopBack0] quit
```

Create a Web authentication server named **webserver**.

```
[Device] web-auth server webserver
```

Configure the redirection URL of the Web authentication server as **http://4.4.4.4/portal/**.

```
[Device-web-auth-server-webserver] url http://4.4.4.4/portal/
```

Specify 4.4.4.4 as the IP address and 80 as the port number of the Web authentication server.

```
[Device-web-auth-server-webserver] ip 4.4.4.4 port 80
[Device-web-auth-server-webserver] quit
```

Configure the IP address of the update server as an authentication-free IP address.

```
[Device] web-auth free-ip 2.2.2.2 24
```

Enable Web authentication on GigabitEthernet 1/0/1 and specify VLAN 2 as the Auth-Fail VLAN.

```
[Device] interface gigabitethernet 1/0/1
[Device–GigabitEthernet1/0/1] port link-type hybrid
[Device–GigabitEthernet1/0/1] mac-vlan enable
[Device–GigabitEthernet1/0/1] web-auth enable apply server webserver
[Device–GigabitEthernet1/0/1] web-auth auth-fail vlan 2
[Device–GigabitEthernet1/0/1] quit
```

7. Configure 802.1X authentication:

Enable 802.1X authentication globally.

```
[Device] dot1x
```

Enable 802.1X authentication (MAC-based access control required) on GigabitEthernet 1/0/1, and specify VLAN 2 as the Auth-Fail VLAN.

```
[Device] interface gigabitethernet 1/0/1
```

```
[Device–GigabitEthernet1/0/1] dot1x port-method macbased
[Device–GigabitEthernet1/0/1] dot1x
[Device–GigabitEthernet1/0/1] dot1x auth-fail vlan 2
[Device–GigabitEthernet1/0/1] quit
```

8. Configure MAC authentication:

Enable MAC authentication globally.

```
[Device] mac-authentication
```

Enable MAC authentication on GigabitEthernet 1/0/1, and specify VLAN 2 as the guest VLAN.

```
[Device] interface gigabitethernet 1/0/1
[Device–GigabitEthernet1/0/1] mac-authentication
[Device–GigabitEthernet1/0/1] mac-authentication guest-vlan 2
[Device–GigabitEthernet1/0/1] quit
```

9. Configure a RADIUS scheme:

Create a RADIUS scheme named **rs1**.

```
[Device] radius scheme rs1
```

Specify the primary authentication and accounting servers and keys.

```
[Device-radius-rs1] primary authentication 1.1.1.2
[Device-radius-rs1] primary accounting 1.1.1.2
[Device-radius-rs1] key authentication simple radius
[Device-radius-rs1] key accounting simple radius
```

Specify usernames sent to the RADIUS server to carry no domain names.

```
[Device-radius-rs1] user-name-format without-domain
[Device-radius-rs1] quit
```

10. Configure an ISP domain:

Create an ISP domain named **triple**.

```
[Device] domain triple
```

Configure the domain to use RADIUS scheme **rs1** for authentication, authorization and accounting of LAN access users.

```
[Device-isp-triple] authentication lan-access radius-scheme rs1
[Device-isp-triple] authorization lan-access radius-scheme rs1
[Device-isp-triple] accounting lan-access radius-scheme rs1
[Device-isp-triple] quit
```

Configure domain **triple** as the default domain. If a username entered by a user includes no ISP domain name, the AAA methods of the default domain is used.

```
[Device] domain default enable triple
```

Verifying the configuration

1. Verify that the Web user can pass Web authentication.

On the Web user terminal, use a Web browser to access an external network and then enter the correct username and password on the authentication page **http://4.4.4.4/portal/logon.html**. (Details not shown.)

Use the **`display web-auth user`** command to display information about online users.

```
[Device] display web-auth user
  Total online web-auth users: 1

User Name: userpt
  MAC address: 6805-ca17-4a0b
  Access interface: GigabitEthernet1/0/1
```

```
  Initial VLAN: 8
  Authorization VLAN: 3
  Authorization ACL ID: N/A
  Authorization user profile: N/A
```

2. Verify that the printer can pass MAC authentication.

Connect the printer to the network. (Details not shown.)

Display information about online MAC authentication users.

```
[Device] display mac-authentication connection
Total connections: 1
Slot ID: 1
User MAC address: f07d-6870-725f
Access interface: GigabitEthernet1/0/1
Username: f07d6870725f
User access state: Successful
Authentication domain: triple
Initial VLAN: 8
Authorization untagged VLAN: 3
Authorization tagged VLAN: N/A
Authorization VSI: N/A
Authorization ACL ID: N/A
Authorization user profile: N/A
Authorization CAR: N/A
Authorization URL: N/A
Termination action: Default
Session timeout period: N/A
Online from: 2015/01/04 18:01:43
Online duration: 0h 0m 2s
```

3. Verify that the 802.1X user can pass 802.1X authentication.

On the 802.1X client, initiate 802.1X authentication and enter the correct username and password. (Details not shown.)

Display information about online 802.1X users.

```
[Device] display dot1x connection
Total connections: 1
Slot ID: 1
User MAC address: 7446-a091-84fe
Access interface: GigabitEthernet1/0/1
Username: userdot
User access state: Successful
Authentication domain: triple
IPv4 address: 3.3.3.3
Authentication method: CHAP
Initial VLAN: 8
Authorization untagged VLAN: 3
Authorization tagged VLAN list: N/A
Authorization VSI: N/A
Authorization ACL ID: N/A
Authorization user profile: N/A
Authorization CAR: N/A
```

```
Authorization URL: N/A
Termination action: Default
Session timeout period: N/A
Online from: 2015/01/04 18:13:01
Online duration: 0h 0m 14s
```

4. Verify that users that pass authentication have been assigned authorization VLANs.

Display MAC-VLAN entries of online users.

```
[Device] display mac-vlan all
  The following MAC VLAN addresses exist:
  S:Static  D:Dynamic
  MAC ADDR         MASK             VLAN ID   PRIO   STATE
  ------------------------------------------------------
  6805-ca17-4a0b   ffff-ffff-ffff   3         0      D
  f07d-6870-725f   ffff-ffff-ffff   3         0      D
  7446-a091-84fe   ffff-ffff-ffff   3         0      D
  Total MAC VLAN address count:3
```

5. Verify that online users have been assigned IP addresses.

```
[Device] display dhcp server ip-in-use
IP address       Client-identifier/    Lease expiration          Type
                  Hardware address
 3.3.3.111        01f0-7d68-7072-5f     Jan  4 18:14:17 2015      Auto:(C)
 3.3.3.2          0168-05ca-174a-0b     Jan  4 18:15:01 2015      Auto:(C)
 3.3.3.3          0174-46a0-9184-fe     Jan  4 18:15:03 2015      Auto:(C)
```

6. When a terminal fails authentication, it is added to VLAN 2. You can use the previous display commands to display the MAC-VLAN entry and IP address of the terminal. (Details not shown.)

Contents

Configuring port security

About port security

Port security combines and extends 802.1X and MAC authentication to provide MAC-based network access control. The feature applies to ports that use different authentication methods for users.

Major functions

Port security provides the following functions:

- Prevents unauthorized access to a network by checking the source MAC address of inbound traffic.
- Prevents access to unauthorized devices or hosts by checking the destination MAC address of outbound traffic.
- Controls MAC address learning and authentication on a port to make sure the port learns only source trusted MAC addresses.

Port security features

NTK

The need to know (NTK) feature prevents traffic interception by checking the destination MAC address in the outbound frames. The feature ensures that frames are sent only to the following hosts:

- Hosts that have passed authentication.
- Hosts whose MAC addresses have been learned or configured on the access device.

Intrusion protection

The intrusion protection feature checks the source MAC address in inbound frames for illegal frames, and takes a predefined action on each detected illegal frame. The action can be disabling the port temporarily, disabling the port permanently, or blocking frames from the illegal MAC address for 3 minutes (not user configurable).

A frame is illegal if its source MAC address cannot be learned in a port security mode or it is from a client that has failed 802.1X or MAC authentication.

Port security modes

Port security supports the following categories of security modes:

- **MAC learning control**—Includes two modes: autoLearn and secure. MAC address learning is permitted on a port in autoLearn mode and disabled in secure mode.
- **Authentication**—Security modes in this category implement MAC authentication, 802.1X authentication, or a combination of these two authentication methods.

Upon receiving a frame, the port in a security mode searches the MAC address table for the source MAC address. If a match is found, the port forwards the frame. If no match is found, the port learns the MAC address or performs authentication, depending on the security mode. If the frame is illegal, the port takes the predefined NTK or intrusion protection action, or sends SNMP notifications. Outgoing frames are not restricted by port security's NTK action unless they trigger the NTK feature.

Table 1 describes the port security modes and the security features.

Table 1 Port security modes

Purpose	Security mode		Features that can be triggered
Turning off the port security feature	noRestrictions (the default mode) In this mode, port security is disabled on the port and access to the port is not restricted.		N/A
Controlling MAC address learning	autoLearn		NTK/intrusion protection
	secure		
Performing 802.1X authentication	userLogin		N/A
	userLoginSecure		NTK/intrusion protection
	userLoginSecureExt		
	userLoginWithOUI		
Performing MAC authentication	macAddressWithRadius		NTK/intrusion protection
Performing a combination of MAC authentication and 802.1X authentication	Or	macAddressOrUserLoginSecure	NTK/intrusion protection
		macAddressOrUserLoginSecureExt	
	Else	macAddressElseUserLoginSecure	
		macAddressElseUserLoginSecureExt	

The mode names are illustrated as follows:

- **userLogin** specifies 802.1X authentication and port-based access control. **userLogin** with **Secure** specifies 802.1X authentication and MAC-based access control. **Ext** indicates allowing multiple 802.1X users to be authenticated and serviced at the same time. A security mode without **Ext** allows only one user to pass 802.1X authentication.
- **macAddress** specifies MAC authentication.
- **Else** specifies that the authentication method before **Else** is applied first. If the authentication fails, whether to turn to the authentication method following **Else** depends on the protocol type of the authentication request.
- **Or** specifies that the authentication method following **Or** is applied first. If the authentication fails, the authentication method before **Or** is applied.

Controlling MAC address learning

- autoLearn.

  A port in this mode can learn MAC addresses. The automatically learned MAC addresses are not added to the MAC address table as dynamic MAC address. Instead, these MAC addresses are added to the secure MAC address table as secure MAC addresses. You can also configure secure MAC addresses by using the **`port-security mac-address security`** command.

  A port in autoLearn mode allows frames sourced from the following MAC addresses to pass:

  - Secure MAC addresses.
  - MAC addresses configured by using the **`mac-address dynamic`** and **`mac-address static`** commands.

  When the number of secure MAC addresses reaches the upper limit, the port transitions to secure mode.

- secure.

MAC address learning is disabled on a port in secure mode. You configure MAC addresses by using the **mac-address static** and **mac-address dynamic** commands. For more information about configuring MAC address table entries, see *Layer 2—LAN Switching Configuration Guide*.

A port in secure mode allows only frames sourced from the following MAC addresses to pass:

- Secure MAC addresses.
- MAC addresses configured by using the **mac-address dynamic** and **mac-address static** commands.

Performing 802.1X authentication

- userLogin.

  A port in this mode performs 802.1X authentication and implements port-based access control. The port can service multiple 802.1X users. Once an 802.1X user passes authentication on the port, any subsequent 802.1X users can access the network through the port without authentication.

- userLoginSecure.

  A port in this mode performs 802.1X authentication and implements MAC-based access control. The port services only one user passing 802.1X authentication.

- userLoginSecureExt.

  This mode is similar to the userLoginSecure mode except that this mode supports multiple online 802.1X users.

- userLoginWithOUI.

  This mode is similar to the userLoginSecure mode. The difference is that a port in this mode also permits frames from one user whose MAC address contains a specific OUI.

  In this mode, the port performs OUI check at first. If the OUI check fails, the port performs 802.1X authentication. The port permits frames that pass OUI check or 802.1X authentication.

NOTE:

An OUI is a 24-bit number that uniquely identifies a vendor, manufacturer, or organization. In MAC addresses, the first three octets are the OUI.

Performing MAC authentication

macAddressWithRadius: A port in this mode performs MAC authentication, and services multiple users.

Performing a combination of MAC authentication and 802.1X authentication

- macAddressOrUserLoginSecure.

  This mode is the combination of the macAddressWithRadius and userLoginSecure modes. The mode allows one 802.1X authentication user and multiple MAC authentication users to log in.

  In this mode, the port performs 802.1X authentication first. By default, if 802.1X authentication fails, MAC authentication is performed.

  However, the port in this mode processes authentication differently when the following conditions exist:

  - The port is enabled with parallel processing of MAC authentication and 802.1X authentication.
  - The port is enabled with the 802.1X unicast trigger.
  - The port receives a packet from an unknown MAC address.

  Under such conditions, the port sends a unicast EAP-Request/Identity packet to the MAC address to initiate 802.1X authentication. After that, the port immediately processes MAC authentication without waiting for the 802.1X authentication result.

- macAddressOrUserLoginSecureExt.

  This mode is similar to the macAddressOrUserLoginSecure mode, except that this mode supports multiple 802.1X and MAC authentication users.
- macAddressElseUserLoginSecure.

  This mode is the combination of the macAddressWithRadius and userLoginSecure modes, with MAC authentication having a higher priority as the **Else** keyword implies. The mode allows one 802.1X authentication user and multiple MAC authentication users to log in.

  In this mode, the port performs MAC authentication upon receiving non-802.1X frames. Upon receiving 802.1X frames, the port performs MAC authentication and then, if the authentication fails, 802.1X authentication.
- macAddressElseUserLoginSecureExt.

  This mode is similar to the macAddressElseUserLoginSecure mode except that this mode supports multiple 802.1X and MAC authentication users as the **Ext** keyword implies.

Restrictions and guidelines: Port security configuration

This feature applies to networks, such as a WLAN, that require different authentication methods for different users on a port.

As a best practice, use the 802.1X authentication or MAC authentication feature rather than port security for scenarios that require only 802.1X authentication or MAC authentication. For more information about 802.1X and MAC authentication, see "Configuring 802.1X" and "Configuring MAC authentication."

Port security settings are supported only on Layer 2 Ethernet interfaces that do not belong to a Layer 2 aggregation group.

To ensure a successful HTTPS redirect for users who are assigned a redirect URL, make sure VLAN interfaces exist for the VLANs that transport their packets.

Port security tasks at a glance

To configure port security, perform the following tasks:

1. Configuring basic features of port security
   - Enabling port security
   - Setting the port security mode
   - Setting port security's limit on the number of secure MAC addresses on a port
   - Configuring secure MAC addresses
   - (Optional.) Configuring NTK
   - (Optional.) Configuring intrusion protection
2. (Optional.) Configuring extended features of port security
   - Ignoring authorization information from the server
   - Configuring MAC move
   - Enabling the authorization-fail-offline feature
   - Setting port security's limit on the number of MAC addresses for specific VLANs on a port
   - Enabling open authentication mode
   - Configuring free VLANs for port security
   - Applying a NAS-ID profile to port security

- Enabling traffic statistics for MAC authentication and 802.1X users
- Specifying an IP address and mask for calculating the source IP of ARP detection packets

The extended port security features can also take effect when port security is disabled but 802.1X or MAC authentication is enabled.

3. (Optional.) Enabling SNMP notifications for port security
4. (Optional.) Enabling port security user logging

Enabling port security

Restrictions and guidelines

When you configure port security, follow these restrictions and guidelines:

- When port security is enabled, you cannot enable 802.1X or MAC authentication, or change the access control mode or port authorization state. Port security automatically modifies these settings in different security modes.
- You can use the **undo port-security enable** command to disable port security. Because the command logs off online users, make sure no online users are present.
- Enabling or disabling port security resets the following security settings to the default:
  - 802.1X access control mode, which is MAC-based.
  - Port authorization state, which is **auto**.

For more information about 802.1X authentication and MAC authentication configuration, see "Configuring 802.1X" and "Configuring MAC authentication."

Prerequisites

Before you enable port security, disable 802.1X and MAC authentication globally.

Procedure

1. Enter system view.
   ```
   system-view
   ```
2. Enable port security.
   ```
   port-security enable
   ```
   By default, port security is disabled.

Setting the port security mode

Restrictions and guidelines

You can specify a port security mode when port security is disabled, but your configuration cannot take effect.

Changing the port security mode of a port logs off the online users of the port.

Do not enable 802.1X authentication or MAC authentication on a port where port security is enabled.

After enabling port security, you can change the port security mode of a port only when the port is operating in noRestrictions (the default) mode. To change the port security mode for a port in any other mode, first use the **undo port-security port-mode** command to restore the default port security mode.

The device supports the URL attribute assigned by a RADIUS server in the following port security modes:

- mac-authentication.

- mac-else-userlogin-secure.
- mac-else-userlogin-secure-ext.
- userlogin-secure.
- userlogin-secure-ext.
- userlogin-secure-or-mac.
- userlogin-secure-or-mac-ext.
- userlogin-withoui.

During authentication, the HTTP or HTTPS requests of a user are redirected to the Web interface specified by the server-assigned URL attribute. After the user passes the Web authentication, the RADIUS server records the MAC address of the user and uses a DM (Disconnect Message) to log off the user. When the user initiates 802.1X or MAC authentication again, it will pass the authentication and come online successfully.

To redirect the HTTPS requests of port security users, specify the HTTPS redirect listening port on the device. For more information, see HTTP redirect in *Layer 3—IP Services Configuration Guide*.

Prerequisites

Before you set a port security mode for a port, complete the following tasks:

- Disable 802.1X and MAC authentication.
- If you are configuring the autoLearn mode, set port security's limit on the number of secure MAC addresses. You cannot change the setting when the port is operating in autoLearn mode.

Procedure

1. Enter system view.

   system-view
2. Set an OUI value for user authentication.

   port-security oui index *index-value* **mac-address** *oui-value*

   By default, no OUI values are configured for user authentication.

   This command is required only for the **userlogin-withoui** mode.

   You can set multiple OUIs, but when the port security mode is **userlogin-withoui**, the port allows one 802.1X user and only one user that matches one of the specified OUIs.
3. Enter interface view.

   interface *interface-type interface-number*
4. Set the port security mode.

   port-security port-mode { **autolearn** | **mac-authentication** | **mac-else-userlogin-secure** | **mac-else-userlogin-secure-ext** | **secure** | **userlogin** | **userlogin-secure** | **userlogin-secure-ext** | **userlogin-secure-or-mac** | **userlogin-secure-or-mac-ext** | **userlogin-withoui** }

   By default, a port operates in noRestrictions mode.

Setting port security's limit on the number of secure MAC addresses on a port

About port security's limit on the number of secure MAC addresses on a port

You can set the maximum number of secure MAC addresses that port security allows on a port for the following purposes:

- Controlling the number of concurrent users on the port.

For a port operating in a security mode (except for autoLearn and secure), the upper limit equals the smaller of the following values:

- The limit of the secure MAC addresses that port security allows.
- The limit of concurrent users allowed by the authentication mode in use.

- Controlling the number of secure MAC addresses on the port in autoLearn mode.

  You can also set the maximum number of secure MAC addresses that port security allows for specific VLANs or each VLAN on a port.

Port security's limit on the number of secure MAC addresses on a port is independent of the MAC learning limit described in MAC address table configuration. For more information about MAC address table configuration, see *Layer 2—LAN Switching Configuration Guide*.

Procedure

1. Enter system view.

   system-view
2. Enter interface view.

   interface *interface-type interface-number*
3. Set the maximum number of secure MAC addresses allowed on a port.

   port-security max-mac-count *max-count*[**vlan** [*vlan-id-list*]]

   By default, port security does not limit the number of secure MAC addresses on a port.

Configuring secure MAC addresses

About secure MAC addresses

Secure MAC addresses are configured or learned in autoLearn mode. If the secure MAC addresses are saved, they can survive a device reboot. You can bind a secure MAC address only to one port in a VLAN.

Secure MAC addresses include static, sticky, and dynamic secure MAC addresses.

Table 2 Comparison of static, sticky, and dynamic secure MAC addresses

Type	Address sources	Aging mechanism	Can be saved and survive a device reboot?
Static	Manually added (by using the **port-security mac-address security** command without the **sticky** keyword).	Not available. The static secure MAC addresses never age out unless you perform any of the following tasks: • Manually remove these MAC addresses. • Change the port security mode. • Disable the port security feature.	Yes.
Sticky	• Manually added (by using the **port-security mac-address security** command with the **sticky** keyword). • Converted from dynamic secure MAC	By default, sticky MAC addresses do not age out. However, you can configure an aging timer or use the aging timer together with the inactivity aging feature to remove old sticky MAC addresses. • If only the aging timer is configured, the aging timer counts up regardless of whether traffic data has been sent from the sticky	Yes. The secure MAC aging timer restarts at a reboot.

Type	Address sources	Aging mechanism	Can be saved and survive a device reboot?
	addresses. • Automatically learned when the dynamic secure MAC feature is disabled.	MAC addresses. • If both the aging timer and the inactivity aging feature are configured, the aging timer restarts once traffic data is detected from the sticky MAC addresses.	
Dynamic	• Converted from sticky MAC addresses. • Automatically learned after the dynamic secure MAC feature is enabled.	Same as sticky MAC addresses.	No. All dynamic secure MAC addresses are lost at reboot.

When the maximum number of secure MAC address entries is reached, the port changes to secure mode. In secure mode, the port cannot add or learn any more secure MAC addresses. The port allows only frames sourced from secure MAC addresses or MAC addresses configured by using the **mac-address dynamic** or **mac-address static** command to pass through.

Prerequisites

Before you configure secure MAC addresses, complete the following tasks:

- Set port security's limit on the number of MAC addresses on the port. Perform this task before you enable autoLearn mode.
- Set the port security mode to autoLearn.
- Configure the port to permit packets of the specified VLAN to pass or add the port to the VLAN. Make sure the VLAN already exists.

Adding secure MAC addresses

1. Enter system view.

   system-view
2. Set the secure MAC aging timer.

   port-security timer autolearn aging [**second**] *time-value*

   By default, secure MAC addresses do not age out.
3. Configure a secure MAC address.
   - Configure a secure MAC address in system view.

     port-security mac-address security [**sticky**] *mac-address* **interface** *interface-type interface-number* **vlan** *vlan-id*
   - Execute the following commands in sequence to configure a secure MAC address in interface view:

     interface *interface-type interface-number*

     port-security mac-address security [**sticky**] *mac-address* **vlan** *vlan-id*

   By default, no manually configured secure MAC addresses exist.

   In a VLAN, a MAC address cannot be specified as both a static secure MAC address and a sticky MAC address.

Enabling inactivity aging for secure MAC addresses

1. Enter system view.
   system-view
2. Enter interface view.
   interface *interface-type interface-number*
3. Enable inactivity aging for secure MAC addresses.
   port-security mac-address aging-type inactivity
   By default, the inactivity aging feature is disabled for secure MAC addresses.

Enabling the dynamic secure MAC feature

1. Enter system view.
   system-view
2. Enter interface view.
   interface *interface-type interface-number*
3. Enable the dynamic secure MAC feature.
   port-security mac-address dynamic
   By default, the dynamic secure MAC feature is disabled. Sticky MAC addresses can be saved to the configuration file. Once saved, they can survive a device reboot.

Configuring NTK

About the NTK feature

The NTK feature checks the destination MAC address in outbound frames to make sure frames are forwarded only to trustworthy devices.

The NTK feature supports the following modes:

- **ntkonly**—Forwards only unicast frames with an authenticated destination MAC address.
- **ntk-withbroadcasts**—Forwards only broadcast and unicast frames with an authenticated destination MAC address.
- **ntk-withmulticasts**—Forwards only broadcast, multicast, and unicast frames with an authenticated destination MAC address.
- **ntkauto**—Forwards only broadcast, multicast, and unicast frames with an authenticated destination MAC address, and only when the port has online users.

Restrictions and guidelines

The NTK feature drops any unicast frame with an unknown destination MAC address.

Not all port security modes support triggering the NTK feature. For more information, see Table 1.

Procedure

1. Enter system view.
   system-view
2. Enter interface view.
   interface *interface-type interface-number*
3. Configure the NTK feature.

port-security ntk-mode { **ntk-withbroadcasts** | **ntk-withmulticasts** | **ntkauto** | **ntkonly** }

By default, NTK is disabled on a port and all frames are allowed to be sent.

Configuring intrusion protection

About intrusion protection

Intrusion protection takes one of the following actions on a port in response to illegal frames:

- **blockmac**—Adds the source MAC addresses of illegal frames to the blocked MAC address list and discards the frames. A blocked MAC address will be unblocked in 3 minutes. This interval is not user configurable.
- **disableport**—Disables the port until you bring it up manually.
- **disableport-temporarily**—Disables the port for a period of time. The period can be configured with the **port-security timer disableport** command.

Restrictions and guidelines

On a port operating in either macAddressElseUserLoginSecure mode or macAddressElseUserLoginSecureExt mode, intrusion protection is triggered only after both MAC authentication and 802.1X authentication fail for the same frame.

Procedure

1. Enter system view.

   system-view
2. Enter interface view.

   interface *interface-type interface-number*
3. Configure the intrusion protection feature.

   port-security intrusion-mode { **blockmac** | **disableport** | **disableport-temporarily** }

   By default, intrusion protection is disabled.
4. (Optional.) Set the silence timeout period during which a port remains disabled.

   a. **quit**

   b. **port-security timer disableport** *time-value*

   By default, the port silence timeout period is 20 seconds.

Ignoring authorization information from the server

About ignoring authorization information from the server

You can configure a port to ignore the authorization information received from the server (local or remote) after an 802.1X or MAC authentication user passes authentication.

Procedure

1. Enter system view.

   system-view
2. Enter interface view.

   interface *interface-type interface-number*
3. Ignore the authorization information received from the authentication server.

   port-security authorization ignore

By default, a port uses the authorization information received from the authentication server.

Configuring MAC move

About MAC move

Port security MAC move takes effect in the following scenarios:

- **Inter-port move on a device**—An online user authenticated through 802.1X or MAC authentication moves between ports on the device. The user VLAN or authentication method might change or stay unchanged after the move.
- **Inter-VLAN move on a port**—An online user authenticated through 802.1X or MAC authentication moves between VLANs on a trunk or hybrid port. In addition, the packets that trigger authentication have VLAN tags.

Port security MAC move allows an online user authenticated through 802.1X or MAC authentication on one port or VLAN to be reauthenticated and come online on another port or VLAN without going offline first. After the user passes authentication on the new port or VLAN, the system removes the authentication session of the user on the original port or VLAN.

NOTE:

For MAC authentication, the MAC move feature applies only when MAC authentication single-VLAN mode is used. The MAC move feature does not apply to MAC authentication users that move between VLANs on a port with MAC authentication multi-VLAN mode enabled.

If this feature is disabled, 802.1X or MAC authenticated users must go offline first before they can be reauthenticated successfully on a new port or VLAN to come online.

For a user moving between ports, the port from which the user moves is called the source port and the port to which the user moves is called the destination port.

On the destination port, an 802.1X or MAC authentication user will reauthenticate in the VLAN authorized on the source port if the source port is enabled with MAC-based VLAN. If that VLAN is not permitted to pass through on the destination port, reauthentication will fail. To avoid this situation, enable VLAN check bypass on the destination port. This feature skips checking VLAN information in the packets that trigger 802.1X authentication or MAC authentication for users moving to the port.

Restrictions and guidelines

As a best practice to minimize security risks, enable MAC move only if user roaming between ports is required.

802.1X or MAC authenticated users cannot move between ports on a device or between VLANs on a port if the maximum number of online users on the authentication server has been reached.

MAC authentication multi-VLAN mode has higher priority than MAC move for users moving between VLANs on a port. If MAC authentication multi-VLAN mode is enabled, these users can come online in the new VLAN without being reauthenticated. To enable MAC authentication multi-VLAN mode, use the **`mac-authentication host-mode multi-vlan`** command. For more information about MAC authentication multi-VLAN mode, see "Configuring MAC authentication."

When you configure VLAN check bypass for users moving between ports, follow these guidelines:

- To ensure a successful reauthentication, enable VLAN check bypass on a destination port if the source port is enabled with MAC-based VLAN.
- If the destination port is an 802.1X-enabled trunk port, you must configure it to send 802.1X protocol packets without VLAN tags. For more information, see "Configuring 802.1X."

Procedure

1. Enter system view.

   `system-view`

2. Enable MAC move.

   port-security mac-move permit

   By default, MAC move is disabled.
3. (Optional.) Enable VLAN check bypass on the port for users moving to it.
   a. Enter interface view.

      interface *interface-type interface-number*
   b. Enable VLAN check bypass.

      port-security mac-move bypass-vlan-check

      By default, the VLAN check bypass feature is disabled.

      This command is supported only in Release 6318P01 and later.

Enabling the authorization-fail-offline feature

About the authorization-fail-offline feature

IMPORTANT:

The authorization-fail-offline feature takes effect only on port security users that have failed ACL or user profile authorization.

The authorization-fail-offline feature logs off port security users that have failed authorization.

A user fails authorization in the following situations:

- The device or server fails to assign the specified authorization attribute to the user.
- The device or server assigns authorization information that does not exist on the device to the user.

This feature does not apply to users that have failed VLAN authorization. The device logs off these users directly.

You can also enable the quiet timer feature for 802.1X or MAC authentication users that are logged off by the authorization-fail-offline feature. The device adds these users to the 802.1X or MAC authentication quiet queue. Within the quiet timer, the device does not process packets from these users or authenticate them. If you do not enable the quiet timer feature, the device immediately authenticates these users upon receiving packets from them.

Prerequisites

For the quiet timer feature to take effect, complete the following tasks:

- For 802.1X users, use the **dot1x quiet-period** command to enable the quiet timer and use the **dot1x timer quiet-period** command to set the timer.
- For MAC authentication users, use the **mac-authentication timer quiet** command to set the quiet timer for MAC authentication.

Procedure

1. Enter system view.

   system-view
2. Enable the authorization-fail-offline feature.

   port-security authorization-fail offline [**quiet-period**]

   By default, this feature is disabled, and the device does not log off users that have failed authorization.

Setting port security's limit on the number of MAC addresses for specific VLANs on a port

About port security's limit on the number of MAC addresses for specific VLANs on a port

Typically, port security allows the access of the following types of MAC addresses on a port:

- MAC addresses that pass 802.1X or MAC authentication.
- MAC addresses in the MAC authentication guest VLAN or MAC authentication critical VLAN.
- MAC addresses in the 802.1X guest VLAN, 802.1X Auth-Fail VLAN, or 802.1X critical VLAN.

This feature limits the number of MAC addresses that port security allows to access a port through specific VLANs. Use this feature to prevent resource contentions among MAC addresses and ensure reliable performance for each access user on the port. When the number of MAC addresses in a VLAN on the port reaches the upper limit, the device denies any subsequent MAC addresses in the VLAN on the port.

Restrictions and guidelines

On a port, the maximum number of MAC addresses in a VLAN cannot be smaller than the number of existing MAC addresses in the VLAN. If the specified maximum number is smaller, the setting does not take effect.

Procedure

1. Enter system view.
   `system-view`
2. Enter interface view.
   `interface` *`interface-type interface-number`*
3. Set port security's limit on the number of MAC addresses for specific VLANs on the port.
   `port-security mac-limit` *`max-number`* **`per-vlan`** *`vlan-id-list`*
   The default setting is 2147483647.

Enabling open authentication mode

About open authentication mode

This feature enables access users (802.1X or MAC authentication users) of a port to come online and access the network even if they use nonexistent usernames or incorrect passwords.

Access users that come online in open authentication mode are called open users. Authorization and accounting are not available for open users. To display open user information, use the following commands:

- **`display dot1x connection open`**.
- **`display mac-authentication connection open`**.

This feature does not affect the access of users that use correct user information.

Restrictions and guidelines

When you configure open authentication mode, follow these restrictions and guidelines:

- If global open authentication mode is enabled, all ports are enabled with open authentication mode regardless of the port-specific open authentication mode setting. If global open authentication mode is disabled, whether a port is enabled with open authentication mode depends on the port-specific open authentication mode setting.

- The open authentication mode setting has lower priority than the 802.1X Auth-Fail VLAN and the MAC authentication guest VLAN. Open authentication mode does not take effect on a port if the port is also configured with the 802.1X Auth-Fail VLAN or the MAC authentication guest VLAN. For information about 802.1X authentication and MAC authentication, see "802.1X overview," "Configuring 802.1X," and "Configuring MAC authentication."

Procedure

1. Enter system view.
   system-view
2. Enable global open authentication mode.
   port-security authentication open global
   By default, global open authentication mode is disabled.
3. Enter interface view.
   interface *interface-type interface-number*
4. Enable open authentication mode on the port.
   port-security authentication open
   By default, open authentication mode is disabled on a port.

Configuring free VLANs for port security

About this task

This feature allows packets from the specified VLANs to not trigger 802.1X or MAC authentication on a port configured with any of the following features:

- 802.1X authentication.
- MAC authentication.
- One of the following port security modes:
  - userLogin.
  - userLoginSecure.
  - userLoginWithOUI.
  - userLoginSecureExt.
  - macAddressWithRadius.
  - macAddressOrUserLoginSecure.
  - macAddressElseUserLoginSecure.
  - macAddressOrUserLoginSecureExt.
  - macAddressElseUserLoginSecureExt.

Software and feature compatibility

This feature is supported only in Release 6328 and later.

Procedure

1. Enter system view.
   system-view
2. Enter interface view.
   interface *interface-type interface-number*
3. Configure free VLANs for port security.
   port-security free-vlan *vlan-id-list*
   By default, no free VLANs for port security exist on a port.

Applying a NAS-ID profile to port security

About NAS-ID profiles

By default, the device sends its device name in the NAS-Identifier attribute of all RADIUS requests.

A NAS-ID profile enables you to send different NAS-Identifier attribute strings in RADIUS requests from different VLANs. The strings can be organization names, service names, or any user categorization criteria, depending on the administrative requirements.

For example, map the NAS-ID **companyA** to all VLANs of company A. The device will send **companyA** in the NAS-Identifier attribute for the RADIUS server to identify requests from any Company A users.

Restrictions and guidelines

You can apply a NAS-ID profile to port security globally or on a port. On a port, the device selects a NAS-ID profile in the following order:

1. The port-specific NAS-ID profile.
2. The NAS-ID profile applied globally.

If no NAS-ID profile is applied or no matching binding is found in the selected profile, the device uses the device name as the NAS-ID.

For more information about the NAS-ID profile configuration, see "Configuring AAA."

Procedure

1. Enter system view.
   system-view
2. Apply a NAS-ID profile.
   - Apply a NAS-ID profile globally.
     port-security nas-id-profile *profile-name*
   - Execute the following commands in sequence to apply a NAS-ID profile to an interface:
     interface *interface-type interface-number*
     port-security nas-id-profile *profile-name*

   By default, no NAS-ID profile is applied in system view or in interface view.

Enabling traffic statistics for MAC authentication and 802.1X users

About this task

By default, 802.1X and MAC authentication user statistics collected and sent to the accounting server only include the online duration of the users. To collect and send their traffic statistics to the accounting server in addition to their online duration, perform this task.

This feature takes effect on 802.1X and MAC authentication users when port security is enabled, or when 802.1X and MAC authentication are separately enabled on the device.

If a port performs MAC authentication or 802.1X authentication in MAC-based access control mode, this feature collects user traffic statistics on a per-MAC basis on the port.

If a port performs 802.1X authentication in port-based access control mode, this feature collects user traffic statistics on a per-port basis on the port.

With this feature enabled, the device requires more ACL resources for new 802.1X or MAC authentication users. If the device has run out of ACL resources, the authentication will fail for new 802.1X or MAC authentication users.

Restrictions and guidelines

This feature is available in Release 6312 and later.

This feature takes effect only on users that come online after the feature is enabled.

Enable this feature only if traffic accounting is required and only if there are sufficient ACL resources. If the network has a large number of online 802.1X and MAC authentication users when this feature is enabled, ACL resources might become insufficient. This issue causes authentication failure of new 802.1X and MAC authentication users. For more information about 802.1X and MAC authentication, see "Configuring 802.1X" and "Configuring MAC authentication."

Procedure

1. Enter system view.

   `system-view`

2. Enable traffic statistics for 802.1X and MAC authentication users.

   `port-security traffic-statistics enable`

   By default, the device does not collect traffic statistics for 802.1X and MAC authentication users.

Specifying an IP address and mask for calculating the source IP of ARP detection packets

About this task

By default, the device uses 0.0.0.0 as the source IP address of ARP detection packets. The network might have users that cannot respond to ARP detection packets with source IP address 0.0.0.0. As a result, the device inadequately determines that these users have gone offline. To resolve the issue, use this feature to specify an IP address and mask for calculating the source IP of ARP detection packets sent to a user in conjunction with the user's IP address.

The device uses the following formula to calculate the source IP address of ARP detection packets: source IP = (user IP & specified mask) | (specified IP & ~specified mask). The ~mask parameter represents the reverse of a mask. For example, the reverse mask of 255.255.255.0 is 0.0.0.255. If the IP address of a user is 192.168.8.1/24 and the IP address and mask specified by using this feature is 1.1.1.11/255.255.255.0, the source IP address of ARP detection packets is 192.168.8.11/24.

Feature and software version compatibility

This feature is supported only in Release 6348P01 and later.

Restrictions and guidelines

This feature takes effect only on users that come online after this feature is configured.

Procedure

1. Enter system view.

   `system-view`

2. Specify an IP address and mask for calculating the source IP of ARP detection packets.

   `port-security packet-detect arp-source-ip factor` *`ip-address`* { *`mask`* | *`mask-length`* }

   By default, no IP address or mask is specified for calculating the source IP of ARP detection packets. The source IP of ARP detection packets is 0.0.0.0.

Enabling SNMP notifications for port security

About SNMP notifications for port security

Use this feature to report critical port security events to an NMS. For port security event notifications to be sent correctly, you must also configure SNMP on the device. For more information about SNMP configuration, see *Network Management and Monitoring Configuration Guide*.

Procedure

1. Enter system view.

   system-view

2. Enable SNMP notifications for port security.

   snmp-agent trap enable port-security [**address-learned** | **dot1x-failure** | **dot1x-logoff** | **dot1x-logon** | **intrusion** | **mac-auth-failure** | **mac-auth-logoff** | **mac-auth-logon**] *

   By default, SNMP notifications are disabled for port security.

Enabling port security user logging

About port security user logging

This feature enables the device to generate logs about port security users and send the logs to the information center. For the logs to be output correctly, you must also configure the information center on the device. For more information about information center configuration, see *Network Management and Monitoring Configuration Guide*.

Restrictions and guidelines

To prevent excessive port security user log entries, use this feature only if you need to analyze abnormal port security user events.

Procedure

1. Enter system view.

   system-view

2. Enable port security user logging.

   port-security access-user log enable [**failed-authorization** | **mac-learning** | **violation** | **vlan-mac-limit**] *

   By default, port security user logging is disabled.

   If you do not specify any parameters, this command enables all types of port security user logs.

Display and maintenance commands for port security

Execute **display** commands in any view:

Task	Command
Display the port security configuration, operation information, and statistics.	**display port-security** [**interface** *interface-type interface-number*]
Display information about blocked MAC addresses.	**display port-security mac-address block** [**interface** *interface-type*

Task	Command
	interface-number] [**vlan** *vlan-id*] [**count**]
Display information about secure MAC addresses.	**display port-security mac-address security** [**interface** *interface-type interface-number*] [**vlan** *vlan-id*] [**count**]

Port security configuration examples

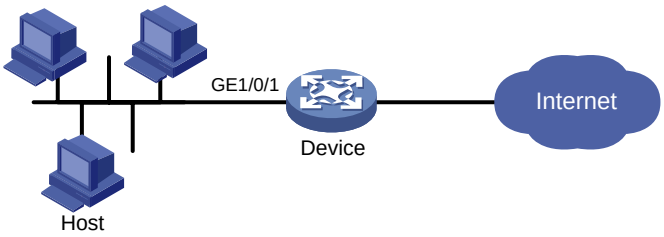
Example: Configuring port security in autoLearn mode

Network configuration

As shown in Figure 1, configure GigabitEthernet 1/0/1 on the device to meet the following requirements:

- Accept up to 64 users without authentication.
- Be permitted to learn and add MAC addresses as sticky MAC addresses, and set the secure MAC aging timer to 30 minutes.
- Stop learning MAC addresses after the number of secure MAC addresses reaches 64. If any frame with an unknown MAC address arrives, intrusion protection starts, and the port shuts down and stays silent for 30 seconds.

Figure 1 Network diagram



Procedure

Enable port security.

```
<Device> system-view
[Device] port-security enable
```

Set the secure MAC aging timer to 30 minutes.

```
[Device] port-security timer autolearn aging 30
```

Set port security's limit on the number of secure MAC addresses to 64 on GigabitEthernet 1/0/1.

```
[Device] interface gigabitethernet 1/0/1
[Device-GigabitEthernet1/0/1] port-security max-mac-count 64
```

Set the port security mode to autoLearn.

```
[Device-GigabitEthernet1/0/1] port-security port-mode autolearn
```

Configure the port to be silent for 30 seconds after the intrusion protection feature is triggered.

```
[Device-GigabitEthernet1/0/1] port-security intrusion-mode disableport-temporarily
[Device-GigabitEthernet1/0/1] quit
[Device] port-security timer disableport 30
```

Verifying the configuration

Verify the port security configuration.

```
[Device] display port-security interface gigabitethernet 1/0/1
Global port security parameters:
   Port security          : Enabled
   AutoLearn aging time   : 30 min
   Disableport timeout    : 30 s
   Blockmac timeout       : 180 s
   MAC move               : Denied
   Authorization fail     : Online
   NAS-ID profile         : Not configured
   Dot1x-failure trap     : Disabled
   Dot1x-logon trap       : Disabled
   Dot1x-logoff trap      : Disabled
   Intrusion trap         : Disabled
   Address-learned trap   : Disabled
   Mac-auth-failure trap  : Disabled
   Mac-auth-logon trap    : Disabled
   Mac-auth-logoff trap   : Disabled
   Open authentication    : Disabled
   OUI value list         :
    Index :  1           Value : 123401

 GigabitEthernet1/0/1 is link-up
   Port mode                       : autoLearn
   NeedToKnow mode                 : Disabled
   Intrusion protection mode       : DisablePortTemporarily
   Security MAC address attribute
       Learning mode               : Sticky
       Aging type                  : Periodical
   Max secure MAC addresses        : 64
   Current secure MAC addresses    : 0
   Authorization                   : Permitted
   NAS-ID profile                  : Not configured
   Free VLANs                      : Not configured
   Open authentication             : Disabled
   MAC-move VLAN check bypass      : Disabled
```

The port allows for MAC address learning, and you can view the number of learned MAC addresses in the **Current secure MAC addresses** field.

Display additional information about the learned MAC addresses.

```
[Device] interface gigabitethernet 1/0/1
[Device-GigabitEthernet1/0/1] display this
#
interface GigabitEthernet1/0/1
 port-security max-mac-count 64
 port-security port-mode autolearn
 port-security mac-address security sticky 0002-0000-0015 vlan 1
 port-security mac-address security sticky 0002-0000-0014 vlan 1
```

```
 port-security mac-address security sticky 0002-0000-0013 vlan 1
 port-security mac-address security sticky 0002-0000-0012 vlan 1
 port-security mac-address security sticky 0002-0000-0011 vlan 1
#
[Device-GigabitEthernet1/0/1] quit
```

Verify that the port security mode changes to **secure** after the number of MAC addresses learned by the port reaches 64.

```
[Device] display port-security interface gigabitethernet 1/0/1
```

Verify that the port will be disabled for 30 seconds after it receives a frame with an unknown MAC address. (Details not shown.)

After the port is re-enabled, delete several secure MAC addresses.

```
[Device] undo port-security mac-address security sticky 0002-0000-0015 vlan 1
[Device] undo port-security mac-address security sticky 0002-0000-0014 vlan 1
...
```

Verify that the port security mode of the port changes to **autoLearn**, and the port can learn MAC addresses again. (Details not shown.)

Example: Configuring port security in userLoginWithOUI mode

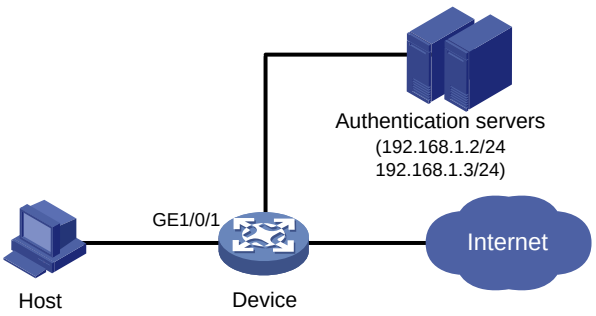
Network configuration

As shown in Figure 2, a client is connected to the device through GigabitEthernet 1/0/1. The device authenticates the client with a RADIUS server in ISP domain **sun**. If the authentication succeeds, the client is authorized to access the Internet.

- The RADIUS server at 192.168.1.2 acts as the primary authentication server and the secondary accounting server. The RADIUS server at 192.168.1.3 acts as the secondary authentication server and the primary accounting server. The shared key for authentication is **name**, and the shared key for accounting is **money**.
- All users use the authentication, authorization, and accounting methods of ISP domain **sun**.
- The RADIUS server response timeout time is 5 seconds. The maximum number of RADIUS packet retransmission attempts is 5. The device sends real-time accounting packets to the RADIUS server at 15-minute intervals, and sends usernames without domain names to the RADIUS server.

Configure GigabitEthernet 1/0/1 to allow only one 802.1X user and a user that uses one of the specified OUI values to be authenticated.

Figure 2 Network diagram



Procedure

The following configuration steps cover some AAA/RADIUS configuration commands. For more information about the commands, see *Security Command Reference*.

Make sure the host and the RADIUS server can reach each other.

1. Configure AAA:

Configure a RADIUS scheme named **radsun**.

```
<Device> system-view
[Device] radius scheme radsun
[Device-radius-radsun] primary authentication 192.168.1.2
[Device-radius-radsun] primary accounting 192.168.1.3
[Device-radius-radsun] secondary authentication 192.168.1.3
[Device-radius-radsun] secondary accounting 192.168.1.2
[Device-radius-radsun] key authentication simple name
[Device-radius-radsun] key accounting simple money
[Device-radius-radsun] timer response-timeout 5
[Device-radius-radsun] retry 5
[Device-radius-radsun] timer realtime-accounting 15
[Device-radius-radsun] user-name-format without-domain
[Device-radius-radsun] quit
```

Configure ISP domain **sun**.

```
[Device] domain sun
[Device-isp-sun] authentication lan-access radius-scheme radsun
[Device-isp-sun] authorization lan-access radius-scheme radsun
[Device-isp-sun] accounting lan-access radius-scheme radsun
[Device-isp-sun] quit
```

2. Configure 802.1X:

Set the 802.1X authentication method to CHAP. By default, the authentication method for 802.1X is CHAP.

```
[Device] dot1x authentication-method chap
```

Specify ISP domain **sun** as the mandatory authentication domain for 802.1X users on GigabitEthernet 1/0/1.

```
[Device] interface gigabitethernet 1/0/1
[Device-GigabitEthernet1/0/1] dot1x mandatory-domain sun
[Device-GigabitEthernet1/0/1] quit
```

3. Configure port security:

Enable port security.

```
[Device] port-security enable
```

Add five OUI values. (You can add up to 16 OUI values. The port permits only one user matching one of the OUIs to pass authentication.)

```
[Device] port-security oui index 1 mac-address 1234-0100-1111
[Device] port-security oui index 2 mac-address 1234-0200-1111
[Device] port-security oui index 3 mac-address 1234-0300-1111
[Device] port-security oui index 4 mac-address 1234-0400-1111
[Device] port-security oui index 5 mac-address 1234-0500-1111
```

Set the port security mode to userLoginWithOUI.

```
[Device] interface gigabitethernet 1/0/1
[Device-GigabitEthernet1/0/1] port-security port-mode userlogin-withoui
[Device-GigabitEthernet1/0/1] quit
```

Verifying the configuration

Verify that GigabitEthernet 1/0/1 allows only one 802.1X user to be authenticated.

```
[Device] display port-security interface gigabitethernet 1/0/1
Global port security parameters:
   Port security          : Enabled
   AutoLearn aging time   : 30 min
   Disableport timeout    : 30 s
   Blockmac timeout       : 180 s
   MAC move               : Denied
   Authorization fail     : Online
   NAS-ID profile         : Not configured
   Dot1x-failure trap     : Disabled
   Dot1x-logon trap       : Disabled
   Dot1x-logoff trap      : Disabled
   Intrusion trap         : Disabled
   Address-learned trap   : Disabled
   Mac-auth-failure trap  : Disabled
   Mac-auth-logon trap    : Disabled
   Mac-auth-logoff trap   : Disabled
   Open authentication    : Disabled
   OUI value list         :
       Index :  1       Value : 123401
       Index :  2       Value : 123402
       Index :  3       Value : 123403
       Index :  4       Value : 123404
       Index :  5       Value : 123405


 GigabitEthernet1/0/1 is link-up
   Port mode                     : userLoginWithOUI
   NeedToKnow mode               : Disabled
   Intrusion protection mode     : NoAction
   Security MAC address attribute
       Learning mode             : Sticky
       Aging type                : Periodical
   Max secure MAC addresses      : Not configured
   Current secure MAC addresses  : 1
   Authorization                 :Permitted
   NAS-ID profile                : Not configured
   Free VLANs                    : Not configured
   Open authentication           : Disabled
   MAC-move VLAN check bypass    : Disabled
```

Display information about the online 802.1X user to verify 802.1X configuration.

```
[Device] display dot1x
```

Verify that the port also allows one user whose MAC address has an OUI among the specified OUIs to pass authentication.

```
[Device] display mac-address interface gigabitethernet 1/0/1
MAC Address     VLAN ID   State          Port/NickName           Aging
1234-0300-0011  1         Learned        GE1/0/1                 Y
```

Example: Configuring port security in macAddressElseUserLoginSecure mode

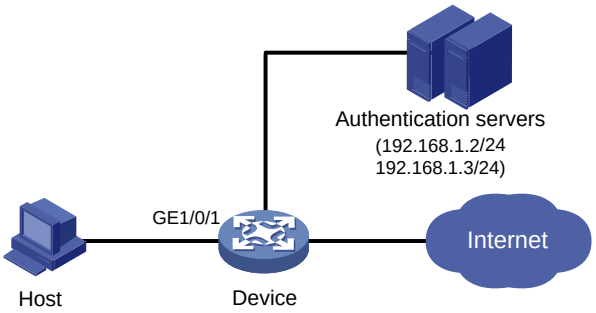
Network configuration

As shown in Figure 3, a client is connected to the device through GigabitEthernet 1/0/1. The device authenticates the client by a RADIUS server in ISP domain **sun**. If the authentication succeeds, the client is authorized to access the Internet.

Configure GigabitEthernet 1/0/1 of the device to meet the following requirements:

- Allow more than one MAC authenticated user to log on.
- For 802.1X users, perform MAC authentication first and then, if MAC authentication fails, 802.1X authentication. Allow only one 802.1X user to log on.
- Use the MAC address of each user as both the username and password for MAC authentication. The MAC addresses are in hexadecimal notation with hyphens, and letters are in upper case.
- Set the total number of MAC authenticated users and 802.1X authenticated users to 64.
- Enable NTK (**ntkonly** mode) to prevent frames from being sent to unknown MAC addresses.

Figure 3 Network diagram



Procedure

Make sure the host and the RADIUS server can reach each other.

1. Configure RADIUS authentication/accounting and ISP domain settings. (See "Example: Configuring port security in userLoginWithOUI mode.")
2. Configure port security:

   # Enable port security.

   ```
   <Device> system-view
   [Device] port-security enable
   ```

   # Use the MAC address of each user as both the username and password for MAC authentication. The MAC addresses are in hexadecimal notation with hyphens, and letters are in upper case.

   ```
   [Device] mac-authentication user-name-format mac-address with-hyphen uppercase
   ```

   # Specify the MAC authentication domain.

   ```
   [Device] mac-authentication domain sun
   ```

   # Set the 802.1X authentication method to CHAP. By default, the authentication method for 802.1X is CHAP.

   ```
   [Device] dot1x authentication-method chap
   ```

   # Set port security's limit on the number of MAC addresses to 64 on the port.

   ```
   [Device] interface gigabitethernet 1/0/1
   [Device-GigabitEthernet1/0/1] port-security max-mac-count 64
   ```

Set the port security mode to macAddressElseUserLoginSecure.

```
[Device-GigabitEthernet1/0/1] port-security port-mode mac-else-userlogin-secure
```

Specify ISP domain **sun** as the mandatory authentication domain for 802.1X users.

```
[Device-GigabitEthernet1/0/1] dot1x mandatory-domain sun
```

Set the NTK mode of the port to ntkonly.

```
[Device-GigabitEthernet1/0/1] port-security ntk-mode ntkonly
[Device-GigabitEthernet1/0/1] quit
```

Verifying the configuration

Verify the port security configuration.

```
[Device] display port-security interface gigabitethernet 1/0/1
Global port security parameters:
   Port security          : Enabled
   AutoLearn aging time   : 30 min
   Disableport timeout    : 30 s
   Blockmac timeout       : 180 s
   MAC move               : Denied
   Authorization fail     : Online
   NAS-ID profile         : Not configured
   Dot1x-failure trap     : Disabled
   Dot1x-logon trap       : Disabled
   Dot1x-logoff trap      : Disabled
   Intrusion trap         : Disabled
   Address-learned trap   : Disabled
   Mac-auth-failure trap  : Disabled
   Mac-auth-logon trap    : Disabled
   Mac-auth-logoff trap   : Disabled
   Open authentication    : Disabled
   OUI value list

 GigabitEthernet1/0/1 is link-up
   Port mode                      : macAddressElseUserLoginSecure
   NeedToKnow mode                : NeedToKnowOnly
   Intrusion protection mode      : NoAction
   Security MAC address attribute
      Learning mode               : Sticky
      Aging type                  : Periodical
   Max secure MAC addresses       : 64
   Current secure MAC addresses   : 0
   Authorization                  : Permitted
   NAS-ID profile                 : Not configured
   Free VLANs                     : Not configured
   Open authentication            : Disabled
   MAC-move VLAN check bypass     : Disabled
```

After users pass authentication, display MAC authentication information. Verify that GigabitEthernet 1/0/1 allows multiple MAC authentication users to be authenticated.

```
[Device] display mac-authentication interface gigabitethernet 1/0/1
 Global MAC authentication parameters:
   MAC authentication                 : Enabled
```

```
   Authentication method              : PAP
   User name format                   : MAC address in uppercase(XX-XX-XX-XX-XX-XX)
           Username                   : mac
           Password                   : Not configured
   Offline detect period              : 300 s
   Quiet period                       : 180 s
   Server timeout                     : 100 s
   Reauth period                      : 3600 s
   User aging period for critical VLAN : 1000 s
   User aging period for guest VLAN    : 1000 s
   Authentication domain              : sun
 Online MAC-auth wired users          : 3

 Silent MAC users:
          MAC address       VLAN ID  From port              Port index

GigabitEthernet1/0/1 is link-up
   MAC authentication              : Enabled
   Carry User-IP                   : Disabled
   Authentication domain           : Not configured
   Auth-delay timer                : Disabled
   Periodic reauth                 : Disabled
   Re-auth server-unreachable      : Logoff
   Guest VLAN                      : Not configured
   Guest VLAN auth-period          : 30 s
   Critical VLAN                   : Not configured
   Critical voice VLAN             : Disabled
   Host mode                       : Single VLAN
   Offline detection               : Enabled
   Authentication order            : Default
   User aging                      : Enabled
   Server-recovery online-user-sync : Enabled

   Auto-tag feature                : Disabled
   VLAN tag configuration ignoring  : Disabled
   Max online users                : 4294967295
   Authentication attempts         : successful 3, failed 7
   Current online users            : 3
          MAC address       Auth state
          1234-0300-0011    Authenticated
          1234-0300-0012    Authenticated
          1234-0300-0013    Authenticated
```

Display 802.1X authentication information. Verify that GigabitEthernet 1/0/1 allows only one 802.1X user to be authenticated.

```
[Device] display dot1x interface gigabitethernet 1/0/1
 Global 802.1X parameters:
   802.1X authentication              : Enabled
   CHAP authentication                : Enabled
```

```
  Max-tx period                          : 30 s
  Handshake period                       : 15 s
  Quiet timer                            : Disabled
      Quiet period                       : 60 s
  Supp timeout                           : 30 s
  Server timeout                         : 100 s
  Reauth period                          : 3600 s
  Max auth requests                      : 2
  User aging period for Auth-Fail VLAN : 1000 s
  User aging period for critical VLAN  : 1000 s
  User aging period for guest VLAN     : 1000 s
  EAD assistant function                 : Disabled
      EAD timeout                        : 30 min
  Domain delimiter                       : @
 Online 802.1X wired users               : 1

 GigabitEthernet1/0/1  is link-up
  802.1X authentication            : Enabled
  Handshake                        : Enabled
  Handshake reply                  : Disabled
  Handshake security               : Disabled
  Unicast trigger                  : Disabled
  Periodic reauth                  : Disabled
  Port role                        : Authenticator
  Authorization mode               : Auto
  Port access control              : MAC-based
  Multicast trigger                : Enabled
  Mandatory auth domain            : sun
  Guest VLAN                       : Not configured
  Auth-Fail VLAN                   : Not configured
  Critical VLAN                    : Not configured
  Critical voice VLAN              : Disabled
  Add Guest VLAN delay             : Disabled
  Re-auth server-unreachable       : Logoff
  Max online users                 : 4294967295
  User IP freezing                 : Disabled
  Reauth period                    : 60 s
  Send Packets Without Tag         : Disabled
  Max Attempts Fail Number         : 0
  User aging                       : Enabled
  Server-recovery online-user-sync : Enabled

  EAPOL packets: Tx 16331, Rx 102
  Sent EAP Request/Identity packets : 16316
       EAP Request/Challenge packets: 6
       EAP Success packets: 4
       EAP Failure packets: 5
  Received EAPOL Start packets : 6
```

```
    EAPOL LogOff packets: 2
    EAP Response/Identity packets : 80
    EAP Response/Challenge packets: 6
    Error packets: 0
  Online 802.1X users: 1
         MAC address         Auth state
         0002-0000-0011      Authenticated
```

Verify that frames with an unknown destination MAC address, multicast address, or broadcast address are discarded. (Details not shown.)

Troubleshooting port security

Cannot set the port security mode

Symptom

Cannot set the port security mode for a port.

Analysis

For a port operating in a port security mode other than noRestrictions, you cannot change the port security mode by using the **`port-security port-mode`** command.

Solution

To resolve the issue:

1. Set the port security mode to noRestrictions.
   ```
   [Device-GigabitEthernet1/0/1] undo port-security port-mode
   ```
2. Set a new port security mode for the port, for example, autoLearn.
   ```
   [Device-GigabitEthernet1/0/1] port-security port-mode autolearn
   ```
3. If the issue persists, contact H3C Support.

Cannot configure secure MAC addresses

Symptom

Cannot configure secure MAC addresses.

Analysis

No secure MAC address can be configured on a port operating in a port security mode other than autoLearn.

Solution

To resolve the issue:

1. Set the port security mode to autoLearn.
   ```
   [Device-GigabitEthernet1/0/1] undo port-security port-mode
   [Device-GigabitEthernet1/0/1] port-security max-mac-count 64
   [Device-GigabitEthernet1/0/1] port-security port-mode autolearn
   [Device-GigabitEthernet1/0/1] port-security mac-address security 1-1-2 vlan 1
   ```
2. If the issue persists, contact H3C Support.

Contents

Configuring user profiles

About user profiles

A user profile defines a set of parameters, such as a QoS policy, for a user or a class of users. A user profile can be reused when a user connected to the network on a different interface.

The user profile application allows flexible traffic policing on a per-user basis. Each time a user passes authentication, the server sends the device the name of the user profile specified for the user. The device applies the parameters in the user profile to the user.

User profiles are typically used for resource allocation per user. For example, the interface-based traffic policing limits the total amount of bandwidth available to a group of users. However, user-profile-based traffic policing can limit the amount of bandwidth available to a single user.

Prerequisites for user profile

A user profile works with authentication methods. You must configure authentication for a user profile. For information about supported authentication methods, see the configuration guides for the related authentication modules.

Configuring a user profile

1. Enter system view.
   system-view
2. Create a user profile and enter user profile view.
   user-profile *profile-name*
3. Apply an existing QoS policy to the user profile.
   qos apply policy *policy-name* { **inbound** | **outbound** }
   By default, no QoS policy is applied to a user profile.
   For information about QoS policies, see *ACL and QoS Configuration Guide*.

Display and maintenance commands for user profiles

Execute **display** commands in any view.

Task	Command
Display configuration and online user information for the specified user profile or all user profiles.	**display user-profile** [**name** *profile-name*] [**slot** *slot-number*]

User profile configuration examples

Example: Configuring user profiles and QoS policies

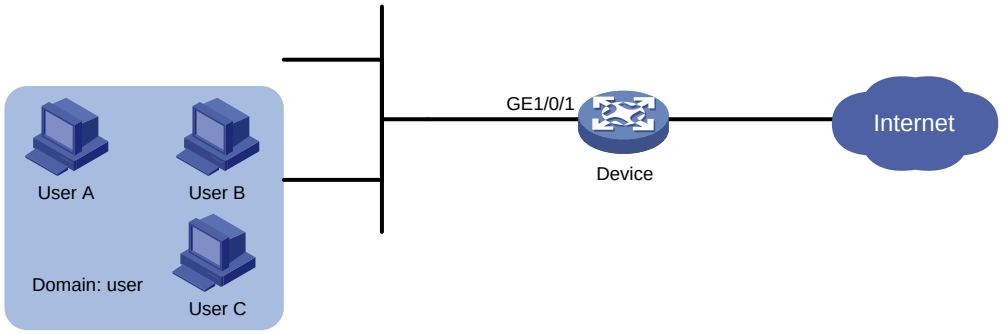
Network requirements

As shown in Figure 1, the device performs local 802.1X authentication on the users in domain **user** for authentication and authorization efficiency.

Configure user profiles and QoS policies on the device to meet the following requirements:

- User A cannot access the Internet during 8: 30 and 12:00 every day even if User A passes 802.1X authentication.
- User B has an upload speed of 2 Mbps after passing 802.1X authentication.
- User C has a download speed of 4 Mbps after passing 802.1X authentication.

Figure 1 Network diagram



Configuration procedure

1. Configure a QoS policy for User A:

   # Create a periodic time range from 8:30 to 12:00 every day.

   ```
   <Device> system-view
   [Device] time-range for_usera 8:30 to 12:00 daily
   ```

   # Create IPv4 basic ACL 2000, and configure a rule to match all packets during the time range **for_usera**.

   ```
   [Device] acl basic 2000
   [Device-acl-basic-2000] rule permit time-range for_usera
   [Device-acl-basic-2000] quit
   ```

   # Create a traffic class named **for_usera**, and use ACL 2000 as the match criterion.

   ```
   [Device] traffic classifier for_usera
   [Device-classifier-for_usera] if-match acl 2000
   [Device-classifier-for_usera] quit
   ```

   # Create a traffic behavior named **for_usera**, and configure the deny action.

   ```
   [Device] traffic behavior for_usera
   [Device-behavior-for_usera] filter deny
   [Device-behavior-for_usera] quit
   ```

   # Create a QoS policy named **for_usera**, and associate traffic class **for_usera** and traffic behavior **for_usera** in the QoS policy.

   ```
   [Device] qos policy for_usera
   [Device-qospolicy-for_usera] classifier for_usera behavior for_usera
   [Device-qospolicy-for_usera] quit
   ```

2. Create a user profile for User A and apply the QoS policy to the user profile:

   # Create a user profile named **usera**.

   ```
   [Device] user-profile usera
   ```

   # Apply QoS policy **for_usera** to the inbound direction of user profile **usera**.

   ```
   [[Device-user-profile-usera] qos apply policy for_usera inbound
   [Device-user-profile-usera] quit
   ```

3. Configure a QoS policy for limiting the traffic rate for User B:

   # Create a traffic class named **class** to match all packets.

   ```
   [Device] traffic classifier class
   [Device-classifier-class] if-match any
   [Device-classifier-class] quit
   ```

   # Create a traffic behavior named **for_userb**, and configure a traffic policing action (CIR 2000 kbps).

   ```
   [Device] traffic behavior for_userb
   [Device-behavior-for_userb] car cir 2000
   [Device-behavior-for_userb] quit
   ```

   # Create a QoS policy named **for_userb**, and associate traffic class **class** and traffic behavior **for_userb** in the QoS policy.

   ```
   [Device] qos policy for_userb
   [Device-qospolicy-for_userb] classifier class behavior for_userb
   [Device-qospolicy-for_userb] quit
   ```

4. Create a user profile for User B and apply the QoS policy to the user profile:

   # Create a user profile named **userb**.

   ```
   [Device] user-profile userb
   ```

   # Apply QoS policy **for_userb** to the inbound direction of user profile **userb**.

   ```
   [Device-user-profile-userb] qos apply policy for_userb inbound
   [Device-user-profile-userb] quit
   ```

5. Configure a QoS policy for limiting the traffic rate for User C:

   # Create a traffic behavior named **for_userc**, and configure a traffic policing action (CIR 4000 kbps).

   ```
   [Device] traffic behavior for_userc
   [Device-behavior-for_userc] car cir 4000
   [Device-behavior-for_userc] quit
   ```

   # Create a QoS policy named **for_userc**, and associate traffic class **class** and traffic behavior **for_userc** in the QoS policy.

   ```
   [Device] qos policy for_userc
   [Device-qospolicy-for_userc] classifier class behavior for_userc
   [Device-qospolicy-for_userc] quit
   ```

6. Create a user profile for User C and apply the QoS policy to the user profile:

   # Create a user profile named **userc**.

   ```
   [Device] user-profile userc
   ```

   # Apply QoS policy **for_userc** to the outbound direction of user profile **userc**.

   ```
   [Device-user-profile-userc] qos apply policy for_userc outbound
   [Device-user-profile-userc] quit
   ```

7. Configure local users:

   # Create a local user named **usera**.

   ```
   [Device] local-user usera class network
   ```

```
New local user added.
```

Set the password to **a12345** for user **usera**.

```
[Device-luser-network-usera] password simple a12345
```

Authorize user **usera** to use the LAN access service.

```
[Device-luser-network-usera] service-type lan-access
```

Specify user profile **usera** as the authorization user profile for user **usera**.

```
[Device-luser-network-usera] authorization-attribute user-profile usera
[Device-luser-network-usera] quit
```

Create a local user named **userb**.

```
[Device] local-user userb class network
New local user added.
```

Set the password to **b12345** for user **userb**.

```
[Device-luser-network-userb] password simple b12345
```

Authorize user **userb** to use the LAN access service.

```
[Device-luser-network-userb] service-type lan-access
```

Specify user profile **userb** as the authorization user profile for user **userb**.

```
[Device-luser-network-userb] authorization-attribute user-profile userb
[Device-luser-network-userb] quit
```

Create a local user named **userc**.

```
[Device] local-user userc class network
New local user added.
```

Set the password to **c12345** for user **userc**.

```
[Device-luser-network-userc] password simple c12345
```

Authorize user **userc** to use the LAN access service.

```
[Device-luser-network-userc] service-type lan-access
```

Specify user profile **userc** as the authorization user profile for user **userc**.

```
[Device-luser-network-userc] authorization-attribute user-profile userc
[Device-luser-network-userc] quit
```

8. Configure the authentication, authorization, and accounting methods for local users:

```
[Device] domain user
[Device-isp-user] authentication lan-access local
[Device-isp-user] authorization lan-access local
[Device-isp-user] accounting login none
[Device-isp-user] quit
```

9. Configure 802.1X:

Enable 802.1X on GigabitEthernet 1/0/1.

```
[Device] interface gigabitethernet 1/0/1
[Device-GigabitEthernet1/0/1] dot1x
```

Enable MAC-based access control on the port. By default, a port uses MAC-based access control.

```
[Device-GigabitEthernet1/0/1] dot1x port-method macbased
[Device-GigabitEthernet1/0/1] quit
```

Enable 802.1X globally.

```
[Device] dot1x
```

Verifying the configuration

Verify that the three users can pass 802.1X authentication and that QoS policies take effect on these users. (Details not shown.)

Display user profile information.

```
<Device> display user-profile
  User-Profile: usera
    Inbound:
      Policy: for_usera

    slot 1:
      User -:
        Authentication type: 802.1X
        Network attributes:
          Interface    : GigabitEthernet1/0/1
          MAC address  : 6805-ca06-557b
          Service VLAN : 1

  User-Profile: userb
    Inbound:
      Policy: for_userb

    slot 1:
      User -:
        Authentication type: 802.1X
        Network attributes:
          Interface    : GigabitEthernet1/0/1
          MAC address  : 80c1-6ee0-2664
          Service VLAN : 1

  User-Profile: userc
    Outbound:
      Policy: for_userc

    slot 1:
      User -:
        Authentication type: 802.1X
        Network attributes:
          Interface    : GigabitEthernet1/0/1
          MAC address  : 6805-ca05-3efa
          Service VLAN : 1
```

Contents

Configuring password control

About password control

Password control allows you to implement the following features:

- Manage login and super password setup, expirations, and updates for local users.
- Control user login status based on predefined policies.

For more information about local users, see "Configuring AAA." For information about super passwords, see RBAC in *Fundamentals Configuration Guide*.

Password setting

Minimum password length

You can define the minimum length of user passwords. The system rejects the setting of a password that is shorter than the configured minimum length.

Password composition policy

A password can be a combination of characters from the following types:

- Uppercase letters A to Z.
- Lowercase letters a to z.
- Digits 0 to 9.
- Special characters in Table 1. For more information about special characters, see CLI in *Fundamentals Configuration Guide*.

Table 1 Special Characters

Character name	Symbol	Character name	Symbol
Ampersand sign	&	Apostrophe	'
Asterisk	*	At sign	@
Back quote	`	Back slash	\
Blank space	N/A	Caret	^
Colon	:	Comma	,
Dollar sign	$	Dot	.
Equal sign	=	Exclamation point	!
Left angle bracket	<	Left brace	{
Left bracket	[	Left parenthesis	(
Minus sign	-	Percent sign	%
Plus sign	+	Pound sign	#
Quotation marks	"	Right angle bracket	>
Right brace	}	Right bracket	]
Right parenthesis	)	Semi-colon	;

Character name	Symbol	Character name	Symbol
Slash	/	Tilde	~
Underscore	_	Vertical bar	|

Depending on the system's security requirements, you can set the minimum number of character types a password must contain and the minimum number of characters for each type, as shown in Table 2.

Table 2 Password composition policy

Password combination level	Minimum number of character types	Minimum number of characters for each type
Level 1	One	One
Level 2	Two	One
Level 3	Three	One
Level 4	Four	One

When a user sets or changes a password, the system checks if the password meets the combination requirement. If it does not, the operation fails.

Password complexity checking policy

A less complicated password is more likely to be cracked, such as a password containing the username or repeated characters. For higher security, you can configure a password complexity checking policy to ensure that all user passwords are relatively complicated. When a user configures a password, the system checks the complexity of the password. If the password is complexity-incompliant, the configuration will fail.

You can apply the following password complexity requirements:

- A password cannot contain the username or the reverse of the username. For example, if the username is **abc**, a password such as **abc982** or **2cba** is not complex enough.
- A minimum of three identical consecutive characters is not allowed. For example, password **a111** is not complex enough.

Password updating and expiration

Password updating

This feature allows you to set the minimum interval at which users can change their passwords. A user can only change the password once within the specified interval.

The minimum interval does not apply to the following situations:

- A user is prompted to change the password at first login.
- The password aging time expires.

Password expiration

Password expiration imposes a lifecycle on a user password. After the password expires, the user needs to change the password.

The system displays an error message for a login attempt with an expired password. The user is asked to provide a new password. The new password must be valid, and the user must enter exactly the same password when confirming it.

Web users, Telnet users, SSH users, and console users can change their own passwords. FTP users must have their passwords changed by the administrator.

Early notice on pending password expiration

When a user logs in, the system checks whether the password will expire in a time equal to or less than the specified notification period. If so, the system notifies the user when the password will expire and provides a choice for the user to change the password.

- If the user sets a new valid password, the system records the new password and the setup time.
- If the user does not or fails to change the password, the system allows the user to log in by using the current password until the password expires.

Web users, Telnet users, SSH users, and console users can change their own passwords. FTP users must have their passwords changed by the administrator.

Login with an expired password

You can allow a user to log in a certain number of times within a period of time after the password expires. For example, if you set the maximum number of logins with an expired password to 3 and the time period to 15 days, a user can log in three times within 15 days after the password expires.

Password history

This feature allows the system to store passwords that a user has used.

When a network access user changes the password, the system compares the new password with the current password and those stored in the password history records. The new password must be different from the current one and those stored in the history records by a minimum of four different characters. Otherwise, the system will display an error message, and the new password is not successfully set.

The local passwords and super passwords for device management users are stored in hash form and cannot be converted to plain texts. When a device management user changes a local password or super password, follow these rules:

- If the new password is set by using the hash method, the system will not compare the new password with the current one and those stored in the history password records.
- If the new password in set in plain text, the system compares the new password with the current password and those stored in the password history records. A new password must be different from those stored in the history password records. If the current password is required, the new password must also be different from the current one by a minimum of four different characters. Otherwise, the system will display an error message, and the new password is not successfully set.

You can set the maximum number of history password records for the system to maintain for each user. When the number of history password records exceeds the setting, the most recent record overwrites the earliest one.

Current login passwords are not stored in the password history for device management users. Device management users have their passwords saved in cipher text, which cannot be recovered to plaintext passwords.

User login control

First login

By default, if the global password control feature is enabled, users must change the password at first login before they can access the system. In this situation, password changes are not subject to the minimum password update interval. If it is not necessary for users to change the password at first login, disable the password change at first login feature.

Login attempt limit

Limiting the number of consecutive login failures can effectively prevent password guessing.

Login attempt limit takes effect on FTP, Web, and VTY users. It does not take effect on the following types of users:

- Nonexistent users (users not configured on the device).
- Users logging in to the device through console ports.

If a user fails to log in, the system adds the user account and the user's IP address to the password control blacklist. When the user fails to log in after making the maximum number of consecutive attempts, login attempt limit limits the user and user account in any of the following ways:

- Disables the user account until the account is manually removed from the password control blacklist.
- Allows the user to continue using the user account. The user's IP address and user account are removed from the password control blacklist when the user uses this account to successfully log in to the device.
- Disables the user account for a period of time.

  The user can use the account to log in when either of the following conditions exists:
  - The locking timer expires.
  - The account is manually removed from the password control blacklist before the locking timer expires.

NOTE:

This account is locked only for this user. Other users can still use this account, and the blacklisted user can use other user accounts.

Maximum account idle time

You can set the maximum account idle time for user accounts. When an account is idle for this period of time since the last successful login, the account becomes invalid.

Login control with a weak password

This feature is available only in Release 6318P01 and later.

The system checks for weak passwords for Telnet, SSH, HTTP, or HTTPS device management users. A password is weak if it does not meet the following requirements:

- Password composition restriction.
- Minimum password length restriction.
- Password complexity checking policy.

By default, the system displays a message about a weak password but does not force the user to change it. To improve the device security, you can enable the mandatory weak password change feature, which forces the users to change the identified weak passwords. The users can log in to the device only after their passwords meet the password requirements.

Password not displayed in any form

For security purposes, nothing is displayed when a user enters a password.

Logging

The system generates a log each time a user changes its password successfully or is added to the password control blacklist because of login failures.

FIPS compliance

The device supports the FIPS mode that complies with NIST FIPS 140-2 requirements. Support for features, commands, and parameters might differ in FIPS mode (see "Configuring FIPS") and non-FIPS mode.

Restrictions and guidelines: Password control configuration

IMPORTANT:

To successfully enable the global password control feature and allow device management users to log in to the device, make sure the device have sufficient storage space.

The password control features can be configured in several different views, and different views support different features. The settings configured in different views or for different objects have the following application ranges:

- Settings for super passwords apply only to super passwords.
- Settings in local user view apply only to the password of the local user.
- Settings in user group view apply to the passwords of the local users in the user group if you do not configure password policies for these users in local user view.
- Global settings in system view apply to the passwords of the local users in all user groups if you do not configure password policies for these users in both local user view and user group view.

For local user passwords, the settings with a smaller application scope have higher priority.

Password control tasks at a glance

To configure password control, perform the following tasks:

1. Enabling password control
2. (Optional.) Setting global password control parameters
3. (Optional.) Setting user group password control parameters
4. (Optional.) Setting local user password control parameters
5. (Optional.) Setting super password control parameters

Enabling password control

About password control

In versions earlier than Release 6318P01:

Enable global password control to make all password control configurations take effect. For a specific password control feature to take effect, enable its own password control feature.

In Release 6318P01 and later versions:

The password expiration feature and the password history management feature take effect only after the global password control feature is also enabled.

Restrictions and guidelines

After global password control is enabled, follow these restrictions and guidelines:

- You cannot display the password and super password configurations for device management users by using the corresponding **display** commands.
- You cannot display the password configuration for network access users by using the corresponding **display** command.
- The passwords configured for local users must contain a minimum of four different characters.
- In FIPS mode, the global password control feature is enabled for device management users and cannot be disabled for them.
- To ensure correct function of password control, configure the device to use NTP to obtain the UTC time. After global password control is enabled, password control will record the UTC time when the password is set. The recorded UTC time might not be consistent with the actual UTC time due to power failure or device reboot. The inconsistency will cause the password expiration feature to malfunction. For information about NTP, see *Network Management and Monitoring Configuration Guide*.
- The device automatically generates a .dat file and saves the file to the storage media. The file is used to record authentication and login information of the local users. Do not manually delete or modify the file.
- The global password control feature enables the system to record history passwords. When the number of history password records of a user reaches the maximum number, the newest history record overwrites the earliest one. To delete the existing history password records, use one of the following methods:
  - Use the **undo password-control enable** command to disable the password control feature globally.
  - Use the **reset password-control history-record** command to clear the passwords manually.

Procedure

1. Enter system view.

   system-view
2. Enable the global password control feature.

   In non-FIPS mode:

   password-control enable [**network-class**]

   By default, the global password control feature is disabled for device management and network access users.

   In FIPS mode:

   password-control enable [**network-class**]

   By default, the global password control feature is enabled for device management users and cannot be disabled. The global password control feature is disabled for network access users.
3. (Optional.) Enable a specific password control feature.

   password-control { **aging** | **composition** | **history** | **length** } **enable**

   By default, all four password control features are enabled.

Setting global password control parameters

Restrictions and guidelines

The global password control parameters in system view apply to all device management and network access local users.

You can configure all password control features for device management users. The password aging time, minimum password length, password complexity policy, password composition policy, and user login attempt limit can be configured in system view, user group view, and local user view.

You can configure only the following password control features for network access users:

- Minimum password length.
- Password complexity policy.
- Password composition policy.
- Minimum password update interval.
- Maximum number of history password records for each user.

Where, the minimum password length, password complexity policy, and password composition policy can be configured in system view, user group view, and local user view.

The password settings with a smaller application scope have higher priority. For local users, password settings configured in local user view have the highest priority, and global settings in system view have the lowest priority.

The **password-control login-attempt** command takes effect immediately and can affect the users already in the password control blacklist. Other password control configurations do not take effect on users that have been logged in or passwords that have been configured.

Procedure

1. Enter system view.

   system-view

2. Configure password settings.
   - Set the minimum password length.

     In non-FIPS mode:

     password-control length *length*

     The default setting is 10 characters.

     In FIPS mode:

     password-control length *length*

     The default length is 15 characters.
   - Configure the password composition policy.

     In non-FIPS mode:

     password-control composition type-number *type-number* [**type-length** *type-length*]

     By default:

     – In versions earlier than Release 6318P01, a password must contain a minimum of one character type and a minimum of one character for each type.

     – In Release 6318P01 and later, a password must contain a minimum of two character types and a minimum of one character for each type.

     In FIPS mode:

     password-control composition type-number *type-number* [**type-length** *type-length*]

     By default, a password must contain a minimum of four character types and a minimum of one character for each type.
   - Configure the password complexity checking policy.

     password-control complexity { **same-character** | **user-name** } **check**

     In versions earlier than Release 6318P01, the system does not perform password complexity checking by default.

     In Release 6318P01 and later, the default settings are as follows:

     – In non-FIPS mode, username checking is enabled and repeated character checking is disabled.

- In FIPS mode, the system does not perform password complexity checking.

- Set the maximum number of history password records for each user.

  password-control history *max-record-number*

  The default setting is 4.

3. Configure password updating and expiration.

- Set the minimum password update interval.

  password-control update interval *interval*

  The default setting is 24 hours.

- Set the password aging time.

  password-control aging *aging-time*

  The default setting is 90 days.

- Set the number of days during which a user is notified of the pending password expiration.

  password-control alert-before-expire *alert-time*

  The default setting is 7 days.

- Set the maximum number of days and maximum number of times that a user can log in after the password expires.

  password-control expired-user-login delay *delay* **times** *times*

  By default, a user can log in three times within 30 days after the password expires.

4. Configure user login control.

- Configure the login attempt limit.

  password-control login-attempt *login-times* [**exceed** { **lock** | **lock-time** *time* | **unlock** }]

  By default, the maximum number of login attempts is 3 and a user failing to log in after the specified number of attempts must wait for 1 minute before trying again.

- Set the maximum account idle time.

  password-control login idle-time *idle-time*

  The default setting is 90 days.

  If a user account is idle for this period of time, the account becomes invalid and can no longer be used to log in to the device. To disable the account idle time restriction, set the idle time value to 0.

- Set the user authentication timeout time.

  password-control authentication-timeout *timeout*

  The default setting is 600 seconds.

  This command takes effect only on Telnet and terminal users.

- Disable password change at first login.

  undo password-control change-password first-login enable

  By default, the password change at first login feature is enabled.

  In FIPS mode, the password change at first login feature cannot be disabled.

- Enable mandatory weak password change.

  password-control change-password weak-password enable

  By default, the mandatory weak password change feature is disabled.

  This feature is available only in Release 6318P01 and later.

Setting user group password control parameters

1. Enter system view.

   system-view

2. Create a user group and enter its view.

   user-group *group-name*

   For information about how to configure a user group, see "Configuring AAA."

3. Configure the password aging time for the user group.

   password-control aging *aging-time*

   By default, the password aging time of the user group equals the global password aging time.

4. Configure the minimum password length for the user group.

   password-control length *length*

   By default, the minimum password length of the user group equals the global minimum password length.

5. Configure the password composition policy for the user group.

   password-control composition type-number *type-number* [**type-length** *type-length*]

   By default, the password composition policy of the user group equals the global password composition policy.

6. Configure the password complexity checking policy for the user group.

   password-control complexity { **same-character** | **user-name** } **check**

   By default, the password complexity checking policy of the user group equals the global password complexity checking policy.

7. Configure the login attempt limit.

   password-control login-attempt *login-times* [**exceed** { **lock** | **lock-time** *time* | **unlock** }]

   By default, the login-attempt policy of the user group equals the global login-attempt policy.

Setting local user password control parameters

1. Enter system view.

   system-view

2. Create a device management or network access user and enter its view.

   - Create a device management user and enter its view.

     local-user *user-name* **class manage**

   - Create a network access user and enter its view.

     local-user *user-name* **class network**

   For information about local user configuration, see "Configuring AAA."

3. Configure the password aging time for the local user.

   password-control aging *aging-time*

   By default, the setting equals that for the user group to which the local user belongs. If no aging time is configured for the user group, the global setting applies to the local user.

   This command is available only for device management users.

4. Configure the minimum password length for the local user.

   password-control length *length*

By default, the setting equals that for the user group to which the local user belongs. If no minimum password length is configured for the user group, the global setting applies to the local user.

5. Configure the password composition policy for the local user.

   password-control composition type-number *type-number* [**type-length** *type-length*]

   By default, the settings equal those for the user group to which the local user belongs. If no password composition policy is configured for the user group, the global settings apply to the local user.

6. Configure the password complexity checking policy for the local user.

   password-control complexity { **same-character** | **user-name** } **check**

   By default, the settings equal those for the user group to which the local user belongs. If no password complexity checking policy is configured for the user group, the global settings apply to the local user.

7. Configure the login attempt limit.

   password-control login-attempt *login-times* [**exceed** { **lock** | **lock-time** *time* | **unlock** }]

   By default, the settings equal those for the user group to which the local user belongs. If no login-attempt policy is configured for the user group, the global settings apply to the local user.

   This command is available only for device management users.

Setting super password control parameters

1. Enter system view.

   system-view

2. Set the password aging time for super passwords.

   password-control super aging *aging-time*

   The default setting is 90 days.

3. Configure the minimum length for super passwords.

   In non-FIPS mode:

   password-control super length *length*

   The default setting is 10 characters.

   In FIPS mode:

   password-control super length *length*

   The default setting is 15 characters.

4. Configure the password composition policy for super passwords.

   In non-FIPS mode:

   password-control super composition type-number *type-number* [**type-length** *type-length*]

   By default:

   - In versions earlier than Release 6318P01, a super password must contain a minimum of one character type and a minimum of one character for each type.
   - In Release 6318P01 and later, a super password must contain a minimum of two character types and a minimum of one character for each type.

   In FIPS mode:

   password-control super composition type-number *type-number* [**type-length** *type-length*]

By default, a super password must contain a minimum of four character types and a minimum of one character for each type.

Display and maintenance commands for password control

Execute **display** commands in any view and **reset** commands in user view.

Task	Command
Display password control configuration.	**display password-control** [**super**]
Display information about users in the password control blacklist.	**display password-control blacklist** [**user-name** *user-name* | **ip** *ipv4-address* | **ipv6** *ipv6-address*]
Delete users from the password control blacklist.	**reset password-control blacklist** [**user-name** *user-name*]
Clear history password records.	**reset password-control history-record** [**user-name** *user-name* | **super** [**role** *role-name*] | **network-class** [**user-name** *user-name*]]

NOTE:

The **reset password-control history-record** command can delete the history password records of one or all users even when the password history management feature is disabled.

Password control configuration examples

Example: Configuring password control

Network configuration

Configure a global password control policy to meet the following requirements:

- A password must contain a minimum of 16 characters.
- A password must contain a minimum of four character types and a minimum of four characters for each type.
- An FTP or VTY user failing to provide the correct password in two successive login attempts is permanently prohibited from logging in.
- A user can log in five times within 60 days after the password expires.
- A password expires after 30 days.
- The minimum password update interval is 36 hours.
- The maximum account idle time is 30 days.
- A password cannot contain the username or the reverse of the username.
- A minimum of three identical consecutive characters is not allowed in a password.

Configure a super password control policy for user role **network-operator** to meet the following requirements:

- A super password must contain a minimum of 24 characters.

- A super password must contain a minimum of four character types and a minimum of five characters for each type.

Configure a password control policy for local Telnet user **test** to meet the following requirements:

- The password must contain a minimum of 24 characters.
- The password must contain a minimum of four character types and a minimum of five characters for each type.
- The password for the local user expires after 20 days.

Procedure

Enable the password control feature globally.

```
<Sysname> system-view
[Sysname] password-control enable
```

Disable a user account permanently if a user fails two consecutive login attempts on the user account.

```
[Sysname] password-control login-attempt 2 exceed lock
```

Set all passwords to expire after 30 days.

```
[Sysname] password-control aging 30
```

Globally set the minimum password length to 16 characters.

```
[Sysname] password-control length 16
```

Set the minimum password update interval to 36 hours.

```
[Sysname] password-control update-interval 36
```

Specify that a user can log in five times within 60 days after the password expires.

```
[Sysname] password-control expired-user-login delay 60 times 5
```

Set the maximum account idle time to 30 days.

```
[Sysname] password-control login idle-time 30
```

Refuse any password that contains the username or the reverse of the username.

```
[Sysname] password-control complexity user-name check
```

Refuse a password that contains a minimum of three identical consecutive characters.

```
[Sysname] password-control complexity same-character check
```

Globally specify that all passwords must each contain a minimum of four character types and a minimum of four characters for each type.

```
[Sysname] password-control composition type-number 4 type-length 4
```

Set the minimum super password length to 24 characters.

```
[Sysname] password-control super length 24
```

Specify that a super password must contain a minimum of four character types and a minimum of five characters for each type.

```
[Sysname] password-control super composition type-number 4 type-length 5
```

Configure a super password used for switching to user role **network-operator** as **123456789ABGFTweuix@#$%!** in plain text.

```
[Sysname] super password role network-operator simple 123456789ABGFTweuix@#$%!
```

Create a device management user named **test**.

```
[Sysname] local-user test class manage
```

Set the service type of the user to **Telnet**.

```
[Sysname-luser-manage-test] service-type telnet
```

Set the minimum password length to 24 for the local user.

```
[Sysname-luser-manage-test] password-control length 24
```

Specify that the password of the local user must contain a minimum of four character types and a minimum of five characters for each type.

```
[Sysname-luser-manage-test] password-control composition type-number 4 type-length 5
```

Set the password for the local user to expire after 20 days.

```
[Sysname-luser-manage-test] password-control aging 20
```

Configure the password of the local user in interactive mode.

```
[Sysname-luser-manage-test] password
Password:
Confirm :
Updating user information. Please wait ... ...
[Sysname-luser-manage-test] quit
```

Verifying the configuration

Display the global password control configuration.

```
<Sysname> display password-control
 Global password control configurations:
 Password control:                    Enabled(device management users)
                                      Disabled (network access users)
 Password aging:                      Enabled (30 days)
 Password length:                     Enabled (16 characters)
 Password composition:                Enabled (4 types, 4 characters per type)
 Password history:                    Enabled (max history record:4)
 Early notice on password expiration:  7 days
 Maximum login attempts:              2
 User authentication timeout:         600 seconds
 Action for exceeding login attempts:  Lock
 Minimum interval between two updates: 36 hours
 User account idle time:              30 days
 Logins with aged password:           5 times in 60 days
 Password complexity:                 Enabled (username checking)
                                      Enabled (repeated characters checking)
 Password change:                     Enabled (first login)
                                      Disabled (mandatory weak password change)
```

Display the password control configuration for super passwords.

```
<Sysname> display password-control super
 Super password control configurations:
 Password aging:                      Enabled (90 days)
 Password length:                     Enabled (24 characters)
 Password composition:                Enabled (4 types, 5 characters per type)
```

Display the password control configuration for local user **test**.

```
<Sysname> display local-user user-name test class manage
Total 1 local users matched.

Device management user test:
  State:                    Active
  Service type:             Telnet
```

```
User group:                system
Bind attributes:
Authorization attributes:
  Work directory:          flash:
  User role list:          network-operator
Password control configurations:
  Password aging:          20 days
  Password length:         24 characters
  Password composition:    4 types, 5 characters per type
```

Contents

Managing public keys

About public key management

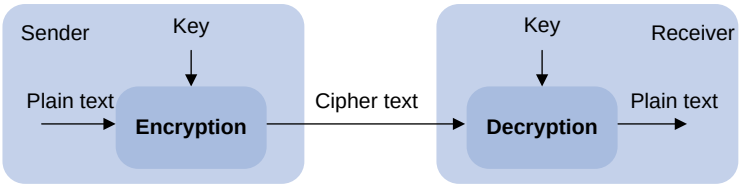
This chapter describes public key management for the following asymmetric key algorithms:

- Revest-Shamir-Adleman Algorithm (RSA).
- Digital Signature Algorithm (DSA).
- Elliptic Curve Digital Signature Algorithm (ECDSA).

Asymmetric key algorithm overview

Asymmetric key algorithms are used by security applications to secure communications between two parties, as shown in Figure 1. Asymmetric key algorithms use two separate keys (one public and one private) for encryption and decryption. Symmetric key algorithms use only one key.

Figure 1 Encryption and decryption



A key owner can distribute the public key in plain text on the network but must keep the private key in privacy. It is mathematically infeasible to calculate the private key even if an attacker knows the algorithm and the public key.

Usage of asymmetric key algorithms

Security applications (such as SSH, SSL, and PKI) use the asymmetric key algorithms for the following purposes:

- **Encryption and decryption**—Any public key receiver can use the public key to encrypt information, but only the private key owner can decrypt the information.
- **Digital signature**—The key owner uses the private key to digitally sign information to be sent. The receiver decrypts the information with the sender's public key to verify information authenticity.

RSA, DSA, and ECDSA can all perform digital signature, but only RSA can perform encryption and decryption.

FIPS compliance

The device supports the FIPS mode that complies with NIST FIPS 140-2 requirements. Support for features, commands, and parameters might differ in FIPS mode (see "Configuring FIPS") and non-FIPS mode.

Public key management tasks at a glance

To manage public keys, perform the following tasks:

1. Creating a local key pair
2. Distributing a local host public key

   Choose one of the following tasks:

   - Exporting a host public key
   - Displaying a host public key

   To enable the peer device to authenticate the local device, you must distribute the local device's public key to the peer device.
3. Configuring a peer host public key

   Choose one of the following tasks:

   - Importing a peer host public key from a public key file
   - Entering a peer host public key

   To encrypt information sent to a peer device or authenticate the digital signature of the peer device, you must configure the peer device's public key on the local device.
4. (Optional.) Destroying a local key pair

Creating a local key pair

Restrictions and guidelines

When you create a local key pair, follow these guidelines:

- The key algorithm must be the same as required by the security application.
- When you create an RSA or DSA key pair, enter an appropriate key modulus length at the prompt. The longer the key modulus length, the higher the security, and the longer the key generation time.

  When you create an ECDSA key pair, choose the appropriate elliptic curve. The elliptic curve determines the ECDSA key length. The longer the key length, the higher the security, and the longer the key generation time.

  See Table 1 for more information about key modulus lengths and key lengths.
- If you do not assign the key pair a name, the system assigns the default name to the key pair and marks the key pair as **default**. You can also assign the default name to another key pair, but the system does not mark the key pair as **default**. The key pair name must be unique among all manually named key pairs that use the same key algorithm. If a name conflict occurs, the system asks whether you want to overwrite the existing key pair.
- The key pairs are automatically saved and can survive system reboots.

Table 1 A comparison of different types of asymmetric key algorithms

Type	Generated key pairs	Modulus/key length

RSA	• In non-FIPS mode:
	  ◦ One host key pair, if you specify a key pair name.
	  ◦ One server key pair and one host key pair, if you do not specify a key pair name.
	  Both key pairs use their default names.
	• In FIPS mode: One host key pair.
	NOTE:
	Only SSH 1.5 uses the RSA server key pair.
		RSA key modulus length:
		• In non-FIPS mode: 512 to 4096 bits, 1024 bits by default.
		To ensure security, use a minimum of 768 bits.
		• In FIPS mode: A multiple of 256 bits in the range of 2048 to 4096 bits, 2048 bits by default.

Type	Generated key pairs	Modulus/key length
DSA	One host key pair.	DSA key modulus length: • In non-FIPS mode: 512 to 2048 bits, 1024 bits by default. To ensure security, use a minimum of 768 bits. • In FIPS mode: 2048 bits.
ECDSA	One host key pair.	ECDSA key length: • In non-FIPS mode: 192, 256, 384, or 521 bits. • In FIPS mode: 256, 384, or 521 bits.

Procedure

1. Enter system view.

   system-view
2. Create a local key pair.

   In non-FIPS mode:

   public-key local create { **dsa** | **ecdsa** [**secp192r1** | **secp256r1** | **secp384r1** | **secp521r1**] | **rsa** } [**name** *key-name*]

   In FIPS mode:

   public-key local create { **dsa** | **ecdsa** [**secp256r1** | **secp384r1** | **secp521r1**] | **rsa** } [**name** *key-name*]

Distributing a local host public key

About distribution of local host public keys

You must distribute a local host public key to a peer device so the peer device can perform the following operations:

- Use the public key to encrypt information sent to the local device.
- Authenticate the digital signature signed by the local device.

To distribute a local host public key, you must first export or display the key.

- Export a host public key:
  - Export a host public key to a file.
  - Export a host public key to the monitor screen, and then save it to a file.

  After the key is exported to a file, transfer the file to the peer device. On the peer device, import the key from the file.
- Display a host public key.

  After the key is displayed, record the key, for example, copy it to an unformatted file. On the peer device, you must literally enter the key.

Exporting a host public key

Restrictions and guidelines

When you export a host public key, follow these restrictions and guidelines:

- If you specify a file name in the command, the command exports the key to the specified file.

- If you do not specify a file name, the command exports the key to the monitor screen. You must manually save the exported key to a file.

Procedure

1. Enter system view.

   system-view

2. Export a local host public key.
   - Export an RSA host public key:

     In non-FIPS mode:

     public-key local export rsa [**name** *key-name*] { **openssh** | **ssh1** | **ssh2** } [*filename*]

     In FIPS mode:

     public-key local export rsa [**name** *key-name*] { **openssh** | **ssh2** } [*filename*]
   - Export an ECDSA host public key.

     public-key local export ecdsa [**name** *key-name*] { **openssh** | **ssh2** } [*filename*]
   - Export a DSA host public key.

     public-key local export dsa [**name** *key-name*] { **openssh** | **ssh2** } [*filename*]

Displaying a host public key

Perform the following tasks in any view:

- Display local RSA public keys.

  display public-key local rsa public [**name** *key-name*]

  Do not distribute the RSA server public key **serverkey (default)** to a peer device.
- Display local ECDSA public keys.

  display public-key local ecdsa public [**name** *key-name*]
- Display local DSA public keys.

  display public-key local dsa public [**name** *key-name*]

Configuring a peer host public key

About peer host public key configuration

To encrypt information sent to a peer device or authenticate the digital signature of the peer device, you must configure the peer device's public key on the local device.

You can configure the peer host public key by using the following methods:

- Import the peer host public key from a public key file (recommended).
- Manually enter (type or copy) the peer host public key.

For information about how to obtain the host public key of a device, see "Distributing a local host public key."

Restrictions and guidelines for peer host public key configuration

When you configure a peer host public key, follow these restrictions and guidelines:

- When you manually enter the peer host public key, make sure the entered key is in the correct format. To obtain the peer host public key in the correct format, use the **display public-key local public** command to display the public key on the peer device and record the key. The format of the public key displayed in any other way might be incorrect. If the key is not in the correct format, the system discards the key and displays an error message.
- Always import rather than enter the peer host public key if you are not sure whether the device supports the format of the recorded peer host public key.

Importing a peer host public key from a public key file

About importing a peer host public key

Before you perform this task, make sure you have exported the host public key to a file on the peer device and obtained the file from the peer device. For information about exporting a host public key, see "Exporting a host public key."

After you import the key, the system automatically converts the imported public key to a string in the Public Key Cryptography Standards (PKCS) format.

Procedure

1. Enter system view.

   system-view
2. Import a peer host public key from a public key file.

   public-key peer *keyname* **import sshkey** *filename*

   By default, no peer host public keys exist.

Entering a peer host public key

About entering a peer host public key

Before you perform this task, make sure you have displayed the key on the peer device and recorded the key. For information about displaying a host public key, see "Displaying a host public key."

Procedure

1. Enter system view.

   system-view
2. Specify a name for the peer host public key and enter public key view.

   public-key peer *keyname*
3. Type or copy the key.

   You can use spaces and carriage returns, but the system does not save them.
4. Exit public key view.

   peer-public-key end

   When you exit public key view, the system automatically saves the peer host public key.

Destroying a local key pair

About destroying a local key pair

To ensure security, destroy the local key pair and generate a new key pair in any of the following situations:

- The local key has leaked. An intrusion event might occur.
- The storage media of the device is replaced.
- The local certificate has expired. For more information about local certificates, see "Configuring PKI."

Procedure

1. Enter system view.
   system-view
2. Destroy a local key pair.
   public-key local destroy { **dsa** | **ecdsa** | **rsa** } [**name** *key-name*]

Display and maintenance commands for public keys

Execute **display** commands in any view.

Task	Command
Display local public keys.	**display public-key local** { **dsa** | **ecdsa** | **rsa** } **public** [**name** *key-name*]
Display peer host public keys.	**display public-key peer** [**brief** | **name** *publickey-name*]

Examples of public key management

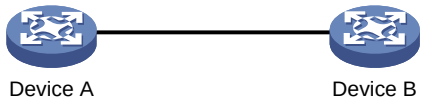
Example: Entering a peer host public key

Network configuration

As shown in Figure 2, to prevent illegal access, Device B authenticates Device A through a digital signature. Before configuring authentication parameters on Device B, use the following procedure to configure the public key of Device A on Device B:

- Create RSA key pairs on Device A and display the public keys of the RSA key pairs.
- Manually specify the RSA host public key of Device A on Device B.

Figure 2 Network diagram



Procedure

1. Configure Device A:

Create local RSA key pairs with the default names on Device A, and use the default key modulus length (1024 bits).

```
<DeviceA> system-view
[DeviceA] public-key local create rsa
The range of public key modulus is (512 ~ 4096).
If the key modulus is greater than 512, it will take a few minutes.
Press CTRL+C to abort.
Input the modulus length [default = 1024]:
Generating Keys...
...
Create the key pair successfully.
```

Display all local RSA public keys.

```
[DeviceA] display public-key local rsa public
=========================================
Key name: hostkey (default)
Key type: RSA
Time when key pair created: 16:48:31 2011/05/12
Key code:
   30819F300D06092A864886F70D010101050003818D0030818902818100DA3B90F59237347B
   8D41B58F8143512880139EC9111BFD31EB84B6B7C7A1470027AC8F04A827B30C2CAF79242E
   45FDFF51A9C7E917DB818D54CB7AEF538AB261557524A7441D288EC54A5D31EFAE4F681257
   6D7796490AF87A8C78F4A7E31F0793D8BA06FB95D54EBB9F94EB1F2D561BF66EA27DFD4788
   CB47440AF6BB25ACA50203010001
=========================================
Key name: serverkey (default)
Key type: RSA
Time when key pair created: 16:48:31 2011/05/12
Key code:
   307C300D06092A864886F70D0101010500036B003068026100C9451A80F7F0A9BA1A90C7BC
   1C02522D194A2B19F19A75D9EF02219068BD7FD90FCC2AF3634EEB9FA060478DD0A1A49ACE
   E1362A4371549ECD85BA04DEE4D6BB8BE53B6AED7F1401EE88733CA3C4CED391BAE633028A
   AC41C80A15953FB22AA30203010001
```

2. Configure Device B:

Enter the host public key of Device A in public key view. The key must be literally the same as displayed on Device A.

```
<DeviceB> system-view
[DeviceB] public-key peer devicea
Enter public key view. Return to system view with "peer-public-key end" command.
[DeviceB-pkey-public-key-devicea]30819F300D06092A864886F70D010101050003818D003081
8902818100DA3B90F59237347B
[DeviceB-pkey-public-key-devicea]8D41B58F8143512880139EC9111BFD31EB84B6B7C7A14700
27AC8F04A827B30C2CAF79242E
[DeviceB-pkey-public-key-devicea]45FDFF51A9C7E917DB818D54CB7AEF538AB261557524A744
1D288EC54A5D31EFAE4F681257
[DeviceB-pkey-public-key-devicea]6D7796490AF87A8C78F4A7E31F0793D8BA06FB95D54EBB9F
94EB1F2D561BF66EA27DFD4788
[DeviceB-pkey-public-key-devicea]CB47440AF6BB25ACA50203010001
```

Save the public key and return to system view.

```
[DeviceB-pkey-public-key-devicea] peer-public-key end
```

Verifying the configuration

Verify that the peer host public key configured on Device B is the same as the key displayed on Device A.

```
[DeviceB] display public-key peer name devicea


=========================================
Key name: devicea
Key type: RSA
Key modulus: 1024
Key code:
    30819F300D06092A864886F70D010101050003818D0030818902818100DA3B90F59237347B
    8D41B58F8143512880139EC9111BFD31EB84B6B7C7A1470027AC8F04A827B30C2CAF79242E
    45FDFF51A9C7E917DB818D54CB7AEF538AB261557524A7441D288EC54A5D31EFAE4F681257
    6D7796490AF87A8C78F4A7E31F0793D8BA06FB95D54EBB9F94EB1F2D561BF66EA27DFD4788
    CB47440AF6BB25ACA50203010001
```

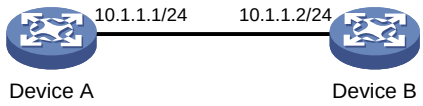
Example: Importing a public key from a public key file

Network configuration

As shown in Figure 3, Device B authenticates Device A through a digital signature. Before configuring authentication parameters on Device B, use the following procedure to configure the public key of Device A on Device B:

- Create RSA key pairs on Device A and export the RSA host public key to a file.
- Import the RSA host public key of Device A from the public key file to Device B.

Figure 3 Network diagram



Procedure

1. Configure Device A:

   # Create local RSA key pairs with the default names on Device A, and use the default key modulus length (1024 bits).

   ```
   <DeviceA> system-view
   [DeviceA] public-key local create rsa
   The range of public key modulus is (512 ~ 4096).
   If the key modulus is greater than 512, it will take a few minutes.
   Press CTRL+C to abort.
   Input the modulus length [default = 1024]:
   Generating Keys...
   ...
   Create the key pair successfully.
   ```

   # Display all local RSA public keys.

   ```
   [DeviceA] display public-key local rsa public
   =========================================
   ```

```
Key name: hostkey (default)
Key type: RSA
Time when key pair created: 16:48:31 2011/05/12
Key code:
   30819F300D06092A864886F70D010101050003818D0030818902818100DA3B90F59237347B
   8D41B58F8143512880139EC9111BFD31EB84B6B7C7A1470027AC8F04A827B30C2CAF79242E
   45FDFF51A9C7E917DB818D54CB7AEF538AB261557524A7441D288EC54A5D31EFAE4F681257
   6D7796490AF87A8C78F4A7E31F0793D8BA06FB95D54EBB9F94EB1F2D561BF66EA27DFD4788
   CB47440AF6BB25ACA50203010001
=========================================
Key name: serverkey (default)
Key type: RSA
Time when key pair created: 16:48:31 2011/05/12
Key code:
   307C300D06092A864886F70D0101010500036B003068026100C9451A80F7F0A9BA1A90C7BC
   1C02522D194A2B19F19A75D9EF02219068BD7FD90FCC2AF3634EEB9FA060478DD0A1A49ACE
   E1362A4371549ECD85BA04DEE4D6BB8BE53B6AED7F1401EE88733CA3C4CED391BAE633028A
   AC41C80A15953FB22AA30203010001
```

Export the RSA host public key to file **devicea.pub**.

```
[DeviceA] public-key local export rsa ssh2 devicea.pub
```

Enable the FTP server, create an FTP user with username **ftp** and password **hello12345**, and configure the FTP user role as **network-admin**.

```
[DeviceA] ftp server enable
[DeviceA] local-user ftp
[DeviceA-luser-manage-ftp] password simple hello12345
[DeviceA-luser-manage-ftp] service-type ftp
[DeviceA-luser-manage-ftp] authorization-attribute user-role network-admin
[DeviceA-luser-manage-ftp] quit
```

2. Configure Device B:

Use FTP in binary mode to get public key file **devicea.pub** from Device A.

```
<DeviceB> ftp 10.1.1.1
Connected to 10.1.1.1 (10.1.1.1).
220 FTP service ready.
User(10.1.1.1:(none)):ftp
331 Password required for ftp.
Password:
230 User logged in.
Remote system type is UNIX.
Using binary mode to transfer files.
ftp> binary
200 TYPE is now 8-bit binary
ftp> get devicea.pub
227 Entering Passive Mode (10,1,1,1,118,252)
150 Accepted data connection
226 File successfully transferred
301 bytes received in 0.003 seconds (98.0 kbyte/s)
ftp> quit
221-Goodbye. You uploaded 0 and downloaded 1 kbytes.
```

```
221 Logout.
```

Import the host public key from key file **devicea.pub**.

```
<DeviceB> system-view
[DeviceB] public-key peer devicea import sshkey devicea.pub
```

Verifying the configuration

Verify that the peer host public key configured on Device B is the same as the key displayed on Device A.

```
[DeviceB] display public-key peer name devicea
=========================================
Key name: devicea
Key type: RSA
Key modulus: 1024
Key code:
    30819F300D06092A864886F70D010101050003818D003081890281810 0DA3B90F59237347B
    8D41B58F8143512880139EC9111BFD31EB84B6B7C7A1470027AC8F04A827B30C2CAF79242E
    45FDFF51A9C7E917DB818D54CB7AEF538AB261557524A7441D288EC54A5D31EFAE4F681257
    6D7796490AF87A8C78F4A7E31F0793D8BA06FB95D54EBB9F94EB1F2D561BF66EA27DFD4788
    CB47440AF6BB25ACA50203010001
```

Contents

Configuring PKI

About PKI

Public Key Infrastructure (PKI) is an asymmetric key infrastructure to encrypt and decrypt data for securing network services.

PKI uses digital certificates to distribute and employ public keys, and provides network communication and e-commerce with security services such as user authentication, data confidentiality, and data integrity. For more information about public keys, see "Managing public keys."

PKI terminology

Digital certificate

A digital certificate is an electronic document signed by a CA that binds a public key with the identity of its owner.

A digital certificate includes the following information:

- Issuer name (name of the CA that issued the certificate).
- Subject name (name of the individual or group to which the certificate is issued).
- Identity information of the subject.
- Subject's public key.
- Signature of the CA.
- Validity period.

A digital certificate must comply with the international standards of ITU-T X.509, of which X.509 v3 is the most commonly used.

This chapter covers the following types of certificates:

- **CA certificate**—Certificate of a CA. Multiple CAs in a PKI system form a CA tree, with the root CA at the top. The root CA generates a self-signed certificate, and each lower level CA holds a CA certificate issued by the CA immediately above it. The chain of these certificates forms a chain of trust.
- **Registration authority (RA) certificate**—Certificate issued by a CA to an RA. RAs act as proxies for CAs to process enrollment requests in a PKI system.
- **Local certificate**—Digital certificate issued by a CA to a local PKI entity, which contains the entity's public key.
- **Peer certificate**—CA-signed digital certificate of a peer, which contains the peer's public key.

Fingerprint of root CA certificate

Each root CA certificate has a unique fingerprint, which is the hash value of the certificate content. The fingerprint of a root CA certificate can be used to authenticate the validity of the root CA.

Certificate revocation list

A certificate revocation list (CRL) is a list of serial numbers for certificates that have been revoked. A CRL is created and signed by the CA that originally issued the certificates.

The CA publishes CRLs periodically to revoke certificates. Entities that are associated with the revoked certificates should not be trusted.

The CA must revoke a certificate when any of the following conditions occurs:

- The certificate subject name is changed.
- The private key is compromised.
- The association between the subject and CA is changed. For example, when an employee terminates employment with an organization.

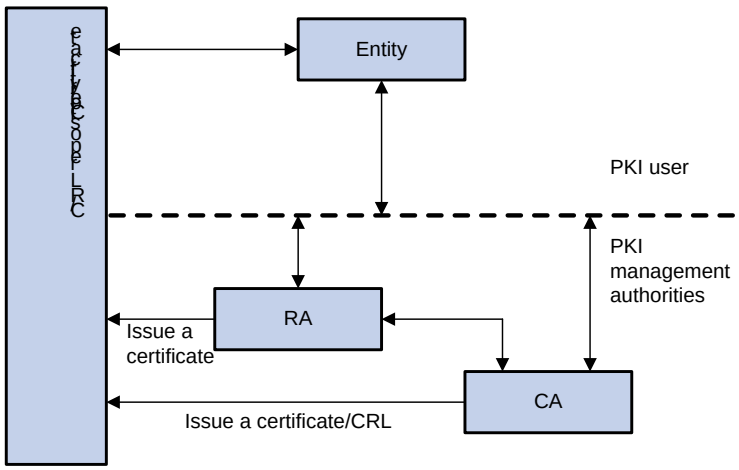
CA policy

A CA policy is a set of criteria that a CA follows to process certificate requests, to issue and revoke certificates, and to publish CRLs. Typically, a CA advertises its policy in a certification practice statement (CPS). You can obtain a CA policy through out-of-band means such as phone, disk, and email. Make sure you understand the CA policy before you select a trusted CA for certificate request because different CAs might use different policies.

PKI architecture

A PKI system consists of PKI entities, CAs, RAs and a certificate/CRL repository, as shown in Figure 1.

Figure 1 PKI architecture



PKI entity

A PKI entity is an end user using PKI certificates. The PKI entity can be an operator, an organization, a device like a router or a switch, or a process running on a computer. PKI entities use SCEP to communicate with the CA or RA.

CA

Certification authority that grants and manages certificates. A CA issues certificates, defines the certificate validity periods, and revokes certificates by publishing CRLs.

RA

Registration authority, which offloads the CA by processing certificate enrollment requests. The RA accepts certificate requests, verifies user identity, and determines whether to ask the CA to issue certificates.

The RA is optional in a PKI system. In cases when there is security concern over exposing the CA to direct network access, it is advisable to delegate some of the tasks to an RA. Then, the CA can concentrate on its primary tasks of signing certificates and CRLs.

Certificate/CRL repository

A certificate distribution point that stores certificates and CRLs, and distributes these certificates and CRLs to PKI entities. It also provides the query function. A PKI repository can be a directory server using the LDAP or HTTP protocol, of which LDAP is commonly used.

Retrieval, usage, and maintenance of a digital certificate

The following workflow describes the retrieval, usage, and maintenance of a digital certificate. This example uses a CA which has an RA to process certificate enrollment requests.

1. A PKI entity generates an asymmetric key pair and submits a certificate request to the RA.

   The certificate request contains the public key and its identity information.
2. The RA verifies the identity of the entity and sends a digital signature containing the identity information and the public key to the CA.
3. The CA verifies the digital signature, approves the request, and issues a certificate.
4. After receiving the certificate from the CA, the RA sends the certificate to the certificate repository and notifies the PKI entity that the certificate has been issued.
5. The PKI entity obtains the certificate from the certificate repository.
6. To establish a secure connection for communication, two PKI entities exchange local certificates to authenticate each other. The connection can be established only if both entities verify that the peer's certificate is valid.
7. You can remove the local certificate of a PKI entity and request a new one when any of the following conditions occur:
   - The local certificate is about to expire.
   - The certificate's private key is compromised.

PKI applications

The PKI technology can meet security requirements of online transactions. As an infrastructure, PKI has a wide range of applications. H3C's PKI system can provide certificate management for IPsec and SSL.

The following are some application examples.

VPN

A VPN is a private data communication network built on the public communication infrastructure. A VPN can use network layer security protocols (for example, IPsec) in conjunction with PKI-based encryption and digital signature technologies for confidentiality.

Secure emails

PKI can address the email requirements for confidentiality, integrity, authentication, and non-repudiation. A common secure email protocol is Secure/Multipurpose Internet Mail Extensions (S/MIME), which is based on PKI and allows for transfer of encrypted mails with signature.

Web security

PKI can be used in the SSL handshake phase to verify the identities of the communicating parties by digital certificates.

FIPS compliance

The device supports the FIPS mode that complies with NIST FIPS 140-2 requirements. Support for features, commands, and parameters might differ in FIPS mode (see "Configuring FIPS") and non-FIPS mode.

PKI tasks at a glance

To configure PKI, perform the following tasks:

1. Configuring a PKI entity
2. Configuring a PKI domain
3. (Optional.) Specifying the storage path for certificates and CRLs
4. Requesting a certificate

   Choose one of the following tasks:
   - Enabling the automatic online certificate request mode
   - Manually submitting an online certificate request
   - Manually submitting a certificate request in offline mode
5. (Optional.) Aborting a certificate request
6. (Optional.) Obtaining certificates

   You can obtain the CA certificate, local certificates, and peer certificates related to a PKI domain from a CA and save them locally for higher lookup efficiency.
7. (Optional.) Verifying PKI certificates
8. (Optional.) Exporting certificates
9. (Optional.) Removing a certificate
10. (Optional.) Configuring a certificate-based access control policy

    Certificate-based access control policies allow you to authorize access to a device (for example, an HTTPS server) based on the attributes of an authenticated client's certificate.

Configuring a PKI entity

About PKI entities

A certificate applicant uses an entity to provide its identity information to a CA. A valid PKI entity must include one or more of following identity categories:

- Distinguished name (DN) of the entity, which further includes the common name, country code, locality, organization, unit in the organization, and state. If you configure the DN for an entity, a common name is required.
- FQDN of the entity.
- IP address of the entity.

Restrictions and guidelines

Follow these restrictions and guidelines when you configure a PKI entity:

- Whether the identity categories are required or optional depends on the CA policy. Follow the CA policy to configure the entity settings. For example, if the CA policy requires the entity DN, but you configure only the IP address, the CA rejects the certificate request from the entity.
- The SCEP add-on on the Windows 2000 CA server has restrictions on the data length of a certificate request. If a request from a PKI entity exceeds the data length limit, the CA server does not respond to the certificate request. In this case, you can use an out-of-band means to submit the request. Other types of CA servers, such as RSA servers and OpenCA servers, do not have such restrictions.

Procedure

1. Enter system view.

   `system-view`
2. Create a PKI entity and enter its view.

   `pki entity` *`entity-name`*
3. Set a common name for the entity.

   `common-name` *`common-name-sting`*

By default, the common name is not set.

4. Set the country code of the entity.
   country *country-code-string*
   By default, the country code is not set.
5. Set the locality of the entity.
   locality *locality-name*
   By default, the locality is not set.
6. Set the organization of the entity.
   organization *org-name*
   By default, the organization is not set.
7. Set the unit of the entity in the organization.
   organization-unit *org-unit-name*
   By default, the unit is not set.
8. Set the state where the entity resides.
   state *state-name*
   By default, the state is not set.
9. Set the FQDN of the entity.
   fqdn *fqdn-name-string*
   By default, the FQDN is not set.
10. Configure the IP address of the entity.
    ip { *ip-address* | **interface** *interface-type interface-number* }
    By default, the IP address is not configured.

Configuring a PKI domain

About PKI domain

A PKI domain contains enrollment information for a PKI entity. It is locally significant and is intended only for use by other applications like IKE and SSL.

PKI domain tasks at a glance

To configure a PKI domain, perform the following tasks:

1. Creating a PKI domain
2. Specifying the trusted CA
3. Specifying the PKI entity name
4. Specifying the certificate request reception authority
5. Specifying the certificate request URL
6. (Optional.) Setting the SCEP polling interval and maximum polling attempts
7. Specifying the LDAP server

   This task is required when either of the following conditions is met:

   - The device must obtain certificates from the CA by using the LDAP protocol.
   - An LDAP URL which does not contain the host name of the LDAP server is specified as the CRL repository URL.
8. Specifying the fingerprint for root CA certificate verification

This step is required if the auto certificate request mode is configured in the PKI domain.

If the manual certificate request mode is configured, you can skip this step and manually verify the fingerprint displayed during verification of the root CA certificate.

9. Specifying the key pair for certificate request
10. (Optional.) Specifying the intended purpose for the certificate
11. (Optional.) Specifying the source IP address for PKI protocol packets

Creating a PKI domain

1. Enter system view.
   system-view
2. Create a PKI domain and enter its view.
   pki domain *domain-name*

Specifying the trusted CA

About specifying the trusted CA

The PKI domain must have a CA certificate before you can request a local certificate. To obtain a CA certificate, the trusted CA name must be specified. The trusted CA name uniquely identifies the CA to be used if multiple CAs exist on the CA server.

Procedure

1. Enter system view.
   system-view
2. Enter PKI domain view.
   pki domain *domain-name*
3. Specify the trusted CA name.
   ca identifier *name*

   By default, no trusted CA name is specified.

Specifying the PKI entity name

1. Enter system view.
   system-view
2. Enter PKI domain view.
   pki domain *domain-name*
3. Specify the PKI entity name.
   certificate request entity *entity-name*

   By default, no PKI entity name is specified.

Specifying the certificate request reception authority

1. Enter system view.
   system-view
2. Enter PKI domain view.
   pki domain *domain-name*
3. Specify the certificate request reception authority.

certificate request from { **ca** | **ra** }

By default, no certificate request reception authority is specified.

Specifying the certificate request URL

1. Enter system view.

   system-view
2. Enter PKI domain view.

   pki domain *domain-name*
3. Specify the URL of the certificate request reception authority to which the device sends certificate requests.

   certificate request url *url-string*

   By default, the certificate request URL is not specified.

Setting the SCEP polling interval and maximum polling attempts

1. Enter system view.

   system-view
2. Enter PKI domain view.

   pki domain *domain-name*
3. Set the SCEP polling interval and maximum number of polling attempts.

   certificate request polling { **count** *count* | **interval** *interval* }

   By default, the device polls the CA server for the certificate request status every 20 minutes. The maximum number of polling attempts is 50.

Specifying the LDAP server

1. Enter system view.

   system-view
2. Enter PKI domain view.

   pki domain *domain-name*
3. Specify the LDAP server.

   ldap-server host *hostname* [**port** *port-number*]

   By default, no LDAP server is specified.

Specifying the fingerprint for root CA certificate verification

1. Enter system view.

   system-view
2. Enter PKI domain view.

   pki domain *domain-name*
3. Configure the fingerprint for verifying the root CA certificate.

   In non-FIPS mode:

   root-certificate fingerprint { **md5** | **sha1** } *string*

   In FIPS mode:

root-certificate fingerprint sha1 *string*

By default, no fingerprint is configured.

Specifying the key pair for certificate request

Restrictions and guidelines

You can specify a nonexistent key pair for certificate request. The PKI entity automatically creates the key pair before submitting a certificate request.

Procedure

1. Enter system view.

   system-view

2. Enter PKI domain view.

   pki domain *domain-name*

3. Specify the key pair for certificate request.
   - Specify an RSA key pair.

     public-key rsa { { **encryption name** *encryption-key-name* [**length** *key-length*] | **signature name** *signature-key-name* [**length** *key-length*] } * | **general name** *key-name* [**length** *key-length*] }
   - Specify an ECDSA key pair.

     In non-FIPS mode:

     public-key ecdsa name *key-name* [**secp192r1** | **secp256r1** | **secp384r1** | **secp521r1**]

     In FIPS mode:

     public-key ecdsa name *key-name* [**secp256r1** | **secp384r1** | **secp521r1**]
   - Specify a DSA key pair.

     public-key dsa name *key-name* [**length** *key-length*]

   By default, no key pair is specified.

Specifying the intended purpose for the certificate

About specifying the intended purpose for a certificate

An issued certificate contains the extensions which restrict the usage of the certificate to specific purposes. You can specify the intended purposes for a certificate, which will be included in the certificate request sent to the CA. However, the actual extensions contained in an issued certificate depend on the CA policy, and they might be different from those specified in the PKI domain. Whether an application will use the certificate during authentication depends on the application's policy.

Supported certificate extensions include:

- **ike**—Certificates carrying this extension can be used by IKE peers.
- **ssl-client**—Certificates carrying this extension can be used by SSL clients.
- **ssl-server**—Certificates carrying this extension can be used by SSL servers.

Procedure

1. Enter system view.

   system-view

2. Enter PKI domain view.

pki domain *domain-name*

3. Specify the intended use for the certificate.

   usage { **ike** | **ssl-client** | **ssl-server** } *

   By default, the certificate can be used by all supported applications, including IKE, SSL client, and SSL server.

Specifying the source IP address for PKI protocol packets

About specifying the source IP address for PKI protocol packets

This task is required if the CA policy requires that the CA server accept certificate requests from a specific IP address or subnet.

Procedure

1. Enter system view.

   system-view

2. Enter PKI domain view.

   pki domain *domain-name*

3. Specify a source IP address for the PKI protocol packets.

   IPv4:

   source ip { *ip-address* | **interface** *interface-type interface-number* }

   IPv6:

   source ipv6 { *ipv6-address* | **interface** *interface-type interface-number* }

   By default, the source IP address of PKI protocol packets is the IP address of their outgoing interface.

Specifying the storage path for certificates and CRLs

About specifying the storage path for certificates and CRLs

The device has a default storage path for certificates and CRLs. You can change the storage path and specify different paths for the certificates and CRLs.

After you change the storage path for certificates or CRLs, the certificate files and CRL files in the original path are moved to the new path. Certificate files use the .cer or .p12 file extension and CRL files use the .crl file extension.

Restrictions and guidelines

If you change the storage path, save the configuration before you reboot or shut down the device to avoid loss of certificates or CRLs.

Procedure

1. Enter system view.

   system-view

2. Specify the storage path for certificates and CRLs.

   pki storage { **certificates** | **crls** } *dir-path*

   By default, the device stores certificates and CRLs in the PKI directory on the storage media of the device.

Requesting a certificate

About certificate request configuration

To request a certificate, a PKI entity must provide its identity information and public key to a CA.

A certificate request can be submitted to a CA in offline or online mode.

- **Offline mode**—A certificate request is submitted by using an out-of-band method, such as phone, disk, or email.
- **Online mode**—A certificate request can be automatically or manually submitted to a CA through the Simple Certificate Enrollment Protocol (SCEP).

Restrictions and guidelines for certificate request configuration

When you request a local certificate in a PKI domain, follow these restrictions and guidelines:

- To prevent an existing local certificate from becoming invalid, do not perform the following tasks:
  - Create a key pair with the same name as the key pair contained in the certificate.

    To create a key pair, use the **`public-key local create`** command.
  - Destroy the key pair contained in the certificate.

    To destroy a key pair, use the **`public-key local destroy`** command.
- To manually request a new certificate in a PKI domain that already has a local certificate, use the following procedure:
  a. Use the **`pki delete-certificate`** command to delete the existing local certificate.
  b. Use the **`public-key local create`** command to generate a new key pair.
  c. Manually submit a certificate request.
- A PKI domain can have local certificates using only one type of cryptographic algorithms (DSA, ECDSA, or RSA). If DSA or ECDSA is used, a PKI domain can have only one local certificate. If RSA is used, a PKI domain can have one local certificate for signature, and one local certificate for encryption.

Prerequisites for certificate request configuration

Make sure the device is time synchronized with the CA server. If the device is not time synchronized with the CA server, the certificate request might fail because the certificate might be considered to be outside of the validity period. For information about configuring the system time, see *Fundamentals Configuration Guide*.

Enabling the automatic online certificate request mode

About automatic online certificate request mode

In auto request mode, a PKI entity with no local certificates automatically submits a certificate request to the CA when an application works with the PKI entity. For example, when IKE negotiation uses a digital signature for identity authentication, but no local certificate is available, the entity automatically submits a certificate request. It saves the certificate locally after obtaining the certificate from the CA.

A CA certificate must be present before you request a local certificate. If no CA certificate exists in the PKI domain, the PKI entity automatically obtains a CA certificate before sending a certificate request.

Restrictions and guidelines

In auto request mode, the device does not automatically request a new certificate if the current certificate is about to expire or has expired, which might cause service interruptions.

Procedure

1. Enter system view.
   system-view
2. Enter PKI domain view.
   pki domain *domain-name*
3. Enable the automatic online certificate request mode.
   certificate request mode auto [**password** { **cipher** | **simple** } *string*]
   By default, the manual request mode applies.
   If the CA policy requires a password for certificate revocation, specify the password in this command.

Manually submitting an online certificate request

About manual online certificate request mode

In manual request mode, you must execute the **pki request-certificate domain** command to request a local certificate in a PKI domain. The certificate will be saved in the domain after it is obtained from the CA.

Procedure

1. Enter system view.
   system-view
2. Enter PKI domain view.
   pki domain *domain-name*
3. Set the certificate request mode to manual.
   certificate request mode manual
   By default, the manual request mode applies.
4. Return to system view.
   quit
5. Obtain a CA certificate.
   See "Obtaining certificates."
   This step is required if the PKI domain does not have a CA certificate. The CA certificate is used to verify the authenticity and validity of the obtained local certificate.
6. Manually submit an SCEP certificate request.
   pki request-certificate domain *domain-name* [**password** *password*]
   This command is not saved in the configuration file.
   If the CA policy requires a password for certificate revocation, specify the password in this command.

Manually submitting a certificate request in offline mode

About certificate request submission in offline mode

Use this method if the CA does not support SCEP or if a network connection between the device and CA is not possible.

Procedure

1. Enter system view.

   system-view
2. Enter PKI domain view.

   pki domain *domain-name*
3. Set the certificate request mode to manual.

   certificate request mode manual

   By default, the manual request mode applies.
4. Return to system view.

   quit
5. Obtain the CA certificate.

   See "Obtaining certificates."

   This step is required if the PKI domain does not have a CA certificate. The CA certificate is used to verify the authenticity and validity of the obtained local certificate.
6. Print the certificate request in PKCS10 format on the terminal or save the certificate request to a PKCS10 file.

   pki request-certificate domain *domain-name* **pkcs10** [**filename** *filename*]

   This command is not saved in the configuration file.
7. Transfer certificate request information to the CA by using an out-of-band method.
8. Transfer the issued local certificate from the CA to the local device by using an out-of-band method.
9. Import the local certificate to the PKI domain.

   pki import domain *domain-name* { **der local filename** *filename* | **p12 local filename** *filename* | **pem local** } [**filename** *filename*] }

Aborting a certificate request

About aborting a certificate request

Before the CA issues a certificate, you can abort a certificate request and change its parameters, such as the common name, country code, or FQDN. You can use the **display pki certificate request-status** command to display the status of a certificate request.

Alternatively, you also can remove a PKI domain to abort the associated certificate request.

Procedure

1. Enter system view.

   system-view
2. Abort a certificate request.

   pki abort-certificate-request domain *domain-name*

   This command is not saved in the configuration file.

Obtaining certificates

About certificate obtaining

You can obtain the CA certificate, local certificates, and peer certificates related to a PKI domain from a CA and save them locally for higher lookup efficiency. To do so, use either the offline mode or the online mode:

- In offline mode, obtain the certificates by an out-of-band means like FTP, disk, or email, and then import them locally. Use this mode when the CRL repository is not specified, the CA server does not support SCEP, or the CA server generates the key pair for the certificates.
- In online mode, you can obtain the CA certificate through SCEP and obtain local certificates or peer certificates through LDAP.

Restrictions and guidelines

Follow these restrictions and guidelines when obtain certificates from a CA

- If a CA certificate already exists locally, you cannot obtain it again in online mode. If you want to obtain a new CA certificate, use the **pki delete-certificate** command to delete the existing CA certificate and local certificates first.
- If local or peer certificates already exist, you can obtain new local or peer certificates to overwrite the existing ones. If RSA is used, a PKI domain can have two local certificates, one for signature and the other for encryption.
- If CRL checking is enabled, obtaining a certificate triggers CRL checking. If the certificate to be obtained has been revoked, the certificate cannot be obtained.
- The device compares the validity period of a certificate with the local system time to determine whether the certificate is valid. Make sure the system time of the device is synchronized with the CA server.

Prerequisites

- Before you obtain local or peer certificates in online mode, make sure an LDAP server is correctly configured in the PKI domain.
- Before you import certificates in offline mode, complete the following tasks:
  - Use FTP or TFTP to upload the certificate files to the storage media of the device.

    If FTP or TFTP is not available, display and copy the contents of a certificate to a file on the device. Make sure the certificate is in PEM format because only certificates in PEM format can be imported.
  - Before you import a local certificate or peer certificate, obtain the CA certificate chain that signs the certificate.

    This step is required only if the CA certificate chain is neither available in the PKI domain nor contained in the certificate to be imported.
  - Before you import a local certificate that contains an encrypted key pair, contact the CA administrator to obtain the password required for importing the certificate.

Procedure

1. Enter system view.

   system-view
2. Obtain certificates.
   - Import certificates in offline mode.

     pki import domain *domain-name* { **der** { **ca** | **local** | **peer** } **filename** *filename* | **p12 local filename** *filename* | **pem** { **ca** | **local** | **peer** } [**filename** *filename*] }
   - Obtain certificates in online mode.

pki retrieve-certificate domain *domain-name* { **ca** | **local** | **peer** *entity-name* }

This command is not saved in the configuration file.

Verifying PKI certificates

About certification verification

A certificate is automatically verified when it is requested, obtained, or used by an application. If the certificate expires, if it is not issued by a trusted CA, or if it is revoked, the certificate cannot be used You can also manually verify a certificate.

You can enable or disable CRL checking in a PKI domain. CRL checking checks whether a certificate is in the CRL. If it is, the certificate has been revoked and its home entity is not trusted.

To use CRL checking, a CRL must be obtained from a CRL repository. The device selects a CRL repository in the following order:

1. CRL repository specified in the PKI domain by using the **crl url** command.
2. CRL repository in the certificate that is being verified.
3. CRL repository in the CA certificate or CRL repository in the upper-level CA certificate if the certificate being verified is a CA certificate

If no CRL repository is found after the selection process, the device obtains the CRL through SCEP. In this scenario, the CA certificate and the local certificates must have been obtained.

A certificate fails CRL checking in the following situations:

- A CRL cannot be obtained during CRL checking of the certificate.
- CRL checking verifies that the certificate has been revoked.

Restrictions and guidelines for certificate verification

When verifying the CA certificate of a PKI domain, the system needs to verify all the certificates in the CA certificate chain. To ensure a successful certificate verification process, the device must have all the PKI domains to which the CA certificates in the certificate chain belong.

The system verifies the CA certificates in the CA certificate chain as follows:

1. Identifies the parent certificate of the lowest-level certificate.

   Each CA certificate contains an issuer field that identifies the parent CA that issued the certificate.
2. Locates the PKI domain to which the parent certificate belongs.
3. Performs CRL checking in the PKI domain to check whether the parent certificate has been revoked. If it has been revoked, the certificate cannot be used.

   This step will not be performed when CRL checking is disabled in the PKI domain.
4. Repeats the previous steps for upper-level certificates in the CA certificate chain until the root CA certificate is reached.
5. Verifies that each CA certificate in the certificate chain is issued by the named parent CA, starting from the root CA.

Verifying certificates with CRL checking

1. Enter system view.

   system-view

2. Enter PKI domain view.
   pki domain *domain-name*
3. (Optional.) Specify the URL of the CRL repository.
   crl url *url-string*
   By default, the URL of the CRL repository is not specified.
4. Enable CRL checking.
   crl check enable
   By default, CRL checking is enabled.
5. Return to system view.
   quit
6. Obtain the CA certificate.
   See "Obtaining certificates."
   The PKI domain must have a CA certificate before you can verify certificates in it.
7. (Optional.) Obtain the CRL and save it locally.
   pki retrieve-crl domain *domain-name*
   To verify a non-root CA certificate and local certificates, the device automatically retrieves the CRL if the PKI domain has no CRL.
   The newly obtained CRL overwrites the old one, if any.
   The obtained CRL is issued by a CA in the CA certificate chain stored in the PKI domain.
8. Manually verify the validity of the certificates.
   pki validate-certificate domain *domain-name* { **ca** | **local** }

Verifying certificates without CRL checking

1. Enter system view.
   system-view
2. Enter PKI domain view.
   pki domain *domain-name*
3. Disable CRL checking.
   undo crl check enable
   By default, CRL checking is enabled.
4. Return to system view.
   quit
5. Obtain a CA certificate for the PKI domain.
   See "Obtaining certificates."
   The PKI domain must have a CA certificate before you can verify certificates in it.
6. Manually verify the certificate validity.
   pki validate-certificate domain *domain-name* { **ca** | **local** }
   This command is not saved in the configuration file.

Exporting certificates

About exporting certificates

You can export the CA certificate and the local certificates in a PKI domain to certificate files. The exported certificate files can then be imported back to the device or other PKI applications.

Restrictions and guidelines

To export all certificates in PKCS12 format, the PKI domain must have a minimum of one local certificate. If the PKI domain does not have any local certificates, the certificates in the PKI domain cannot be exported.

If you do not specify a file name when you export a certificate in PEM format, this command displays the certificate content on the terminal.

When you export a local certificate with RSA key pairs to a file, the certificate file name might be different from the file name specified in the command. The actual certificate file name depends on the purpose of the key pair contained in the certificate. For more information about the file naming rule, see the **pki export** command in *Security Command Reference*.

Procedure

1. Enter system view.

   system-view

2. Export certificates.
   - Export certificates in DER format.

     pki export domain *domain-name* **der** { **all** | **ca** | **local** } **filename** *filename*
   - Export certificates in PKCS12 format.

     pki export domain *domain-name* **p12** { **all** | **local** } **passphrase** *p12-key* **filename** *filename*
   - Export certificates in PEM format.

     pki export domain *domain-name* **pem** { { **all** | **local** } [{ **3des-cbc** | **aes-128-cbc** | **aes-192-cbc** | **aes-256-cbc** | **des-cbc** } *pem-key*] | **ca** } [**filename** *filename*]

Removing a certificate

About certificate removal

You can remove certificates from a PKI domain in the following situations:

- Remove a CA certificate, local certificate, or peer certificate if the certificate has expired or is about to expire.
- Remove a local certificate if the certificate's private key is compromised, or if you want to request a new local certificate to replace the existing one.

Restrictions and guidelines

After you remove the CA certificate, the system automatically removes the local certificates, peer certificates, and CRLs from the domain.

To remove a local certificate and request a new certificate, perform the following tasks:

1. Remove the local certificate.
2. Use the **public-key local destroy** command to destroy the existing local key pair.
3. Use the **public-key local create** command to generate a new key pair.
4. Request a new certificate.

For more information about the **public-key local destroy** and **public-key local create** commands, see *Security Command Reference*.

Procedure

1. Enter system view.

   system-view

2. Remove a certificate.

   pki delete-certificate domain *domain-name* { **ca** | **local** | **peer** [**serial** *serial-num*] }

   If you use the **peer** keyword without specifying a serial number, this command removes all peer certificates.

Configuring a certificate-based access control policy

About certificate-based access control policies

Certificate-based access control policies allow you to authorize access to a device (for example, an HTTPS server) based on the attributes of an authenticated client's certificate.

Access control rules and certificate attribute groups

A certificate-based access control policy is a set of access control rules (permit or deny statements), each associated with a certificate attribute group. A certificate attribute group contains multiple attribute rules, each defining a matching criterion for an attribute in the certificate issuer name, subject name, or alternative subject name field.

Certificate matching mechanism

If a certificate matches all attribute rules in a certificate attribute group associated with an access control rule, the system determines that the certificate matches the access control rule. In this scenario, the match process stops, and the system performs the access control action defined in the access control rule.

The following conditions describe how a certificate-based access control policy verifies the validity of a certificate:

- If a certificate matches a permit statement, the certificate passes the verification.
- If a certificate matches a deny statement or does not match any statements in the policy, the certificate is regarded invalid.
- If a statement is associated with a non-existing attribute group, or the attribute group does not have attribute rules, the certificate matches the statement.
- If the certificate-based access control policy specified for a security application (for example, HTTPS) does not exist, all certificates in the application pass the verification.

Procedure

1. Enter system view.

   system-view

2. Create a certificate attribute group and enter its view.

   pki certificate attribute-group *group-name*

3. Configure an attribute rule for issuer name, subject name, or alternative subject name.

   attribute *id* { **alt-subject-name** { **fqdn** | **ip** } | { **issuer-name** | **subject-name** } { **dn** | **fqdn** | **ip** } } { **ctn** | **equ** | **nctn** | **nequ**} *attribute-value*

   By default, not attribute rules are configured.

4. Return to system view.

   quit

5. Create a certificate-based access control policy and enter its view.

pki certificate access-control-policy *policy-name*

By default, no certificate-based access control policies exist.

6. Create a certificate access control rule.

   rule [*id*] { **deny** | **permit** } *group-name*

   By default, no certificate access control rules are configured, and all certificates can pass the verification.

   You can create multiple certificate access control rules for a certificate-based access control policy.

Display and maintenance commands for PKI

Execute **display** commands in any view.

Task	Command
Display certificate-based access control policy information.	**display pki certificate access-control-policy** [*policy-name*]
Display certificate attribute group information.	**display pki certificate attribute-group** [*group-name*]
Display the contents of a certificate.	**display pki certificate domain** *domain-name* { **ca** | **local** | **peer** [**serial** *serial-num*] }
Display certificate request status.	**display pki certificate request-status** [**domain** *domain-name*]
Display locally stored CRLs in a PKI domain.	**display pki crl domain** *domain-name*

PKI configuration examples

You can use different software applications, such as Windows server, RSA Keon, and OpenCA, to act as the CA server.

If you use Windows server or OpenCA, you must install the SCEP add-on for Windows server or enable SCEP for OpenCA. In either case, when you configure a PKI domain, you must use the **certificate request from ra** command to specify the RA to accept certificate requests.

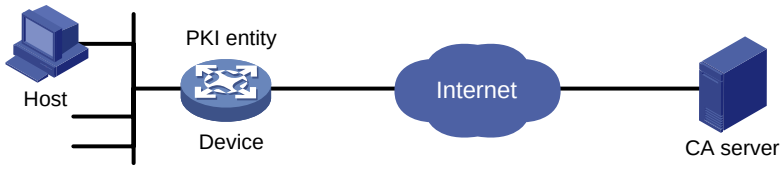
If you use RSA Keon, the SCEP add-on is not required. When you configure a PKI domain, you must use the **certificate request from ca** command to specify the CA to accept certificate requests.

Example: Requesting a certificate from an RSA Keon CA server

Network configuration

Configure the PKI entity (the device) to request a local certificate from the CA server.

Figure 2 Network diagram



Configuring the RSA Keon CA server

1. Create a CA server named **myca**:

   In this example, you must configure these basic attributes on the CA server:

   - **Nickname**—Name of the trusted CA.
   - **Subject DN**—DN attributes of the CA, including the common name (CN), organization unit (OU), organization (O), and country (C).

   You can use the default values for other attributes.

2. Configure extended attributes:

   Configure parameters in the **Jurisdiction Configuration** section on the management page of the CA server:

   - Select the correct extension profiles.
   - Enable the SCEP autovetting function to enable the CA server to automatically approve certificate requests without manual intervention.
   - Specify the IP address list for SCEP autovetting.

Configuring the device

1. Synchronize the system time of the device with the CA server for the device to correctly request certificates or obtain CRLs. (Details not shown.)
2. Create an entity named **aaa** and set the common name to **Device**.

   ```
   <Device> system-view
   [Device] pki entity aaa
   [Device-pki-entity-aaa] common-name Device
   [Device-pki-entity-aaa] quit
   ```

3. Configure a PKI domain:

   # Create a PKI domain named **torsa** and enter its view.

   ```
   [Device] pki domain torsa
   ```

   # Specify the name of the trusted CA. The setting must be the same as CA name configured on the CA server. This example uses **myca**.

   ```
   [Device-pki-domain-torsa] ca identifier myca
   ```

   # Configure the URL of the CA server. The URL format is **http://***host:port*/*Issuing Jurisdiction ID*, where *Issuing Jurisdiction ID* is a hexadecimal string generated on the CA server.

   ```
   [Device-pki-domain-torsa] certificate request url
   http://1.1.2.22:446/80f6214aa8865301d07929ae481c7ceed99f95bd
   ```

   # Configure the device to send certificate requests to **ca**.

   ```
   [Device-pki-domain-torsa] certificate request from ca
   ```

   # Set the PKI entity name to **aaa**.

   ```
   [Device-pki-domain-torsa] certificate request entity aaa
   ```

   # Specify the URL of the CRL repository.

   ```
   [Device-pki-domain-torsa] crl url ldap://1.1.2.22:389/CN=myca
   ```

   # Specify a 1024-bit general-purpose RSA key pair named **abc** for certificate request.

```
[Device-pki-domain-torsa] public-key rsa general name abc length 1024
[Device-pki-domain-torsa] quit
```

4. Generate the RSA key pair.

```
[Device] public-key local create rsa name abc
The range of public key modulus is (512 ~ 4096).
If the key modulus is greater than 512,it will take a few minutes.
Press CTRL+C to abort.
Input the modulus length [default = 1024]:
Generating Keys...
.........................++++++
.....................................++++++
Create the key pair successfully.
```

5. Request a local certificate:

Obtain the CA certificate and save it locally.

```
[Device] pki retrieve-certificate domain torsa ca
The trusted CA's finger print is:
    MD5  fingerprint:EDE9 0394 A273 B61A F1B3 0072 A0B1 F9AB
    SHA1 fingerprint: 77F9 A077 2FB8 088C 550B A33C 2410 D354 23B2 73A8
Is the finger print correct?(Y/N):y
Retrieved the certificates successfully.
```

Submit a certificate request manually and set the certificate revocation password to **1111**. The certificate revocation password is required when an RSA Keon CA server is used.

```
[Device] pki request-certificate domain torsa password 1111
Start to request general certificate ...
……
Request certificate of domain torsa successfully
```

Verifying the configuration

Display information about the local certificate in PKI domain **torsa**.

```
[Device] display pki certificate domain torsa local
Certificate:
    Data:
        Version: 3 (0x2)
        Serial Number:
            15:79:75:ec:d2:33:af:5e:46:35:83:bc:bd:6e:e3:b8
        Signature Algorithm: sha1WithRSAEncryption
        Issuer: CN=myca
        Validity
            Not Before: Jan  6 03:10:58 2013 GMT
            Not After : Jan  6 03:10:58 2014 GMT
        Subject: CN=Device
        Subject Public Key Info:
            Public Key Algorithm: rsaEncryption
                Public-Key: (1024 bit)
                Modulus:
                    00:ab:45:64:a8:6c:10:70:3b:b9:46:34:8d:eb:1a:
                    a1:b3:64:b2:37:27:37:9d:15:bd:1a:69:1d:22:0f:
                    3a:5a:64:0c:8f:93:e5:f0:70:67:dc:cd:c1:6f:7a:
                    0c:b1:57:48:55:81:35:d7:36:d5:3c:37:1f:ce:16:
```

```
                    7e:f8:18:30:f6:6b:00:d6:50:48:23:5c:8c:05:30:
                    6f:35:04:37:1a:95:56:96:21:95:85:53:6f:f2:5a:
                    dc:f8:ec:42:4a:6d:5c:c8:43:08:bb:f1:f7:46:d5:
                    f1:9c:22:be:f3:1b:37:73:44:f5:2d:2c:5e:8f:40:
                    3e:36:36:0d:c8:33:90:f3:9b
                Exponent: 65537 (0x10001)
        X509v3 extensions:
            X509v3 CRL Distribution Points:

                Full Name:
                  DirName: CN = myca

    Signature Algorithm: sha1WithRSAEncryption
        b0:9d:d9:ac:a0:9b:83:99:bf:9d:0a:ca:12:99:58:60:d8:aa:
        73:54:61:4b:a2:4c:09:bb:9f:f9:70:c7:f8:81:82:f5:6c:af:
        25:64:a5:99:d1:f6:ec:4f:22:e8:6a:96:58:6c:c9:47:46:8c:
        f1:ba:89:b8:af:fa:63:c6:c9:77:10:45:0d:8f:a6:7f:b9:e8:
        25:90:4a:8e:c6:cc:b8:1a:f8:e0:bc:17:e0:6a:11:ae:e7:36:
        87:c4:b0:49:83:1c:79:ce:e2:a3:4b:15:40:dd:fe:e0:35:52:
        ed:6d:83:31:2c:c2:de:7c:e0:a7:92:61:bc:03:ab:40:bd:69:
        1b:f5
```

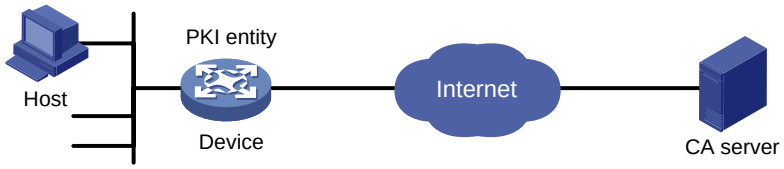
To display detailed information about the CA certificate, use the **display pki certificate domain** command.

Example: Requesting a certificate from a Windows Server 2003 CA server

Network configuration

Configure the PKI entity (the device) to request a local certificate from a Windows Server 2003 CA server.

Figure 3 Network diagram



Configuring the Windows Server 2003 CA server

1. Install the certificate service component:
   a. Select **Control Panel** > **Add or Remove Programs** from the start menu.
   b. Select **Add/Remove Windows Components** > **Certificate Services**.
   c. Click **Next** to begin the installation.
   d. Set the CA name. In this example, set the CA name to **myca**.
2. Install the SCEP add-on:

   By default, Windows Server 2003 does not support SCEP. You must install the SCEP add-on on the server for a PKI entity to register and obtain a certificate from the server. After the SCEP

add-on installation is complete, you will see a URL. Specify this URL as the certificate request URL on the device.

3. Modify the certificate service attributes:
   a. Select **Control Panel** > **Administrative Tools** > **Certificate Authority** from the start menu.

      If the certificate service component and SCEP add-on have been installed successfully, there should be two certificates issued by the CA to the RA.

   b. Right-click the CA server in the navigation tree and select **Properties** > **Policy Module**.
   c. Click **Properties**, and then select **Follow the settings in the certificate template, if applicable. Otherwise, automatically issue the certificate**.
4. Modify the Internet information services attributes:
   a. Select **Control Panel** > **Administrative Tools** > **Internet Information Services (IIS) Manager** from the start menu.
   b. Select **Web Sites** from the navigation tree.
   c. Right-click **Default Web Site** and select **Properties** > **Home Directory**.
   d. Specify the path for certificate service in the **Local path** field.
   e. Specify a unique TCP port number for the default website to avoid conflict with existing services. This example uses port 8080.

Configuring the device

1. Synchronize the device's system time with the CA server for the device to correctly request certificates. (Details not shown.)
2. Create an entity named **aaa** and set the common name to **test**.

```
<Device> system-view
[Device] pki entity aaa
[Device-pki-entity-aaa] common-name test
[Device-pki-entity-aaa] quit
```

3. Configure a PKI domain:

   # Create a PKI domain named **winserver** and enter its view.

```
[Device] pki domain winserver
```

   # Set the name of the trusted CA to **myca**.

```
[Device-pki-domain-winserver] ca identifier myca
```

   # Configure the certificate request URL. The URL format is **http://***host:port***/certsrv/mscep/mscep.dll**, where *host:port* is the host IP address and port number of the CA server.

```
[Device-pki-domain-winserver] certificate request url
http://4.4.4.1:8080/certsrv/mscep/mscep.dll
```

   # Configure the device to send certificate requests to **ra**.

```
[Device-pki-domain-winserver] certificate request from ra
```

   # Set the PKI entity name to **aaa**.

```
[Device-pki-domain-winserver] certificate request entity aaa
```

   # Configure a 1024-bit general-purpose RSA key pair named **abc** for certificate request.

```
[Device-pki-domain-winserver] public-key rsa general name abc length 1024
[Device-pki-domain-winserver] quit
```

4. Generate RSA key pair **abc**.

```
[Device] public-key local create rsa name abc
The range of public key modulus is (512 ~ 4096).
If the key modulus is greater than 512,it will take a few minutes.
Press CTRL+C to abort.
```

```
Input the modulus length [default = 1024]:
Generating Keys...
.........................++++++
.....................................++++++
Create the key pair successfully.
```

5. Request a local certificate:

Obtain the CA certificate and save it locally.

```
[Device] pki retrieve-certificate domain winserver ca
The trusted CA's finger print is:
    MD5  fingerprint:766C D2C8 9E46 845B 4DCE 439C 1C1F 83AB
    SHA1 fingerprint:97E5 DDED AB39 3141 75FB DB5C E7F8 D7D7 7C9B 97B4
Is the finger print correct?(Y/N):y
Retrieved the certificates successfully.
```

Submit a certificate request manually.

```
[Device] pki request-certificate domain winserver
Start to request general certificate ...
…
Request certificate of domain winserver successfully
```

Verifying the configuration

Display information about the local certificate in PKI domain **winserver**.

```
[Device] display pki certificate domain winserver local
Certificate:
    Data:
        Version: 3 (0x2)
        Serial Number:
             (Negative)01:03:99:ff:ff:ff:ff:fd:11
        Signature Algorithm: sha1WithRSAEncryption
        Issuer: CN=sec
        Validity
            Not Before: Dec 24 07:09:42 2012 GMT
            Not After : Dec 24 07:19:42 2013 GMT
        Subject: CN=test
        Subject Public Key Info:
            Public Key Algorithm: rsaEncryption
                Public-Key: (2048 bit)
                Modulus:
                    00:c3:b5:23:a0:2d:46:0b:68:2f:71:d2:14:e1:5a:
                    55:6e:c5:5e:26:86:c1:5a:d6:24:68:02:bf:29:ac:
                    dc:31:41:3f:5d:5b:36:9e:53:dc:3a:bc:0d:11:fb:
                    d6:7d:4f:94:3c:c1:90:4a:50:ce:db:54:e0:b3:27:
                    a9:6a:8e:97:fb:20:c7:44:70:8f:f0:b9:ca:5b:94:
                    f0:56:a5:2b:87:ac:80:c5:cc:04:07:65:02:39:fc:
                    db:61:f7:07:c6:65:4c:e4:5c:57:30:35:b4:2e:ed:
                    9c:ca:0b:c1:5e:8d:2e:91:89:2f:11:e3:1e:12:8a:
                    f8:dd:f8:a7:2a:94:58:d9:c7:f8:1a:78:bd:f5:42:
                    51:3b:31:5d:ac:3e:c3:af:fa:33:2c:fc:c2:ed:b9:
                    ee:60:83:b3:d3:e5:8e:e5:02:cf:b0:c8:f0:3a:a4:
                    b7:ac:a0:2c:4d:47:5f:39:4b:2c:87:f2:ee:ea:d0:
```

```
                c3:d0:8e:2c:80:83:6f:39:86:92:98:1f:d2:56:3b:
                d7:94:d2:22:f4:df:e3:f8:d1:b8:92:27:9c:50:57:
                f3:a1:18:8b:1c:41:ba:db:69:07:52:c1:9a:3d:b1:
                2d:78:ab:e3:97:47:e2:70:14:30:88:af:f8:8e:cb:
                68:f9:6f:07:6e:34:b6:38:6a:a2:a8:29:47:91:0e:
                25:39
            Exponent: 65537 (0x10001)
        X509v3 extensions:
            X509v3 Key Usage:
                Digital Signature, Non Repudiation, Key Encipherment, Data Encipherment
            X509v3 Subject Key Identifier:
                C9:BB:D5:8B:02:1D:20:5B:40:94:15:EC:9C:16:E8:9D:6D:FD:9F:34
            X509v3 Authority Key Identifier:
                keyid:32:F1:40:BA:9E:F1:09:81:BD:A8:49:66:FF:F8:AB:99:4A:30:21:9B

            X509v3 CRL Distribution Points:

                Full Name:
                  URI:file://\\g07904c\CertEnroll\sec.crl

            Authority Information Access:
                CA Issuers - URI:http://gc/CertEnroll/gc_sec.crt
                CA Issuers - URI:file://\\gc\CertEnroll\gc_sec.crt

            1.3.6.1.4.1.311.20.2:
                .0.I.P.S.E.C.I.n.t.e.r.m.e.d.i.a.t.e.O.f.f.l.i.n.e
    Signature Algorithm: sha1WithRSAEncryption
        76:f0:6c:2c:4d:bc:22:59:a7:39:88:0b:5c:50:2e:7a:5c:9d:
        6c:28:3c:c0:32:07:5a:9c:4c:b6:31:32:62:a9:45:51:d5:f5:
        36:8f:47:3d:47:ae:74:6c:54:92:f2:54:9f:1a:80:8a:3f:b2:
        14:47:fa:dc:1e:4d:03:d5:d3:f5:9d:ad:9b:8d:03:7f:be:1e:
        29:28:87:f7:ad:88:1c:8f:98:41:9a:db:59:ba:0a:eb:33:ec:
        cf:aa:9b:fc:0f:69:3a:70:f2:fa:73:ab:c1:3e:4d:12:fb:99:
        31:51:ab:c2:84:c0:2f:e5:f6:a7:c3:20:3c:9a:b0:ce:5a:bc:
        0f:d9:34:56:bc:1e:6f:ee:11:3f:7c:b2:52:f9:45:77:52:fb:
        46:8a:ca:b7:9d:02:0d:4e:c3:19:8f:81:46:4e:03:1f:58:03:
        bf:53:c6:c4:85:95:fb:32:70:e6:1b:f3:e4:10:ed:7f:93:27:
        90:6b:30:e7:81:36:bb:e2:ec:f2:dd:2b:bb:b9:03:1c:54:0a:
        00:3f:14:88:de:b8:92:63:1e:f5:b3:c2:cf:0a:d5:f4:80:47:
        6f:fa:7e:2d:e3:a7:38:46:f6:9e:c7:57:9d:7f:82:c7:46:06:
        7d:7c:39:c4:94:41:bd:9e:5c:97:86:c8:48:de:35:1e:80:14:
        02:09:ad:08
```

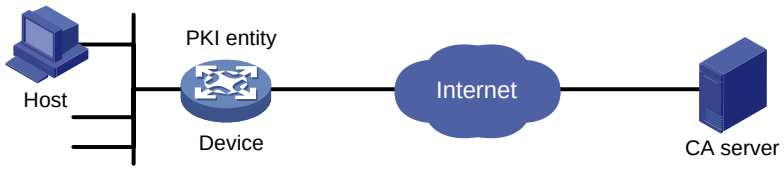
To display detailed information about the CA certificate, use the **display pki certificate domain** command.

Example: Requesting a certificate from an OpenCA server

Network configuration

Configure the PKI entity (the device) to request a local certificate from the CA server.

Figure 4 Network diagram



Configuring the OpenCA server

Configure the OpenCA server as instructed in related manuals. (Details not shown.)

Make sure the version of the OpenCA server is later than version 0.9.2 because the earlier versions do not support SCEP.

Configuring the device

1. Synchronize the device's system time with the CA server for the device to correctly request certificates. (Details not shown.)
2. Create a PKI entity named **aaa** and configure the common name, country code, organization name, and OU for the entity.

```
<Device> system-view
[Device] pki entity aaa
[Device-pki-entity-aaa] common-name rnd
[Device-pki-entity-aaa] country CN
[Device-pki-entity-aaa] organization test
[Device-pki-entity-aaa] organization-unit software
[Device-pki-entity-aaa] quit
```

3. Configure a PKI domain:

   # Create a PKI domain named **openca** and enter its view.

```
[Device] pki domain openca
```

   # Set the name of the trusted CA to **myca**.

```
[Device-pki-domain-openca] ca identifier myca
```

   # Configure the certificate request URL. The URL is in the format **http://***host***/cgi-bin/pki/scep**, where *host* is the host IP address of the OpenCA server.

```
[Device-pki-domain-openca] certificate request url
http://192.168.222.218/cgi-bin/pki/scep
```

   # Configure the device to send certificate requests to the RA.

```
[Device-pki-domain-openca] certificate request from ra
```

   # Specify PKI entity **aaa** for certificate request.

```
[Device-pki-domain-openca] certificate request entity aaa
```

   # Configure a 1024-bit general-purpose RSA key pair named **abc** for certificate request.

```
[Device-pki-domain-openca] public-key rsa general name abc length 1024
[Device-pki-domain-openca] quit
```

4. Generate RSA key pair **abc**.

```
[Device] public-key local create rsa name abc
The range of public key modulus is (512 ~ 4096).
```

```
If the key modulus is greater than 512,it will take a few minutes.
Press CTRL+C to abort.
Input the modulus length [default = 1024]:
Generating Keys...
.....................++++++
.................................++++++
Create the key pair successfully.
```

5. Request a local certificate:

Obtain the CA certificate and save it locally.

```
[Device] pki retrieve-certificate domain openca ca
The trusted CA's finger print is:
    MD5  fingerprint:5AA3 DEFD 7B23 2A25 16A3 14F4 C81C C0FA
    SHA1 fingerprint:9668 4E63 D742 4B09 90E0 4C78 E213 F15F DC8E 9122
Is the finger print correct?(Y/N):y
Retrieved the certificates successfully.
```

Submit a certificate request manually.

```
[Device] pki request-certificate domain openca
Start to request general certificate ...
…
Request certificate of domain openca successfully
```

Verifying the configuration

Display information about the local certificate in PKI domain **openca**.

```
[Device] display pki certificate domain openca local
Certificate:
    Data:
        Version: 3 (0x2)
        Serial Number:
            21:1d:b8:d2:e4:a9:21:28:e4:de
        Signature Algorithm: sha256WithRSAEncryption
        Issuer: C=CN, L=shangdi, ST=pukras, O=OpenCA Labs, OU=mysubUnit, CN=sub-ca,
DC=pki-subdomain, DC=mydomain-sub, DC=com
        Validity
            Not Before: Jun 30 09:09:09 2011 GMT
            Not After : May  1 09:09:09 2012 GMT
        Subject: CN=rnd, O=test, OU=software, C=CN
        Subject Public Key Info:
            Public Key Algorithm: rsaEncryption
                Public-Key: (1024 bit)
                Modulus:
                    00:b8:7a:9a:b8:59:eb:fc:70:3e:bf:19:54:0c:7e:
                    c3:90:a5:d3:fd:ee:ff:c6:28:c6:32:fb:04:6e:9c:
                    d6:5a:4f:aa:bb:50:c4:10:5c:eb:97:1d:a7:9e:7d:
                    53:d5:31:ff:99:ab:b6:41:f7:6d:71:61:58:97:84:
                    37:98:c7:7c:79:02:ac:a6:85:f3:21:4d:3c:8e:63:
                    8d:f8:71:7d:28:a1:15:23:99:ed:f9:a1:c3:be:74:
                    0d:f7:64:cf:0a:dd:39:49:d7:3f:25:35:18:f4:1c:
                    59:46:2b:ec:0d:21:1d:00:05:8a:bf:ee:ac:61:03:
                    6c:1f:35:b5:b4:cd:86:9f:45
```

```
                Exponent: 65537 (0x10001)
        X509v3 extensions:
            X509v3 Basic Constraints:
                CA:FALSE
            Netscape Cert Type:
                SSL Client, S/MIME
            X509v3 Key Usage:
                Digital Signature, Non Repudiation, Key Encipherment
            X509v3 Extended Key Usage:
                TLS Web Client Authentication, E-mail Protection, Microsoft
Smartcardlogin
Netscape Comment:
                User Certificate of OpenCA Labs
            X509v3 Subject Key Identifier:
                24:71:C9:B8:AD:E1:FE:54:9A:EA:E9:14:1B:CD:D9:45:F4:B2:7A:1B
            X509v3 Authority Key Identifier:
                keyid:85:EB:D5:F7:C9:97:2F:4B:7A:6D:DD:1B:4D:DD:00:EE:53:CF:FD:5B

            X509v3 Issuer Alternative Name:
                DNS:root@docm.com, DNS:, IP Address:192.168.154.145, IP
Address:192.168.154.138
            Authority Information Access:
                CA Issuers - URI:http://192.168.222.218/pki/pub/cacert/cacert.crt
                OCSP - URI:http://192.168.222.218:2560/
                1.3.6.1.5.5.7.48.12 - URI:http://192.168.222.218:830/

            X509v3 CRL Distribution Points:

                Full Name:
                  URI:http://192.168.222.218/pki/pub/crl/cacrl.crl

    Signature Algorithm: sha256WithRSAEncryption
        5c:4c:ba:d0:a1:35:79:e6:e5:98:69:91:f6:66:2a:4f:7f:8b:
        0e:80:de:79:45:b9:d9:12:5e:13:28:17:36:42:d5:ae:fc:4e:
        ba:b9:61:f1:0a:76:42:e7:a6:34:43:3e:2d:02:5e:c7:32:f7:
        6b:64:bb:2d:f5:10:6c:68:4d:e7:69:f7:47:25:f5:dc:97:af:
        ae:33:40:44:f3:ab:e4:5a:a0:06:8f:af:22:a9:05:74:43:b6:
        e4:96:a5:d4:52:32:c2:a8:53:37:58:c7:2f:75:cf:3e:8e:ed:
        46:c9:5a:24:b1:f5:51:1d:0f:5a:07:e6:15:7a:02:31:05:8c:
        03:72:52:7c:ff:28:37:1e:7e:14:97:80:0b:4e:b9:51:2d:50:
        98:f2:e4:5a:60:be:25:06:f6:ea:7c:aa:df:7b:8d:59:79:57:
        8f:d4:3e:4f:51:c1:34:e6:c1:1e:71:b5:0d:85:86:a5:ed:63:
        1e:08:7f:d2:50:ac:a0:a3:9e:88:48:10:0b:4a:7d:ed:c1:03:
        9f:87:97:a3:5e:7d:75:1d:ac:7b:6f:bb:43:4d:12:17:9a:76:
        b0:bf:2f:6a:cc:4b:cd:3d:a1:dd:e0:dc:5a:f3:7c:fb:c3:29:
        b0:12:49:5c:12:4c:51:6e:62:43:8b:73:b9:26:2a:f9:3d:a4:
        81:99:31:89
```

To display detailed information about the CA certificate, use the **display pki certificate domain** command.

Example: Configuring IKE negotiation with RSA digital signature from a Windows Server 2003 CA server

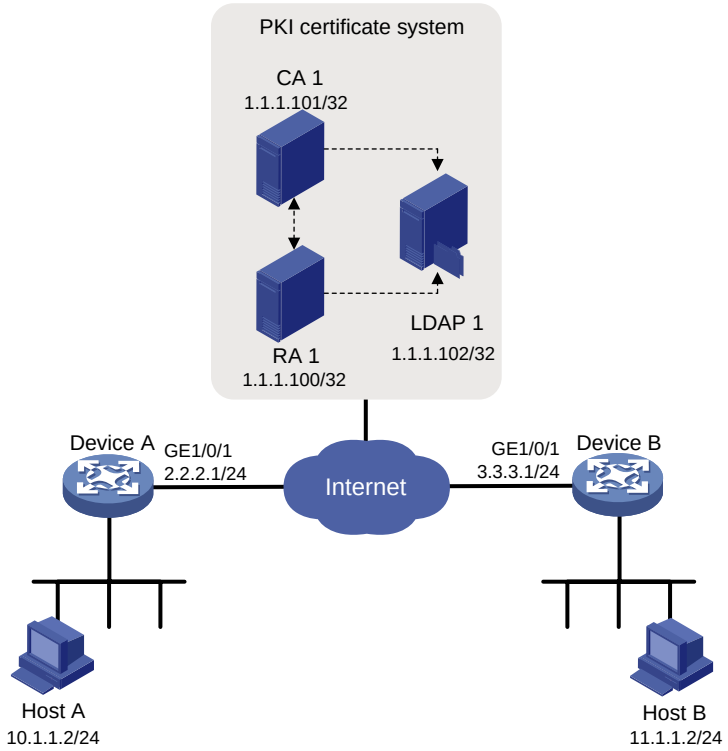
Network configuration

As shown in Figure 5, an IPsec tunnel is required to be established between Device A and Device B. The IPsec tunnel protects the traffic between Host A on subnet 10.1.1.0/24 and Host B on subnet 1.1.1.0/24.

Device A and Device B use IKE to set up SAs, and the IKE proposal uses RSA digital signature for identity authentication.

Device A and Device B use the same CA.

Figure 5 Network diagram



Configuring the Windows Server 2003 CA server

See "Example: Requesting a certificate from a Windows Server 2003 CA server."

Configuring Device A

Configure a PKI entity.

```
<DeviceA> system-view
[DeviceA] pki entity en
[DeviceA-pki-entity-en] ip 2.2.2.1
[DeviceA-pki-entity-en] common-name devicea
[DeviceA-pki-entity-en] quit
```

Configure a PKI domain.

```
[DeviceA] pki domain 1
[DeviceA-pki-domain-1] ca identifier CA1
[DeviceA-pki-domain-1] certificate request url http://1.1.1.100/certsrv/mscep/mscep.dll
```

```
[DeviceA-pki-domain-1] certificate request entity en
[DeviceA-pki-domain-1] ldap-server host 1.1.1.102
```

Configure the device to send certificate requests to **ra**.

```
[DeviceA-pki-domain-1] certificate request from ra
```

Configure a 1024-bit general-purpose RSA key pair named **abc** for certificate request.

```
[DeviceA-pki-domain-1] public-key rsa general name abc length 1024
[DeviceA-pki-domain-1] quit
```

Generate the RSA key pair.

```
[DeviceA] public-key local create rsa name abc
The range of public key modulus is (512 ~ 4096).
If the key modulus is greater than 512,it will take a few minutes.
Press CTRL+C to abort.
Input the modulus length [default = 1024]:
Generating Keys...
.........................++++++
.....................................++++++
Create the key pair successfully.
```

Obtain the CA certificate and save it locally.

```
[DeviceA] pki retrieve-certificate domain 1 ca
```

Submit a certificate request manually.

```
[DeviceA] pki request-certificate domain 1
```

Create IKE proposal 1, and configure the authentication method as RSA digital signature.

```
[DeviceA] ike proposal 1
[DeviceA-ike-proposal-1] authentication-method rsa-signature
[DeviceA-ike-proposal-1] quit
```

Specify the PKI domain used in IKE negotiation for IKE profile **peer**.

```
[DeviceA] ike profile peer
[DeviceA-ike-profile-peer] certificate domain 1
```

Configuring Device B

Configure a PKI entity.

```
<DeviceB> system-view
[DeviceB] pki entity en
[DeviceB-pki-entity-en] ip 3.3.3.1
[DeviceB-pki-entity-en] common-name deviceb
[DeviceB-pki-entity-en] quit
```

Configure a PKI domain.

```
[DeviceB] pki domain 1
[DeviceB-pki-domain-1] ca identifier CA1
[DeviceB-pki-domain-1] certificate request url http://1.1.1.100/certsrv/mscep/mscep.dll
[DeviceB-pki-domain-1] certificate request entity en
[DeviceB-pki-domain-1] ldap-server host 1.1.1.102
```

Configure the device to send certificate requests to **ra**.

```
[DeviceB-pki-domain-1] certificate request from ra
```

Configure a 1024-bit general-purpose RSA key pair named **abc** for certificate request.

```
[DeviceB-pki-domain-1] public-key rsa general name abc length 1024
```

```
[DeviceB-pki-domain-1] quit
```

Generate the RSA key pair.

```
[DeviceB] public-key local create rsa name abc
The range of public key modulus is (512 ~ 4096).
If the key modulus is greater than 512,it will take a few minutes.
Press CTRL+C to abort.
Input the modulus length [default = 1024]:
Generating Keys...
.........................++++++
.....................................++++++
Create the key pair successfully.
```

Obtain the CA certificate and save it locally.

```
[DeviceB] pki retrieve-certificate domain 1 ca
The trusted CA's finger print is:
    MD5  fingerprint:5C41 E657 A0D6 ECB4 6BD6 1823 7473 AABC
    SHA1 fingerprint:1616 E7A5 D89A 2A99 9419 1C12 D696 8228 87BC C266
Is the finger print correct?(Y/N):y
Retrieved the certificates successfully.
```

Submit a certificate request manually.

```
[DeviceB] pki request-certificate domain 1
Start to request general certificate ...
...
Certificate requested successfully.
```

Create IKE proposal 1, and configure the authentication method as RSA digital signature.

```
[DeviceB] ike proposal 1
[DeviceB-ike-proposal-1] authentication-method rsa-signature
[DeviceB-ike-proposal-1] quit
```

Specify the PKI domain used in IKE negotiation for IKE profile **peer**.

```
[DeviceB] ike profile peer
[DeviceB-ike-profile-peer] certificate domain 1
```

The configurations are for IKE negotiation with RSA digital signature. For information about how to configure IPsec SAs to be set up, see "Configuring IPsec."

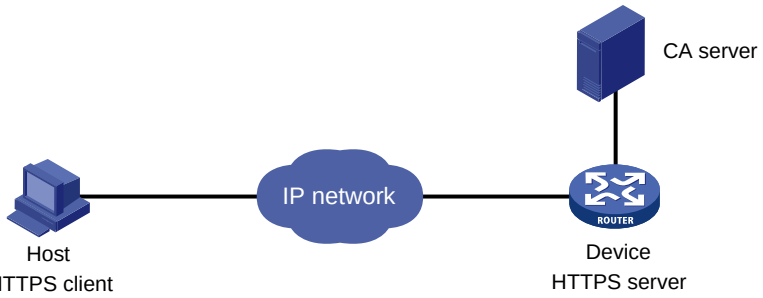
Example: Configuring a certificate-based access control policy

Network configuration

As shown in Figure 6, the host accesses the device through HTTPS.

Configure a certificate-based access control policy on the device to authenticate the host and verify the validity of the host's certificate.

Figure 6 Network diagram



Procedure

1. Create PKI domain **domain1** to be used by SSL. (Details not shown.)
2. Request an SSL server certificate for the device from the CA server. (Details not shown.)
3. Configure the HTTPS server:

   # Configure an SSL server policy named **abc**.

   ```
   <Device> system-view
   [Device] ssl server-policy abc
   [Device-ssl-server-policy-abc] pki-domain domain1
   [Device-ssl-server-policy-abc] client-verify enable
   [Device-ssl-server-policy-abc] quit
   ```

   # Apply SSL server policy **abc** to the HTTPS server.

   ```
   [Device] ip https ssl-server-policy abc
   ```

   # Enable the HTTPS server.

   ```
   [Device] ip https enable
   ```

4. Configure certificate attribute groups:

   # Create a certificate attribute group named **mygroup1** and add two attribute rules. The first rule defines that the DN in the subject DN contains the string of **aabbcc**. The second rule defines that the IP address of the certificate issuer is **10.0.0.1**.

   ```
   [Device] pki certificate attribute-group mygroup1
   [Device-pki-cert-attribute-group-mygroup1] attribute 1 subject-name dn ctn aabbcc
   [Device-pki-cert-attribute-group-mygroup1] attribute 2 issuer-name ip equ 10.0.0.1
   [Device-pki-cert-attribute-group-mygroup1] quit
   ```

   # Create a certificate attribute group named **mygroup2** and add two attribute rules. The first rule defines that the FQDN in the alternative subject name does not contain the string of **apple**. The second rule defines that the DN of the certificate issuer name contains the string of **aabbcc**.

   ```
   [Device] pki certificate attribute-group mygroup2
   [Device-pki-cert-attribute-group-mygroup2] attribute 1 alt-subject-name fqdn nctn
   apple
   [Device-pki-cert-attribute-group-mygroup2] attribute 2 issuer-name dn ctn aabbcc
   [Device-pki-cert-attribute-group-mygroup2] quit
   ```

5. Configure a certificate-based access control policy:

   # Create a certificate-based access control policy named **myacp**.

   ```
   [Device] pki certificate access-control-policy myacp
   ```

   # Define a statement to deny the certificates that match the attribute rules in certificate attribute group **mygroup1**.

   ```
   [Device-pki-cert-acp-myacp] rule 1 deny mygroup1
   ```

Define a statement to permit the certificates that match the attribute rules in certificate attribute group **mygroup2**.

```
[Device-pki-cert-acp-myacp] rule 2 permit mygroup2
[Device-pki-cert-acp-myacp] quit
```

Apply certificate-based access control policy **myacp** to the HTTPS server.

```
[Device] ip https certificate access-control-policy myacp
```

Verifying the configuration

On the host, access the HTTPS server through a Web browser.

The server first verifies the validity of the host's certificate according to the configured certificate-based access control policy. In the host's certificate, the subject DN is **aabbcc**, the IP address of the certificate issuer is **1.1.1.1**, and the FQDN of the alternative subject name is **banaba**.

The host's certificate does not match certificate attribute group **mygroup1** specified in **rule 1** of the certificate-based access control policy. The certificate continues to match against rule 2.

The host's certificate matches certificate attribute group **mygroup2** specified in **rule 2**. Because **rule 2** is a permit statement, the certificate passes the verification and the host can access the HTTPS server.

Example: Importing and exporting certificates

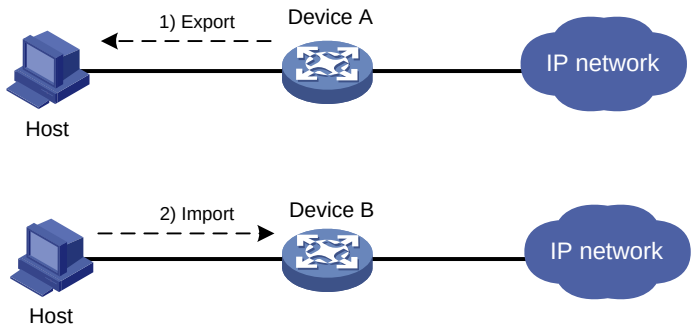
Network configuration

As shown in Figure 7, Device B will replace Device A in the network. PKI domain **exportdomain** on Device A has two local certificates containing the private key and one CA certificate. To make sure the certificates are still valid after Device B replaces Device A, copy the certificates on Device A to Device B as follows:

1. Export the certificates in PKI domain **exportdomain** on Device A to .pem certificate files.

   During the export, encrypt the private key in the local certificates using 3DES_CBC with the password 11111.
2. Transfer the certificate files from Device A to Device B through the FTP host.
3. Import the certificate files to PKI domain **importdomain** on Device B.

Figure 7 Network diagram



Procedure

1. Export the certificates on Device A:

   # Export the CA certificate to a .pem file.

   ```
   <DeviceA> system-view
   [DeviceA] pki export domain exportdomain pem ca filename pkicachain.pem
   ```

   # Export the local certificate to a file named **pkilocal.pem** in PEM format, and use 3DES_CBC to encrypt the private key with the password **111111**.

```
[DeviceA] pki export domain exportdomain pem local 3des-cbc 111111 filename
pkilocal.pem
```

Now, Device A has three certificate files in PEM format:

- A CA certificate file named **pkicachain.pem**.
- A local certificate file named **pkilocal.pem-signature**, which contains the private key for signature.
- A local certificate file named **pkilocal.pem-encryption**, which contains the private key for encryption.

Display local certificate file **pkilocal.pem-signature**.

```
[DeviceA] quit
<DeviceA> more pkilocal.pem-signature
Bag Attributes
    friendlyName:
    localKeyID: 90 C6 DC 1D 20 49 4F 24 70 F5 17 17 20 2B 9E AC 20 F3 99 89
subject=/C=CN/O=OpenCA Labs/OU=Users/CN=subsign 11
issuer=/C=CN/L=shangdi/ST=pukras/O=OpenCA Labs/OU=docm/CN=subca1
-----BEGIN CERTIFICATE-----
MIIEgjCCA2qgAwIBAgILAJgsebpejZc5UwAwDQYJKoZIhvcNAQELBQAwZjELMAkG
…
-----END CERTIFICATE-----
Bag Attributes
    friendlyName:
    localKeyID: 90 C6 DC 1D 20 49 4F 24 70 F5 17 17 20 2B 9E AC 20 F3 99 89
Key Attributes: <No Attributes>
-----BEGIN ENCRYPTED PRIVATE KEY-----
MIICxjBABgkqhkiG9w0BBQ0wMzAbBgkqhkiG9w0BBQwwDgQIZtjSjfslJCoCAggA
…
-----END ENCRYPTED PRIVATE KEY-----
```

Display local certificate file **pkilocal.pem-encryption**.

```
<DeviceA> more pkilocal.pem-encryption
Bag Attributes
    friendlyName:
    localKeyID: D5 DF 29 28 C8 B9 D9 49 6C B5 44 4B C2 BC 66 75 FE D6 6C C8
subject=/C=CN/O=OpenCA Labs/OU=Users/CN=subencr 11
issuer=/C=CN/L=shangdi/ST=pukras/O=OpenCA Labs/OU=docm/CN=subca1
-----BEGIN CERTIFICATE-----
MIIEUDCCAzigAwIBAgIKCHxnAVyzWhIPLzANBgkqhkiG9w0BAQsFADBmMQswCQYD
…
-----END CERTIFICATE-----
Bag Attributes
    friendlyName:
    localKeyID: D5 DF 29 28 C8 B9 D9 49 6C B5 44 4B C2 BC 66 75 FE D6 6C C8
Key Attributes: <No Attributes>
-----BEGIN ENCRYPTED PRIVATE KEY-----
MIICxjBABgkqhkiG9w0BBQ0wMzAbBgkqhkiG9w0BBQwwDgQI7H0mb4O7/GACAggA
…
-----END ENCRYPTED PRIVATE KEY-----
```

2. Download certificate files **pkicachain.pem**, **pkilocal.pem-signature**, and **pkilocal.pem-encryption** from Device A to the host through FTP. (Details not shown.)
3. Upload certificate files **pkicachain.pem**, **pkilocal.pem-signature**, and **pkilocal.pem-encryption** from the host to Device B through FTP. (Details not shown.)
4. Import the certificate files to Device B:

   # Disable CRL checking. (You can configure CRL checking as required. This example assumes CRL checking is not required.)

   ```
   <DeviceB> system-view
   [DeviceB] pki domain importdomain
   [DeviceB-pki-domain-importdomain] undo crl check enable
   ```

   # Specify RSA key pair **sign** for signature and RSA key pair **encr** for encryption.

   ```
   [DeviceB-pki-domain-importdomain] public-key rsa signature name sign encryption name encr
   [DeviceB-pki-domain-importdomain] quit
   ```

   # Import CA certificate file **pkicachain.pem** in PEM format to the PKI domain.

   ```
   [DeviceB] pki import domain importdomain pem ca filename pkicachain.pem
   ```

   # Import local certificate file **pkilocal.pem-signature** in PEM format to the PKI domain. The certificate file contains a key pair.

   ```
   [DeviceB] pki import domain importdomain pem local filename pkilocal.pem-signature
   Please input the password:******
   ```

   # Import local certificate file **pkilocal.pem-encryption** in PEM format to the PKI domain. The certificate file contains a key pair.

   ```
   [DeviceB] pki import domain importdomain pem local filename pkilocal.pem-encryption
   Please input the password:******
   ```

   # Display the imported local certificate information on Device B.

   ```
   [DeviceB] display pki certificate domain importdomain local
   Certificate:
       Data:
           Version: 3 (0x2)
           Serial Number:
               98:2c:79:ba:5e:8d:97:39:53:00
           Signature Algorithm: sha256WithRSAEncryption
           Issuer: C=CN, L=shangdi, ST=pukras, O=OpenCA Labs, OU=docm, CN=subca1
           Validity
               Not Before: May 26 05:56:49 2011 GMT
               Not After : Nov 22 05:56:49 2012 GMT
           Subject: C=CN, O=OpenCA Labs, OU=Users, CN=subsign 11
           Subject Public Key Info:
               Public Key Algorithm: rsaEncryption
                   Public-Key: (1024 bit)
                   Modulus:
                       00:9f:6e:2f:f6:cb:3d:08:19:9a:4a:ac:b4:ac:63:
                       ce:8d:6a:4c:3a:30:19:3c:14:ff:a9:50:04:f5:00:
                       ee:a3:aa:03:cb:b3:49:c4:f8:ae:55:ee:43:93:69:
                       6c:bf:0d:8c:f4:4e:ca:69:e5:3f:37:5c:83:ea:83:
                       ad:16:b8:99:37:cb:86:10:6b:a0:4d:03:95:06:42:
                       ef:ef:0d:4e:53:08:0a:c9:29:dd:94:28:02:6e:e2:
                       9b:87:c1:38:2d:a4:90:a2:13:5f:a4:e3:24:d3:2c:
                       bf:98:db:a7:c2:36:e2:86:90:55:c7:8c:c5:ea:12:
   ```

```
                    01:31:69:bf:e3:91:71:ec:21
                Exponent: 65537 (0x10001)
        X509v3 extensions:
            X509v3 Basic Constraints:
                CA:FALSE
            Netscape Cert Type:
                SSL Client, S/MIME
            X509v3 Key Usage:
                Digital Signature, Non Repudiation
            X509v3 Extended Key Usage:
                TLS Web Client Authentication, E-mail Protection, Microsoft
Smartcardlogin
            Netscape Comment:
                User Certificate of OpenCA Labs
            X509v3 Subject Key Identifier:
                AA:45:54:29:5A:50:2B:89:AB:06:E5:BD:0D:07:8C:D9:79:35:B1:F5
            X509v3 Authority Key Identifier:
                keyid:70:54:40:61:71:31:02:06:8C:62:11:0A:CC:A5:DB:0E:7E:74:DE:DD

            X509v3 Subject Alternative Name:
                email:subsign@docm.com
            X509v3 Issuer Alternative Name:
                DNS:subca1@docm.com, DNS:, IP Address:1.1.2.2, IP Address:2.2.1.1
            Authority Information Access:
                CA Issuers - URI:http://titan/pki/pub/cacert/cacert.crt
                OCSP - URI:http://titan:2560/
                1.3.6.1.5.5.7.48.12 - URI:http://titan:830/

            X509v3 CRL Distribution Points:

                Full Name:
                  URI:http://192.168.40.130/pki/pub/crl/cacrl.crl

    Signature Algorithm: sha256WithRSAEncryption
        18:e7:39:9a:ad:84:64:7b:a3:85:62:49:e5:c9:12:56:a6:d2:
        46:91:53:8e:84:ba:4a:0a:6f:28:b9:43:bc:e7:b0:ca:9e:d4:
        1f:d2:6f:48:c4:b9:ba:c5:69:4d:90:f3:15:c4:4e:4b:1e:ef:
        2b:1b:2d:cb:47:1e:60:a9:0f:81:dc:f2:65:6b:5f:7a:e2:36:
        29:5d:d4:52:32:ef:87:50:7c:9f:30:4a:83:de:98:8b:6a:c9:
        3e:9d:54:ee:61:a4:26:f3:9a:40:8f:a6:6b:2b:06:53:df:b6:
        5f:67:5e:34:c8:c3:b5:9b:30:ee:01:b5:a9:51:f9:b1:29:37:
        02:1a:05:02:e7:cc:1c:fe:73:d3:3e:fa:7e:91:63:da:1d:f1:
        db:28:6b:6c:94:84:ad:fc:63:1b:ba:53:af:b3:5d:eb:08:b3:
        5b:d7:22:3a:86:c3:97:ef:ac:25:eb:4a:60:f8:2b:a3:3b:da:
        5d:6f:a5:cf:cb:5a:0b:c5:2b:45:b7:3e:6e:39:e9:d9:66:6d:
        ef:d3:a0:f6:2a:2d:86:a3:01:c4:94:09:c0:99:ce:22:19:84:
        2b:f0:db:3e:1e:18:fb:df:56:cb:6f:a2:56:35:0d:39:94:34:
        6d:19:1d:46:d7:bf:1a:86:22:78:87:3e:67:fe:4b:ed:37:3d:
        d6:0a:1c:0b
```

```
Certificate:
    Data:
        Version: 3 (0x2)
        Serial Number:
            08:7c:67:01:5c:b3:5a:12:0f:2f
        Signature Algorithm: sha256WithRSAEncryption
        Issuer: C=CN, L=shangdi, ST=pukras, O=OpenCA Labs, OU=docm, CN=subca1
        Validity
            Not Before: May 26 05:58:26 2011 GMT
            Not After : Nov 22 05:58:26 2012 GMT
        Subject: C=CN, O=OpenCA Labs, OU=Users, CN=subencr 11
        Subject Public Key Info:
            Public Key Algorithm: rsaEncryption
                Public-Key: (1024 bit)
                Modulus:
                    00:db:26:13:d3:d1:a4:af:11:f3:6d:37:cf:d0:d4:
                    48:50:4e:0f:7d:54:76:ed:50:28:c6:71:d4:48:ae:
                    4d:e7:3d:23:78:70:63:18:33:f6:94:98:aa:fa:f6:
                    62:ed:8a:50:c6:fd:2e:f4:20:0c:14:f7:54:88:36:
                    2f:e6:e2:88:3f:c2:88:1d:bf:8d:9f:45:6c:5a:f5:
                    94:71:f3:10:e9:ec:81:00:28:60:a9:02:bb:35:8b:
                    bf:85:75:6f:24:ab:26:de:47:6c:ba:1d:ee:0d:35:
                    75:58:10:e5:e8:55:d1:43:ae:85:f8:ff:75:81:03:
                    8c:2e:00:d1:e9:a4:5b:18:39
                Exponent: 65537 (0x10001)
        X509v3 extensions:
            X509v3 Basic Constraints:
                CA:FALSE
            Netscape Cert Type:
                SSL Server
            X509v3 Key Usage:
                Key Encipherment, Data Encipherment
            Netscape Comment:
                VPN Server of OpenCA Labs
            X509v3 Subject Key Identifier:
                CC:96:03:2F:FC:74:74:45:61:38:1F:48:C0:E8:AA:18:24:F0:2B:AB
            X509v3 Authority Key Identifier:
                keyid:70:54:40:61:71:31:02:06:8C:62:11:0A:CC:A5:DB:0E:7E:74:DE:DD

            X509v3 Subject Alternative Name:
                email:subencr@docm.com
            X509v3 Issuer Alternative Name:
                DNS:subca1@docm.com, DNS:, IP Address:1.1.2.2, IP Address:2.2.1.1
            Authority Information Access:
                CA Issuers - URI:http://titan/pki/pub/cacert/cacert.crt
                OCSP - URI:http://titan:2560/
                1.3.6.1.5.5.7.48.12 - URI:http://titan:830/
```

```
            X509v3 CRL Distribution Points:

                Full Name:
                  URI:http://192.168.40.130/pki/pub/crl/cacrl.crl

        Signature Algorithm: sha256WithRSAEncryption
            53:69:66:5f:93:f0:2f:8c:54:24:8f:a2:f2:f1:29:fa:15:16:
            90:71:e2:98:e3:5c:c6:e3:d4:5f:7a:f6:a9:4f:a2:7f:ca:af:
            c4:c8:c7:2c:c0:51:0a:45:d4:56:e2:81:30:41:be:9f:67:a1:
            23:a6:09:50:99:a1:40:5f:44:6f:be:ff:00:67:9d:64:98:fb:
            72:77:9e:fd:f2:4c:3a:b2:43:d8:50:5c:48:08:e7:77:df:fb:
            25:9f:4a:ea:de:37:1e:fb:bc:42:12:0a:98:11:f2:d9:5b:60:
            bc:59:72:04:48:59:cc:50:39:a5:40:12:ff:9d:d0:69:3a:5e:
            3a:09:5a:79:e0:54:67:a0:32:df:bf:72:a0:74:63:f9:05:6f:
            5e:28:d2:e8:65:49:e6:c7:b5:48:7d:95:47:46:c1:61:5a:29:
            90:65:45:4a:88:96:e4:88:bd:59:25:44:3f:61:c6:b1:08:5b:
            86:d2:4f:61:4c:20:38:1c:f4:a1:0b:ea:65:87:7d:1c:22:be:
            b6:17:17:8a:5a:0f:35:4c:b8:b3:73:03:03:63:b1:fc:c4:f5:
            e9:6e:7c:11:e8:17:5a:fb:39:e7:33:93:5b:2b:54:72:57:72:
            5e:78:d6:97:ef:b8:d8:6d:0c:05:28:ea:81:3a:06:a0:2e:c3:
            79:05:cd:c3
```

To display detailed information about the CA certificate, use the **`display pki certificate domain`** command.

Troubleshooting PKI configuration

This section provides troubleshooting information for common problems with PKI.

Failed to obtain the CA certificate

Symptom

The CA certificate cannot be obtained.

Analysis

- The network connection is down, for example, because the network cable is damaged or the connectors have bad contact.
- No trusted CA is specified.
- The certificate request URL is incorrect or not specified.
- The system time of the device is not synchronized with the CA server.
- The CA server does not accept the source IP address specified in the PKI domain, or no source IP address is specified.
- The fingerprint of the root CA certificate is illegal.

Solution

1. Fix the network connection problems, if any.
2. Configure the trusted CA and all other required parameters in the PKI domain.
3. Use the **`ping`** command to verify that the CA server is reachable.

4. Synchronize the system time of the device with the CA server.
5. Specify the correct source IP address that the CA server can accept. For the correct settings, contact the CA administrator.
6. Verify the fingerprint of the CA certificate on the CA server.
7. If the problem persists, contact H3C Support.

Failed to obtain local certificates

Symptom

The local certificates can be obtained.

Analysis

- The network connection is down.
- The PKI domain does not have a CA certificate before you submit the local certificate request.
- The LDAP server is not configured or is incorrectly configured.
- No key pair is specified for certificate request in the PKI domain, or the specified key pair does not match the one contained in the local certificates to the obtained.
- No PKI entity is configured in the PKI domain, or the PKI entity configuration is incorrect.
- CRL checking is enabled, but the PKI domain does not have a CRL and cannot obtain one.
- The CA server does not accept the source IP address specified in the PKI domain, or no source IP address is specified.
- The system time of the device is not synchronized with the CA server.

Solution

1. Fix the network connection problems, if any..
2. Obtain or import the CA certificate.
3. Configure the correct LDAP server parameters.
4. Specify the key pair for certificate request, or remove the existing key pair, specify a new key pair, and submit a local certificate request again.
5. Check the registration policy on the CA or RA, and make sure the attributes of the PKI entity meet the policy requirements.
6. Obtain the CRL from the CRL repository.
7. Specify the correct source IP address that the CA server can accept. For the correct settings, contact the CA administrator.
8. Synchronize the system time of the device with the CA server.
9. If the problem persists, contact H3C Support.

Failed to request local certificates

Symptom

Local certificate requests cannot be submitted.

Analysis

- The network connection is down, for example, because the network cable is damaged or the connectors have bad contact.
- The PKI domain does not have a CA certificate before the local certificate request is submitted.
- The certificate request URL is incorrect or is not specified.

- The certificate request reception authority is incorrect or is not specified.
- Required PKI entity parameters are not configured or are incorrectly configured.
- No key pair is specified in the PKI domain for certificate request, or the key pair is changed during a certificate request process.
- Exclusive certificate request applications are running in the PKI domain.
- The CA server does not accept the source IP address specified in the PKI domain, or no source IP address is specified.
- The system time of the device is not synchronized with the CA server.

Solution

1. Fix the network connection problems, if any.
2. Obtain or import the CA certificate.
3. Use the **ping** command to verify that the registration server is reachable.
4. Use the **certificate request from** command to specify the correct certificate request reception authority.
5. Configure the PKI entity parameters as required by the registration policy on the CA or RA.
6. Specify the key pair for certificate request, or remove the existing key pair, specify a new key pair, and submit a local certificate request again.
7. Use the **pki abort-certificate-request domain** command to abort the certificate request.
8. Specify the correct source IP address that the CA server can accept. For the correct settings, contact the CA administrator.
9. Synchronize the system time of the device with the CA server.
10. If the problem persists, contact H3C Support.

Failed to obtain CRLs

Symptom

CRLs cannot be obtained.

Analysis

- The network connection is down, for example, because the network cable is damaged or the connectors have bad contact.
- The PKI domain does not have a CA certificate before you try to obtain CRLs.
- The URL of the CRL repository is not configured and cannot be obtained from the CA certificate or local certificates in the PKI domain.
- The specified URL of the CRL repository is incorrect.
- The device tries to obtain CRLs through SCEP, but it experiences the following problems:
  - The PKI domain does not have local certificates.
  - The key pairs in the certificates have been changed.
  - The PKI domain has incorrect URL for certificate request.
- The CRL repository uses LDAP for CRL distribution. However, the IP address or host name of the LDAP server is neither contained in the CRL repository URL nor configured in the PKI domain.
- The CA does not issue CRLs.
- The CA server does not accept the source IP address specified in the PKI domain, or no source IP address is specified.

Solution

1. Fix the network connection problems, if any.
2. Obtain or import the CA certificate.
3. If the URL of the CRL repository cannot be obtained, verify that the following conditions exist:
   - The URL for certificate request is valid.
   - A local certificate has been successfully obtained.
   - The local certificate contains a public key that matches the locally stored key pair.
4. Make sure the LDAP server address is contained in the CRL repository URL, or is configured in the PKI domain.
5. Make sure the CA server support publishing CRLs.
6. Specify a correct source IP address that the CA server can accept. For the correct settings, contact the CA administrator.
7. If the problem persists, contact H3C Support.

Failed to import the CA certificate

Symptom

The CA certificate cannot be imported.

Analysis

- CRL checking is enabled, but the device does not have a CRL in the PKI domain and cannot obtain one.
- The specified format in which the CA certificate file is to be imported does not match actual certificate file format.

Solution

1. Use the **`undo crl check enable`** command to disable CRL checking in the PKI domain.
2. Make sure the format of the imported file is correct.
3. If the problem persists, contact H3C Support.

Failed to import the local certificate

Symptom

The local certificate cannot be imported.

Analysis

- The PKI domain does not have a CA certificate, and the local certificate file to be imported does not contain the CA certificate chain.
- CRL checking is enabled, but the device does not have a CRL in the PKI domain and cannot obtain one.
- The specified format in which the local certificate file is to be imported does not match actual certificate file format.
- The device and the certificate do not have the local key pair.
- The certificate has been revoked.
- The certificate is out of the validity period.
- The system time is incorrect.

Solution

1. Obtain or import the CA certificate.
2. Use the **undo crl check enable** command to disable CRL checking, or obtain the correct CRL before you import certificates.
3. Make sure the format of the file to be imported is correct.
4. Make sure the certificate file contains the private key.
5. Make sure the certificate is not revoked.
6. Make sure the certificate is valid.
7. Configure the correct system time for the device.
8. If the problem persists, contact H3C Support.

Failed to export certificates

Symptom

Certificates cannot be exported.

Analysis

- The PKI domain does not have local certificates when you export all certificates in PKCS12 format.
- The specified export path does not exist.
- The specified export path is illegal.
- The public key of the local certificate to be exported does not match the public key of the key pair configured in the PKI domain.
- The storage space of the device is full.

Solution

1. Obtain or request local certificates first.
2. Use the **mkdir** command to create the required path.
3. Specify a correct export path.
4. Configure the correct key pair in the PKI domain.
5. Clear up the storage space of the device.
6. If the problem persists, contact H3C Support.

Failed to set the storage path

Symptom

The storage path for certificates or CRLs cannot be set.

Analysis

- The specified storage path does not exist.
- The specified storage path is illegal.
- The storage space of the device is full.

Solution

1. Use the **mkdir** command to create the path.
2. Specify a valid storage path for certificates or CRLs.
3. Clear up the storage space of the device.

4. If the problem persists, contact H3C Support.

Contents

Configuring IPsec

About IPsec

IP Security (IPsec) is defined by the IETF to provide interoperable, high-quality, cryptography-based security for IP communications. It is a Layer 3 VPN technology that transmits data in a secure channel established between two endpoints (such as two security gateways). Such a secure channel is usually called an IPsec tunnel.

IPsec framework

IPsec is a security framework that has the following protocols and algorithms:

- Authentication Header (AH).
- Encapsulating Security Payload (ESP).
- Internet Key Exchange (IKE).
- Algorithms for authentication and encryption.

AH and ESP are security protocols that provide security services. IKE performs automatic key exchange. For more information about IKE, see "Configuring IKE."

IPsec security services

IPsec provides the following security services for data packets in the IP layer:

- **Confidentiality**—The sender encrypts packets before transmitting them over the Internet, protecting the packets from being eavesdropped en route.
- **Data integrity**—The receiver verifies the packets received from the sender to make sure they are not tampered with during transmission.
- **Data origin authentication**—The receiver verifies the authenticity of the sender.
- **Anti-replay**—The receiver examines packets and drops outdated and duplicate packets.

Benefits of IPsec

IPsec delivers the following benefits:

- Reduced key negotiation overhead and simplified maintenance by supporting the IKE protocol. IKE provides automatic key negotiation and automatic IPsec security association (SA) setup and maintenance.
- Good compatibility. You can apply IPsec to all IP-based application systems and services without modifying them.
- Encryption on a per-packet rather than per-flow basis. Per-packet encryption allows for flexibility and greatly enhances IP security.

Security protocols

IPsec comes with two security protocols, AH and ESP. They define how to encapsulate IP packets and the security services that they can provide.

- AH (protocol 51) defines the encapsulation of the AH header in an IP packet, as shown in Figure 3. AH can provide data origin authentication, data integrity, and anti-replay services to

prevent data tampering, but it cannot prevent eavesdropping. Therefore, it is suitable for transmitting non-confidential data. The authentication algorithms supported by AH include HMAC-MD5 and HMAC-SHA1.

- ESP (protocol 50) defines the encapsulation of the ESP header and trailer in an IP packet, as shown in Figure 3. ESP can provide data encryption, data origin authentication, data integrity, and anti-replay services. Unlike AH, ESP can guarantee data confidentiality because it can encrypt the data before encapsulating the data to IP packets. ESP-supported encryption algorithms include DES, 3DES, and AES, and authentication algorithms include HMAC-MD5 and HMAC-SHA1.

Both AH and ESP provide authentication services, but the authentication service provided by AH is stronger. In practice, you can choose either or both security protocols. When both AH and ESP are used, an IP packet is encapsulated first by ESP and then by AH.

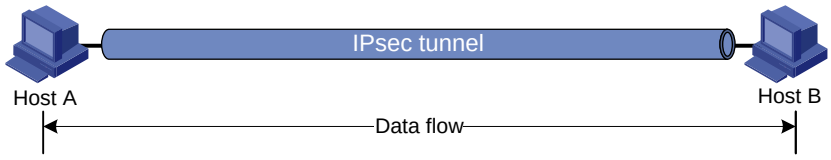
Encapsulation modes

IPsec supports the following encapsulation modes: transport mode and tunnel mode.

Transport mode

The security protocols protect the upper layer data of an IP packet. Only the transport layer data is used to calculate the security protocol headers. The calculated security protocol headers and the encrypted data (only for ESP encapsulation) are placed after the original IP header. You can use the transport mode when end-to-end security protection is required (the secured transmission start and end points are the actual start and end points of the data). The transport mode is typically used for protecting host-to-host communications, as shown in Figure 1.

Figure 1 IPsec protection in transport mode



Tunnel mode

The security protocols protect the entire IP packet. The entire IP packet is used to calculate the security protocol headers. The calculated security protocol headers and the encrypted data (only for ESP encapsulation) are encapsulated in a new IP packet. In this mode, the encapsulated packet has two IP headers. The inner IP header is the original IP header. The outer IP header is added by the network device that provides the IPsec service. You must use the tunnel mode when the secured transmission start and end points are not the actual start and end points of the data packets (for example, when two gateways provide IPsec but the data start and end points are two hosts behind the gateways). The tunnel mode is typically used for protecting gateway-to-gateway communications, as shown in Figure 2.

Figure 2 IPsec protection in tunnel mode

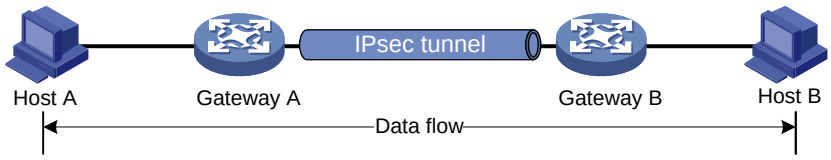
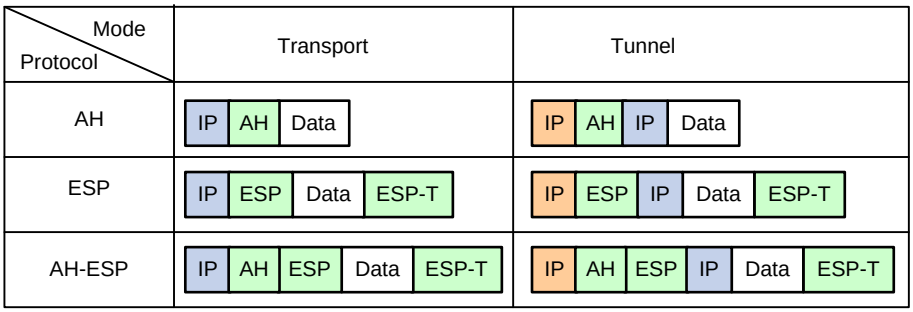


Figure 3 shows how the security protocols encapsulate an IP packet in different encapsulation modes.

Figure 3 Security protocol encapsulations in different modes



Security association

A security association (SA) is an agreement negotiated between two communicating parties called IPsec peers. An SA includes the following parameters for data protection:

- Security protocols (AH, ESP, or both).
- Encapsulation mode (transport mode or tunnel mode).
- Authentication algorithm (HMAC-MD5 or HMAC-SHA1).
- Encryption algorithm (DES, 3DES, or AES).
- Shared keys and their lifetimes.

An SA is unidirectional. At least two SAs are needed to protect data flows in a bidirectional communication. If two peers want to use both AH and ESP to protect data flows between them, they construct an independent SA for each protocol in each direction.

An SA is uniquely identified by a triplet, which consists of the security parameter index (SPI), destination IP address, and security protocol identifier. An SPI is a 32-bit number. It is transmitted in the AH/ESP header.

An SA can be set up manually or through IKE.

- **Manual mode**—Configure all parameters for the SA through commands. This configuration mode is complex and does not support some advanced features (such as periodic key update), but it can implement IPsec without IKE. This mode is mainly used in small and static networks or when the number of IPsec peers in the network is small.
- **IKE negotiation mode**—The peers negotiate and maintain the SA through IKE. This configuration mode is simple and has good expansibility. As a best practice, set up SAs through IKE negotiations in medium- and large-scale dynamic networks.

A manually configured SA never ages out. An IKE-created SA has a lifetime, which comes in two types:

- **Time-based lifetime**—Defines how long the SA can be valid after it is created.
- **Traffic-based lifetime**—Defines the maximum traffic that the SA can process.

If both lifetime timers are configured for an SA, the SA becomes invalid when either of the lifetime timers expires. Before the SA expires, IKE negotiates a new SA, which takes over immediately after its creation.

Authentication and encryption

Authentication algorithms

IPsec uses hash algorithms to perform authentication. A hash algorithm produces a fixed-length digest for an arbitrary-length message. IPsec peers respectively calculate message digests for each packet. The receiver compares the local digest with that received from the sender. If the digests are

identical, the receiver considers the packet intact and the sender's identity valid. IPsec uses the Hash-based Message Authentication Code (HMAC) based authentication algorithms, including HMAC-MD5 and HMAC-SHA1. Compared with HMAC-SHA1, HMAC-MD5 is faster but less secure.

Encryption algorithms

IPsec uses symmetric encryption algorithms, which encrypt and decrypt data by using the same keys. The following encryption algorithms are available for IPsec on the device:

- **DES**—Encrypts a 64-bit plaintext block with a 56-bit key. DES is the least secure but the fastest algorithm.
- **3DES**—Encrypts plaintext data with three 56-bit DES keys. The key length totals up to 168 bits. It provides moderate security strength and is slower than DES.
- **AES**—Encrypts plaintext data with a 128-bit, 192-bit, or 256-bit key. AES provides the highest security strength and is slower than 3DES.

IPsec-protected traffic

IPsec tunnels can protect the following types of traffic:

- Packets that match specific ACLs.
- Packets routed to a tunnel interface.
- Packets of IPv6 routing protocols.

Two peers use security policies (IPsec policies or IPsec profiles) to protect packets between them. A security policy defines the range of packets to be protected by IPsec and the security parameters used for the protection. For more information about IPsec policies and IPsec profiles, see "IPsec policy and IPsec profile."

The following information describes how IPsec protects packets:

- When an IPsec peer identifies the packets to be protected according to the security policy, it sets up an IPsec tunnel and sends the packet to the remote peer through the tunnel. The IPsec tunnel can be manually configured beforehand, or it can be set up through IKE negotiation triggered by the packet. The IPsec tunnels are actually the IPsec SAs. The inbound packets are protected by the inbound SA, and the outbound packets are protected by the outbound SA.
- When the remote IPsec peer receives the packet, it drops, de-encapsulates, or directly forwards the packet according to the configured security policy.

ACL-based IPsec

To implement ACL-based IPsec, configure an ACL to define the data flows to be protected, specify the ACL in an IPsec policy, and then apply the IPsec policy to an interface. You can apply an IPsec policy to physical interfaces such as serial interfaces and Ethernet interfaces, or virtual interfaces such as tunnel interfaces and virtual template interfaces.

ACL-based IPsec works as follows:

- When packets sent by the interface match a permit rule of the ACL, the packets are protected by the outbound IPsec SA and encapsulated with IPsec.
- When the interface receives an IPsec packet destined for the local device, it searches for the inbound IPsec SA according to the SPI in the IPsec packet header for de-encapsulation. If the de-encapsulated packet matches a permit rule of the ACL, the device processes the packet. If the de-encapsulated packet does not match any permit rule of the ACL, the device drops the packet.

The device supports the following data flow protection modes:

- **Standard mode**—One IPsec tunnel protects one data flow. The data flow permitted by an ACL rule is protected by one IPsec tunnel that is established solely for it.

- **Aggregation mode**—One IPsec tunnel protects all data flows permitted by all the rules of an ACL. This mode is only used to communicate with old-version devices.
- **Per-host mode**—One IPsec tunnel protects one host-to-host data flow. One host-to-host data flow is identified by one ACL rule and protected by one IPsec tunnel established solely for it. This mode consumes more system resources when multiple data flows exist between two subnets to be protected.

IPv6 routing protocol-based IPsec

You can implement IPv6 routing protocol-based IPsec by binding an IPsec profile to an IPv6 routing protocol. All packets of the protocol are encapsulated with IPsec. Supported IPv6 routing protocols include OSPFv3 and RIPng.

All packets of the applications that are not bound to IPsec and the IPsec packets that failed to be de-encapsulated are dropped.

In one-to-many communication scenarios, you must configure the IPsec SAs for an IPv6 routing protocol in manual mode because of the following reasons:

- The automatic key exchange mechanism protects communications between two points. In one-to-many communication scenarios, automatic key exchange cannot be implemented.
- One-to-many communication scenarios require that all the devices use the same SA parameters (SPI and key) to receive and send packets. IKE negotiated SAs cannot meet this requirement.

IPsec policy and IPsec profile

IPsec policies and IPsec profiles define the parameters used to establish IPsec tunnels between two peers and the range of packets to be protected.

IPsec policy

An IPsec policy is a set of IPsec policy entries that have the same name but different sequence numbers.

An IPsec policy contains the following settings:

- An ACL that defines the range of data flows to be protected.
- An IPsec transform set that defines the security parameters used for IPsec protection.
- IPsec SA establishment mode.

  Supported IPsec SA establishment modes are manual configuration and IKE negotiation.
- Local and remote IP addresses that define the start and end points of the IPsec tunnel.

In the same IPsec policy, an IPsec policy entry with a smaller sequence number has a higher priority. When sending a packet, the interface applied with an IPsec policy looks through the IPsec policy's entries in ascending order of sequence numbers. If the packet matches the ACL of an IPsec policy entry, the interface encapsulates the packet according to the IPsec policy entry. If no match is found, the interface sends the packet out without IPsec protection.

When the interface receives an IPsec packet destined for the local device, it searches for the inbound IPsec SA according to the SPI in the IPsec packet header for de-encapsulation. If the de-encapsulated packet matches a permit rule of the ACL, the device processes the packet. If the de-encapsulated packet does not match a permit rule of the ACL, the device drops the packet.

IPsec profile

An IPsec profile has similar settings as an IPsec policy. It is uniquely identified by a name and does not support ACL configuration.

IPsec profiles can be classified into the following types:

- **Manual IPsec profile**—A manual IPsec profile is used to protect IPv6 routing protocols. It specifies the IPsec transform set used for protecting data flows, and the SPIs and keys used by the SAs.
- **IKE-based IPsec profile**—An IKE-based IPsec profile is applied to tunnel interfaces to protect tunneled traffic. It specifies the IPsec transform sets used for protecting data flows, and the IKE profile used for IKE negotiation.

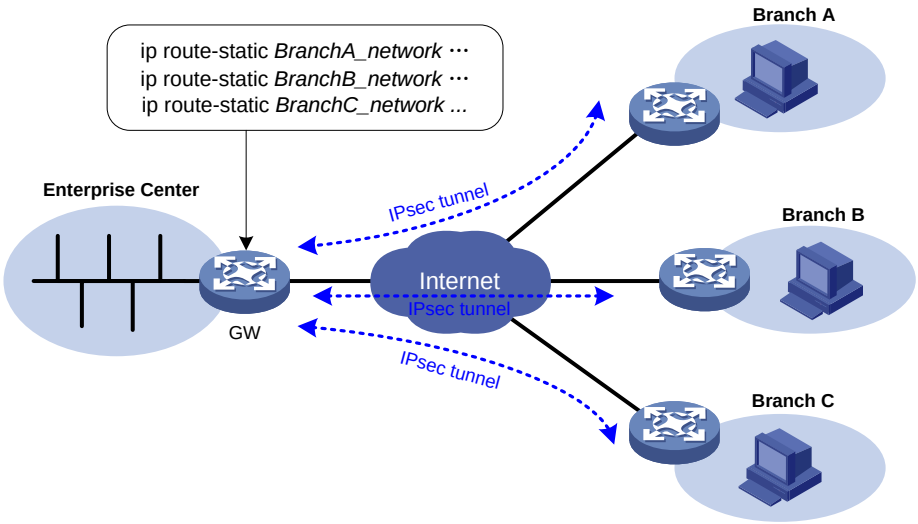
IPsec RRI

IPsec Reverse Route Injection (RRI) enables an IPsec tunnel gateway to automatically add and delete static routes destined for the protected private networks. It automatically adds the static routes when the IPsec SAs are established and deletes the static routes when the IPsec SAs are deleted. This greatly reduces the static route configuration work load on the gateway and increases the scalability of the IPsec VPN.

IPsec RRI is applicable to gateways that must provide many IPsec tunnels (for example, a headquarters gateway).

As shown in Figure 4, the traffic between the enterprise center and the branches are protected by IPsec. The gateway at the enterprise center is configured with static routes to route traffic to the IPsec-protected interfaces. It is difficult to add or modify static routes on the gateway at the enterprise center if the IPsec VPN has a large number of branches or if the network structure changes.

Figure 4 IPsec VPN



After you can enable IPsec RRI on the gateway, the gateway automatically adds a static route to the routing table each time an IPsec tunnel is established. The destination IP address is the protected private network, and the next hop is the remote IP address of the IPsec tunnel. Traffic destined for the peer end is routed to the IPsec tunnel interface and thereby protected by IPsec.

You can advertise the static routes created by IPsec RRI in the internal network, and the internal network device can use them to forward traffic in the IPsec VPN.

You can set preferences for the static routes created by IPsec RRI to implement flexible route management. For example, you can set the same preference for multiple routes to the same destination to implement load sharing, or you can set different preferences to implement route backup.

You can also set tags for the static routes created by IPsec RRI to implement flexible route control through routing policies.

Protocols and standards

- RFC 2401, *Security Architecture for the Internet Protocol*
- RFC 2402, *IP Authentication Header*
- RFC 2406, *IP Encapsulating Security Payload*
- RFC 4552, *Authentication/Confidentiality for OSPFv3*

FIPS compliance

The device supports the FIPS mode that complies with NIST FIPS 140-2 requirements. Support for features, commands, and parameters might differ in FIPS mode (see "Configuring FIPS") and non-FIPS mode.

Restrictions and guidelines: IPsec configuration

Typically, IKE uses UDP port 500 for communication, and AH and ESP use the protocol numbers 51 and 50, respectively. Make sure traffic of these protocols is not denied on the interfaces with IKE or IPsec configured.

Implementing ACL-based IPsec

ACLs for IPsec take effect only on traffic that is generated by the device and traffic that is destined for the device. They do not take effect on traffic forwarded through the device. For example, an ACL-based IPsec tunnel can protect log messages the device sends to a log server, but it does not protect data flows and voice flows that are forwarded by the device.

ACL-based IPsec tasks at a glance

To configure ACL-based IPsec, perform the following tasks:

1. Configuring an ACL
2. Configuring an IPsec transform set
3. Configuring an IPsec policy

   Choose one of the following tasks:
   - Configuring a manual IPsec policy
   - Configuring an IKE-based IPsec policy
4. Applying an IPsec policy to an interface
5. (Optional.) Configuring accessibility features for ACL-based IPsec
   - Enabling ACL checking for de-encapsulated packets
   - Configuring IPsec anti-replay
   - Configuring IPsec anti-replay redundancy
   - Binding a source interface to an IPsec policy
   - Enabling QoS pre-classify
   - Configuring the DF bit of IPsec packets
   - Configuring IPsec RRI
   - Configuring the global IPsec SA lifetime and idle timeout
   - Configuring IPsec fragmentation

- Setting the maximum number of IPsec tunnels

6. (Optional.) Configuring logging and SNMP notification for IPsec.
   - Enabling logging for IPsec packets
   - Configuring SNMP notifications for IPsec

Configuring an ACL

IPsec uses ACLs to identify the traffic to be protected.

Keywords in ACL rules

An ACL is a collection of ACL rules. Each ACL rule is a deny or permit statement. A permit statement identifies a data flow protected by IPsec, and a deny statement identifies a data flow that is not protected by IPsec. IPsec compares a packet against the ACL rules and processes the packet according to the first rule it matches.

- Each ACL rule matches both the outbound traffic and the returned inbound traffic. Suppose there is a rule **rule 0 permit ip source 1.1.1.0 0.0.0.255 destination 2.2.2.0 0.0.0.255**. This rule matches both traffic from 1.1.1.0 to 2.2.2.0 and traffic from 2.2.2.0 to 1.1.1.0.
- In the outbound direction, if a permit statement is matched, IPsec considers that the packet requires protection and continues to process it. If a deny statement is matched or no match is found, IPsec considers that the packet does not require protection and delivers it to the next module.
- In the inbound direction:
  - Non-IPsec packets that match a permit statement are dropped.
  - IPsec packets destined for the device itself are de-encapsulated. By default, the de-encapsulated packets are compared against the ACL rules. Only those that match a permit statement are processed. Other packets are dropped. If ACL checking for de-encapsulated IPsec packets is disabled, the de-encapsulated packets are not compared against the ACL rules and are directly processed by other modules.

When defining ACL rules for IPsec, follow these guidelines:

- Permit only data flows that need to be protected and use the **any** keyword with caution. With the **any** keyword specified in a permit statement, all outbound traffic matching the permit statement will be protected by IPsec. All inbound IPsec packets matching the permit statement will be received and processed, but all inbound non-IPsec packets will be dropped. This will cause all the inbound traffic that does not need IPsec protection to be dropped.
- Avoid statement conflicts in the scope of IPsec policy entries. When creating a deny statement, be careful with its match scope and match order relative to permit statements. The policy entries in an IPsec policy have different match priorities. ACL rule conflicts between them are prone to cause mistreatment of packets. For example, when configuring a permit statement for an IPsec policy entry to protect an outbound traffic flow, you must avoid the situation that the traffic flow matches a deny statement in a higher priority IPsec policy entry. Otherwise, the packets will be sent out as normal packets. If they match a permit statement at the receiving end, they will be dropped by IPsec.

The following example shows how an improper statement causes unexpected packet dropping. Only the ACL-related configuration is presented.

Assume Router A is connected to subnet 1.1.2.0/24 and Router B is connected to subnet 3.3.3.0/24, and the IPsec policy configuration on Router A and Router B is as follows:

- IPsec configuration on Router A:

```
acl advanced 3000
 rule 0 permit ip source 1.1.1.0 0.0.0.255 destination 2.2.2.0 0.0.0.255
 rule 1 deny ip
acl advanced 3001
```

```
 rule 0 permit ip source 1.1.2.0 0.0.0.255 destination 3.3.3.0 0.0.0.255
 rule 1 deny ip
#
ipsec policy testa 1 isakmp <---IPsec policy entry with a higher priority
 security acl 3000
 ike-profile aa
 transform-set 1
#
ipsec policy testa 2 isakmp <---IPsec policy entry with a lower priority
 security acl 3001
 ike-profile bb
 transform-set 1
```

- IPsec configuration on Router B:

```
acl advanced 3001
 rule 0 permit ip source 3.3.3.0 0.0.0.255 destination 1.1.2.0 0.0.0.255
 rule 1 deny ip
#
ipsec policy testb 1 isakmp
 security acl 3001
 ike-profile aa
 transform-set 1
```

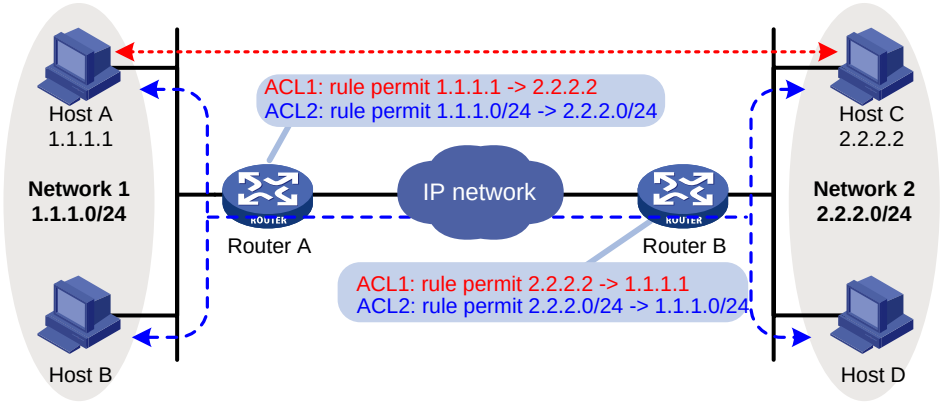
On Router A, apply the IPsec policy **testa** to the outbound interface of Router A. The IPsec policy contains two policy entries, **testa 1** and **testa 2**. The ACLs used by the two policy entries each contain a rule that matches traffic from 1.1.2.0/24 to 3.3.3.0/24. The one used in the policy entry **testa 1** is a deny statement and the one used in the policy entry **testa 2** is a permit statement. Because **testa 1** is matched prior to **testa 2**, traffic from 1.1.2.0/24 to 3.3.3.0/24 will match the deny statement and be sent as normal traffic. When the traffic arrives at Router B, the traffic matches rule 0 (a permit statement) in ACL 3001 used in the applied IPsec policy **testb**. Because non-IPsec traffic that matches a permit statement must be dropped on the inbound interface, Router B drops the traffic.

To make sure subnet 1.1.2.0/24 can access subnet 3.3.3.0/24, you can delete the deny rule in ACL 3000 on Router A.

Mirror image ACLs

To make sure SAs can be set up and the traffic protected by IPsec can be processed correctly between two IPsec peers, create mirror image ACLs on the IPsec peers. As shown in Figure 5, ACL rules on Router B are mirror images of the rules on Router A. In this way, SAs can be created successfully for the traffic between Host A and Host C and for the traffic between Network 1 and Network 2.

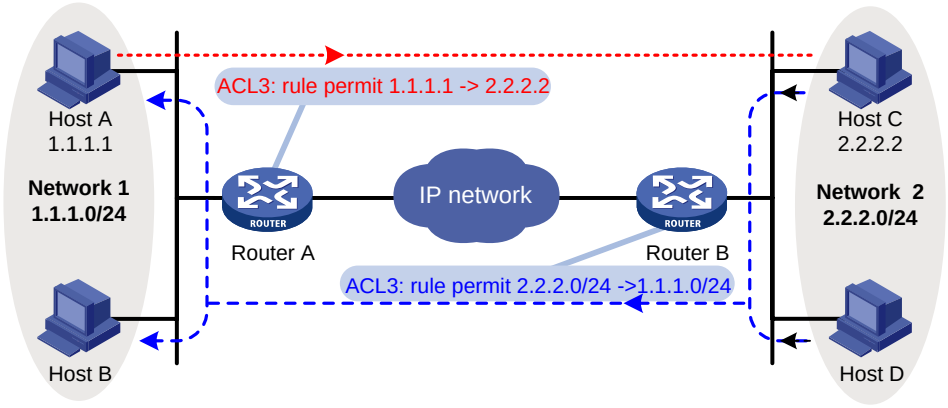
Figure 5 Mirror image ACLs



If the ACL rules on IPsec peers do not form mirror images of each other, SAs can be set up only when both of the following requirements are met:

- The range specified by an ACL rule on one peer is covered by its counterpart ACL rule on the other peer. As shown in Figure 6, the range specified by the ACL rule configured on Router A is covered by its counterpart on Router B.
- The peer with the narrower rule initiates SA negotiation. If a wider ACL rule is used by the SA initiator, the negotiation request might be rejected because the matching traffic is beyond the scope of the responder. As shown in Figure 6, the SA negotiation initiated by Host A to Host C is accepted but the SA negotiations from Host C to Host A, from Host C to Host B, and from Host D to Host A are rejected.

Figure 6 Non-mirror image ACLs



Configuring an IPsec transform set

About IPsec transform set

An IPsec transform set, part of an IPsec policy, defines the security parameters for IPsec SA negotiation, including the security protocol, encryption algorithms, and authentication algorithms.

Restrictions and guidelines

Changes to an IPsec transform set affect only SAs negotiated after the changes. To apply the changes to existing SAs, execute the reset ipsec sa command to clear the SAs so that they can be set up by using the updated parameters.

In FIPS mode, you must specify both the ESP encryption algorithm and the ESP authentication algorithm for an IPsec transform set that uses the ESP security protocol.

When you set the packet encapsulation mode (tunnel or transport) for an IPsec transform set, follow these guidelines:

- The transport mode applies only when the source and destination IP addresses of data flows match those of the IPsec tunnel.
- IPsec for IPv6 routing protocols supports only the transport mode.

When you configure the Perfect Forward Secrecy (PFS) feature in an IPsec transform set, follow these guidelines:

- In IKEv1, the security level of the DH group of the initiator must be higher than or equal to that of the responder. This restriction does not apply to IKEv2.
- The end without the PFS feature performs SA negotiation according to the PFS requirements of the peer end.

You can specify multiple authentication or encryption algorithms for the same security protocol. The algorithm specified earlier has a higher priority.

Some algorithms are available only for IKEv2. See Table 1.

Table 1 Algorithms available only for IKEv2

Type	Algorithms
Encryption algorithm	aes-ctr-128 aes-ctr-192 aes-ctr-256 camellia-cbc-128 camellia-cbc-192 camellia-cbc-256 gmac-128 gmac-192 gmac-256 gcm-128 gcm-192 gcm-256
Authentication algorithm	aes-xcbc-mac
PFS algorithm	dh-group19 dh-group20

Procedure

1. Enter system view.

   system-view

2. Create an IPsec transform set and enter its view.

   ipsec transform-set *transform-set-name*

3. Specify the security protocol for the IPsec transform set.

   protocol { **ah** | **ah-esp** | **esp** }

   By default, the ESP security protocol is used.

4. Specify the encryption algorithms for ESP. Skip this step if the **protocol ah** command is configured.

   In non-FIPS mode:

   esp encryption-algorithm { **3des-cbc** | **aes-cbc-128** | **aes-cbc-192** | **aes-cbc-256** | **aes-ctr-128** | **aes-ctr-192** | **aes-ctr-256** |

camellia-cbc-128 | **camellia-cbc-192** | **camellia-cbc-256** | **des-cbc** | **gmac-128** | **gmac-192** | **gmac-256** | **gcm-128** | **gcm-192** | **gcm-256** | **null** } *

By default, no encryption algorithm is specified for ESP.

In FIPS mode:

esp encryption-algorithm { **aes-cbc-128** | **aes-cbc-192** | **aes-cbc-256** | **aes-ctr-128** | **aes-ctr-192** | **aes-ctr-256** | **gmac-128** | **gmac-192** | **gmac-256** | **gcm-128** | **gcm-192** | **gcm-256** } *

By default, no encryption algorithm is specified for ESP.

5. Specify the authentication algorithms for ESP. Skip this step if the **protocol ah** command is configured.

   In non-FIPS mode:

   esp authentication-algorithm { **aes-xcbc-mac** | **md5** | **sha1** | **sha256** | **sha384** | **sha512** } *

   By default, no authentication algorithm is specified for ESP.

   The **aes-xcbc-mac** algorithm is available only for IKEv2.

   In FIPS mode:

   esp authentication-algorithm { **sha1** | **sha256** | **sha384** | **sha512** } *

   By default, no authentication algorithm is specified for ESP.

6. Specify the authentication algorithms for AH. Skip this step if the **protocol esp** command is configured.

   In non-FIPS mode:

   ah authentication-algorithm { **aes-xcbc-mac** | **md5** | **sha1** | **sha256** | **sha384** | **sha512** } *

   By default, no authentication algorithm is specified for AH.

   The **aes-xcbc-mac** algorithm is available only for IKEv2.

   In FIPS mode:

   ah authentication-algorithm { **sha1** | **sha256** | **sha384** | **sha512** } *

   By default, no authentication algorithm is specified for AH.

7. Specify the packet encapsulation mode.

   encapsulation-mode { **transport** | **tunnel** }

   By default, the security protocol encapsulates IP packets in tunnel mode.

8. (Optional.) Enable the PFS feature.

   In non-FIPS mode:

   pfs { **dh-group1** | **dh-group2** | **dh-group5** | **dh-group14** | **dh-group24** | **dh-group19** | **dh-group20** }

   In FIPS mode:

   pfs { **dh-group14** | **dh-group19** | **dh-group20** }

   By default, the PFS feature is disabled.

   For more information about PFS, see "Configuring IKE."

9. (Optional.) Enable the Extended Sequence Number (ESN) feature.

   esn enable [**both**]

   By default, the ESN feature is disabled.

Configuring a manual IPsec policy

In a manual IPsec policy, the parameters are configured manually, such as the keys, the SPIs, and the IP addresses of the two ends in tunnel mode.

Restrictions and guidelines

When you configure a manual IPsec policy, make sure the IPsec configuration at both ends of the IPsec tunnel meets the following requirements:

- The IPsec policies at the two ends must have IPsec transform sets that use the same security protocols, security algorithms, and encapsulation mode.
- The remote IPv4 address configured on the local end must be the same as the primary IPv4 address of the interface applied with the IPsec policy at the remote end. The remote IPv6 address configured on the local end must be the same as the first IPv6 address of the interface applied with the IPsec policy at the remote end.
- At each end, configure parameters for both the inbound SA and the outbound SA, and make sure the SAs in each direction are unique: For an outbound SA, make sure its triplet (remote IP address, security protocol, and SPI) is unique. For an inbound SA, make sure its SPI is unique.
- The local inbound SA must use the same SPI and keys as the remote outbound SA. The same is true of the local outbound SA and remote inbound SA.
- The keys for the IPsec SAs at the two tunnel ends must be configured in the same format. For example, if the local end uses a key in hexadecimal format, the remote end must also use a key in hexadecimal format. If you configure a key in both the character and the hexadecimal formats, only the most recent configuration takes effect.
- If you configure a key in character format for ESP, the device automatically generates an authentication key and an encryption key for ESP.

Procedure

1. Enter system view.

   system-view

2. Create a manual IPsec policy entry and enter its view.

   ipsec { **ipv6-policy** | **policy** } *policy-name seq-number* **manual**

3. (Optional.) Configure a description for the IPsec policy.

   description *text*

   By default, no description is configured.

4. Specify an ACL for the IPsec policy.

   security acl [**ipv6**] { *acl-number* | **name** *acl-name* }

   By default, no ACL is specified for an IPsec policy.

   You can specify only one ACL for an IPsec policy.

5. Specify an IPsec transform set for the IPsec policy.

   transform-set *transform-set-name*

   By default, no IPsec transform set is specified for an IPsec policy.

   You can specify only one IPsec transform set for a manual IPsec policy.

6. Specify the remote IP address of the IPsec tunnel.

   remote-address { *ipv4-address* | **ipv6** *ipv6-address* }

   By default, the remote IP address of the IPsec tunnel is not specified.

7. Configure an SPI for the inbound IPsec SA.

   sa spi inbound { **ah** | **esp** } *spi-number*

   By default, no SPI is configured for the inbound IPsec SA.

8. Configure an SPI for the outbound IPsec SA.

   sa spi outbound { **ah** | **esp** } *spi-number*

   By default, no SPI is configured for the outbound IPsec SA.

9. Configure keys for the IPsec SA.
   - Configure an authentication key in hexadecimal format for AH.

     sa hex-key authentication { **inbound** | **outbound** } **ah** { **cipher** | **simple** } *string*
   - Configure an authentication key in character format for AH.

     sa string-key { **inbound** | **outbound** } **ah** { **cipher** | **simple** } *string*
   - Configure a key in character format for ESP.

     sa string-key { **inbound** | **outbound** } **esp** { **cipher** | **simple** } *string*
   - Configure an authentication key in hexadecimal format for ESP.

     sa hex-key authentication { **inbound** | **outbound** } **esp** { **cipher** | **simple** }
   - Configure an encryption key in hexadecimal format for ESP.

     sa hex-key encryption { **inbound** | **outbound** } **esp** { **cipher** | **simple** } *string*

   By default, no keys are configured for the IPsec SA.

   Configure keys correctly for the security protocol (AH, ESP, or both) you have specified in the IPsec transform set used by the IPsec policy.

Configuring an IKE-based IPsec policy

About IKE-based IPsec policy configuration

In an IKE-based IPsec policy, the parameters are automatically negotiated through IKE.

To configure an IKE-based IPsec policy, use one of the following methods:

- Directly configure it by configuring the parameters in IPsec policy view.
- Configure it by using an existing IPsec policy template with the parameters to be negotiated configured.

  A device using an IPsec policy that is configured in this way cannot initiate an SA negotiation, but it can respond to a negotiation request. The parameters not defined in the template are determined by the initiator. For example, in an IPsec policy template, the ACL is optional. If you do not specify an ACL, the IPsec protection range has no limit. So the device accepts all ACL settings of the negotiation initiator.

  When the remote end's information (such as the IP address) is unknown, this method allows the remote end to initiate negotiations with the local end.

The configurable parameters for an IPsec policy template are the same as those when you directly configure an IKE-based IPsec policy. The difference is that more parameters are optional for an IPsec policy template. Except the IPsec transform sets and the IKE profile, all other parameters are optional.

Restrictions and guidelines for IKE-based IPsec policy configuration

The IPsec policies at the two tunnel ends must have IPsec transform sets that use the same security protocols, security algorithms, and encapsulation mode.

The IPsec policies at the two tunnel ends must have the same IKE profile parameters.

An IKE-based IPsec policy can use a maximum of six IPsec transform sets. During an IKE negotiation, IKE searches for a fully matched IPsec transform set at the two ends of the IPsec tunnel. If no match is found, no SA can be set up, and the packets expecting to be protected will be dropped.

The remote IP address of the IPsec tunnel is required on an IKE negotiation initiator and is optional on the responder. The remote IP address specified on the local end must be the same as the local IP address specified on the remote end.

The IPsec SA uses the local lifetime settings or those proposed by the peer, whichever are smaller.

The IPsec SA can have both a time-based lifetime and a traffic-based lifetime. The IPsec SA expires when either lifetime expires.

If you specify both an IKEv1 profile and an IKEv2 profile for an IPsec policy, the IKEv2 profile is used preferentially. For more information about IKEv1 and IKEv2 profiles, see "Configuring IKE" and "Configuring IKEv2."

Directly configuring an IKE-based IPsec policy

1. Enter system view.

   system-view

2. Create an IKE-based IPsec policy entry and enter its view.

   ipsec { **ipv6-policy** | **policy** } *policy-name seq-number* **isakmp**

3. (Optional.) Configure a description for the IPsec policy.

   description *text*

   By default, no description is configured.

4. Specify an ACL for the IPsec policy.

   security acl [**ipv6**] { *acl-number* | **name** *acl-name* } [**aggregation** | **per-host**]

   By default, no ACL is specified for an IPsec policy.

   You can specify only one ACL for an IPsec policy.

5. Specify IPsec transform sets for the IPsec policy.

   transform-set *transform-set-name*&<1-6>

   By default, no IPsec transform sets are specified for an IPsec policy.

6. Specify an IKE profile or IKEv2 profile for the IPsec policy.
   - Specify an IKE profile.

     ike-profile *profile-name*

     By default, no IKE profile is specified for an IPsec policy.
   - Specify an IKEv2 profile.

     ikev2-profile *profile-name*

     By default, no IKEv2 profile is specified for an IPsec policy.

7. Specify the local IP address of the IPsec tunnel.

   local-address { *ipv4-address* | **ipv6** *ipv6-address* }

   By default, the local IPv4 address of the IPsec tunnel is the primary IPv4 address of the interface to which the IPsec policy is applied. The local IPv6 address of the IPsec tunnel is the first IPv6 address of the interface to which the IPsec policy is applied.

   The local IP address specified by this command must be the same as the IP address used as the local IKE identity.

   In a VRRP network, the local IP address must be the virtual IP address of the VRRP group to which the IPsec-applied interface belongs.

8. Specify the remote IP address of the IPsec tunnel.

   remote-address { [**ipv6**] *host-name* | *ipv4-address* | **ipv6** *ipv6-address* }

   By default, the remote IP address of the IPsec tunnel is not specified.

9. (Optional.) Set the lifetime or idle timeout for the IPsec SA.

- Set the IPsec SA lifetime.

  sa duration { **time-based** *seconds* | **traffic-based** *kilobytes* }

  By default, the global SA lifetime is used.
- Set the IPsec SA idle timeout.

  sa idle-time *seconds*

  By default, the global IPsec SA idle timeout is used.

10. (Optional.) Enable the Traffic Flow Confidentiality (TFC) padding feature.

tfc enable

By default, the TFC padding feature is disabled.

Configuring an IKE-based IPsec policy by using an IPsec policy template

1. Enter system view.

system-view

2. Create an IPsec policy template and enter its view.

ipsec { **ipv6-policy-template** | **policy-template** } *template-name seq-number*

3. (Optional.) Configure a description for the IPsec policy template.

description *text*

By default, no description is configured.

4. (Optional.) Specify an ACL for the IPsec policy template.

security acl [**ipv6**] { *acl-number* | **name** *acl-name* } [**aggregation** | **per-host**]

By default, no ACL is specified for an IPsec policy template.

You can specify only one ACL for an IPsec policy template.

5. Specify IPsec transform sets for the IPsec policy template.

transform-set *transform-set-name*&<1-6>

By default, no IPsec transform sets are specified for an IPsec policy template.

6. Specify an IKE profile or IKEv2 profile for the IPsec policy template.
- Specify an IKE profile.

  ike-profile *profile-name*

  By default, no IKE profile is specified for an IPsec policy template.

  Make sure the specified IKE profile is not used by another IPsec policy or IPsec policy template.
- Specify an IKEv2 profile.

  ikev2-profile *profile-name*

  By default, no IKEv2 profile is specified for an IPsec policy template.

7. Specify the local IP address of the IPsec tunnel.

local-address { *ipv4-address* | **ipv6** *ipv6-address* }

The default local IPv4 address and IPv6 address is the primary IPv4 address and first IPv6 address of the interface where the IPsec policy is applied.

The local IP address specified by this command must be the same as the IP address used as the local IKE identity.

In a VRRP network, the local IP address must be the virtual IP address of the VRRP group to which the IPsec-applied interface belongs.

8. Specify the remote IP address of the IPsec tunnel.

remote-address { [**ipv6**] *host-name* | *ipv4-address* | **ipv6** *ipv6-address* }

By default, the remote IP address of the IPsec tunnel is not specified.

9. (Optional.) Set the lifetime and idle timeout for the IPsec SA.
   - Set the IPsec SA lifetime.
     sa duration { **time-based** *seconds* | **traffic-based** *kilobytes* }
     By default, the global SA lifetime is used.
   - Set the IPsec SA idle timeout.
     sa idle-time *seconds*
     By default, the global IPsec SA idle timeout is used.
10. (Optional.) Enable the Traffic Flow Confidentiality (TFC) padding feature.
    tfc enable
    By default, the TFC padding feature is disabled.
11. Return to system view.
    quit
12. Create an IPsec policy by using the IPsec policy template.
    ipsec { **ipv6-policy** | **policy** } *policy-name seq-number* **isakmp template** *template-name*

Applying an IPsec policy to an interface

Restrictions and guidelines

You can apply an IPsec policy to interfaces to protect data flows.

- An IKE-based IPsec policy can be applied to multiple interfaces. As a best practice, apply an IKE-based IPsec policy to only one interface.
- A manual IPsec policy can be applied to only one interface.

To cancel the IPsec protection, remove the application of the IPsec policy.

Procedure

1. Enter system view.
   system-view
2. Enter interface view.
   interface *interface-type interface-number*
3. Apply an IPsec policy to the interface.
   ipsec apply { **ipv6-policy** | **policy** } *policy-name*
   By default, no IPsec policy is applied to an interface.
   On one interface, you can apply only one IPv4 IPsec policy and one IPv6 IPsec policy.

Enabling ACL checking for de-encapsulated packets

About ACL checking for de-encapsulated packets

This feature compares the de-encapsulated incoming IPsec packets against the ACL in the IPsec policy and discards those that do not match any permit rule of the ACL. This feature can protect networks against attacks using forged IPsec packets.

This feature applies only to tunnel-mode IPsec.

Procedure

1. Enter system view.

system-view

2. Enable ACL checking for de-encapsulated packets.

   ipsec decrypt-check enable

   By default, ACL checking for de-encapsulated packets is enabled.

Configuring IPsec anti-replay

About IPsec anti-replay

IPsec anti-replay protects networks against anti-replay attacks by using a sliding window mechanism called anti-replay window. This feature checks the sequence number of each received IPsec packet against the current IPsec packet sequence number range of the sliding window. If the sequence number is not in the current sequence number range, the packet is considered a replayed packet and is discarded.

IPsec packet de-encapsulation involves complicated calculation. De-encapsulation of replayed packets is not required, and the de-encapsulation process consumes large amounts of resources and degrades performance, resulting in DoS. IPsec anti-replay can check and discard replayed packets before de-encapsulation.

In some situations, service data packets are received in a different order than their original order. The IPsec anti-replay feature drops them as replayed packets, which impacts communications. If this happens, disable IPsec anti-replay checking or adjust the size of the anti-replay window as required.

Restrictions and guidelines

IPsec anti-replay does not affect manually created IPsec SAs. According to the IPsec protocol, only IKE-based IPsec SAs support anti-replay.

Set the anti-replay window size as small as possible to reduce the impact on system performance.

Failure to detect anti-replay attacks might result in denial of services. If you want to disable IPsec anti-replay, make sure you understand the impact of the operation on network security.

Procedure

1. Enter system view.

   system-view

2. Enable IPsec anti-replay.

   ipsec anti-replay check

   By default, IPsec anti-replay is enabled.

3. Set the size of the IPsec anti-replay window.

   ipsec anti-replay window *width*

   The default size is 64.

Configuring IPsec anti-replay redundancy

About IPsec anti-replay redundancy

This feature synchronizes the following information from the active device to the standby device at configurable packet-based intervals:

- Lower bound values of the IPsec anti-replay window for inbound packets.
- IPsec anti-replay sequence numbers for outbound packets.

This feature, used together with IPsec redundancy, ensures uninterrupted IPsec traffic forwarding and anti-replay protection when the active device fails.

Procedure

1. Enter system view.

   system-view

2. Enable IPsec redundancy.

   ipsec redundancy enable

   By default, IPsec redundancy is disabled.

3. Enter IPsec policy view or IPsec policy template view.
   - Enter IPsec policy view.

     ipsec { **ipv6-policy** | **policy** } *policy-name seq-number* [**isakmp** | **manual**]

   - Enter IPsec policy template view.

     ipsec { **ipv6-policy-template** | **policy-template** } *template-name seq-number*

4. Set the anti-replay window synchronization interval for inbound packets and the sequence number synchronization interval for outbound packets.

   redundancy replay-interval inbound *inbound-interval* **outbound** *outbound-interval*

   By default, the active device synchronizes the anti-replay window every time it receives 1000 packets and synchronizes the sequence number every time it sends 100000 packets.

Binding a source interface to an IPsec policy

About source interface and IPsec policy binding

For high availability, a core device is usually connected to an ISP through two links, which operate in backup or load sharing mode. The two interfaces negotiate with their peers to establish IPsec SAs respectively. When one interface fails and a link failover occurs, the other interface needs to take some time to renegotiate SAs, resulting in service interruption.

To solve these problems, bind a source interface to an IPsec policy and apply the policy to both interfaces. This enables the two physical interfaces to use the same source interface to negotiate IPsec SAs. As long as the source interface is up, the negotiated IPsec SAs will not be removed and will keep working, regardless of link failover.

Restrictions and guidelines

Only the IKE-based IPsec policies can be bound to a source interface.

An IPsec policy can be bound to only one source interface.

A source interface can be bound to multiple IPsec policies.

If the source interface bound to an IPsec policy is removed, the IPsec policy becomes a common IPsec policy.

If no local address is specified for an IPsec policy that has been bound to a source interface, the IPsec policy uses the IP address of the bound source interface to perform IKE negotiation. If a local address is specified, the IPsec policy uses the local address to perform IKE negotiation.

Procedure

1. Enter system view.

   system-view

2. Bind a source interface to an IPsec policy.

   ipsec { **ipv6-policy** | **policy** } *policy-name* **local-address** *interface-type interface-number*

By default, no source interface is bound to an IPsec policy.

Enabling QoS pre-classify

About QoS pre-classify

When both an IPsec policy and a QoS policy are applied to an interface, QoS classifies packets by using the new headers added by IPsec. If you want QoS to classify packets by using the headers of the original IP packets, enable the QoS pre-classify feature.

Restrictions and guidelines

If you configure both IPsec and QoS on an interface, make sure the IPsec traffic classification rules match the QoS traffic classification rules. If the rules do not match, QoS might classify the packets of one IPsec SA to different queues, causing packets to be sent out of order. When IPsec anti-replay is enabled, IPsec will drop the incoming packets that are out of the anti-replay window, resulting in packet loss.

IPsec traffic classification rules are determined by the rules of the specified ACL. For more information about QoS policy and classification, see *ACL and QoS Configuration Guide*.

Procedure

1. Enter system view.

   system-view

2. Enter IPsec policy view or IPsec policy template view.
   - Enter IPsec policy view.

     ipsec { **ipv6-policy** | **policy** } *policy-name seq-number* [**isakmp** | **manual**]
   - Enter IPsec policy template view.

     ipsec { **ipv6-policy-template** | **policy-template** } *template-name seq-number*

3. Enable QoS pre-classify.

   qos pre-classify

   By default, QoS pre-classify is disabled.

Configuring the DF bit of IPsec packets

About DF bit configuration for IPsec packets

Perform this task to configure the Don't Fragment (DF) bit in the new IP header of IPsec packets in one of the following ways:

- **clear**—Clears the DF bit in the new header.
- **set**—Sets the DF bit in the new header.
- **copy**—Copies the DF bit in the original IP header to the new IP header.

You can configure the DF bit in system view and interface view. The interface-view DF bit setting takes precedence over the system-view DF bit setting. If the interface-view DF bit setting is not configured, the interface uses the system-view DF bit setting.

Restrictions and guidelines for DF bit configuration for IPsec packets

The DF bit setting takes effect only in tunnel mode, and it changes the DF bit in the new IP header rather than the original IP header.

Configure the same DF bit setting on the interfaces where the same IPsec policy bound to a source interface is applied.

If the DF bit is set, the devices on the path cannot fragment the IPsec packets. To prevent IPsec packets from being discarded, make sure the path MTU is larger than the IPsec packet size. As a best practice, clear the DF bit if you cannot make sure the path MTU is larger than the IPsec packet size.

Configuring the DF bit of IPsec packets on an interface

1. Enter system view.
   system-view
2. Enter interface view.
   interface *interface-type interface-number*
3. Configure the DF bit of IPsec packets on the interface.
   ipsec df-bit { **clear** | **copy** | **set** }
   By default, the interface uses the global DF bit setting.

Configuring the DF bit of IPsec packets globally

1. Enter system view.
   system-view
2. Configure the DF bit of IPsec packets globally.
   ipsec global-df-bit { **clear** | **copy** | **set** }
   By default, IPsec copies the DF bit in the original IP header to the new IP header.

Configuring IPsec RRI

Restrictions and guidelines

Enabling IPsec RRI for an IPsec policy deletes all existing IPsec SAs created by this IPsec policy. IPsec RRI creates static routes according to new IPsec SAs.

Disabling IPsec RRI for an IPsec policy deletes all existing IPsec SAs created by this IPsec policy and the associated static routes.

IPsec RRI is supported in both tunnel mode and transport mode.

If you change the preference value or tag value for an IPsec policy, the device deletes all IPsec SAs created by this IPsec policy, and the associated static routes. The change takes effect for future IPsec RRI-created static routes.

IPsec RRI does not generate a static route to a destination address to be protected if the destination address is not defined in the ACL used by an IPsec policy or an IPsec policy template. You must manually configure a static route to the destination address.

Procedure

1. Enter system view.
   system-view
2. Enter IPsec policy view or IPsec policy template view.
   - Enter IPsec policy view.
     ipsec { **policy** | **ipv6-policy** } *policy-name seq-number* **isakmp**
   - Enter IPsec policy template view.
     ipsec { **ipv6-policy-template** | **policy-template** } *template-name seq-number*
3. Enable IPsec RRI.
   reverse-route dynamic
   By default, IPsec RRI is disabled.

4. (Optional.) Set the preference value for the static routes created by IPsec RRI.
   reverse-route preference *number*
   The default value is 60.
5. (Optional.) Set the tag value for the static routes created by IPsec RRI.
   reverse-route tag *tag-value*
   The default value is 0.

Configuring IPsec for IPv6 routing protocols

IPsec protection for IPv6 routing protocols tasks at a glance

To configure IPsec protection for IPv6 routing protocols, perform the following tasks:

1. Configuring an IPsec transform set
2. Configuring a manual IPsec profile
3. Applying the IPsec profile to an IPv6 routing protocol
4. (Optional.) Configuring IPsec fragmentation
5. (Optional.) Setting the maximum number of IPsec tunnels
6. (Optional.) Enabling logging for IPsec packets
7. (Optional.) Configuring SNMP notifications for IPsec

Configuring a manual IPsec profile

About manual IPsec profile

A manual IPsec profile specifies the IPsec transform set used for protecting data flows, and the SPIs and keys used by the SAs.

Restrictions and guidelines

When you configure a manual IPsec profile, make sure the IPsec profile configuration at both tunnel ends meets the following requirements:

- The IPsec transform set specified in the IPsec profile at the two tunnel ends must have the same security protocol, encryption and authentication algorithms, and packet encapsulation mode.
- The local inbound and outbound IPsec SAs must have the same SPI and key.
- The IPsec SAs on the devices in the same scope must have the same key. The scope is defined by protocols. For OSPFv3, the scope consists of OSPFv3 neighbors or an OSPFv3 area. For RIPng, the scope consists of directly-connected neighbors or a RIPng process.
- The keys for the IPsec SAs at the two tunnel ends must be configured in the same format. For example, if the local end uses a key in hexadecimal format, the remote end must also use a key in hexadecimal format. If you configure a key in both the character and the hexadecimal formats, only the most recent configuration takes effect.
- If you configure a key in character format for ESP, the device automatically generates an authentication key and an encryption key for ESP.

Procedure

1. Enter system view.
   system-view
2. Create a manual IPsec profile and enter its view.
   ipsec profile *profile-name* **manual**

The **manual** keyword is not needed if you enter the view of an existing IPsec profile.

3. (Optional.) Configure a description for the IPsec profile.

   description *text*

   By default, no description is configured.

4. Specify an IPsec transform set.

   transform-set *transform-set-name*

   By default, no IPsec transform set is specified in an IPsec profile.

   The specified IPsec transform set must use the transport mode.

5. Configure an SPI for an SA.

   sa spi { **inbound** | **outbound** } { **ah** | **esp** } *spi-number*

   By default, no SPI is configured for an SA.

6. Configure keys for the IPsec SA.

   - Configure an authentication key in hexadecimal format for AH.

     sa hex-key authentication { **inbound** | **outbound** } **ah** { **cipher** | **simple** } *string*

   - Configure an authentication key in character format for AH.

     sa string-key { **inbound** | **outbound** } **ah** { **cipher** | **simple** } *string*

   - Configure a key in character format for ESP.

     sa string-key { **inbound** | **outbound** } **esp** { **cipher** | **simple** } *string*

   - Configure an authentication key in hexadecimal format for ESP.

     sa hex-key authentication { **inbound** | **outbound** } **esp** { **cipher** | **simple** }

   - Configure an encryption key in hexadecimal format for ESP.

     sa hex-key encryption { **inbound** | **outbound** } **esp** { **cipher** | **simple** } *string*

   By default, no keys are configured for the IPsec SA.

   Configure a key for the security protocol (AH, ESP, or both) you have specified.

Applying the IPsec profile to an IPv6 routing protocol

For information about the configuration procedure, see OSPFv3, and RIPng configuration in *Layer 3—IP Routing Configuration Guide*.

Configuring the global IPsec SA lifetime and idle timeout

About global IPsec SA lifetime and idle timeout

If the IPsec SA lifetime and idle timeout are not configured in an IPsec policy, IPsec policy template, or IPsec profile, the global settings are used.

When IKE negotiates IPsec SAs, it uses the local lifetime settings or those proposed by the peer, whichever are smaller.

An IPsec SA can have both a time-based lifetime and a traffic-based lifetime. The IPsec SA expires when either lifetime expires.

Procedure

1. Enter system view.

   system-view

2. Set the global IPsec SA lifetime or idle timeout.
   - Set the global IPsec SA lifetime.

     ipsec sa global-duration { **time-based** *seconds* | **traffic-based** *kilobytes* }

     By default, the time-based SA lifetime is 3600 seconds, and the traffic-based SA lifetime is 1843200 kilobytes.
   - Set the global SA idle timeout.

     ipsec sa idle-time *seconds*

     By default, the global IPsec SA idle timeout feature is disabled.

Configuring IPsec fragmentation

About IPsec fragmentation

Perform this task to configure the device to fragment packets before or after IPsec encapsulation.

If you configure the device to fragment packets before IPsec encapsulation, the device predetermines the encapsulated packet size before the actual encapsulation. If the encapsulated packet size exceeds the MTU of the output interface, the device fragments the packets before encapsulation. If a packet's DF bit is set, the device drops the packet and sends an ICMP error message.

If you configure the device to fragment packets after IPsec encapsulation, the device directly encapsulates the packets and fragments the encapsulated packets in subsequent service modules.

Restrictions and guidelines

This feature takes effect on IPsec protected IPv4 packets.

Procedure

1. Enter system view.

   system-view

2. Configure IPsec fragmentation.

   ipsec fragmentation { **after-encryption** | **before-encryption** }

   By default, the device fragments packets before IPsec encapsulation.

Setting the maximum number of IPsec tunnels

Restrictions and guidelines

To maximize concurrent performance of IPsec when memory is sufficient, increase the maximum number of IPsec tunnels. To ensure service availability when memory is insufficient, decrease the maximum number of IPsec tunnels.

Procedure

1. Enter system view.

   system-view

2. Set the maximum number of IPsec tunnels.

   ipsec limit max-tunnel *tunnel-limit*

The number of IPsec tunnels is not limited.

Enabling logging for IPsec packets

About IPsec packet logging

Perform this task to enable logging for IPsec packets that are discarded for reasons such as IPsec SA lookup failure, AH-ESP authentication failure, and ESP encryption failure. The log information includes the source and destination IP addresses, SPI value, and sequence number of a discarded IPsec packet, and the reason for the discard.

Procedure

1. Enter system view.

   `system-view`
2. Enable logging for IPsec packets.

   `ipsec logging packet enable`

   By default, logging for IPsec packets is disabled.

Configuring SNMP notifications for IPsec

About SNMP notifications for IPsec

After you enable SNMP notifications for IPsec, the IPsec module notifies the NMS of important module events. The notifications are sent to the device's SNMP module. For the notifications to be sent correctly, you must also configure SNMP on the device. For more information about SNMP notifications, see *Network Management and Monitoring Configuration Guide*.

To generate and output SNMP notifications for a specific IPsec failure or event type, perform the following tasks:

1. Enable SNMP notifications for IPsec globally.
2. Enable SNMP notifications for the failure or event type.

Procedure

1. Enter system view.

   `system-view`
2. Enable SNMP notifications for IPsec globally.

   `snmp-agent trap enable ipsec global`

   By default, SNMP notifications for IPsec are disabled.
3. Enable SNMP notifications for the specified failure or event types.

   `snmp-agent trap enable ipsec` [**`auth-failure`** | **`decrypt-failure`** | **`encrypt-failure`** | **`invalid-sa-failure`** | **`no-sa-failure`** | **`policy-add`** | **`policy-attach`** | **`policy-delete`** | **`policy-detach`** | **`tunnel-start`** | **`tunnel-stop`**] *

   By default, SNMP notifications for all failure and event types are disabled.

Display and maintenance commands for IPsec

Execute **`display`** commands in any view and **`reset`** commands in user view.

Task	Command
Display IPsec policy information.	**display ipsec** { **ipv6-policy** | **policy** } [*policy-name* [*seq-number*]]
Display IPsec policy template information.	**display ipsec** { **ipv6-policy-template** | **policy-template** } [*template-name* [*seq-number*]]
Display IPsec profile information.	**display ipsec profile** [*profile-name*]
Display IPsec SA information.	**display ipsec sa** [**brief** | **count** | **interface** *interface-type interface-number* | { **ipv6-policy** | **policy** } *policy-name* [*seq-number*] | **profile** *profile-name* | **remote** [**ipv6**] *ip-address*]
Display IPsec statistics.	**display ipsec statistics** [**tunnel-id** *tunnel-id*]
Display IPsec transform set information.	**display ipsec transform-set** [*transform-set-name*]
Display IPsec tunnel information.	**display ipsec tunnel** { **brief** | **count** | **tunnel-id** *tunnel-id* }
Clear IPsec SAs.	**reset ipsec sa** [{ **ipv6-policy** | **policy** } *policy-name* [*seq-number*] | **profile** *policy-name* | **remote** { *ipv4-address* | **ipv6** *ipv6-address* } | **spi** { *ipv4-address* | **ipv6** *ipv6-address* } { **ah** | **esp** } *spi-num*]
Clear IPsec statistics.	**reset ipsec statistics** [**tunnel-id** *tunnel-id*]

IPsec configuration examples

Example: Configuring a manual mode IPsec tunnel for IPv4 packets

Network configuration

As shown in Figure 7, establish an IPsec tunnel between Switch A and Switch B to protect data flows between the switches. Configure the tunnel as follows:

- Specify the encapsulation mode as tunnel, the security protocol as ESP, the encryption algorithm as AES-CBC-192, and the authentication algorithm as HMAC-SHA1.
- Manually set up IPsec SAs.

Figure 7 Network diagram

Procedure

1. Configure Switch A:

Configure an IP address for VLAN-interface 1.

```
<SwitchA> system-view
[SwitchA] interface vlan-interface 1
[SwitchA-Vlan-interface1] ip address 2.2.2.1 255.255.255.0
[SwitchA-Vlan-interface1] quit
```

Configure an IPv4 advanced ACL to identify the data flows between Switch A and Switch B.

```
[SwitchA] acl advanced 3101
[SwitchA-acl-ipv4-adv-3101] rule 0 permit ip source 2.2.2.1 0 destination 2.2.3.1 0
[SwitchA-acl-ipv4-adv-3101] quit
```

Create an IPsec transform set named **tran1**.

```
[SwitchA] ipsec transform-set tran1
```

Specify the encapsulation mode as **tunnel**.

```
[SwitchA-ipsec-transform-set-tran1] encapsulation-mode tunnel
```

Specify the security protocol as **ESP**.

```
[RouterA-ipsec-transform-set-tran1] protocol esp
```

Specify the ESP encryption and authentication algorithms.

```
[SwitchA-ipsec-transform-set-tran1] esp encryption-algorithm aes-cbc-192
[SwitchA-ipsec-transform-set-tran1] esp authentication-algorithm sha1
[SwitchA-ipsec-transform-set-tran1] quit
```

Create a manual IPsec policy entry. Specify the policy name as **map1** and set the sequence number to 10.

```
[SwitchA] ipsec policy map1 10 manual
```

Specify ACL 3101.

```
[SwitchA-ipsec-policy-manual-map1-10] security acl 3101
```

Specify IPsec transform set **tran1**.

```
[SwitchA-ipsec-policy-manual-map1-10] transform-set tran1
```

Specify the remote IP address of the IPsec tunnel as 2.2.3.1.

```
[SwitchA-ipsec-policy-manual-map1-10] remote-address 2.2.3.1
```

Configure inbound and outbound SPIs for ESP.

```
[SwitchA-ipsec-policy-manual-map1-10] sa spi outbound esp 12345
[SwitchA-ipsec-policy-manual-map1-10] sa spi inbound esp 54321
```

Configure the inbound and outbound SA keys for ESP.

```
[SwitchA-ipsec-policy-manual-map1-10] sa string-key outbound esp simple abcdefg
[SwitchA-ipsec-policy-manual-map1-10] sa string-key inbound esp simple gfedcba
[SwitchA-ipsec-policy-manual-map1-10] quit
```

Apply IPsec policy **map1** to VLAN-interface 1.

```
[SwitchA] interface vlan-interface 1
[SwitchA-Vlan-interface1] ipsec apply policy map1
```

2. Configure Switch B:

Configure an IP address for VLAN-interface 1.

```
<SwitchB> system-view
[SwitchB] interface vlan-interface 1
[SwitchB-Vlan-interface1] ip address 2.2.3.1 255.255.255.0
[SwitchB-Vlan-interface1] quit
```

Configure an IPv4 advanced ACL to identify the data flows between Switch B and Switch A.

```
[SwitchB] acl advanced 3101
[SwitchB-acl-ipv4-adv-3101] rule 0 permit ip source 2.2.3.1 0 destination 2.2.2.1 0
[SwitchB-acl-ipv4-adv-3101] quit
```

Create an IPsec transform set named **tran1**.

```
[SwitchB] ipsec transform-set tran1
```

Specify the encapsulation mode as **tunnel**.

```
[SwitchB-ipsec-transform-set-tran1] encapsulation-mode tunnel
```

Specify the security protocol as **ESP**.

```
[SwitchB-ipsec-transform-set-tran1] protocol esp
```

Specify the ESP encryption and authentication algorithms.

```
[SwitchB-ipsec-transform-set-tran1] esp encryption-algorithm aes-cbc-192
[SwitchB-ipsec-transform-set-tran1] esp authentication-algorithm sha1
[SwitchB-ipsec-transform-set-tran1] quit
```

Create a manual IPsec policy entry. Specify the policy name as **use1** and set the sequence number to 10.

```
[SwitchB] ipsec policy use1 10 manual
```

Specify ACL 3101.

```
[SwitchB-ipsec-policy-manual-use1-10] security acl 3101
```

Specify IPsec transform set **tran1**.

```
[SwitchB-ipsec-policy-manual-use1-10] transform-set tran1
```

Specify the remote IP address of the IPsec tunnel as 2.2.2.1.

```
[SwitchB-ipsec-policy-manual-use1-10] remote-address 2.2.2.1
```

Configure the inbound and outbound SPIs for ESP.

```
[SwitchB-ipsec-policy-manual-use1-10] sa spi outbound esp 54321
[SwitchB-ipsec-policy-manual-use1-10] sa spi inbound esp 12345
```

Configure the inbound and outbound SA keys for ESP.

```
[SwitchB-ipsec-policy-manual-use1-10] sa string-key outbound esp simple gfedcba
[SwitchB-ipsec-policy-manual-use1-10] sa string-key inbound esp simple abcdefg
[SwitchB-ipsec-policy-manual-use1-10] quit
```

Apply IPsec policy **use1** to VLAN-interface 1.

```
[SwitchB] interface vlan-interface 1
[SwitchB-Vlan-interface1] ipsec apply policy use1
```

Verifying the configuration

After the configuration is completed, an IPsec tunnel between Switch A and Switch B is established, and the traffic between the switches is IPsec-protected. This example uses Switch A to verify the configuration.

Use the **display ipsec sa** command to display IPsec SAs on Switch A.

```
[SwitchA] display ipsec sa
-------------------------------
Interface: Vlan-interface 1
-------------------------------

  -----------------------------
  IPsec policy: map1
  Sequence number: 10
  Mode: manual
  -----------------------------
```

```
Tunnel id: 549
Encapsulation mode: tunnel
Path MTU: 1443
Tunnel:
    local  address: 2.2.2.1
    remote address: 2.2.3.1
Flow:
    as defined in ACL 3101
[Inbound ESP SA]
  SPI: 54321 (0x0000d431)
  Transform set: ESP-ENCRYPT-AES-CBC-192 ESP-AUTH-SHA1
  No duration limit for this SA
[Outbound ESP SA]
  SPI: 12345 (0x00003039)
  Transform set: ESP-ENCRYPT-AES-CBC-192 ESP-AUTH-SHA1
  No duration limit for this SA
```

Example: Configuring an IKE-based IPsec tunnel for IPv4 packets

Network configuration

As shown in Figure 8, establish an IPsec tunnel between Switch A and Switch B to protect data flows between them. Configure the IPsec tunnel as follows:

- Specify the encapsulation mode as tunnel, the security protocol as ESP, the encryption algorithm as AES-CBC-192, and the authentication algorithm as HMAC-SHA1.
- Set up SAs through IKE negotiation.

Figure 8 Network diagram

Procedure

1. Configure Switch A:

Configure an IP address for VLAN-interface 1.

```
<SwitchA> system-view
[SwitchA] interface vlan-interface 1
[SwitchA-Vlan-interface1] ip address 2.2.2.1 255.255.255.0
[SwitchA-Vlan-interface1] quit
```

Configure an IPv4 advanced ACL to identify data flows from Switch A to Switch B.

```
[SwitchA] acl number 3101
[SwitchA-acl-adv-3101] rule 0 permit ip source 2.2.2.1 0 destination 2.2.3.1 0
[SwitchA-acl-adv-3101] quit
```

Create an IPsec transform set named **tran1**.

```
[SwitchA] ipsec transform-set tran1
```

Specify the encapsulation mode as **tunnel**.

```
[SwitchA-ipsec-transform-set-tran1] encapsulation-mode tunnel
```

Specify the security protocol as **ESP**.

```
[SwitchA-ipsec-transform-set-tran1] protocol esp
```

Specify the ESP encryption and authentication algorithms.

```
[SwitchA-ipsec-transform-set-tran1] esp encryption-algorithm aes-cbc-192
[SwitchA-ipsec-transform-set-tran1] esp authentication-algorithm sha1
[SwitchA-ipsec-transform-set-tran1] quit
```

Create an IKE keychain named **keychain1**.

```
[SwitchA] ike keychain keychain1
```

Specify **12345zxcvb!@#$%ZXCVB** in plain text as the preshared key to be used with the remote peer at 2.2.3.1.

```
[SwitchA-ike-keychain-keychain1] pre-shared-key address 2.2.3.1 255.255.255.0 key
simple 12345zxcvb!@#$%ZXCVB
[SwitchA-ike-keychain-keychain1] quit
```

Create and configure the IKE profile named **profile1**.

```
[SwitchA] ike profile profile1
[SwitchA-ike-profile-profile1] keychain keychain1
[SwitchA-ike-profile-profile1] match remote identity address 2.2.3.1 255.255.255.0
[SwitchA-ike-profile-profile1] quit
```

Create an IKE-based IPsec policy entry. Specify the policy name as **map1** and set the sequence number to 10.

```
[SwitchA] ipsec policy map1 10 isakmp
```

Apply ACL 3101.

```
[SwitchA-ipsec-policy-isakmp-map1-10] security acl 3101
```

Apply IPsec transform set **tran1**.

```
[SwitchA-ipsec-policy-isakmp-map1-10] transform-set tran1
```

Specify the local and remote IP addresses of the IPsec tunnel as 2.2.2.1 and 2.2.3.1.

```
[SwitchA-ipsec-policy-isakmp-map1-10] local-address 2.2.2.1
[SwitchA-ipsec-policy-isakmp-map1-10] remote-address 2.2.3.1
```

Apply IKE profile **profile1**.

```
[SwitchA-ipsec-policy-isakmp-map1-10] ike-profile profile1
[SwitchA-ipsec-policy-isakmp-map1-10] quit
```

Apply IPsec policy **map1** to VLAN interface 1.

```
[SwitchA] interface vlan-interface 1
[SwitchA-Vlan-interface1] ipsec apply policy map1
```

2. Configure Switch B:

Configure an IP address for VLAN-interface 1.

```
<SwitchB> system-view
[SwitchB] interface vlan-interface 1
[SwitchB-Vlan-interface1] ip address 2.2.3.1 255.255.255.0
[SwitchB-Vlan-interface1] quit
```

Configure an IPv4 advanced ACL to identify data flows from Switch B to Switch A.

```
[SwitchB] acl number 3101
[SwitchB-acl-adv-3101] rule 0 permit ip source 2.2.3.1 0 destination 2.2.2.1 0
[SwitchB-acl-adv-3101] quit
```

Create an IPsec transform set named **tran1**.

```
[SwitchB] ipsec transform-set tran1
```

Specify the encapsulation mode as **tunnel**.

```
[SwitchB-ipsec-transform-set-tran1] encapsulation-mode tunnel
```

Specify the security protocol as **ESP**.

```
[SwitchB-ipsec-transform-set-tran1] protocol esp
```

Specify the ESP encryption and authentication algorithms.

```
[SwitchB-ipsec-transform-set-tran1] esp encryption-algorithm aes-cbc-192
[SwitchB-ipsec-transform-set-tran1] esp authentication-algorithm sha1
[SwitchB-ipsec-transform-set-tran1] quit
```

Create an IKE keychain named **keychain1**.

```
[SwitchB] ike keychain keychain1
```

Specify **12345zxcvb!@#$%ZXCVB** in plain text as the preshared key to be used with the remote peer at 2.2.2.1.

```
[SwitchB-ike-keychain-keychain1] pre-shared-key address 2.2.2.1 255.255.255.0 key
simple 12345zxcvb!@#$%ZXCVB
[SwitchB-ike-keychain-keychain1] quit
```

Create and configure the IKE profile named **profile1**.

```
[SwitchB] ike profile profile1
[SwitchB-ike-profile-profile1] keychain keychain1
[SwitchB-ike-profile-profile1] match remote identity address 2.2.2.1 255.255.255.0
[SwitchB-ike-profile-profile1] quit
```

Create an IKE-based IPsec policy entry. Specify the policy name as **use1** and set the sequence number to 10.

```
[SwitchB] ipsec policy use1 10 isakmp
```

Apply ACL 3101.

```
[SwitchB-ipsec-policy-isakmp-use1-10] security acl 3101
```

Apply IPsec transform set **tran1**.

```
[SwitchB-ipsec-policy-isakmp-use1-10] transform-set tran1
```

Specify the local and remote IP addresses of the IPsec tunnel as 2.2.3.1 and 2.2.2.1.

```
[SwitchB-ipsec-policy-isakmp-use1-10] local-address 2.2.3.1
[SwitchB-ipsec-policy-isakmp-use1-10] remote-address 2.2.2.1
```

Apply IKE profile **profile1**.

```
[SwitchB-ipsec-policy-isakmp-use1-10] ike-profile profile1
[SwitchB-ipsec-policy-isakmp-use1-10] quit
```

Apply IPsec policy **use1** to VLAN-interface 1.

```
[SwitchB] interface vlan-interface 1
[SwitchB-Vlan-interface1] ipsec apply policy use1
```

Verifying the configuration

Initiate a connection between Switch A and Switch B to trigger IKE negotiation. After IPsec SAs are successfully negotiated by IKE, the traffic between the two switches is IPsec-protected.

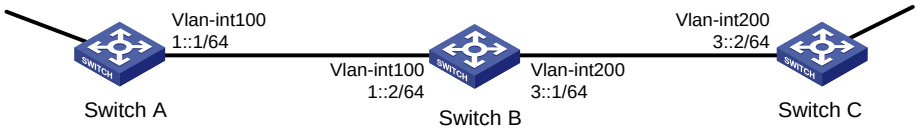
Example: Configuring IPsec for RIPng

Network configuration

As shown in Figure 9, Switch A, Switch B, and Switch C learn IPv6 routes through RIPng.

Establish an IPsec tunnel between the switches to protect the RIPng packets transmitted in between. Specify the security protocol as ESP, the encryption algorithm as 128-bit AES, and the authentication algorithm as HMAC-SHA1 for the IPsec tunnel.

Figure 9 Network diagram



Requirements analysis

To meet the network configuration requirements, perform the following tasks:

1. Configure basic RIPng.

   For more information about RIPng configurations, see *Layer 3—IP Routing Configuration Guide*.

2. Configure an IPsec profile.
   - The IPsec profiles on all the switches must have IPsec transform sets that use the same security protocol, authentication and encryption algorithms, and encapsulation mode.
   - The SPI and key configured for the inbound SA and those for the outbound SA must be the same on each switch.
   - The SPI and key configured for the SAs on all the switches must be the same.
3. Apply the IPsec profile to a RIPng process or to an interface.

Procedure

1. Configure Switch A:

   # Configure IPv6 addresses for interfaces. (Details not shown.)

   # Configure basic RIPng.

```
<SwitchA> system-view
[SwitchA] ripng 1
[SwitchA-ripng-1] quit
[SwitchA] interface vlan-interface 100
[SwitchA-Vlan-interface100] ripng 1 enable
[SwitchA-Vlan-interface100] quit
```

   # Create and configure the IPsec transform set named **tran1**.

```
[SwitchA] ipsec transform-set tran1
[SwitchA-ipsec-transform-set-tran1] encapsulation-mode transport
[SwitchA-ipsec-transform-set-tran1] protocol esp
[SwitchA-ipsec-transform-set-tran1] esp encryption-algorithm aes-cbc-128
[SwitchA-ipsec-transform-set-tran1] esp authentication-algorithm sha1
[SwitchA-ipsec-transform-set-tran1] quit
```

   # Create and configure the IPsec profile named **profile001**.

```
[SwitchA] ipsec profile profile001 manual
[SwitchA-ipsec-profile-manual-profile001] transform-set tran1
[SwitchA-ipsec-profile-manual-profile001] sa spi outbound esp 123456
[SwitchA-ipsec-profile-manual-profile001] sa spi inbound esp 123456
[SwitchA-ipsec-profile-manual-profile001] sa string-key outbound esp simple abcdefg
[SwitchA-ipsec-profile-manual-profile001] sa string-key inbound esp simple abcdefg
[SwitchA-ipsec-profile-manual-profile001] quit
```

   # Apply the IPsec profile to RIPng process 1.

```
[SwitchA] ripng 1
[SwitchA-ripng-1] enable ipsec-profile profile001
[SwitchA-ripng-1] quit
```

2. Configure Switch B:

Configure IPv6 addresses for interfaces. (Details not shown.)

Configure basic RIPng.

```
<SwitchB> system-view
[SwitchB] ripng 1
[SwitchB-ripng-1] quit
[SwitchB] interface vlan-interface 200
[SwitchB-Vlan-interface200] ripng 1 enable
[SwitchB-Vlan-interface200] quit
[SwitchB] interface vlan-interface 100
[SwitchB-Vlan-interface100] ripng 1 enable
[SwitchB-Vlan-interface100] quit
```

Create and configure the IPsec transform set named **tran1**.

```
[SwitchB] ipsec transform-set tran1
[SwitchB-ipsec-transform-set-tran1] encapsulation-mode transport
[SwitchB-ipsec-transform-set-tran1] protocol esp
[SwitchB-ipsec-transform-set-tran1] esp encryption-algorithm aes-cbc-128
[SwitchB-ipsec-transform-set-tran1] esp authentication-algorithm sha1
[SwitchB-ipsec-transform-set-tran1] quit
```

Create and configure the IPsec profile named **profile001**.

```
[SwitchB] ipsec profile profile001 manual
[SwitchB-ipsec-profile-manual-profile001] transform-set tran1
[SwitchB-ipsec-profile-manual-profile001] sa spi outbound esp 123456
[SwitchB-ipsec-profile-manual-profile001] sa spi inbound esp 123456
[SwitchB-ipsec-profile-manual-profile001] sa string-key outbound esp simple abcdefg
[SwitchB-ipsec-profile-manual-profile001] sa string-key inbound esp simple abcdefg
[SwitchB-ipsec-profile-manual-profile001] quit
```

Apply the IPsec profile to RIPng process 1.

```
[SwitchB] ripng 1
[SwitchB-ripng-1] enable ipsec-profile profile001
[SwitchB-ripng-1] quit
```

3. Configure Switch C:

Configure IPv6 addresses for interfaces. (Details not shown.)

Configure basic RIPng.

```
<SwitchC> system-view
[SwitchC] ripng 1
[SwitchC-ripng-1] quit
[SwitchC] interface vlan-interface 200
[SwitchC-Vlan-interface200] ripng 1 enable
[SwitchC-Vlan-interface200] quit
```

Create and configure the IPsec transform set named **tran1**.

```
[SwitchC] ipsec transform-set tran1
[SwitchC-ipsec-transform-set-tran1] encapsulation-mode transport
[SwitchC-ipsec-transform-set-tran1] protocol esp
[SwitchC-ipsec-transform-set-tran1] esp encryption-algorithm aes-cbc-128
[SwitchC-ipsec-transform-set-tran1] esp authentication-algorithm sha1
[SwitchC-ipsec-transform-set-tran1] quit
```

Create and configure the IPsec profile named **profile001**.

```
[SwitchC] ipsec profile profile001 manual
[SwitchC-ipsec-profile-manual-profile001] transform-set tran1
[SwitchC-ipsec-profile-manual-profile001] sa spi outbound esp 123456
[SwitchC-ipsec-profile-manual-profile001] sa spi inbound esp 123456
[SwitchC-ipsec-profile-manual-profile001] sa string-key outbound esp simple abcdefg
[SwitchC-ipsec-profile-manual-profile001] sa string-key inbound esp simple abcdefg
[SwitchC-ipsec-profile-manual-profile001] quit
```

Apply the IPsec profile to RIPng process 1.

```
[SwitchC] ripng 1
[SwitchC-ripng-1] enable ipsec-profile profile001
[SwitchC-ripng-1] quit
```

Verifying the configuration

After the configuration is completed, Switch A, Switch B, and Switch C learn IPv6 routing information through RIPng. IPsec SAs are set up successfully on the switches to protect RIPng packets. This example uses Switch A to verify the configuration.

Display the RIPng configuration. The output shows that IPsec profile **profile001** has been applied to RIPng process 1.

```
[SwitchA] display ripng 1
    RIPng process : 1
       Preference : 100
       Checkzero : Enabled
       Default Cost : 0
       Maximum number of load balanced routes : 8
       Update time   :   30 secs  Timeout time         :  180 secs
       Suppress time :  120 secs  Garbage-Collect time :  120 secs
       Update output delay:   20(ms)  Output count:    3
       Graceful-restart interval:   60 secs
       Triggered Interval : 5 50 200
       Number of periodic updates sent : 186
       Number of triggered updates sent : 1
       IPsec profile name: profile001
```

Display the established IPsec SAs.

```
[SwitchA] display ipsec sa
------------------------------
Global IPsec SA
------------------------------

  ----------------------------
  IPsec profile: profile001
  Mode: Manual
  ----------------------------
    Encapsulation mode: transport
    [Inbound ESP SA]
      SPI: 123456 (0x3039)
      Connection ID: 90194313219
      Transform set: ESP-ENCRYPT-AES-CBC-128 ESP-AUTH-SHA1
```

```
  No duration limit for this SA
[Outbound ESP SA]
  SPI: 123456 (0x3039)
  Connection ID: 64424509441
  Transform set: ESP-ENCRYPT-AES-CBC-128ESP-AUTH-SHA1
  No duration limit for this SA
```

Example: Configuring IPsec RRI

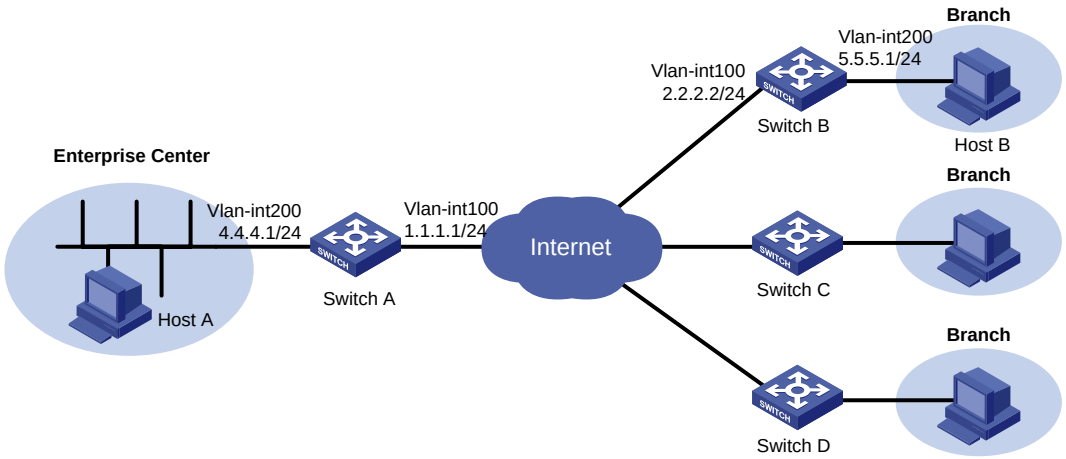
Network configuration

As shown in Figure 10, branches access the enterprise center through an IPsec VPN.

Configure the IPsec VPN as follows:

- Configure an IPsec tunnel between Switch A and each branch gateway (Switch B, Switch C, and Switch D) to protect traffic between subnets 4.4.4.0/24 and 5.5.5.0/24.
- Configure the tunnels to use security protocol ESP, encryption algorithm DES, and authentication algorithm SHA1-HMAC-96. Use IKE for IPsec SA negotiation.
- Configure IKE proposal to use the preshared key authentication method, encryption algorithm 3DES, and authentication algorithm HMAC-SHA1.
- Configure IPsec RRI on Switch A to automatically create static routes to the branches based on the established IPsec SAs.

Figure 10 Network diagram



Procedure

1. Assign IPv4 addresses to the interfaces on the switches according to Figure 10. (Details not shown.)
2. Configure Switch A:

   # Create an IPsec transform set named **tran1**, and specify **ESP** as the security protocol, **DES** as the encryption algorithm, and **HMAC-SHA-1-96** as the authentication algorithm.

   ```
   <SwitchA> system-view
   [SwitchA] ipsec transform-set tran1
   [SwitchA-ipsec-transform-set-tran1] encapsulation-mode tunnel
   [SwitchA-ipsec-transform-set-tran1] protocol esp
   [SwitchA-ipsec-transform-set-tran1] esp encryption-algorithm des
   [SwitchA-ipsec-transform-set-tran1] esp authentication-algorithm sha1
   [SwitchA-ipsec-transform-set-tran1] quit
   ```

Create and configure the IKE profile named **profile1**.

```
[SwitchA] ike profile profile1
[SwitchA-ike-profile-profile1] keychain key1
[SwitchA-ike-profile-profile1] match remote identity address 2.2.2.2 255.255.255.0
[SwitchA-ike-profile-profile1] quit
```

Create an IPsec policy template named **temp1**. Specify IPsec transform set **tran1** and IKE profile **profile1** for the IPsec policy template.

```
[SwitchA] ipsec policy-template temp1 1
[SwitchA-ipsec-policy-template-temp1-1] transform-set tran1
[SwitchA-ipsec-policy-template-temp1-1] ike-profile profile1
```

Enable IPsec RRI, set the preference to 100 and the tag to 1000 for the static routes created by IPsec RRI.

```
[SwitchA-ipsec-policy-template-temp1-1] reverse-route dynamic
[SwitchA-ipsec-policy-template-temp1-1] reverse-route preference 100
[SwitchA-ipsec-policy-template-temp1-1] reverse-route tag 1000
[SwitchA-ipsec-policy-template-temp1-1] quit
```

Create an IKE-based IPsec policy entry by using IPsec policy template **temp1**. Specify the policy name as **map1** and set the sequence number to 10.

```
[SwitchA] ipsec policy map1 10 isakmp template temp1
```

Create an IKE proposal named **1**, and specify **3DES** as the encryption algorithm, **HMAC-SHA1** as the authentication algorithm, and **pre-share** as the authentication method.

```
[SwitchA] ike proposal 1
[SwitchA-ike-proposal-1] encryption-algorithm 3des-cbc
[SwitchA-ike-proposal-1] authentication-algorithm sha
[SwitchA-ike-proposal-1] authentication-method pre-share
[SwitchA-ike-proposal-1] quit
```

Create an IKE keychain named **key1** and specify **123** in plain text as the preshared key to be used with the remote peer at 2.2.2.2.

```
[SwitchA] ike keychain key1
[SwitchA-ike-keychain-key1] pre-shared-key address 2.2.2.2 key simple 123
[SwitchA-ike-keychain-key1] quit
```

Apply IPsec policy **map1** to VLAN-interface 100.

```
[SwitchA] interface vlan-interface 100
[SwitchA-Vlan-interface100] ipsec apply policy map1
[SwitchA-Vlan-interface100] quit
```

3. Configure Switch B:

Create an IPsec transform set named **tran1**, and specify **ESP** as the security protocol, **DES** as the encryption algorithm, and **HMAC-SHA-1-96** as the authentication algorithm.

```
[SwitchB] ipsec transform-set tran1
[SwitchB-ipsec-transform-set-tran1] encapsulation-mode tunnel
[SwitchB-ipsec-transform-set-tran1] protocol esp
[SwitchB-ipsec-transform-set-tran1] esp encryption-algorithm des
[SwitchB-ipsec-transform-set-tran1] esp authentication-algorithm sha1
[SwitchB-ipsec-transform-set-tran1] quit
```

Configure IPv4 advanced ACL 3000 to identify traffic from subnet 5.5.5.0/24 to subnet 4.4.4.0/24.

```
[SwitchB] acl advanced 3000
[SwitchB-acl-ipv4-adv-3000] rule permit ip source 5.5.5.0 0.0.0.255 destination
4.4.4.0 0.0.0.255
```

```
[SwitchB-acl-ipv4-adv-3000] quit
```

Create and configure the IKE profile named **profile1**.

```
[SwitchB] ike profile profile1
[SwitchB-ike-profile-profile1] keychain key1
[SwitchB-ike-profile-profile1] match remote identity address 1.1.1.1 255.255.255.0
[SwitchB-ike-profile-profile1] quit
```

Create an IKE-based IPsec policy entry named **map1** and configure the following settings for the policy entry:

- Set the sequence number to 10.
- Specify transform set **tran1** and ACL 3000.
- Specify the remote IP address for the tunnel as 1.1.1.1.
- Specify IKE profile **profile1**.

```
[SwitchB] ipsec policy map1 10 isakmp
[SwitchB-ipsec-policy-isakmp-map1-10] transform-set tran1
[SwitchB-ipsec-policy-isakmp-map1-10] security acl 3000
[SwitchB-ipsec-policy-isakmp-map1-10] remote-address 1.1.1.1
[SwitchB-ipsec-policy-isakmp-map1-10] ike-profile profile1
[SwitchB-ipsec-policy-isakmp-map1-10] quit
```

Create an IKE proposal named **1**, and specify **3DES** as the encryption algorithm, **HMAC-SHA1** as the authentication algorithm, and **pre-share** as the authentication method.

```
[SwitchB] ike proposal 1
[SwitchB-ike-proposal-1] encryption-algorithm 3des-cbc
[SwitchB-ike-proposal-1] authentication-algorithm sha
[SwitchB-ike-proposal-1] authentication-method pre-share
[SwitchB-ike-proposal-1] quit
```

Create an IKE keychain named **key1** and specify **123** in plain text as the preshared key to be used with the remote peer at 1.1.1.1.

```
[SwitchB] ike keychain key1
[SwitchB-ike-keychain-key1] pre-shared-key address 1.1.1.1 key simple 123
[SwitchB-ike-keychain-key1] quit
```

Apply IPsec policy **map1** to VLAN-interface 100.

```
[SwitchB] interface vlan-interface 100
[SwitchB-Vlan-interface100] ipsec apply policy map1
[SwitchB-Vlan-interface100] quit
```

Make sure Switch B has a route to the peer private network, with the outgoing interface as VLAN-interface 100.

4. Configure Switch C and Switch D in the same way Switch B is configured.

Verifying the configuration

1. Verify that IPsec RRI can automatically create a static route from Switch A to Switch B:

Initiate a connection from subnet 5.5.5.0/24 to subnet 4.4.4.0/24. IKE negotiation is triggered to establish IPsec SAs between Switch A and Switch B. (Details not shown.)

Verify that IPsec SAs are established on Switch A.

```
[SwitchA] display ipsec sa
------------------------------
Interface: Vlan-interface100
------------------------------
```

```
----------------------------
IPsec policy: map1
Sequence number: 10
Mode: Template
----------------------------
  Tunnel id: 0
  Encapsulation mode: tunnel
  Perfect Forward Secrecy:
  Inside VPN:
  Extended Sequence Numbers enable: N
  Traffic Flow Confidentiality enable: N
  Path MTU: 1463
  Tunnel:
      local  address: 1.1.1.1
      remote address: 2.2.2.2
  Flow:
      sour addr: 4.4.4.0/255.255.255.0  port: 0  protocol: ip
      dest addr: 5.5.5.0/255.255.255.0  port: 0  protocol: ip

  [Inbound ESP SAs]
    SPI: 1014286405 (0x3c74c845)
    Connection ID: 90194313219
    Transform set: ESP-ENCRYPT-DES-CBC ESP-AUTH-SHA1
    SA duration (kilobytes/sec): 1843200/3600
    SA remaining duration (kilobytes/sec): 1843199/3590
    Max received sequence-number: 4
    Anti-replay check enable: Y
    Anti-replay window size: 64
    UDP encapsulation used for NAT traversal: N
    Status: Active

  [Outbound ESP SAs]
    SPI: 4011716027 (0xef1dedbb)
    Connection ID: 64424509441
    Transform set: ESP-ENCRYPT-DES-CBC ESP-AUTH-SHA1
    SA duration (kilobytes/sec): 1843200/3600
    SA remaining duration (kilobytes/sec): 1843199/3590
    Max sent sequence-number: 4
    UDP encapsulation used for NAT traversal: N
    Status: Active
```

Verify that IPsec RRI has created a static route to reach Switch B.

```
[SwitchA] display ip routing-table verbose
```

2. Verify that Switch A can automatically create static routes to Switch C and Switch D in the same way that you verify the IPsec RRI feature by using Switch A and Switch B. (Details not shown.)

Configuring IKE

Unless otherwise specified, the term "IKE" in this chapter refers to IKEv1.

About IKE

Built on a framework defined by ISAKMP, Internet Key Exchange (IKE) provides automatic key negotiation and SA establishment services for IPsec.

Benefits of IKE

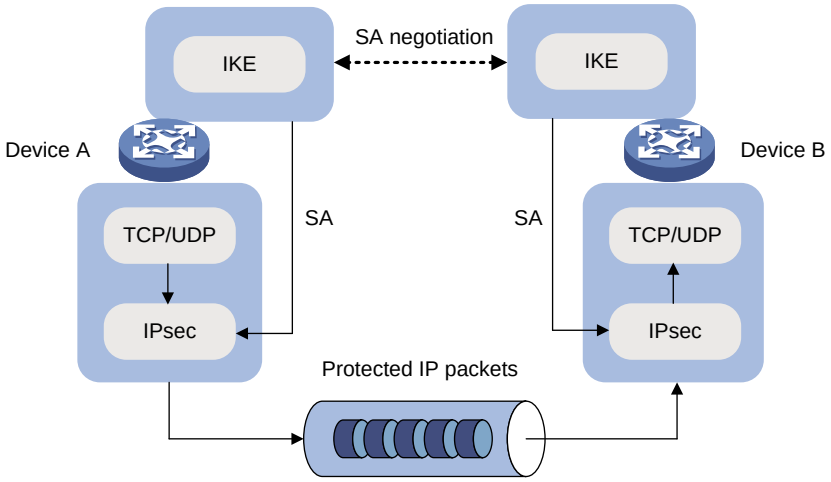
IKE provides the following benefits for IPsec:

- Automatically negotiates IPsec parameters.
- Performs DH exchanges to calculate shared keys, making sure each SA has a key that is independent of other keys.
- Automatically negotiates SAs when the sequence number in the AH or ESP header overflows, making sure IPsec can provide the anti-replay service by using the sequence number.

Relationship between IPsec and IKE

As shown in Figure 11, IKE negotiates SAs for IPsec and transfers the SAs to IPsec, and IPsec uses the SAs to protect IP packets.

Figure 11 Relationship between IKE and IPsec



IKE negotiation process

IKE negotiates keys and SAs for IPsec in two phases:

1. **Phase 1**—The two peers establish an IKE SA, a secure, authenticated channel for communication.
2. **Phase 2**—Using the IKE SA established in phase 1, the two peers negotiate to establish IPsec SAs.

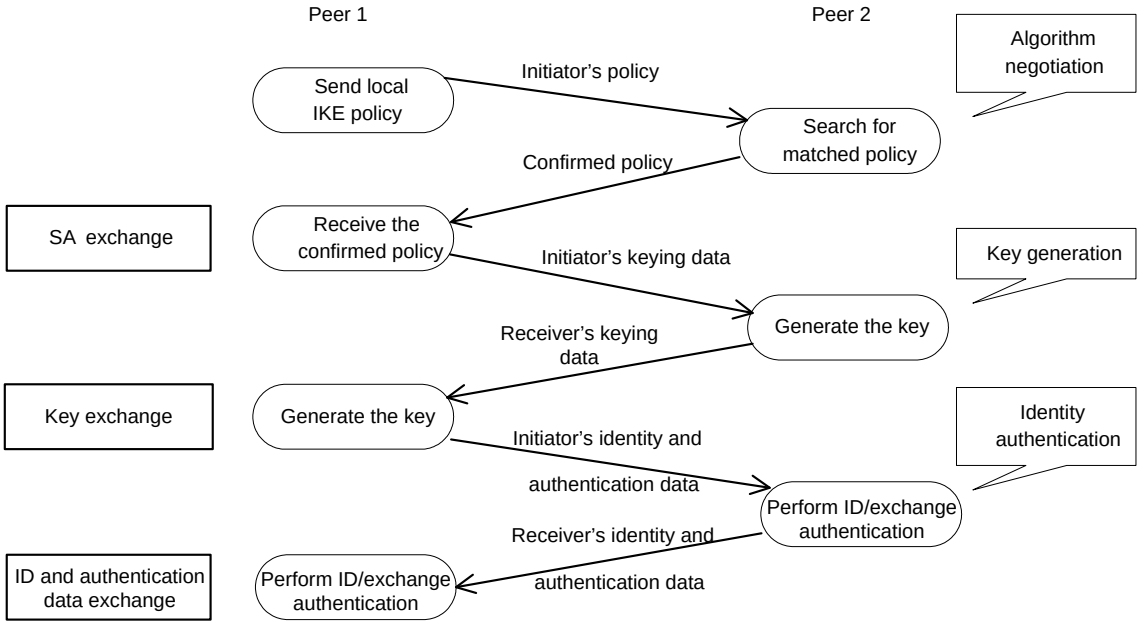
Phase 1 negotiation can use either main mode or aggressive mode.

IKE exchange process in main mode

As shown in Figure 12, the main mode of IKE negotiation in phase 1 involves three pairs of messages:

- **SA exchange**—Used for negotiating the IKE security policy.
- **Key exchange**—Used for exchanging the DH public value and other values, such as the random number. The two peers use the exchanged data to generate key data and use the encryption key and authentication key to ensure the security of IP packets.
- **ID and authentication data exchange**—Used for identity authentication.

Figure 12 IKE exchange process in main mode



IKE exchange process in aggressive mode

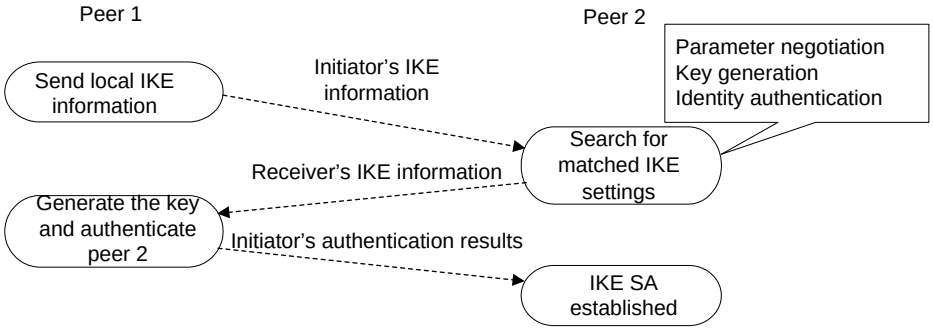
As shown in Figure 13, the process of phase 1 IKE negotiation in aggressive mode is as follows:

1. The initiator (peer 1) sends a message containing the local IKE information to peer 2. The message includes parameters used for IKE SA establishment, keying data, and peer 1's identity information.
2. Peer 2 chooses the IKE establishment parameters to use, generate the key, and authenticate peer 1's identity. Then it sends the IKE data to peer 1.
3. Peer 1 generates the key, authenticates peer 2's identity, and sends the results to peer 1.

After the preceding process, an IKE SA is established between peer 1 and peer 2.

The aggressive mode is faster than the main mode but it does not provide identity information protection. The main mode provides identity information protection but is slower. Choose the appropriate negotiation mode according to your requirements.

Figure 13 IKE exchange process in aggressive mode



IKE security mechanism

IKE has a series of self-protection mechanisms and supports secure identity authentication, key distribution, and IPsec SA establishment on insecure networks.

Identity authentication

The IKE identity authentication mechanism is used to authenticate the identity of the communicating peers. The device supports the following identity authentication methods:

- **Preshared key authentication**—Two communicating peers use the pre-configured shared key for identity authentication.
- **RSA signature authentication** and **DSA signature authentication**—Two communicating peers use the digital certificates issued by the CA for identity authentication.

The preshared key authentication method does not require certificates and is easy to configure. It is usually deployed in small networks.

The signature authentication methods provide higher security and are usually deployed in networks with the headquarters and some branches. When deployed in a network with many branches, a signature authentication method can simplify the configuration because only one PKI domain is required. If you use the preshared key authentication method, you must configure a preshared key for each branch on the Headquarters node.

DH algorithm

The DH algorithm is a public key algorithm. With this algorithm, two peers can exchange keying material and then use the material to calculate the shared keys. Due to the decryption complexity, a third party cannot decrypt the keys even after intercepting all keying materials.

PFS

The Perfect Forward Secrecy (PFS) feature is a security feature based on the DH algorithm. After PFS is enabled, an additional DH exchange is performed in IKE phase 2 to make sure IPsec keys have no derivative relations with IKE keys and a broken key brings no threats to other keys.

Protocols and standards

- RFC 2408, *Internet Security Association and Key Management Protocol (ISAKMP)*
- RFC 2409, *The Internet Key Exchange (IKE)*
- RFC 2412, *The OAKLEY Key Determination Protocol*
- Internet Draft, *draft-ietf-ipsec-isakmp-xauth-06*
- Internet Draft, *draft-dukes-ike-mode-cfg-02*

FIPS compliance

The device supports the FIPS mode that complies with NIST FIPS 140-2 requirements. Support for features, commands, and parameters might differ in FIPS mode (see "Configuring FIPS") and non-FIPS mode.

IKE tasks at a glance

To configure IKE, perform the following tasks:

1. (Optional.) Configuring an IKE profile
   a. Creating an IKE profile
   b. Configuring peer IDs for the IKE profile
   c. Specifying the IKE keychain or PKI domain
   d. Configuring the IKE phase 1 negotiation mode
   e. Specifying IKE proposals for the IKE profile
   f. Configuring the local ID for the IKE profile
   g. Configuring optional features for the IKE profile
2. Configuring an IKE proposal
3. Configuring an IKE keychain
4. (Optional.)Configuring the global identity information
5. (Optional.)Configuring the IKE keepalive feature
6. (Optional.)Configuring the IKE NAT keepalive feature
7. (Optional.)Configuring global IKE DPD
8. (Optional.)Enabling invalid SPI recovery
9. (Optional.)Setting the maximum number of IKE SAs
10. (Optional.)Configuring SNMP notifications for IKE

Prerequisites for IKE configuration

Determine the following parameters prior to IKE configuration:

- The algorithms to be used during IKE negotiation, including the identity authentication method, encryption algorithm, authentication algorithm, and DH group.
  - Different algorithms provide different levels of protection. A stronger algorithm provides more resistance to decryption but uses more resources.
  - A DH group that uses more bits provides higher security but needs more time for processing.
- The preshared key or PKI domain for IKE negotiation. For more information about PKI, see "Configuring PKI."
- The IKE-based IPsec policies for the communicating peers. If you do not specify an IKE profile in an IPsec policy, the device selects an IKE profile for the IPsec policy. If no IKE profile is configured, the globally configured IKE settings are used. For more information about IPsec, see "Configuring IPsec."

Configuring an IKE profile

Creating an IKE profile

About IKE profile

Perform this task to create an IKE profile.

An IKE profile is intended to provide a set of parameters for IKE negotiation.

Procedure

1. Enter system view.
   system-view
2. Create an IKE profile and enter its view.
   ike profile *profile-name*

Configuring peer IDs for the IKE profile

About peer ID configuration

Perform this task to configure the peer IDs for IKE profile matching. When the device needs to select an IKE profile for IKE negotiation with a peer, it compares the received peer ID with the peer IDs of its local IKE profiles. If a match is found, it uses the IKE profile with the matching peer ID for IKE negotiation.

Restrictions and guidelines

For an IKE profile, you can configure multiple peer IDs. A peer ID configured earlier has a higher priority.

Two IKE peers must both have or both not have peer IDs configured.

Procedure

1. Enter system view.
   system-view
2. Enter IKE profile view.
   ike profile *profile-name*
3. Configure a peer ID for the IKE profile.
   match remote { **certificate** *policy-name* | **identity** { **address** { { *ipv4-address* [*mask* | *mask-length*] | **range** *low-ipv4-address high-ipv4-address* } | **ipv6** { *ipv6-address* [*prefix-length*] | **range** *low-ipv6-address high-ipv6-address* } } | **fqdn** *fqdn-name* | **user-fqdn** *user-fqdn-name* } }

Specifying the IKE keychain or PKI domain

Restrictions and guidelines

Configure the IKE keychain or PKI domain for the IKE proposals to use. To use digital signature authentication, configure a PKI domain. To use preshared key authentication, configure an IKE keychain.

Procedure

1. Enter system view.

system-view

2. Enter IKE profile view.

   ike profile *profile-name*

3. Specify the keychain for preshared key authentication or the PKI domain used to request a certificate for digital signature authentication.

   - Specify the keychain.

     keychain *keychain-name*

   - Specify the PKI domain.

     certificate domain *domain-name*

   By default, no IKE keychain or PKI domain is specified in an IKE profile.

Configuring the IKE phase 1 negotiation mode

Restrictions and guidelines

Specify the IKE phase 1 negotiation mode (main or aggressive) that the device uses as the initiator. When the device acts as the responder, it uses the IKE negotiation mode of the initiator.

Procedure

1. Enter system view.

   system-view

2. Enter IKE profile view.

   ike profile *profile-name*

3. Specify the IKE negotiation mode for phase 1.

   In non-FIPS mode:

   exchange-mode { **aggressive** | **main** }

   In FIPS mode:

   exchange-mode main

   By default, IKE negotiation in phase 1 uses the main mode.

Specifying IKE proposals for the IKE profile

Restrictions and guidelines

Specify the IKE proposals that the device can use as the initiator. An IKE proposal specified earlier has a higher priority. When the device acts as the responder, it uses the IKE proposals configured in system view to match the IKE proposals received from the initiator. If no matching proposal is found, the negotiation fails.

Procedure

1. Enter system view.

   system-view

2. Enter IKE profile view.

   ike profile *profile-name*

3. Specify IKE proposals for the IKE profile.

   proposal *proposal-number*&<1-6>

   By default, no IKE proposals are specified for an IKE profile and the IKE proposals configured in system view are used for IKE negotiation.

Configuring the local ID for the IKE profile

Restrictions and guidelines

For digital signature authentication, the device can use an ID of any type. If the local ID is an IP address that is different from the IP address in the local certificate, the device uses the FQDN (the device name configured by using the **sysname** command) instead.

For preshared key authentication, the device can use an ID of any type other than the DN.

Procedure

1. Enter system view.

   system-view

2. Enter IKE profile view.

   ike profile *profile-name*

3. Configure the local ID.

   local-identity { **address** { *ipv4-address* | **ipv6** *ipv6-address* } | **dn** | **fqdn** [*fqdn-name*] | **user-fqdn** [*user-fqdn-name*] }

   By default, no local ID is configured for an IKE profile, and an IKE profile uses the local ID configured in system view. If the local ID is not configured in system view, the IKE profile uses the IP address of the interface to which the IPsec policy or IPsec policy template is applied as the local ID.

Configuring optional features for the IKE profile

1. Enter system view.

   system-view

2. Enter IKE profile view.

   ike profile *profile-name*

3. Configure optional features as needed.

   - Configure IKE DPD.

     dpd interval *interval* [**retry** *seconds*] { **on-demand** | **periodic** }

     By default, IKE DPD is not configured for an IKE profile and an IKE profile uses the DPD settings configured in system view. If IKE DPD is not configured in system view either, the device does not perform dead IKE peer detection.

     The IKE DPD settings configured in the IKE profile view take precedence over those configured in system view.

   - Specify the local interface or IP address to which the IKE profile can be applied.

     match local address { *interface-type interface-number* | { *ipv4-address* | **ipv6** *ipv6-address* } }

     By default, an IKE profile can be applied to any local interface or IP address.

     An IKE profile configured with this command has a higher priority over those not configured with this command.

   - Specify a priority for the IKE profile.

     priority *priority*

     By default, the priority of an IKE profile is 100.

     The device selects a local IKE profile for IKE negotiation as follows:

     – First, it selects an IKE profile with the **match local address** command configured.

     – If a tie exists, it selects the IKE profile with a smaller priority number.

- If a tie still exists, it selects the IKE profile configured earlier.

Configuring an IKE proposal

About IKE proposal

An IKE proposal defines a set of attributes describing how IKE negotiation in phase 1 should take place. You can create multiple IKE proposals with different priorities. The priority of an IKE proposal is represented by its sequence number. The lower the sequence number, the higher the priority.

Two peers must have at least one matching IKE proposal for successful IKE negotiation. During IKE negotiation:

- The initiator sends its IKE proposals to the peer.
  - If the initiator is using an IPsec policy with an IKE profile, the initiator sends all IKE proposals specified in the IKE profile to the peer. An IKE proposal specified earlier for the IKE profile has a higher priority.
  - If the initiator is using an IPsec policy with no IKE profile, the initiator sends all its IKE proposals to the peer. An IKE proposal with a smaller number has a higher priority.
- The peer searches its own IKE proposals for a match. The search starts from the IKE proposal with the highest priority and proceeds in descending order of priority until a match is found. The matching IKE proposals are used to establish the IKE SA. If all user-defined IKE proposals are found mismatching, the two peers use their default IKE proposals to establish the IKE SA.

Two matching IKE proposals have the same encryption algorithm, authentication method, authentication algorithm, and DH group. The SA lifetime takes the smaller one of the two proposals' SA lifetime settings.

Procedure

1. Enter system view.

   system-view

2. Create an IKE proposal and enter its view.

   ike proposal *proposal-number*

   By default, a default IKE proposal exists.

3. Configure a description for the IKE proposal.

   description

   By default, an IKE proposal does not have a description.

4. Specify an encryption algorithm for the IKE proposal.

   In non-FIPS mode:

   encryption-algorithm { **3des-cbc** | **aes-cbc-128** | **aes-cbc-192** | **aes-cbc-256** | **des-cbc** }

   By default, the 56-bit DES encryption algorithm in CBC mode is used .

   In FIPS mode:

   encryption-algorithm { **aes-cbc-128** | **aes-cbc-192** | **aes-cbc-256** }

   By default, the 128-bit AES encryption algorithm in CBC mode is used.

5. Specify an authentication method for the IKE proposal.

   authentication-method{ **dsa-signature** | **ecdsa-signature** | **pre-share** | **rsa-signature** }

   By default, the preshared key authentication method is used.

6. Specify an authentication algorithm for the IKE proposal.

   In non-FIPS mode:

authentication-algorithm { **md5** | **sha** | **sha256** | **sha384** | **sha512** }

By default, the HMAC-SHA1 authentication algorithm is used.

In FIPS mode:

authentication-algorithm { **sha** | **sha256** | **sha384** | **sha512** }

By default, the HMAC-SHA256 authentication algorithm is used.

7. Specify a DH group for key negotiation in phase 1.

   In non-FIPS mode:

   dh{ **group1** | **group14** | **group19** | **group2** | **group20** | **group24** | **group5** }

   DH group 1 (the 768-bit DH group) is used by default.

   In FIPS mode:

   dh{ **group14** | **group19** | **group20** | **group24** }

   DH group 14 (the 2048-bit DH group) is used by default.

8. (Optional.) Set the IKE SA lifetime for the IKE proposal.

   sa duration *seconds*

   By default, the IKE SA lifetime is 86400 seconds.

Configuring an IKE keychain

About IKE keychain

Perform this task when you configure the IKE to use the preshared key for authentication.

Follow these guidelines when you configure an IKE keychain:

- Two peers must be configured with the same preshared key to pass preshared key authentication.
- You can specify the local address configured in IPsec policy or IPsec policy template view (using the **local-address** command) for the IKE keychain to be applied. If no local address is configured, specify the IP address of the interface that uses the IPsec policy.
- The device determines the priority of an IKE keychain as follows:
  a. The device examines the existence of the **match local address** command. An IKE keychain with the **match local address** command configured has a higher priority.
  b. If a tie exists, the device compares the priority numbers. An IKE keychain with a smaller priority number has a higher priority.
  c. If a tie still exists, the device prefers an IKE keychain configured earlier.

Procedure

1. Enter system view.

   system-view

2. Create an IKE keychain and enter its view.

   ike keychain *keychain-name*

3. Configure a preshared key.

   In non-FIPS mode:

   pre-shared-key { **address** { *ipv4-address* [*mask* | *mask-length*] | **ipv6** *ipv6-address* [*prefix-length*] } | **hostname** *host-name* } **key** { **cipher** | **simple** } *string*

   In FIPS mode:

pre-shared-key { **address** { *ipv4-address* [*mask* | *mask-length*] | **ipv6** *ipv6-address* [*prefix-length*] } | **hostname** *host-name* } **key** [**cipher** *string*]

By default, no preshared key is configured.

4. (Optional.) Specify a local interface or IP address to which the IKE keychain can be applied.

   match local address { *interface-type interface-number* | { *ipv4-address* | **ipv6** *ipv6-address* } }

   By default, an IKE keychain can be applied to any local interface or IP address.

5. (Optional.) Specify a priority for the IKE keychain.

   priority *priority*

   The default priority is 100.

Configuring the global identity information

Restrictions and guidelines

The global identity can be used by the device for all IKE SA negotiations, and the local identity (set by the **local-identity** command) can be used only by the device that uses the IKE profile.

When signature authentication is used, you can set any type of the identity information.

When preshared key authentication is used, you cannot set the DN as the identity.

Procedure

1. Enter system view.

   system-view

2. Configure the global identity to be used by the local end.

   ike identity { **address** { *ipv4-address* | **ipv6** *ipv6-address* } | **dn** | **fqdn** [*fqdn-name*] | **user-fqdn** [*user-fqdn-name*] }

   By default, the IP address of the interface to which the IPsec policy or IPsec policy template is applied is used as the IKE identity.

3. (Optional.) Configure the local device to always obtain the identity information from the local certificate for signature authentication.

   ike signature-identity from-certificate

   By default, the local end uses the identity information specified by **local-identity** or **ike identity** for signature authentication.

   Configure this command when the aggressive mode and signature authentication are used and the device interconnects with a Comware 5-based peer device. Comware 5 supports only DN for signature authentication.

Configuring the IKE keepalive feature

About the IKE keepalive feature

IKE sends keepalive packets to query the liveness of the peer. If the peer is configured with the keepalive timeout time, you must configure the keepalive interval on the local device. If the peer receives no keepalive packets during the timeout time, the IKE SA is deleted along with the IPsec SAs it negotiated.

Restrictions and guidelines

Configure IKE DPD instead of IKE keepalive unless IKE DPD is not supported on the peer. The IKE keepalive feature sends keepalives at regular intervals, which consumes network bandwidth and resources.

The keepalive timeout time configured on the local device must be longer than the keepalive interval configured at the peer. Since it seldom occurs that more than three consecutive packets are lost on a network, you can set the keepalive timeout three times as long as the keepalive interval.

Procedure

1. Enter system view.
   system-view
2. Set the IKE SA keepalive interval.
   ike keepalive interval *interval*
   By default, no keepalives are sent to the peer.
3. Set the IKE SA keepalive timeout time.
   ike keepalive timeout *seconds*
   By default, IKE SA keepalive never times out.

Configuring the IKE NAT keepalive feature

About the IKE NAT keepalive feature

If IPsec traffic passes through a NAT device, you must configure the NAT traversal feature. If no packet travels across an IPsec tunnel in a period of time, the NAT sessions are aged and deleted, disabling the tunnel from transmitting data to the intended end. To prevent NAT sessions from being aged, configure the NAT keepalive feature on the IKE gateway behind the NAT device to send NAT keepalive packets to its peer periodically to keep the NAT session alive.

Procedure

1. Enter system view.
   system-view
2. Set the IKE NAT keepalive interval.
   ike nat-keepalive *seconds*
   The default interval is 20 seconds.

Configuring global IKE DPD

About IKE DPD

DPD detects dead peers. It can operate in periodic mode or on-demand mode.

- **Periodic DPD**—Sends a DPD message at regular intervals. It features an earlier detection of dead peers, but consumes more bandwidth and CPU.
- **On-demand DPD**—Sends a DPD message based on traffic. When the device has traffic to send and is not aware of the liveness of the peer, it sends a DPD message to query the status of the peer. If the device has no traffic to send, it never sends DPD messages. As a best practice, use the on-demand mode.

The IKE DPD works as follows:

1. The local device sends a DPD message to the peer, and waits for a response from the peer.
2. If the peer does not respond within the retry interval specified by the **retry** *seconds* parameter, the local device resends the message.

3. If still no response is received within the retry interval, the local end sends the DPD message again. The system allows a maximum of two retries.
4. If the local device receives no response after two retries, the device considers the peer to be dead, and deletes the IKE SA along with the IPsec SAs it negotiated.
5. If the local device receives a response from the peer during the detection process, the peer is considered alive. The local device performs a DPD detection again when the triggering interval is reached or it has traffic to send, depending on the DPD mode.

Restrictions and guidelines

When DPD settings are configured in both IKE profile view and system view, the DPD settings in IKE profile view apply. If DPD is not configured in IKE profile view, the DPD settings in system view apply.

It is a good practice to set the triggering interval longer than the retry interval so that a DPD detection is not triggered during a DPD retry.

Procedure

1. Enter system view.

   system-view
2. Enable sending IKE DPD messages.

   ike dpd interval *interval* [**retry** *seconds*] { **on-demand** | **periodic** }

   By default, IKE DPD is disabled.

Enabling invalid SPI recovery

About invalid SPI recovery

An IPsec "black hole" occurs when one IPsec peer fails (for example, a peer can fail if a reboot occurs). One peer fails and loses its SAs with the other peer. When an IPsec peer receives a data packet for which it cannot find an SA, an invalid SPI is encountered. The peer drops the data packet and tries to send an SPI invalid notification to the data originator. This notification is sent by using the IKE SA. Because no IKE SA is available, the notification is not sent. The originating peer continues sending the data by using the IPsec SA that has the invalid SPI, and the receiving peer keeps dropping the traffic.

The invalid SPI recovery feature enables the receiving peer to set up an IKE SA with the originator so that an SPI invalid notification can be sent. Upon receiving the notification, the originating peer deletes the IPsec SA that has the invalid SPI. If the originator has data to send, new SAs will be set up.

Restrictions and guidelines

Use caution when you enable the invalid SPI recovery feature because using this feature can result in a DoS attack. Attackers can make a great number of invalid SPI notifications to the same peer.

Procedure

1. Enter system view.

   system-view
2. Enable invalid SPI recovery.

   ike invalid-spi-recovery enable

   By default, the invalid SPI recovery is disabled.

Setting the maximum number of IKE SAs

About maximum number of IKE SAs configuration

You can set the maximum number of half-open IKE SAs and the maximum number of established IKE SAs.

- The supported maximum number of half-open IKE SAs depends on the device's processing capability. Adjust the maximum number of half-open IKE SAs to make full use of the device's processing capability without affecting the IKE SA negotiation efficiency.
- The supported maximum number of established IKE SAs depends on the device's memory space. Adjust the maximum number of established IKE SAs to make full use of the device's memory space without affecting other applications in the system.

Procedure

1. Enter system view.

   system-view

2. Set the maximum number of half-open IKE SAs and the maximum number of established IKE SAs.

   ike limit { **max-negotiating-sa** *negotiation-limit* | **max-sa** *sa-limit* }

   By default, there is no limit to the maximum number of IKE SAs.

Configuring SNMP notifications for IKE

About SNMP notification configuration for IKE

After you enable SNMP notifications for IKE, the IKE module notifies the NMS of important module events. The notifications are sent to the device's SNMP module. For the notifications to be sent correctly, you must also configure SNMP on the device. For more information about SNMP notifications, see *Network Management and Monitoring Configuration Guide*.

To generate and output SNMP notifications for a specific IKE failure or event type, perform the following tasks:

1. Enable SNMP notifications for IKE globally.
2. Enable SNMP notifications for the failure or event type.

Procedure

1. Enter system view

   system-view

2. Enable SNMP notifications for IKE globally.

   snmp-agent trap enable ike global

   By default, SNMP notifications for IKE are disabled.

3. Enable SNMP notifications for the specified failure or event types.

   snmp-agent trap enable ike [**attr-not-support** | **auth-failure** | **cert-type-unsupport** | **cert-unavailable** | **decrypt-failure** | **encrypt-failure** | **invalid-cert-auth** | **invalid-cookie** | **invalid-id** | **invalid-proposal** | **invalid-protocol** | **invalid-sign** | **no-sa-failure** | **proposal-add** | **proposal–delete** | **tunnel-start** | **tunnel-stop** | **unsupport-exch-type**] *

   By default, SNMP notifications for all failure and event types are disabled.

Display and maintenance commands for IKE

Execute **display** commands in any view and **reset** commands in user view.

Task	Command
Display configuration information about all IKE proposals.	**display ike proposal**
Display information about the current IKE SAs.	**display ike sa** [**verbose** [**connection-id** *connection-id* | **remote-address** [**ipv6**] *remote-address*]]
Display IKE statistics.	**display ike statistics**
Delete IKE SAs.	**reset ike sa** [**connection-id** *connection-id*]
Clear IKE MIB statistics.	**reset ike statistics**

IKE configuration examples

Example: Configuring main-mode IKE with preshared key authentication

Network configuration

As shown in Figure 14, configure an IKE-based IPsec tunnel between Switch A and Switch B to secure the communication between the switches.

- Configure the two switches to use the default IKE proposal for the IKE negotiation.
- Configure the two switches to use the preshared key authentication method for the IKE negotiation.

Figure 14 Network diagram

Procedure

1. Make sure Switch A and Switch B can reach each other.
2. Configure Switch A:

   # Configure an IP address for VLAN-interface 1.

   ```
   <SwitchA> system-view
   [SwitchA] interface vlan-interface 1
   [SwitchA-vlan-interface1] ip address 1.1.1.1 255.255.0.0
   [SwitchA-vlan-interface1] quit
   ```

   # Configure IPv4 advanced ACL 3101 to identify the traffic from Switch A to Switch B.

   ```
   [SwitchA] acl advanced 3101
   ```

```
[SwitchA-acl-ipv4-adv-3101] rule 0 permit ip source 1.1.1.1 0 destination 2.2.2.2 0
[SwitchA-acl-ipv4-adv-3101] quit
```

Create an IPsec transform set named **tran1**.

```
[SwitchA] ipsec transform-set tran1
```

Set the packet encapsulation mode to **tunnel**.

```
[SwitchA-ipsec-transform-set-tran1] encapsulation-mode tunnel
```

Use the ESP protocol for the IPsec transform set.

```
[SwitchA-ipsec-transform-set-tran1] protocol esp
```

Specify the encryption and authentication algorithms.

```
[SwitchA-ipsec-transform-set-tran1] esp encryption-algorithm aes-cbc-192
[SwitchA-ipsec-transform-set-tran1] esp authentication-algorithm sha1
[SwitchA-ipsec-transform-set-tran1] quit
```

Create an IKE keychain named **keychain1**.

```
[SwitchA] ike keychain keychain1
```

Specify **12345zxcvb!@#$%ZXCVB** in plain text as the preshared key to be used with the remote peer at 2.2.2.2.

```
[SwitchA-ike-keychain-keychain1] pre-shared-key address 2.2.2.2 255.255.0.0 key
simple 12345zxcvb!@#$%ZXCVB
[SwitchA-ike-keychain-keychain1] quit
```

Create an IKE profile named **profile1**.

```
[SwitchA] ike profile profile1
```

Specify IKE keychain **keychain1**.

```
[SwitchA-ike-profile-profile1] keychain keychain1
```

Configure a peer ID with the identity type as IP address and the value as **2.2.2.2/16**.

```
[SwitchA-ike-profile-profile1] match remote identity address 2.2.2.2 255.255.0.0
[SwitchA-ike-profile-profile1] quit
```

Create an IKE-based IPsec policy entry. Specify the policy name as **map1** and set the sequence number to 10.

```
[SwitchA] ipsec policy map1 10 isakmp
```

Specify the remote IP address 2.2.2.2 for the IPsec tunnel.

```
[SwitchA-ipsec-policy-isakmp-map1-10] remote-address 2.2.2.2
```

Specify ACL 3101 to identify the traffic to be protected.

```
[SwitchA-ipsec-policy-isakmp-map1-10] security acl 3101
```

Specify IPsec transform set **tran1** for the IPsec policy.

```
[SwitchA-ipsec-policy-isakmp-map1-10] transform-set tran1
```

Specify IKE profile **profile1** for the IPsec policy.

```
[SwitchA-ipsec-policy-isakmp-map1-10] ike-profile profile1
[SwitchA-ipsec-policy-isakmp-map1-10] quit
```

Apply IPsec policy **map1** to VLAN-interface 1.

```
[SwitchA] interface vlan-interface 1
[SwitchA-Vlan-interface1] ipsec apply policy map1
```

3. Configure Switch B:

Configure an IP address for VLAN-interface 1.

```
<SwitchB> system-view
[SwitchB] interface Vlan-interface1
[SwitchB-Vlan-interface1] ip address 2.2.2.2 255.255.0.0
[SwitchB-Vlan-interface1] quit
```

Configure IPv4 advanced ACL 3101 to identify the traffic from Switch B to Switch A.

```
[SwitchB] acl number 3101
[SwitchB-acl-adv-3101] rule 0 permit ip source 2.2.2.2 0 destination 1.1.1.1 0
[SwitchB-acl-adv-3101] quit
```

Create an IPsec transform set named **tran1**.

```
[SwitchB] ipsec transform-set tran1
```

Set the packet encapsulation mode to **tunnel**.

```
[SwitchB-ipsec-transform-set-tran1] encapsulation-mode tunnel
```

Use the ESP protocol for the IPsec transform set.

```
[SwitchB-ipsec-transform-set-tran1] protocol esp
```

Specify the encryption and authentication algorithms.

```
[SwitchB-ipsec-transform-set-tran1] esp encryption-algorithm aes-cbc-192
[SwitchB-ipsec-transform-set-tran1] esp authentication-algorithm sha1
[SwitchB-ipsec-transform-set-tran1] quit
```

Create an IKE keychain named **keychain1**.

```
[SwitchB]ike keychain keychain1
```

Specify **12345zxcvb!@#$%ZXCVB** in plain text as the preshared key to be used with the remote peer at 1.1.1.1.

```
[SwitchB-ike-keychain-keychain1] pre-shared-key address 1.1.1.1 255.255.0.0 key
simple 12345zxcvb!@#$%ZXCVB
[SwitchB-ike-keychain-keychain1] quit
```

Create an IKE profile named **profile1**.

```
[SwitchB] ike profile profile1
```

Specify IKE keychain **keychain1**

```
[SwitchB-ike-profile-profile1] keychain keychain1
```

Configure a peer ID with the identity type as IP address and the value as **1.1.1.1/16**.

```
[SwitchB-ike-profile-profile1] match remote identity address 1.1.1.1 255.255.0.0
[SwitchB-ike-profile-profile1] quit
```

Create an IKE-based IPsec policy entry. Specify the policy name as **use1** and set the sequence number to 10.

```
[SwitchB] ipsec policy use1 10 isakmp
```

Specify the remote IP address 1.1.1.1 for the IPsec tunnel.

```
[SwitchB-ipsec-policy-isakmp-use1-10] remote-address 1.1.1.1
```

Specify ACL 3101 to identify the traffic to be protected.

```
[SwitchB-ipsec-policy-isakmp-use1-10] security acl 3101
```

Specify IPsec transform set **tran1** for the IPsec policy.

```
[SwitchB-ipsec-policy-isakmp-use1-10] transform-set tran1
```

Specify IKE profile **profile1** for the IPsec policy.

```
[SwitchB-ipsec-policy-isakmp-use1-10] ike-profile profile1
[SwitchB-ipsec-policy-isakmp-use1-10] quit
```

Apply IPsec policy **use1** to VLAN-interface 1.

```
[SwitchB] interface vlan-interface 1
[SwitchB-Vlan-interface1] ipsec apply policy use1
```

Verifying the configuration

Initiate a connection between Switch A and Switch B to trigger IKE negotiation. After IPsec SAs are successfully negotiated by IKE, the traffic between the two switches is IPsec-protected.

Example: Configuring an IKE-based IPsec tunnel for IPv4 packets

Network configuration

As shown in Figure 15, establish an IPsec tunnel between Switch A and Switch B to protect data flows between the switches. Configure the IPsec tunnel as follows:

- Specify the encapsulation mode as tunnel, the security protocol as ESP, the encryption algorithm as AES-CBC-192, and the authentication algorithm as HMAC-SHA1.
- Set up SAs through IKE negotiation.

Figure 15 Network diagram

Procedure

1. Configure Switch A:

   # Configure an IP address for VLAN-interface 1.

   ```
   <SwitchA> system-view
   [SwitchA] interface vlan-interface 1
   [SwitchA-Vlan-interface1] ip address 2.2.2.1 255.255.255.0
   [SwitchA-Vlan-interface1] quit
   ```

   # Configure an IPv4 advanced ACL to identify the data flows from Switch A to Switch B.

   ```
   [SwitchA] acl advanced 3101
   [SwitchA-acl-ipv4-adv-3101] rule 0 permit ip source 2.2.2.1 0 destination 2.2.3.1 0
   [SwitchA-acl-ipv4-adv-3101] quit
   ```

   # Create an IPsec transform set named **tran1**.

   ```
   [SwitchA] ipsec transform-set tran1
   ```

   # Specify the encapsulation mode as **tunnel**.

   ```
   [SwitchA-ipsec-transform-set-tran1] encapsulation-mode tunnel
   ```

   # Specify the security protocol as **ESP**.

   ```
   [SwitchA-ipsec-transform-set-tran1] protocol esp
   ```

   # Specify the ESP encryption and authentication algorithms.

   ```
   [SwitchA-ipsec-transform-set-tran1] esp encryption-algorithm aes-cbc-192
   [SwitchA-ipsec-transform-set-tran1] esp authentication-algorithm sha1
   [SwitchA-ipsec-transform-set-tran1] quit
   ```

   # Create an IKE keychain named **keychain1**.

   ```
   [SwitchA] ike keychain keychain1
   ```

   # Specify **12345zxcvb!@#$%ZXCVB** in plain text as the preshared key to be used with the remote peer at 2.2.3.1.

   ```
   [SwitchA-ike-keychain-keychain1] pre-shared-key address 2.2.3.1 255.255.255.0 key
   simple 12345zxcvb!@#$%ZXCVB
   [SwitchA-ike-keychain-keychain1] quit
   ```

   # Create and configure an IKE profile named **profile1**.

   ```
   [SwitchA] ike profile profile1
   [SwitchA-ike-profile-profile1] keychain keychain1
   ```

```
[SwitchA-ike-profile-profile1] match remote identity address 2.2.3.1 255.255.255.0
[SwitchA-ike-profile-profile1] quit
```

Create an IKE-based IPsec policy entry. Specify the policy name as **map1** and set the sequence number to 10.

```
[SwitchA] ipsec policy map1 10 isakmp
```

Specify ACL 3101.

```
[SwitchA-ipsec-policy-isakmp-map1-10] security acl 3101
```

Specify IPsec transform set **tran1**.

```
[SwitchA-ipsec-policy-isakmp-map1-10] transform-set tran1
```

Specify the local and remote IP addresses of the IPsec tunnel as 2.2.2.1 and 2.2.3.1.

```
[SwitchA-ipsec-policy-isakmp-map1-10] local-address 2.2.2.1
[SwitchA-ipsec-policy-isakmp-map1-10] remote-address 2.2.3.1
```

Specify IKE profile **profile1**.

```
[SwitchA-ipsec-policy-isakmp-map1-10] ike-profile profile1
[SwitchA-ipsec-policy-isakmp-map1-10] quit
```

Apply IPsec policy **map1** to VLAN-interface 1.

```
[SwitchA] interface vlan-interface 1
[SwitchA-Vlan-interface1] ipsec apply policy map1
```

2. Configure Switch B:

Configure an IP address for VLAN-interface 1.

```
<SwitchB> system-view
[SwitchB] interface vlan-interface 1
[SwitchB-Vlan-interface1] ip address 2.2.3.1 255.255.255.0
[SwitchB-Vlan-interface1] quit
```

Configure an IPv4 advanced ACL to identify the data flows from Switch B to Switch A.

```
[SwitchB] acl advanced 3101
[SwitchB-acl-ipv4-adv-3101] rule 0 permit ip source 2.2.3.1 0 destination 2.2.2.1 0
[SwitchB-acl-ipv4-adv-3101] quit
```

Create an IPsec transform set named **tran1**.

```
[SwitchB] ipsec transform-set tran1
```

Specify the encapsulation mode as **tunnel**.

```
[SwitchB-ipsec-transform-set-tran1] encapsulation-mode tunnel
```

Specify the security protocol as **ESP**.

```
[SwitchB-ipsec-transform-set-tran1] protocol esp
```

Specify the ESP encryption and authentication algorithms.

```
[SwitchB-ipsec-transform-set-tran1] esp encryption-algorithm aes-cbc-192
[SwitchB-ipsec-transform-set-tran1] esp authentication-algorithm sha1
[SwitchB-ipsec-transform-set-tran1] quit
```

Create an IKE keychain named **keychain1**.

```
[SwitchB] ike keychain keychain1
```

Specify **12345zxcvb!@#$%ZXCVB** in plain text as the preshared key to be used with the remote peer at 2.2.2.1.

```
[SwitchB-ike-keychain-keychain1] pre-shared-key address 2.2.2.1 255.255.255.0 key
simple 12345zxcvb!@#$%ZXCVB
[SwitchB-ike-keychain-keychain1] quit
```

Create and configure an IKE profile named **profile1**.

```
[SwitchB] ike profile profile1
```

```
[SwitchB-ike-profile-profile1] keychain keychain1
[SwitchB-ike-profile-profile1] match remote identity address 2.2.2.1 255.255.255.0
[SwitchB-ike-profile-profile1] quit
```

Create an IKE-based IPsec policy entry. Specify the policy name as **use1** and set the sequence number to 10.

```
[SwitchB] ipsec policy use1 10 isakmp
```

Specify ACL 3101.

```
[SwitchB-ipsec-policy-isakmp-use1-10] security acl 3101
```

Specify IPsec transform set **tran1**.

```
[SwitchB-ipsec-policy-isakmp-use1-10] transform-set tran1
```

Specify the local and remote IP addresses of the IPsec tunnel as 2.2.3.1 and 2.2.2.1.

```
[SwitchB-ipsec-policy-isakmp-use1-10] local-address 2.2.3.1
[SwitchB-ipsec-policy-isakmp-use1-10] remote-address 2.2.2.1
```

Specify IKE profile **profile1**.

```
[SwitchB-ipsec-policy-isakmp-use1-10] ike-profile profile1
[SwitchB-ipsec-policy-isakmp-use1-10] quit
```

Apply IPsec policy **use1** to VLAN-interface 1.

```
[SwitchB] interface vlan-interface 1
[SwitchB-Vlan-interface1] ipsec apply policy use1
```

Verifying the configuration

Initiate a connection between Switch A and Switch B to trigger IKE negotiation. After IPsec SAs are successfully negotiated by IKE, the traffic between the two switches is IPsec-protected.

Troubleshooting IKE

IKE negotiation failed because no matching IKE proposals were found

Symptom

1. The IKE SA is in Unknown state.

```
<Sysname> display ike sa
    Connection-ID   Remote                Flag         DOI
-----------------------------------------------------------------
    1               192.168.222.5         Unknown      IPsec
Flags:
RD--READY RL--REPLACED FD-FADING RK-REKEY
```

2. When IKE event debugging and packet debugging are enabled, the following messages appear:

   IKE event debugging message:

```
The attributes are unacceptable.
```

   IKE packet debugging message:

```
Construct notification packet: NO_PROPOSAL_CHOSEN.
```

Analysis

Certain IKE proposal settings are incorrect.

Solution

1. Examine the IKE proposal configuration to see whether the two ends have matching IKE proposals.
2. Modify the IKE proposal configuration to make sure the two ends have matching IKE proposals.

IKE negotiation failed because no IKE proposals or IKE keychains are specified correctly

Symptom

1. The IKE SA is in Unknown state.

```
<Sysname> display ike sa
    Connection-ID   Remote                Flag         DOI
-----------------------------------------------------------------
    1               192.168.222.5         Unknown      IPsec
Flags:
RD--READY RL--REPLACED FD-FADING RK-REKEY
```

2. The following IKE event debugging or packet debugging message appeared:

   IKE event debugging message:

```
Notification PAYLOAD_MALFORMED is received.
```

   IKE packet debugging message:

```
Construct notification packet: PAYLOAD_MALFORMED.
```

Analysis

- If the following debugging information appeared, the matched IKE profile is not using the matched IKE proposal:

```
Failed to find proposal 1 in profile profile1.
```

- If the following debugging information appeared, the matched IKE profile is not using the matched IKE keychain:

```
Failed to find keychain keychain1 in profile profile1.
```

Solution

- Verify that the matched IKE proposal (IKE proposal 1 in this debugging message example) is specified for the IKE profile (IKE profile 1 in the example).
- Verify that the matched IKE keychain (IKE keychain 1 in this debugging message example) is specified for the IKE profile (IKE profile 1 in the example).

IPsec SA negotiation failed because no matching IPsec transform sets were found

Symptom

1. The **`display ike sa`** command shows that the IKE SA negotiation succeeded and the IKE SA is in RD state, but the **`display ipsec sa`** command shows that the expected IPsec SA has not been negotiated yet.
2. The following IKE debugging message appeared:

```
The attributes are unacceptable.
```

   Or:

```
Construct notification packet: NO_PROPOSAL_CHOSEN.
```

Analysis

Certain IPsec policy settings are incorrect.

Solution

1. Examine the IPsec configuration to see whether the two ends have matching IPsec transform sets.
2. Modify the IPsec configuration to make sure the two ends have matching IPsec transform sets.

IPsec SA negotiation failed due to invalid identity information

Symptom

1. The **display ike sa** command shows that the IKE SA negotiation succeeded and the IKE SA is in RD state, but the **display ipsec sa** command shows that the expected IPsec SA has not been negotiated yet.
2. The following IKE debugging message appeared:

   ```
   Notification INVALID_ID_INFORMATION is received.
   ```

   Or:

   ```
   Failed to get IPsec policy when renegotiating IPsec SA. Delete IPsec SA.
   Construct notification packet: INVALID_ID_INFORMATION.
   ```

Analysis

Certain IPsec policy settings of the responder are incorrect. Verify the settings as follows:

1. Use the **display ike sa verbose** command to verify that matching IKE profiles were found in IKE negotiation phase 1. If no matching IKE profiles were found and the IPsec policy is using an IKE profile, the IPsec SA negotiation fails.

   # Identify whether matching IKE profiles were found in IKE negotiation phase 1. The following output shows that no matching IKE profile was found:

   ```
   <Sysname> display ike sa verbose
      ----------------------------------------------
      Connection ID: 3
      Outside VPN:
      Inside VPN:
      Profile:
      Transmitting entity: Responder
      ----------------------------------------------
      Local IP: 192.168.222.5
      Local ID type: IPV4_ADDR
      Local ID: 192.168.222.5

      Remote IP: 192.168.222.71
      Remote ID type: IPV4_ADDR
      Remote ID: 192.168.222.71

      Authentication-method: PRE-SHARED-KEY
      Authentication-algorithm: MD5
      Encryption-algorithm: 3DES-CBC

      Life duration(sec): 86400
      Remaining key duration(sec): 85847
   ```

```
  Exchange-mode: Main
  Diffie-Hellman group: Group 1
  NAT traversal: Not detected
```

Identify whether the IPsec policy is using an IKE profile. The following output shows that an IKE profile is used by the IPsec policy.

```
[Sysname] display ipsec policy
-----------------------------------------
IPsec Policy: policy1
Interface: GigabitEthernet1/0/1
-----------------------------------------

  ----------------------------
  Sequence number: 1
  Mode: ISAKMP
  ----------------------------
  Description:
  Security data flow: 3000
  Selector mode: aggregation
  Local address: 192.168.222.5
  Remote address: 192.168.222.71
  Transform set:  transform1
  IKE profile: profile1
  SA duration(time based):
  SA duration(traffic based):
  SA idle time:
```

2. Verify that the ACL specified for the IPsec policy is correctly configured. If the flow range defined by the responder's ACL is smaller than that defined by the initiator's ACL, IPsec proposal matching will fail.

For example, if the initiator's ACL defines a flow from one network segment to another but the responder's ACL defines a flow from one host to another host, IPsec proposal matching will fail.

On the initiator:

```
[Sysname] display acl 3000
Advanced IPv4 ACL 3000, 1 rule,
ACL's step is 5
 rule 0 permit ip source 192.168.222.0 0.0.0.255 destination 192.168.222.0 0.0.0.255
```

On the responder:

```
[Sysname] display acl 3000
Advanced IPv4 ACL 3000, 1 rule,
ACL's step is 5
 rule 0 permit ip source 192.168.222.71 0 destination 192.168.222.5 0
```

3. Verify that the IPsec policy has a remote address and an IPsec transform set configured and that the IPsec transform set has all necessary settings configured.

If, for example, the IPsec policy has no remote address configured, the IPsec SA negotiation will fail:

```
[Sysname] display ipsec policy
-----------------------------------------
IPsec Policy: policy1
Interface: GigabitEthernet1/0/1
-----------------------------------------
```

```
  ----------------------------
  Sequence number: 1
  Mode: ISAKMP
  ----------------------------
  Security data flow: 3000
  Selector mode: aggregation
  Local address: 192.168.222.5
  Remote address:
  Transform set:  transform1
  IKE profile: profile1
  SA duration(time based):
  SA duration(traffic based):
  SA idle time:
```

Solution

1. If the IPsec policy specifies an IKE profile but no matching IKE profiles was found in IKE negotiation, perform one of the following tasks on the responder:
   - Remove the specified IKE profile from the IPsec policy.
   - Modify the specified IKE profile to match the IKE profile of the initiator.
2. If the flow range defined by the responder's ACL is smaller than that defined by the initiator's ACL, modify the responder's ACL so the ACL defines a flow range equal to or greater than that of the initiator's ACL.

   For example:

   ```
   [Sysname] display acl 3000
   Advanced IPv4 ACL 3000, 2 rules,
   ACL's step is 5
    rule 0 permit ip source 192.168.222.0 0.0.0.255 destination 192.168.222.0 0.0.0.255
   ```
3. Configure the missing settings (for example, the remote address).

Configuring IKEv2

About IKEv2

Internet Key Exchange version 2 (IKEv2) is an enhanced version of IKEv1. The same as IKEv1, IKEv2 has a set of self-protection mechanisms and can be used on insecure networks for reliable identity authentication, key distribution, and IPsec SA negotiation. IKEv2 provides stronger protection against attacks and higher key exchange ability and needs fewer message exchanges than IKEv1.

IKEv2 negotiation process

Compared with IKEv1, IKEv2 simplifies the negotiation process and is much more efficient.

IKEv2 defines three types of exchanges: initial exchanges, CREATE_CHILD_SA exchange, and INFORMATIONAL exchange.

As shown in Figure 16, IKEv2 uses two exchanges during the initial exchange process: IKE_SA_INIT and IKE_AUTH, each with two messages.

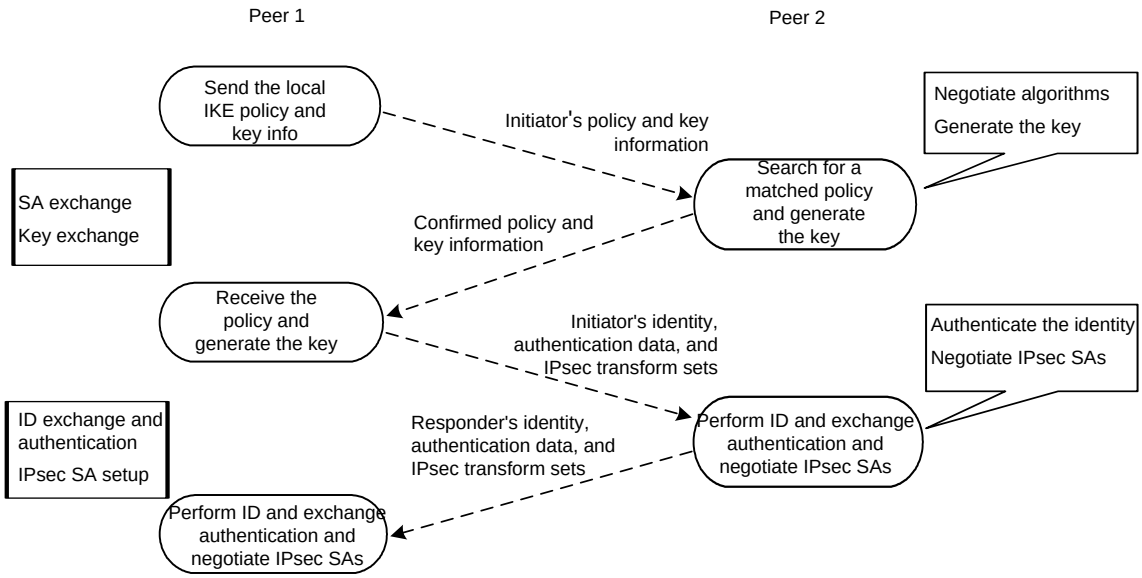
- **IKE_SA_INIT exchange**—Negotiates IKE SA parameters and exchanges keys.
- **IKE_AUTH exchange**—Authenticates the identity of the peer and establishes IPsec SAs.

After the four-message initial exchanges, IKEv2 sets up one IKE SA and one pair of IPsec SAs. For IKEv1 to set up one IKE SA and one pair of IPsec SAs, it must go through two phases that use a minimum of six messages.

To set up one more pair of IPsec SAs within the IKE SA, IKEv2 goes on to perform an additional two-message exchange—the CREATE_CHILD_SA exchange. One CREATE_CHILD_SA exchange creates one pair of IPsec SAs. IKEv2 also uses the CREATE_CHILD_SA exchange to rekey IKE SAs and Child SAs.

IKEv2 uses the INFORMATIONAL exchange to convey control messages about errors and notifications.

Figure 16 IKEv2 Initial exchange process



New features in IKEv2

DH guessing

In the IKE_SA_INIT exchange, the initiator guesses the DH group that the responder is most likely to use and sends it in an IKE_SA_INIT request message. If the initiator's guess is correct, the responder responds with an IKE_SA_INIT response message and the IKE_SA_INIT exchange is finished. If the guess is wrong, the responder responds with an INVALID_KE_PAYLOAD message that contains the DH group that it wants to use. The initiator then uses the DH group selected by the responder to reinitiate the IKE_SA_INIT exchange. The DH guessing mechanism allows for more flexible DH group configuration and enables the initiator to adapt to different responders.

Cookie challenging

Messages for the IKE_SA_INIT exchange are in plain text. An IKEv1 responder cannot confirm the validity of the initiators and must maintain half-open IKE SAs, which makes the responder susceptible to DoS attacks. An attacker can send a large number of IKE_SA_INIT requests with forged source IP addresses to the responder, exhausting the responder's system resources.

IKEv2 introduces the cookie challenging mechanism to prevent such DoS attacks. When an IKEv2 responder maintains a threshold number of half-open IKE SAs, it starts the cookie challenging mechanism. The responder generates a cookie and includes it in the response sent to the initiator. If the initiator initiates a new IKE_SA_INIT request that carries the correct cookie, the responder considers the initiator valid and proceeds with the negotiation. If the carried cookie is incorrect, the responder terminates the negotiation.

The cookie challenging mechanism automatically stops working when the number of half-open IKE SAs drops below the threshold.

IKEv2 SA rekeying

For security purposes, both IKE SAs and IPsec SAs have a lifetime and must be rekeyed when the lifetime expires. An IKEv1 SA lifetime is negotiated. An IKEv2 SA lifetime, in contrast, is configured. If two peers are configured with different lifetimes, the peer with the shorter lifetime always initiates the SA rekeying. This mechanism reduces the possibility that two peers will simultaneously initiate a rekeying. Simultaneous rekeying results in redundant SAs and SA status inconsistency on the two peers.

IKEv2 message retransmission

Unlike IKEv1 messages, IKEv2 messages appear in request/response pairs. IKEv2 uses the Message ID field in the message header to identify the request/response pair. If an initiator sends a request but receives no response with the same Message ID value within a specific period of time, the initiator retransmits the request.

It is always the IKEv2 initiator that initiates the retransmission, and the retransmitted message must use the same Message ID value.

Protocols and standards

- RFC 2408, *Internet Security Association and Key Management Protocol (ISAKMP)*
- RFC 4306, *Internet Key Exchange (IKEv2) Protocol*
- RFC 4718, *IKEv2 Clarifications and Implementation Guidelines*
- RFC 2412, *The OAKLEY Key Determination Protocol*
- RFC 5996, *Internet Key Exchange Protocol Version 2 (IKEv2)*

IKEv2 tasks at a glance

To configure IKEv2, perform the following tasks:

1. Configuring an IKEv2 profile
   a. Creating an IKEv2 profile
   b. Specifying the local and remote identity authentication methods
   c. Configuring the IKEv2 keychain or PKI domain
   d. Configuring the local ID for the IKEv2 profile
   e. Configuring peer IDs for the IKEv2 profile
   f. Configuring optional features for the IKEv2 profile
2. Configuring an IKEv2 policy
3. Configuring an IKEv2 proposal

   If you specify an IKEv2 proposal in an IKEv2 policy, you must configure the IKEv2 proposal.
4. Configuring an IKEv2 keychain

   This task is required when either end or both ends use the preshared key authentication method.
5. (Optional.) Enabling the cookie challenging feature

   The cookie challenging feature takes effect only on IKEv2 responders.
6. (Optional.) Configuring the IKEv2 DPD feature
7. (Optional.) Configuring the IKEv2 NAT keepalive feature

Prerequisites for IKEv2 configuration

Determine the following parameters prior to IKEv2 configuration:

- The strength of the algorithms for IKEv2 negotiation, including the encryption algorithms, integrity protection algorithms, PRF algorithms, and DH groups. Different algorithms provide different levels of protection. A stronger algorithm means better resistance to decryption of protected data but requires more resources. Typically, the longer the key, the stronger the algorithm.
- The local and remote identity authentication methods.
  - To use the preshared key authentication method, you must determine the preshared key.
  - To use the RSA digital signature authentication method, you must determine the PKI domain for the local end to use. For information about PKI, see "Configuring PKI."

Configuring an IKEv2 profile

Creating an IKEv2 profile

About IKEv2 profile

An IKEv2 profile is intended to provide a set of parameters for IKEv2 negotiation.

Procedure

1. Enter system view.

   `system-view`
2. Create an IKEv2 profile and enter its view.

   `ikev2 profile` *`profile-name`*

Specifying the local and remote identity authentication methods

Restrictions and guidelines

The local and remote identity authentication methods must both be specified and they can be different. You can specify only one local identity authentication method and multiple remote identity authentication methods.

Procedure

1. Enter system view.

   system-view

2. Enter IKEv2 profile view.

   ikev2 profile *profile-name*

3. Specify the local and remote identity authentication methods.

   authentication-method { **local** | **remote** } { **dsa-signature** | **ecdsa-signature** | **pre-share** | **rsa-signature** }

   By default, no local or remote identity authentication method is configured.

Configuring the IKEv2 keychain or PKI domain

Restrictions and guidelines

Configure the IKEv2 keychain or PKI domain for the IKEv2 profile to use. To use digital signature authentication, configure a PKI domain. To use preshared key authentication, configure an IKEv2 keychain.

Procedure

1. Enter system view.

   system-view

2. Enter IKEv2 profile view.

   ikev2 profile *profile-name*

3. Specify the keychain for preshared key authentication or the PKI domain used to request a certificate for digital signature authentication.

   - Specify the keychain.

     keychain *keychain-name*

   - Specify the PKI domain.

     certificate domain *domain-name* [**sign** | **verify**]

   By default, no IKEv2 keychain or PKI domain is specified for an IKEv2 profile.

Configuring the local ID for the IKEv2 profile

Restrictions and guidelines

For digital signature authentication, the device can use an ID of any type. If the local ID is an IP address that is different from the IP address in the local certificate, the device uses the FQDN as the local ID. The FQDN is the device name configured by using the **sysname** command.

For preshared key authentication, the device can use an ID of any type other than the DN.

Procedure

1. Enter system view.

   system-view

2. Enter IKEv2 profile view.

   ikev2 profile *profile-name*

3. Configure the local ID.

   identity local { **address** { *ipv4-address* | **ipv6** *ipv6-address* } | **dn** | **email** *email-string* | **fqdn** *fqdn-name* | **key-id** *key-id-string* }

   By default, no local ID is configured, and the device uses the IP address of the interface where the IPsec policy applies as the local ID.

Configuring peer IDs for the IKEv2 profile

About peer ID configuration

Perform this task to configure the peer ID for IKEv2 profile matching. When the device needs to select an IKEv2 profile for IKEv2 negotiation with a peer, it compares the received peer ID with the peer IDs of its local IKE profiles. If a match is found, it uses the IKEv2 profile with the matching peer ID for negotiation. IKEv2 profiles will be compared in descending order of their priorities.

Procedure

1. Enter system view.

   system-view

2. Enter IKEv2 profile view.

   ikev2 profile *profile-name*

3. Configure a peer ID.

   match remote { **certificate** *policy-name* | **identity** { **address** { { *ipv4-address* [*mask* | *mask-length*] | **range** *low-ipv4-address high-ipv4-address* } | **ipv6** { *ipv6-address* [*prefix-length*] | **range** *low-ipv6-address high-ipv6-address* } } | **fqdn** *fqdn-name* | **email** *email-string* | **key-id** *key-id-string* } }

   You must configure a minimum of one peer ID on each of the two peers.

Configuring optional features for the IKEv2 profile

1. Enter system view.

   system-view

2. Enter IKEv2 profile view.

   ikev2 profile *profile-name*

3. Configure optional features as needed.

   - Configure IKEv2 DPD.

     dpd interval *interval* [**retry** *seconds*] { **on-demand** | **periodic** }

     By default, IKEv2 DPD is not configured for an IKEv2 profile and an IKEv2 profile uses the DPD settings configured in system view. If IKEv2 DPD is not configured in system view either, the device does not perform dead IKEv2 peer detection.

   - Specify the local interface or IP address to which the IKEv2 profile can be applied.

     match local address { *interface-type interface-number* | *ipv4-address* | **ipv6** *ipv6-address* }

     By default, an IKEv2 profile can be applied to any local interface or local IP address.

Use this command to specify which address or interface can use the IKEv2 profile for IKEv2 negotiation. Specify the local address configured in IPsec policy or IPsec policy template view (using the **local-address** command) for this command. If no local address is configured, specify the IP address of the interface that uses the IPsec policy.

- Specify a priority for the IKEv2 profile.

  priority *priority*

  By default, the priority of an IKEv2 profile is 100.

  When the device needs to select an IKEv2 profile for IKEv2 negotiation with a peer, it compares the received peer ID with the peer ID of its local IKEv2 profiles in descending order of their priorities

- Set the IKEv2 SA lifetime for the IKEv2 profile.

  sa duration *seconds*

  By default, the IKEv2 SA lifetime is 86400 seconds.

  The local and remote ends can use different IKEv2 SA lifetimes and they do not negotiate the lifetime. The end with a smaller SA lifetime will initiate an SA negotiation when the lifetime expires.

- Set the IKEv2 NAT keepalive interval.

  nat-keepalive *seconds*

  By default, the global IKEv2 NAT keepalive setting is used.

  Configure this command when the device is behind a NAT gateway. The device sends NAT keepalive packets regularly to its peer to prevent the NAT session from being aged because of no matching traffic.

- Enable the configuration exchange feature.

  config-exchange { **request** | **set** { **accept** | **send** } }

  By default, all configuration exchange options are disabled.

  This feature applies to scenarios where the headquarters and branches communicate through virtual tunnels. It enables exchanges of IP address request and set messages between the IPsec gateway at a branch and the IPsec gateway at the headquarters.

Table 2 Parameter descriptions

Parameter	Description
request	Enables the IPsec gateway at a branch to submit IP address request messages to the IPsec gateway at the headquarters.
set accept	Enables the IPsec gateway at a branch to accept the IP addresses pushed by the IPsec gateway at the headquarters.
set send	Enables the IPsec gateway at the headquarters to push IP addresses to IPsec gateways at branches.

Configuring an IKEv2 policy

About IKEv2 policy selection mechanism

During the IKE_SA_INIT exchange, each end tries to find a matching IKEv2 policy, using the IP address of the local security gateway as the matching criterion.

- If IKEv2 policies are configured, IKEv2 searches for an IKEv2 policy that uses the IP address of the local security gateway. If no IKEv2 policy uses the IP address or the policy is using an incomplete proposal, the IKE_SA_INIT exchange fails.
- If no IKEv2 policy is configured, IKEv2 uses the system default IKEv2 policy **default**.

The device matches IKEv2 policies in the descending order of their priorities. To determine the priority of an IKEv2 policy:

1. First, the device examines the existence of the **match local address** command. An IKEv2 policy with the **match local address** command configured has a higher priority.
2. If a tie exists, the device compares the priority numbers. An IKEv2 policy with a smaller priority number has a higher priority.
3. If a tie still exists, the device prefers an IKEv2 policy configured earlier.

Procedure

1. Enter system view.

   system-view
2. Create an IKEv2 policy and enter its view.

   ikev2 policy *policy-name*

   By default, an IKEv2 policy named **default** exists.
3. Specify the local interface or address used for IKEv2 policy matching.

   match local address { *interface-type interface-number* | *ipv4-address* | **ipv6** *ipv6-address* }

   By default, no local interface or address is used for IKEv2 policy matching, and the policy matches any local interface or address.
4. Specify an IKEv2 proposal for the IKEv2 policy.

   proposal *proposal-name*

   By default, no IKEv2 proposal is specified for an IKEv2 policy.
5. Specify a priority for the IKEv2 policy.

   priority *priority*

   By default, the priority of an IKEv2 policy is 100.

Configuring an IKEv2 proposal

About IKEv2 proposal

An IKEv2 proposal contains security parameters used in IKE_SA_INIT exchanges, including the encryption algorithms, integrity protection algorithms, PRF algorithms, and DH groups. An algorithm specified earlier has a higher priority.

Restrictions and guidelines

A complete IKEv2 proposal must have at least one set of security parameters, including one encryption algorithm, one integrity protection algorithm, one PRF algorithm, and one DH group.

You can specify multiple IKEv2 proposals for an IKEv2 policy. A proposal specified earlier has a higher priority.

Procedure

1. Enter system view.

   system-view
2. Create an IKEv2 proposal and enter its view.

   ikev2 proposal *proposal-name*

   By default, an IKEv2 proposal named **default** exists.

   In non-FIPS mode, the default proposal uses the following settings:
   - Encryption algorithms AES-CBC-128 and 3DES.
   - Integrity protection algorithms HMAC-SHA1 and HMAC-MD5.

- PRF algorithms HMAC-SHA1 and HMAC-MD5.
- DH groups 2 and 5.

In FIPS mode, the default proposal uses the following settings:

- Encryption algorithms AES-CBC-128 and AES-CTR-128.
- Integrity protection algorithms HMAC-SHA1 and HMAC-SHA256.
- PRF algorithms HMAC-SHA1 and HMAC-SHA256.
- DH groups 14 and 19.

3. Specify the encryption algorithms.

   In non-FIPS mode:

   encryption { **3des-cbc** | **aes-cbc-128** | **aes-cbc-192** | **aes-cbc-256** | **aes-ctr-128** | **aes-ctr-192** | **aes-ctr-256** | **camellia-cbc-128** | **camellia-cbc-192** | **camellia-cbc-256** | **des-cbc** } *

   In FIPS mode:

   encryption { **aes-cbc-128** | **aes-cbc-192** | **aes-cbc-256** | **aes-ctr-128** | **aes-ctr-192** | **aes-ctr-256** } *

   By default, an IKEv2 proposal does not have any encryption algorithms.

4. Specify the integrity protection algorithms.

   In non-FIPS mode:

   integrity { **aes-xcbc-mac** | **md5** | **sha1** | **sha256** | **sha384** | **sha512** } *

   In FIPS mode:

   integrity { **sha1** | **sha256** | **sha384** | **sha512** } *

   By default, an IKEv2 proposal does not have any integrity protection algorithms.

5. Specify the DH groups.

   In non-FIPS mode:

   dh { **group1** | **group14** | **group2** | **group24** | **group5** | **group19** | **group20** } *

   In FIPS mode:

   dh { **group14** | **group19** | **group20** } *

   By default, an IKEv2 proposal does not have any DH groups.

6. Specify the PRF algorithms.

   In non-FIPS mode:

   prf { **aes-xcbc-mac** | **md5** | **sha1** | **sha256** | **sha384** | **sha512** } *

   In FIPS mode:

   prf { **sha1** | **sha256** | **sha384** | **sha512** } *

   By default, an IKEv2 proposal uses the integrity protection algorithms as the PRF algorithms.

Configuring an IKEv2 keychain

About IKEv2 keychain

An IKEv2 keychain specifies the preshared keys used for IKEv2 negotiation.

An IKEv2 keychain can have multiple IKEv2 peers. Each peer has a symmetric preshared key or an asymmetric preshared key pair, and information for identifying the peer (such as the peer's host name, IP address or address range, or ID).

An IKEv2 negotiation initiator uses the peer host name or IP address/address range as the matching criterion to search for a peer. A responder uses the peer host IP address/address range or ID as the matching criterion to search for a peer.

Procedure

1. Enter system view.
   system-view
2. Create an IKEv2 keychain and enter its view.
   ikev2 keychain *keychain-name*
3. Create an IKEv2 peer and enter its view.
   peer *name*
4. Configure a host name for the peer:
   hostname *name*
   By default, no host name is configured for an IKEv2 peer.
5. Configure a host IP address or address range for the peer:
   address { *ipv4-address* [*mask* | *mask-length*] | **ipv6** *ipv6-address* [*prefix-length*] }
   By default, no host IP address or address range is configured for an IKEv2 peer.
   You must configure different host IP addresses/address ranges for different peers.
6. Configure an ID for the peer:
   identity { **address** { *ipv4-address* | **ipv6** { *ipv6-address* } } | **fqdn** *fqdn-name* | **email** *email-string* | **key-id** *key-id-string* }
   By default, no identity information is configured for an IKEv2 peer.
7. Configure a preshared key for the peer.
   pre-shared-key [**local** | **remote**] { **ciphertext** | **plaintext** } *string*
   By default, an IKEv2 peer does not have a preshared key.

Configure global IKEv2 parameters

Enabling the cookie challenging feature

About the cookie challenging feature

Enable cookie challenging on responders to protect them against DoS attacks that use a large number of source IP addresses to forge IKE_SA_INIT requests.

Procedure

1. Enter system view.
   system-view
2. Enable IKEv2 cookie challenging.
   ikev2 cookie-challenge *number*
   By default, IKEv2 cookie challenging is disabled.

Configuring the IKEv2 DPD feature

About IKEv2 DPD

IKEv2 DPD detects dead IKEv2 peers in periodic or on-demand mode.

- **Periodic IKEv2 DPD**—Verifies the liveness of an IKEv2 peer by sending DPD messages at regular intervals.
- **On-demand IKEv2 DPD**—Verifies the liveness of an IKEv2 peer by sending DPD messages before sending data.
  - Before the device sends data, it identifies the time interval for which the last IPsec packet has been received from the peer. If the time interval exceeds the DPD interval, it sends a DPD message to the peer to detect its liveliness.
  - If the device has no data to send, it never sends DPD messages.

Restrictions and guidelines

If you configure IKEv2 DPD in both IKEv2 profile view and system view, the IKEv2 DPD settings in IKEv2 profile view apply. If you do not configure IKEv2 DPD in IKEv2 profile view, the IKEv2 DPD settings in system view apply.

Procedure

1. Enter system view.
   system-view
2. Configure global IKEv2 DPD.
   ikev2 dpd interval *interval* [**retry** *seconds*] { **on-demand** | **periodic** }
   By default, global DPD is disabled.

Configuring the IKEv2 NAT keepalive feature

About the IKEv2 NAT keepalive feature

Configure this feature on the IKEv2 gateway behind the NAT device. The gateway then sends NAT keepalive packets regularly to its peer to keep the NAT session alive, so that the peer can access the device.

The NAT keepalive interval must be shorter than the NAT session lifetime.

This feature takes effect after the device detects the NAT device.

Procedure

1. Enter system view.
   system-view
2. Set the IKEv2 NAT keepalive interval.
   ikev2 nat-keepalive *seconds*
   By default, the IKEv2 NAT keepalive interval is 10 seconds.

Display and maintenance commands for IKEv2

Execute **display** commands in any view and **reset** commands in user view.

Task	Command
Display the IKEv2 policy configuration.	**display ikev2 policy** [*policy-name* | **default**]
Display the IKEv2 profile configuration.	**display ikev2 profile** [*profile-name*]

Task	Command
Display the IKEv2 proposal configuration.	**display ikev2 proposal** [*name* | **default**]
Display the IKEv2 SA information.	**display ikev2 sa** [**count** | [{ **local** | **remote** } { *ipv4-address* | **ipv6** *ipv6-address* }] [**verbose** [**tunnel** *tunnel-id*]]]
Display IKEv2 statistics.	**display ikev2 statistics**
Delete IKEv2 SAs and the child SAs negotiated through the IKEv2 SAs.	**reset ikev2 sa** [[{ **local** | **remote** } { *ipv4-address* | **ipv6** *ipv6-address* }] | **tunnel** *tunnel-id*] [**fast**]
Clear IKEv2 statistics.	**reset ikev2 statistics**

Troubleshooting IKEv2

IKEv2 negotiation failed because no matching IKEv2 proposals were found

Symptom

The IKEv2 SA is in IN-NEGO status.

```
<Sysname> display ikev2 sa
Tunnel ID   Local                      Remote                     Status
  ------------------------------------------------------------------------------
  5           123.234.234.124/500         123.234.234.123/500         IN-NEGO
Status:
IN-NEGO: Negotiating, EST: Established, DEL:Deleting
```

Analysis

Certain IKEv2 proposal settings are incorrect.

Solution

1. Examine the IKEv2 proposal configuration to see whether the two ends have matching IKEv2 proposals.
2. Modify the IKEv2 proposal configuration to make sure the two ends have matching IKEv2 proposals.

IPsec SA negotiation failed because no matching IPsec transform sets were found

Symptom

The **display ikev2 sa** command shows that the IKEv2 SA negotiation succeeded and the IKEv2 SA is in EST status. The **display ipsec sa** command shows that the expected IPsec SAs have not been negotiated yet.

Analysis

Certain IPsec policy settings are incorrect.

Solution

1. Examine the IPsec configuration to see whether the two ends have matching IPsec transform sets.
2. Modify the IPsec configuration to make sure the two ends have matching IPsec transform sets.

IPsec tunnel establishment failed

Symptom

The ACLs and IKEv2 proposals are correctly configured on both ends. The two ends cannot establish an IPsec tunnel or cannot communicate through the established IPsec tunnel.

Analysis

The IKEv2 SA or IPsec SAs on either end are lost. The reason might be that the network is unstable and the device reboots.

Solution

1. Use the **display ikev2 sa** command to examine whether an IKEv2 SA exists on both ends. If the IKEv2 SA on one end is lost, delete the IKEv2 SA on the other end by using the **reset ikev2 sa** command and trigger new negotiation. If an IKEv2 SA exists on both ends, go to the next step.
2. Use the **display ipsec sa** command to examine whether IPsec SAs exist on both ends. If the IPsec SAs on one end are lost, delete the IPsec SAs on the other end by using the **reset ipsec sa** command and trigger new negotiation.

Contents

Configuring SSH

About SSH

Secure Shell (SSH) is a network security protocol. Using encryption and authentication, SSH can implement secure remote access and file transfer over an insecure network.

SSH uses the typical client-server model to establish a channel for secure data transfer based on TCP.

SSH includes two versions: SSH1.x and SSH2.0 (hereinafter referred to as SSH1 and SSH2), which are not compatible. SSH2 is better than SSH1 in performance and security.

SSH applications

The device supports the following SSH applications:

- **Secure Telnet**—Stelnet provides secure and reliable network terminal access services. Through Stelnet, a user can securely log in to a remote server. Stelnet can protect devices against attacks, such as IP spoofing and plain text password interception. The device can act as an Stelnet server or an Stelnet client.
- **Secure File Transfer Protocol**—Based on SSH2, SFTP uses SSH connections to provide secure file transfer. The device can act as an SFTP server, allowing a remote user to log in to the SFTP server for secure file management and transfer. The device can also act as an SFTP client, enabling a user to log in from the device to a remote device for secure file transfer.
- **Secure Copy**—Based on SSH2, SCP offers a secure method to copy files. The device can act as an SCP server, allowing a user to log in to the device for file upload and download. The device can also act as an SCP client, enabling a user to log in from the device to a remote device for secure file transfer.
- **NETCONF over SSH**—Based on SSH2, it enables users to securely log in to the device through SSH and perform NETCONF operations on the device through the NETCONF-over-SSH connections. The device can act only as a NETCONF-over-SSH server. For more information about NETCONF, see *Network Management and Monitoring Configuration Guide*.

When acting as an SSH server or client, the device supports the following SSH versions:

- When acting as an Stelnet, SFTP, or SCP server, the device supports both SSH2 and SSH1 in non-FIPS mode and only SSH2 in FIPS mode.
- When acting as an SSH client, the device supports only SSH2.
- When acting as a NETCONF-over-SSH server, the device supports only SSH2.

How SSH works

This section uses SSH2 as an example to describe the stages to establish an SSH session.

Table 1 Stages to establish an SSH session

Stages	Description
Connection establishment	The SSH server listens to connection requests on port 22. After a client initiates a connection request, the server and the client establish a TCP connection.
Version negotiation	The two parties determine a version to use.

Stages	Description
Algorithm negotiation	SSH supports multiple algorithms. Based on the local algorithms, the two parties negotiate the following algorithms: • Key exchange algorithm for generating session keys. • Encryption algorithm for encrypting data. • Public key algorithm for the digital signature and authentication. • HMAC algorithm for protecting data integrity.
Key exchange	The two parties use the DH exchange algorithm to dynamically generate the session keys and session ID. • The session keys are used for protecting data transfer. • The session ID is used for identifying the SSH connection. In this stage, the client also authenticates the server.
Authentication	The SSH server authenticates the client in response to the client's authentication request.
Session request	After passing the authentication, the client sends a session request to the server to request the establishment of a session (or request the Stelnet, SFTP, SCP, or NETCONF service).
Interaction	After the server grants the request, the client and the server start to communicate with each other in the session. In this stage, you can paste commands in text format and execute them at the CLI. The text pasted at one time must be no more than 2000 bytes. As a best practice to ensure the correct execution of commands, paste commands that are in the same view. To execute commands of more than 2000 bytes, save the commands in a configuration file, upload the file to the server through SFTP, and use it to restart the server.

SSH authentication methods

This section describes authentication methods that are supported by the device when it acts as an SSH server.

Password authentication

The SSH server authenticates a client through the AAA mechanism. The password authentication process is as follows:

1. The client sends the server an authentication request that includes the encrypted username and password.
2. The server performs the following operations:
   a. Decrypts the request to get the username and password in plain text.
   b. Verifies the username and password locally or through remote AAA authentication.
   c. Informs the client of the authentication result.

If the remote AAA server requires the user to enter a password for secondary authentication, it send the SSH server an authentication response carrying a prompt. The prompt is transparently transmitted to the client to notify the user to enter a specific password. When the user enters the correct password, the AAA sever examines the password validity. If the password is valid, the SSH server returns an authentication success message to the client.

SSH1 clients do not support secondary password authentication initiated by the AAA server.

For more information about AAA, see "Configuring AAA."

Keyboard-interactive authentication

In keyboard-interactive authentication, the remote authentication server and user exchanges information for authentication as follows:

1. The remote authentication server sends a prompt to the SSH server in an authentication response.

   The prompt indicates the information required to be provided by the user.
2. The SSH server transparently transmits the prompt to the client terminal.
3. The user enters the required information as prompted.

This process repeats multiple times if the remote authentication server requires more interactive information. The remote authentication server returns an authentication success message after the user provides all required interactive information.

If the remote authentication server does not require interactive information, the keyboard-interactive authentication process is the same as the password authentication.

Publickey authentication

The server authenticates a client by verifying the digital signature of the client. The publickey authentication process is as follows:

1. The client sends the server a publickey authentication request that includes the username, public key, and public key algorithm name.

   If the digital certificate of the client is required in authentication, the client also encapsulates the digital certificate in the authentication request. The digital certificate carries the public key information of the client.
2. The server verifies the client's public key.
   - If the public key is invalid, the server informs the client of the authentication failure.
   - If the public key is valid, the server requests the digital signature of the client. After receiving the signature, the server uses the public key to verify the signature and informs the client of the authentication result.

When acting as an SSH server, the device supports using the public key algorithms DSA, ECDSA, and RSA to verify digital signatures.

When acting as an SSH client, the device supports using the public key algorithms DSA, ECDSA, and RSA to generate digital signatures.

For more information about public key configuration, see "Managing public keys."

Password-publickey authentication

The server requires SSH2 clients to pass both password authentication and publickey authentication. However, an SSH1 client only needs to pass either authentication.

Any authentication

The server requires clients to pass keyboard-interactive authentication, password authentication, or publickey authentication. Success with any one authentication method is sufficient to connect to the server.

SSH support for Suite B

Suite B contains a set of encryption and authentication algorithms that meet high security requirements. Table 2 lists all algorithms in Suite B.

The SSH server and client support using the X.509v3 certificate for identity authentication in compliance with the algorithm, negotiation, and authentication specifications defined in RFC 6239.

Table 2 Suite B algorithms

Security level	Key exchange algorithm	Encryption algorithm and HMAC algorithm	Public key algorithm
128-bit	ecdh-sha2-nistp256	AES128-GCM	x509v3-ecdsa-sha2-nistp256
192-bit	ecdh-sha2-nistp384	AES256-GCM	x509v3-ecdsa-sha2-nistp384
Both	ecdh-sha2-nistp256 ecdh-sha2-nistp384	AES128-GCM AES256-GCM	x509v3-ecdsa-sha2-nistp256 x509v3-ecdsa-sha2-nistp384

FIPS compliance

The device supports the FIPS mode that complies with NIST FIPS 140-2 requirements. Support for features, commands, and parameters might differ in FIPS mode and non-FIPS mode. For more information about FIPS mode, see "Configuring FIPS."

Configuring the device as an SSH server

SSH server tasks at a glance

To configure an SSH server, perform the following tasks:

1. Generating local key pairs
2. (Optional.) Specifying the SSH service port
3. Enabling the SSH server
   - Enabling the Stelnet server
   - Enabling the SFTP server
   - Enabling the SCP server
   - Enabling NETCONF over SSH
4. Configuring the user lines for SSH login

   Required only for Stelnet and NETCONF-over-SSH servers.
5. Configuring a client's host public key

   Required for authentication method **publickey**, **password-publickey,** or **any**.
6. Configuring an SSH user
   - Required for authentication method **keyboard-interactive**, **publickey**, **password-publickey,** or **any**.
   - Optional for the **password** authentication method.
7. (Optional.) Configuring the SSH management parameters

   SSH management settings, such as authentication and connection control settings, help improve security of SSH connections.
8. (Optional.) Specifying a PKI domain for the SSH server
9. (Optional.) Disconnecting SSH sessions

Generating local key pairs

About local key pairs

The DSA, ECDSA, or RSA key pairs on the SSH server are required for generating the session keys and session ID in the key exchange stage. They can also be used by a client to authenticate the server. When a client authenticates the server, it compares the public key received from the server with the server's public key that the client saved locally. If the keys are consistent, the client uses the locally saved server's public key to decrypt the digital signature received from the server. If the decryption succeeds, the server passes the authentication.

To support SSH clients that use different types of key pairs, generate DSA, ECDSA, and RSA key pairs on the SSH server.

- **RSA key pairs**—The SSH server generates a server key pair and a host key pair for RSA. The RSA server key pair is only used in SSH1 to encrypt the session key for secure transmission of the session key. It is not used in SSH2, because no session key transmission is required in SSH2.
- **DSA key pair**—The SSH server generates only one DSA host key pair. SSH1 does not support the DSA algorithm.
- **ECDSA key pair**—The SSH server generates only one ECDSA host key pair.

Restrictions and guidelines

Local DSA, ECDSA, and RSA key pairs for SSH use default names. You cannot assign names to the key pairs.

If the device does not have RSA key pairs with default names, it automatically generates one RSA server key pair and one RSA host key pair when SSH starts. Both key pairs use their default names. The SSH application starts when you execute an SSH server command on the device.

The key modulus length must be less than 2048 bits when you generate the DSA key pair on the SSH server.

When you generate an ECDSA key pair, you can generate only a **secp256r1** or **secp384r1** ECDSA key pair.

The SSH server operating in FIPS mode supports only ECDSA and RSA key pairs. Do not generate a DSA key pair on the SSH server in FIPS mode.

Procedure

1. Enter system view.
   system-view
2. Generate local key pairs.
   public-key local create { **dsa** | **ecdsa** { **secp256r1** | **secp384r1** } | **rsa** }

Specifying the SSH service port

About the SSH service port

The default port of the SSH service is 22. You can specify another port for the SSH service to improve security of SSH connections.

Procedure

1. Enter system view.
   system-view
2. Specify the SSH service port.
   ssh server port *port-number*

CAUTION:

- If you modify the SSH port number when the SSH server is enabled, the SSH service is restarted and all SSH connections are terminated after the modification. SSH users must reconnect to the SSH server to access the server.
- If you set the SSH port to a well-known port number, the service that uses the well-known port number might fail to start. Well-known port numbers are in the range of 1 to 1024.

By default, the SSH service port is 22.

Enabling the Stelnet server

About enabling the Stelnet server

After you enable the Stelnet server on the device, a client can log in to the device through Stelnet.

Procedure

1. Enter system view.
   ```
   system-view
   ```
2. Enable the Stelnet server.
   ```
   ssh server enable
   ```
   By default, the Stelnet server is disabled.

Enabling the SFTP server

About enabling the SFTP server

After you enable the SFTP server on the device, a client can log in to the device through SFTP.

Restrictions and guidelines

When acting as an SFTP server, the device does not support SFTP connections initiated by SSH1 clients.

Procedure

1. Enter system view.
   ```
   system-view
   ```
2. Enable the SFTP server.
   ```
   sftp server enable
   ```
   By default, the SFTP server is disabled.

Enabling the SCP server

About enabling the SCP server

After you enable the SCP server on the device, a client can log in to the device through SCP.

Restrictions and guidelines

When acting as an SCP server, the device does not support SCP connections initiated by SSH1 clients.

Procedure

1. Enter system view.
   ```
   system-view
   ```

2. Enable the SCP server.

   scp server enable

   By default, the SCP server is disabled.

Enabling NETCONF over SSH

About enabling NETCONF over SSH

After you enable NETCONF over SSH on the device, a client can perform NETCONF operations on the device through a NETCONF-over-SSH connection.

Restrictions and guidelines

When acting as a server in the NETCONF-over-SSH connection, the device does not support connection requests initiated by SSH1 clients.

Procedure

1. Enter system view.

   system-view

2. Enable NETCONF over SSH.

   netconf ssh server enable

   By default, NETCONF over SSH is disabled.

   For more information about NETCONF over SSH commands, see *Network Management and Monitoring Command Reference*.

Configuring the user lines for SSH login

About user line configuration for SSH login

Depending on the SSH application, an SSH client can be an Stelnet client, SFTP client, SCP client, or NETCONF-over-SSH client.

Only Stelnet and NETCONF-over-SSH clients require the user line configuration. The user line configuration takes effect on the clients at the next login.

Procedure

1. Enter system view.

   system-view

2. Enter VTY user line view.

   line vty *number* [*ending-number*]

3. Set the login authentication mode to scheme.

   authentication-mode scheme

   By default, the authentication mode is **password**.

   For more information about this command, see *Fundamentals Command Reference*.

Configuring a client's host public key

About the client's host public key

In publickey authentication, the server compares the SSH username and the client's host public key received from the client with the locally saved SSH username and the client's host public key. If they are the same, the server checks the digital signature that the client sends. The client generates the digital signature by using the private key that is paired with the client's host public key.

For publickey authentication, password-publickey authentication, or any authentication, you must perform the following tasks:

1. Configure the client's DSA, ECDSA, or RSA host public key on the server.
2. Specify the associated host private key on the client to generate the digital signature.

   If the device acts as an SSH client, specify the public key algorithm on the client. The algorithm determines the associated host private key for generating the digital signature.

Client public key configuration methods

You can configure the client host public key by using the following methods:

- Manually enter the content of a client's host public key on the server.
  a. Display the host public key on the client and record the key.
  b. Type the client's host public key character by character on the server, or use the copy and paste method.

  The manually entered key must be in DER format without being converted. For the displayed key to meet the requirement when the client is an H3C device, use the **display public-key local public** command. The format of the public key displayed in any other way (for example, by using the **public-key local export** command) might be incorrect. If the key is not in correct format, the system discards the key.
- Import the client host public key from a public key file.
  a. Save the client public key file to the server. For example, transfer the client public key file to the server in binary mode through FTP or TFTP.
  b. Import the client public key from the locally saved public key file.

     During the import process, the server automatically converts the host public key to a string in PKCS format.

Restrictions and guidelines

As a best practice, configure no more than 20 SSH client's host public keys on an SSH server.

Import the client's host public key as a best practice.

Entering a client's host public key

1. Enter system view.

   system-view
2. Enter public key view.

   public-key peer *keyname*
3. Configure a client's host public key.

   Enter the content of the client's host public key character by character, or use the copy and paste method.

   When you enter the content of a client's host public key, you can use spaces and carriage returns between characters but the system does not save them. For more information, see "Managing public keys."
4. Exit public key view and save the key.

   peer-public-key end

Importing a client's host public key from the public key file

1. Enter system view.

   system-view
2. Import a client's public key from the public key file.

   public-key peer *keyname* **import sshkey** *filename*

Configuring an SSH user

About the SSH user

Configure an SSH user and a local user depending on the authentication method.

- If the authentication method is **publickey**, you must create an SSH user and a local user on the SSH server. The two users must have the same username, so that the SSH user can be assigned the correct working directory and user role.
- If the authentication method is **password**, you must perform one of the following tasks:
  - For local authentication, configure a local user on the SSH server.
  - For remote authentication, configure an SSH user on a remote authentication server, for example, a RADIUS server.

  You do not need to create an SSH user by using the **ssh user** command. However, if you want to display all SSH users, including the password-only SSH users, for centralized management, you can use this command to create them. If such an SSH user has been created, make sure you have specified the correct service type and authentication method.
- If the authentication method is **keyboard-interactive**, **password-publickey**, or **any**, you must create an SSH user on the SSH server and perform one of the following tasks:
  - For local authentication, configure a local user on the SSH server.
  - For remote authentication, configure an SSH user on a remote authentication server, for example, a RADIUS server.

  In either case, the local user or the SSH user configured on the remote authentication server must have the same username as the SSH user.

For information about configuring local users and remote authentication, see "Configuring AAA."

Restrictions and guidelines

If you change the authentication parameters for a logged-in SSH user, the change takes effect on the user at the next login.

When the device operates as an SSH server in FIPS mode, the device does not support authentication method **any** or **publickey**.

For an SFTP or SCP user, the working directory depends on the authentication method.

- If the authentication method is **publickey** or **password-publickey**, the working folder is specified by the **authorization-attribute** command in the associated local user view.
- If the authentication method is **keyboard-interactive** or **password**, the working directory is authorized by AAA.

For an SSH user, the user role also depends on the authentication method.

- If the authentication method is **publickey** or **password-publickey**, the user role is specified by the **authorization-attribute** command in the associated local user view.
- If the authentication method is **keyboard-interactive** or **password**, the user role is authorized by AAA.

For all authentication methods except keyboard-interactive authentication and password authentication, you must specify a client's host public key or digital certificate.

- For a client that sends the user's public key information directly to the server, specify the client's host public key on the server. The specified public key must already exist. For more information about public keys, see "Configuring a client's host public key." If you specify multiple client public keys, the device verifies the user identity by using the public keys in the order they are specified. The user is valid if the user passes one public key check.
- For a client that sends the user's public key information to the server through a digital certificate, specify the PKI domain on the server. This PKI domain verifies the client's digital certificate. For successful verification, the specified PKI domain must have the correct CA certificate. To

specify the PKI domain, use the **ssh user** or **ssh server pki-domain** command. For more information about configuring a PKI domain, see "Configuring PKI."

Procedure

1. Enter system view.

   system-view

2. Create an SSH user, and specify the service type and authentication method.

   In non-FIPS mode:

   ssh user *username* **service-type** { **all** | **netconf** | **scp** | **sftp** | **stelnet** } **authentication-type** { **keyboard-interactive** | **password** | { **any** | **password-publickey** | **publickey** } [**assign** { **pki-domain** *domain-name* | **publickey** *keyname*&<1-6> }] }

   In FIPS mode:

   ssh user *username* **service-type** { **all** | **netconf** | **scp** | **sftp** | **stelnet** } **authentication-type** { **keyboard-interactive** | **password** | **password-publickey** [**assign** { **pki-domain** *domain-name* | **publickey** *keyname*&<1-6> }] }

   An SSH server supports up to 1024 SSH users.

Configuring the SSH management parameters

Enabling the SSH server to support SSH1 clients

1. Enter system view.

   system-view

2. Enable the SSH server to support SSH1 clients.

   ssh server compatible-ssh1x enable

   By default, the SSH server does not support SSH1 clients.

   This command is not available in FIPS mode.

Enabling SSH algorithm renegotiation and key re-exchange

1. Enter system view.

   system-view

2. Enable SSH algorithm renegotiation and key re-exchange.

   ssh server key-re-exchange enable [**interval** *interval*]

   By default, SSH algorithm renegotiation and key re-exchange are disabled.

   This command is not available in FIPS mode.

   The command takes effect only on new SSH connections that are established after the command is configured, and it does not affect existing SSH connections.

Setting the minimum interval for updating the RSA server key pair

1. Enter system view.

   system-view

2. Set the minimum interval for updating the RSA server key pair.

   ssh server rekey-interval *interval*

   By default, the device does not update the RSA server key pair.

   This command is not available in FIPS mode.

   This configuration takes effect only on SSH1 clients.

Setting the SSH user authentication timeout timer

1. Enter system view.

   system-view

2. Set the SSH user authentication timeout timer.

   ssh server authentication-timeout *time-out-value*

   The default setting is 60 seconds.

   Perform this task to prevent malicious occupation of TCP connections. If a user does not finish the authentication when the timeout timer expires, the connection cannot be established.

Setting the maximum number of SSH authentication attempts

1. Enter system view.

   system-view

2. Set the maximum number of SSH authentication attempts.

   ssh server authentication-retries *retries*

   The default setting is 3.

   Perform this task to prevent malicious hacking of usernames and passwords. If the authentication method is **any**, the total number of publickey authentication attempts and password authentication attempts cannot exceed the upper limit.

Specifying an SSH login control ACL

1. Enter system view.

   system-view

2. Specify an SSH login control ACL.

   IPv4:

   ssh server acl { *advanced-acl-number* | *basic-acl-number* | **mac** *mac-acl-number* }

   IPv6:

   ssh server ipv6 acl { **ipv6** { *advanced-acl-number* | *basic-acl-number* } | **mac** *mac-acl-number* }

   This feature uses an ACL to filter SSH clients that initiate SSH connections to the server. By default, no ACLs are specified and all SSH users can initiate SSH connections to the server.

Enabling logging for SSH login attempts that are denied by the SSH login control ACL

1. Enter system view.

   system-view

2. Enable logging for SSH login attempts that are denied by the SSH login control ACL.

   ssh server acl-deny-log enable

   By default, logging is disabled for login attempts that are denied by the SSH login control ACL.

   This command enables SSH to generate log messages for SSH login attempts that are denied by the SSH login control ACL and send the messages to the information center.

Setting the DSCP value in the packets that the SSH server sends to SSH clients

1. Enter system view.

   system-view

2. Set the DSCP value in the packets that the SSH server sends to the SSH clients.

   IPv4:

   ssh server dscp *dscp-value*

   IPv6:

ssh server ipv6 dscp *dscp-value*

By default, the DSCP value of SSH packets is 48.

The DSCP value of a packet defines the priority of the packet and affects the transmission priority of the packet. A bigger DSCP value represents a higher priority.

Setting the SFTP connection idle timeout timer

1. Enter system view.

   system-view
2. Set the SFTP connection idle timeout timer.

   sftp server idle-timeout *time-out-value*

   By default, the SFTP connection idle timeout is 10 minutes.

   When the SFTP connection idle timeout timer expires, the system automatically tears the connection down and releases the connection resources.

Setting the maximum number of online SSH users

1. Enter system view.

   system-view
2. Set the maximum number of online SSH users.

   aaa session-limit ssh *max-sessions*

   The default setting is 32.

   When the number of online SSH users reaches the upper limit, the system denies new SSH connection requests. Changing the upper limit does not affect online SSH users.

   For more information about this command, see AAA commands in *Security Command Reference*.

Specifying a PKI domain for the SSH server

About specifying a PKI domain for the SSH server

The PKI domain specified for the SSH server has the following functions:

- The SSH server uses the PKI domain to send its certificate to the client in the key exchange stage.
- The SSH server uses the PKI domain to authenticate the client's certificate if no PKI domain is specified for the client authentication by using the **ssh user** command.

Procedure

1. Enter system view.

   system-view
2. Specify a PKI domain for the SSH server.

   ssh server pki-domain *domain-name*

   By default, no PKI domain is specified for the SSH server.

Disconnecting SSH sessions

About disconnecting SSH sessions

The device supports concurrent login sessions. To avoid an SSH login user interfering with your configuration, you can disconnect that SSH login user.

Procedure

Execute the following command in user view to disconnect SSH sessions:

free ssh { **user-ip** { *ip-address* | **ipv6** *ipv6-address* } [**port** *port-number*] | **user-pid** *pid-number* | **username** *username* }

Configuring the device as an Stelnet client

Stelnet client tasks at a glance

To configure an Stelnet client, perform the following tasks:

1. Generating local key pairs

   Only required for authentication method **publickey**, **password-publickey**, or **any**.
2. (Optional.) Specifying the source IP address for outgoing SSH packets
3. Establishing a connection to an Stelnet server
4. (Optional.) Deleting server public keys saved in the public key file on the Stelnet client
5. (Optional.) Establishing a connection to an Stelnet server based on Suite B

Generating local key pairs

About generating local key pairs

You must generate local key pairs on Stelnet clients when the Stelnet server uses the **publickey**, **password-publickey**, or **any** authentication method.

Restrictions and guidelines

Local DSA, ECDSA, and RSA key pairs for SSH use default names. You cannot assign names to the key pairs.

The key modulus length must be less than 2048 bits when you generate a DSA key pair.

When you generate an ECDSA key pair, you can generate only a **secp256r1** or **secp384r1** ECDSA key pair.

The Stelnet client operating in FIPS mode supports only ECDSA and RSA key pairs.

Procedure

1. Enter system view.

   system-view
2. Generate local key pairs.

   public-key local create { **dsa** | **ecdsa** { **secp256r1** | **secp384r1** } | **rsa** }

Specifying the source IP address for outgoing SSH packets

About specifying the source IP address for outgoing SSH packets

After you specify the source IP address for outgoing SSH packets on an Stelnet client, the client uses the specified IP address to communicate with the Stelnet server.

Restrictions and guidelines

As a best practice, specify the IP address of a loopback interface as the source address of outgoing SSH packets for the following purposes:

- Ensuring the communication between the Stelnet client and the Stelnet server.

- Improving the manageability of Stelnet clients in authentication service.

Procedure

1. Enter system view.

   system-view

2. Specify the source address for outgoing SSH packets.

   IPv4:

   ssh client source { **interface** *interface-type interface-number* | **ip** *ip-address* }

   By default, an IPv4 Stelnet client uses the primary IPv4 address of the output interface in the matching route as the source address of the outgoing SSH packets.

   IPv6:

   ssh client ipv6 source { **interface** *interface-type interface-number* | **ipv6** *ipv6-address* }

   By default, an IPv6 Stelnet client automatically selects a source IPv6 address for outgoing SSH packets in compliance with RFC 3484.

Establishing a connection to an Stelnet server

About establishing a connection to an Stelnet server

Perform this task to enable the Stelnet client feature on the device and establish a connection to the Stelnet server. You can specify the public key algorithm and the preferred encryption, HMAC, and key exchange algorithms to be used during the connection.

To access the server, a client must use the server's host public key to authenticate the server. As a best practice, configure the server's host public key on the device in an insecure network. If the server's host public key is not configured on the client, the client will notify you to confirm whether to continue with the access.

- If you choose to continue, the client accesses the server and downloads the server's host public key. The downloaded public key will be used to authenticate the server in subsequent accesses.

  If the server public key is not specified the when you connect to the server, the device saves the server public key to the public key file. It does not save the server public key to the configuration file.
- If you choose to not continue, the connection cannot be established.

Restrictions and guidelines for establishing a connection to an Stelnet server

An Stelnet client cannot establish connections to both IPv4 and IPv6 Stelnet servers.

Establishing a connection to an IPv4 Stelnet server

Execute the following command in user view to establish a connection with an IPv4 Stelnet server:

In non-FIPS mode:

ssh2 *server* [*port-number*] [**identity-key** { **dsa** | **ecdsa-sha2-nistp256** | **ecdsa-sha2-nistp384** | **rsa** | { **x509v3-ecdsa-sha2-nistp256** | **x509v3-ecdsa-sha2-nistp384** } **pki-domain** *domain-name* } | **prefer-compress zlib** | **prefer-ctos-cipher** { **3des-cbc** | **aes128-cbc** | **aes128-ctr** | **aes128-gcm** | **aes192-ctr** | **aes256-cbc** | **aes256-ctr** | **aes256-gcm** | **des-cbc** } | **prefer-ctos-hmac** { **md5** | **md5-96** | **sha1** | **sha1-96** | **sha2-256** | **sha2-512** } | **prefer-kex** { **dh-group-exchange-sha1** | **dh-group1-sha1** | **dh-group14-sha1** | **ecdh-sha2-nistp256** | **ecdh-sha2-nistp384** } | **prefer-stoc-cipher** { **3des-cbc** | **aes128-cbc** | **aes128-ctr** | **aes128-gcm** | **aes192-ctr** | **aes256-cbc** | **aes256-ctr** | **aes256-gcm** | **des-cbc** } | **prefer-stoc-hmac** { **md5** | **md5-96** | **sha1**

| **sha1-96** | **sha2-256** | **sha2-512** }] * [**dscp** *dscp-value* | **escape** *character* | { **public-key** *keyname* | **server-pki-domain** *domain-name* } | **source** { **interface** *interface-type interface-number* | **ip** *ip-address* }] *

In FIPS mode:

ssh2 *server* [*port-number*] [**identity-key** { **ecdsa-sha2-nistp256** | **ecdsa-sha2-nistp384** | **rsa** | { **x509v3-ecdsa-sha2-nistp256** | **x509v3-ecdsa-sha2-nistp384** } **pki-domain** *domain-name* } | **prefer-compress zlib** | **prefer-ctos-cipher** { **aes128-cbc** | **aes128-ctr** | **aes128-gcm** | **aes192-ctr** | **aes256-cbc** | **aes256-ctr** | **aes256-gcm** } | **prefer-ctos-hmac** { **sha1** | **sha1-96** | **sha2-256** | **sha2-512** } | **prefer-kex** { **dh-group14-sha1** | **ecdh-sha2-nistp256** | **ecdh-sha2-nistp384** } | **prefer-stoc-cipher** { **aes128-cbc** | **aes128-ctr** | **aes128-gcm** | **aes192-ctr** | **aes256-cbc** | **aes256-ctr** | **aes256-gcm** } | **prefer-stoc-hmac** { **sha1** | **sha1-96** | **sha2-256** | **sha2-512** }] * [**escape** *character* | { **public-key** *keyname* | **server-pki-domain** *domain-name* } | **source** { **interface** *interface-type interface-number* | **ip** *ip-address* }] *

Establishing a connection to an IPv6 Stelnet server

Execute the following command in user view to establish a connection to an IPv6 Stelnet server:

In non-FIPS mode:

ssh2 ipv6 *server* [*port-number*] [**-i** *interface-type interface-number*] [**identity-key** { **dsa** | **ecdsa-sha2-nistp256** | **ecdsa-sha2-nistp384** | **rsa** | { **x509v3-ecdsa-sha2-nistp256** | **x509v3-ecdsa-sha2-nistp384** } **pki-domain** *domain-name* } | **prefer-compress zlib** | **prefer-ctos-cipher** { **3des-cbc** | **aes128-cbc** | **aes128-ctr** | **aes128-gcm** | **aes192-ctr** | **aes256-cbc** | **aes256-ctr** | **aes256-gcm** | **des-cbc** } | **prefer-ctos-hmac** { **md5** | **md5-96** | **sha1** | **sha1-96** | **sha2-256** | **sha2-512** } | **prefer-kex** { **dh-group-exchange-sha1** | **dh-group1-sha1** | **dh-group14-sha1** | **ecdh-sha2-nistp256** | **ecdh-sha2-nistp384** } | **prefer-stoc-cipher** { **3des-cbc** | **aes128-cbc** | **aes128-ctr** | **aes128-gcm** | **aes192-ctr** | **aes256-cbc** | **aes256-ctr** | **aes256-gcm** | **des-cbc** } | **prefer-stoc-hmac** { **md5** | **md5-96** | **sha1** | **sha1-96** | **sha2-256** | **sha2-512** }] * [**dscp** *dscp-value* | **escape** *character* | { **public-key** *keyname* | **server-pki-domain** *domain-name* } | **source** { **interface** *interface-type interface-number* | **ipv6** *ipv6-address* }] *

In FIPS mode:

ssh2 ipv6 *server* [*port-number*] [**-i** *interface-type interface-number*] [**identity-key** { **ecdsa-sha2-nistp256** | **ecdsa-sha2-nistp384** | **rsa** | { **x509v3-ecdsa-sha2-nistp256** | **x509v3-ecdsa-sha2-nistp384** } **pki-domain** *domain-name* } | **prefer-compress zlib** | **prefer-ctos-cipher** { **aes128-cbc** | **aes128-ctr** | **aes128-gcm** | **aes192-ctr** | **aes256-cbc** | **aes256-ctr** | **aes256-gcm** } | **prefer-ctos-hmac** { **sha1** | **sha1-96** | **sha2-256** | **sha2-512** } | **prefer-kex** { **dh-group14-sha1** | **ecdh-sha2-nistp256** | **ecdh-sha2-nistp384** } | **prefer-stoc-cipher** { **aes128-cbc** | **aes128-ctr** | **aes128-gcm** | **aes192-ctr** | **aes256-cbc** | **aes256-ctr** | **aes256-gcm** } | **prefer-stoc-hmac** { **sha1** | **sha1-96** | **sha2-256** | **sha2-512** }] * [**escape** *character* | { **public-key** *keyname* | **server-pki-domain** *domain-name* } | **source** { **interface** *interface-type interface-number* | **ipv6** *ipv6-address* }] *

Deleting server public keys saved in the public key file on the Stelnet client

About deleting server public keys saved in the public key file on the Stelnet client

When the Stelnet client switches to FIPS mode but the locally saved server public key does not comply with FIPS, the client cannot connect to the server. To connect to the server, delete the server public key saved on the client and make sure a FIPS-compliant public key has been generated on the server.

Procedure

1. Enter system view.
   system-view
2. Delete server public keys saved in the public key file on the Stelnet client.
   delete ssh client server-public-key [**server-ip** *ip-address*]

Establishing a connection to an Stelnet server based on Suite B

Execute the following command in user view to establish a connection to an Stelnet server based on Suite B:

IPv4:

ssh2 *server* [*port-number*] **suite-b** [**128-bit** | **192-bit**] **pki-domain** *domain-name* [**server-pki-domain** *domain-name*] [**prefer-compress zlib**] [**dscp** *dscp-value* | **escape** *character* | **source** { **interface** *interface-type interface-number* | **ip** *ip-address* }] *

IPv6:

ssh2 ipv6 *server* [*port-number*] [**-i** *interface-type interface-number*] **suite-b** [**128-bit** | **192-bit**] **pki-domain** *domain-name* [**server-pki-domain** *domain-name*] [**prefer-compress zlib**] [**dscp** *dscp-value* | **escape** *character* | **source** { **interface** *interface-type interface-number* | **ipv6** *ipv6-address* }] *

Configuring the device as an SFTP client

SFTP client tasks at a glance

To configure an SFTP client, perform the following tasks:

1. Generating local key pairs
   Only required for authentication method **publickey**, **password-publickey**, or **any**.
2. (Optional.) Specifying the source IP address for outgoing SFTP packets
3. Establishing a connection to an SFTP server
4. (Optional.) Deleting server public keys saved in the public key file on the SFTP client
5. (Optional.) Establishing a connection to an SFTP server based on Suite B
6. (Optional.) Working with SFTP directories
7. (Optional.) Working with SFTP files
8. (Optional.) Displaying help information
9. (Optional.) Terminating the connection with the SFTP server

Generating local key pairs

About generating local key pairs

You must generate local key pairs on SFTP clients when the SFTP server uses the **publickey**, **password-publickey**, or **any** authentication method.

Restrictions and guidelines

Local DSA, ECDSA, and RSA key pairs for SSH use default names. You cannot assign names to the key pairs.

The key modulus length must be less than 2048 bits when you generate a DSA key pair.

When you generate an ECDSA key pair, you can generate only a **secp256r1** or **secp384r1** ECDSA key pair.

The SFTP client operating in FIPS mode supports only ECDSA and RSA key pairs.

Procedure

1. Enter system view.
   system-view
2. Generate local key pairs.
   public-key local create { **dsa** | **ecdsa** { **secp256r1** | **secp384r1** } | **rsa** }

Specifying the source IP address for outgoing SFTP packets

About specifying the source IP address for outgoing SFTP packets

After you specify the source IP address for outgoing SFTP packets on an SFTP client, the client uses the specified IP address to communicate with the SFTP server.

Restrictions and guidelines

As a best practice, specify the IP address of a loopback interface as the source address of outgoing SFTP packets for the following purposes:

- Ensuring the communication between the SFTP client and the SFTP server.
- Improving the manageability of SFTP clients in authentication service.

Procedure

1. Enter system view.
   system-view
2. Specify the source address for outgoing SFTP packets.

   IPv4:

   sftp client source { **ip** *ip-address* | **interface** *interface-type interface-number* }

   By default, an SFTP client uses the primary IPv4 address of the output interface in the matching route as the source address of the outgoing SFTP packets.

   IPv6:

   sftp client ipv6 source { **ipv6** *ipv6-address* | **interface** *interface-type interface-number* }

   By default, an IPv6 SFTP client automatically selects a source IPv6 address for the outgoing SFTP packets in compliance with RFC 3484.

Establishing a connection to an SFTP server

About establishing a connection to an SFTP server

Perform this task to enable the SFTP client feature on the device and establish a connection to the SFTP server. You can specify the public key algorithm and the preferred encryption, HMAC, and key exchange algorithms to be used during the connection.

To access the server, a client must use the server's host public key to authenticate the server. As a best practice, configure the server's host public key on the device in an insecure network. If the server's host public key is not configured on the client, the client will notify you to confirm whether to continue with the access.

- If you choose to continue, the client accesses the server and downloads the server's host public key. The downloaded public key will be used to authenticate the server in subsequent accesses.

  If the server public key is not specified when you connect to the server, the device saves the server public key to the public key file. It does not save the server public key to the configuration file.
- If you choose to not continue, the connection cannot be established.

Restrictions and guidelines for establishing a connection to an SFTP server

An SFTP client cannot establish connections to both IPv4 and IPv6 SFTP servers.

Establishing a connection to an IPv4 SFTP server

Execute the following command in user view to establish a connection to an IPv4 SFTP server:

In non-FIPS mode:

sftp *server* [*port-number*] [**identity-key** { **dsa** | **ecdsa-sha2-nistp256** | **ecdsa-sha2-nistp384** | **rsa** | { **x509v3-ecdsa-sha2-nistp256** | **x509v3-ecdsa-sha2-nistp384** } **pki-domain** *domain-name* } | **prefer-compress zlib** | **prefer-ctos-cipher** { **3des-cbc** | **aes128-cbc** | **aes128-ctr** | **aes128-gcm** | **aes192-ctr** | **aes256-cbc** | **aes256-ctr** | **aes256-gcm** | **des-cbc** } | **prefer-ctos-hmac** { **md5** | **md5-96** | **sha1** | **sha1-96** | **sha2-256** | **sha2-512** } | **prefer-kex** { **dh-group-exchange-sha1** | **dh-group1-sha1** | **dh-group14-sha1** | **ecdh-sha2-nistp256** | **ecdh-sha2-nistp384** } | **prefer-stoc-cipher** { **3des-cbc** | **aes128-cbc** | **aes128-ctr** | **aes128-gcm** | **aes192-ctr** | **aes256-cbc** | **aes256-ctr** | **aes256-gcm** | **des-cbc** } | **prefer-stoc-hmac** { **md5** | **md5-96** | **sha1** | **sha1-96** | **sha2-256** | **sha2-512** }] * [**dscp** *dscp-value* | { **public-key** *keyname* | **server-pki-domain** *domain-name* } | **source** { **interface** *interface-type interface-number* | **ip** *ip-address* }] *

In FIPS mode:

sftp *server* [*port-number*] [**identity-key** { **ecdsa-sha2-nistp256** | **ecdsa-sha2-nistp384** | **rsa** | { **x509v3-ecdsa-sha2-nistp256** | **x509v3-ecdsa-sha2-nistp384** } **pki-domain** *domain-name* } | **prefer-compress zlib** | **prefer-ctos-cipher** { **aes128-cbc** | **aes128-ctr** | **aes128-gcm** | **aes192-ctr** | **aes256-cbc** | **aes256-ctr** | **aes256-gcm** } | **prefer-ctos-hmac** { **sha1** | **sha1-96** | **sha2-256** | **sha2-512** } | **prefer-kex** { **dh-group14-sha1** | **ecdh-sha2-nistp256** | **ecdh-sha2-nistp384** } | **prefer-stoc-cipher** { **aes128-cbc** | **aes128-ctr** | **aes128-gcm** | **aes192-ctr** | **aes256-cbc** | **aes256-ctr** | **aes256-gcm** } | **prefer-stoc-hmac** { **sha1** | **sha1-96** | **sha2-256** | **sha2-512** }] * [{ **public-key** *keyname* | **server-pki-domain** *domain-name* } | **source** { **interface** *interface-type interface-number* | **ip** *ip-address* }] *

Establishing a connection to an IPv6 SFTP server

Execute the following command in user view to establish a connection to an IPv6 SFTP server:

In non-FIPS mode:

sftp ipv6 *server* [*port-number*] [**-i** *interface-type interface-number*] [**identity-key** { **dsa** | **ecdsa-sha2-nistp256** | **ecdsa-sha2-nistp384** | **rsa** | { **x509v3-ecdsa-sha2-nistp256** | **x509v3-ecdsa-sha2-nistp384** } **pki-domain** *domain-name* } | **prefer-compress zlib** | **prefer-ctos-cipher** { **3des-cbc** | **aes128-cbc** | **aes128-ctr** | **aes128-gcm** | **aes192-ctr** | **aes256-cbc** | **aes256-ctr** | **aes256-gcm** | **des-cbc** } | **prefer-ctos-hmac** { **md5** | **md5-96** | **sha1** | **sha1-96** | **sha2-256** | **sha2-512** } | **prefer-kex** { **dh-group-exchange-sha1** | **dh-group1-sha1** | **dh-group14-sha1** | **ecdh-sha2-nistp256** | **ecdh-sha2-nistp384** } | **prefer-stoc-cipher** { **3des-cbc** | **aes128-cbc** | **aes128-ctr** | **aes128-gcm** | **aes192-ctr** | **aes256-cbc** | **aes256-ctr** | **aes256-gcm** | **des-cbc** } | **prefer-stoc-hmac** { **md5** | **md5-96** | **sha1** | **sha1-96** | **sha2-256** | **sha2-512** }] * [**dscp** *dscp-value* | { **public-key** *keyname* | **server-pki-domain** *domain-name* } | **source** { **interface** *interface-type interface-number* | **ipv6** *ipv6-address* }] *

In FIPS mode:

sftp ipv6 *server* [*port-number*] [**-i** *interface-type interface-number*] [**identity-key** { **ecdsa-sha2-nistp256** | **ecdsa-sha2-nistp384** | **rsa** | { **x509v3-ecdsa-sha2-nistp256** | **x509v3-ecdsa-sha2-nistp384** } **pki-domain** *domain-name* } | **prefer-compress zlib** | **prefer-ctos-cipher** { **aes128-cbc** | **aes128-ctr** | **aes128-gcm** | **aes192-ctr** | **aes256-cbc** | **aes256-ctr** | **aes256-gcm** } | **prefer-ctos-hmac** { **sha1** | **sha1-96** | **sha2-256** | **sha2-512** } | **prefer-kex** { **dh-group14-sha1** | **ecdh-sha2-nistp256** | **ecdh-sha2-nistp384** } | **prefer-stoc-cipher** { **aes128-cbc** | **aes128-ctr** | **aes128-gcm** | **aes192-ctr** | **aes256-cbc** | **aes256-ctr** | **aes256-gcm** } | **prefer-stoc-hmac** { **sha1** | **sha1-96** | **sha2-256** | **sha2-512** }] * [{ **public-key** *keyname* | **server-pki-domain** *domain-name* } | **source** { **interface** *interface-type interface-number* | **ipv6** *ipv6-address* }] *

Deleting server public keys saved in the public key file on the SFTP client

About deleting server public keys saved in the public key file on the SFTP client

When the SFTP client switches to FIPS mode but the locally saved server public key does not comply with FIPS, the client cannot connect to the server. To connect to the server, delete the server public key saved on the client and make sure a FIPS-compliant public key has been generated on the server.

Procedure

1. Enter system view.

   system-view

2. Delete server public keys saved in the public key file on the SFTP client.

   delete ssh client server-public-key [**server-ip** *ip-address*]

Establishing a connection to an SFTP server based on Suite B

Execute the following command in user view to establish a connection to an SFTP server based on Suite B:

IPv4:

sftp *server* [*port-number*] **suite-b** [**128-bit** | **192-bit**] **pki-domain** *domain-name* [**server-pki-domain** *domain-name*] [**prefer-compress zlib**] [**dscp** *dscp-value* | **source** { **interface** *interface-type interface-number* | **ip** *ip-address* }] *

IPv6:

sftp ipv6 *server* [*port-number*] [**-i** *interface-type interface-number*] **suite-b** [**128-bit** | **192-bit**] **pki-domain** *domain-name* [**server-pki-domain** *domain-name*] [**prefer-compress zlib**] [**dscp** *dscp-value* | **escape** *character* | **source** { **interface** *interface-type interface-number* | **ipv6** *ipv6-address* }] *

Working with SFTP directories

About SFTP directory operations

After you establish a connection to an SFTP server, you can operate directories of the SFTP server.

Changing the working directory on the SFTP server

1. Enter SFTP client view.

   For more information, see "Establishing a connection to an SFTP server."
2. Change the working directory on the SFTP server.

   cd [*remote-path*]
3. (Optional.) Return to the upper-level directory.

   cdup

Displaying the current working directory on the SFTP server

1. Enter SFTP client view.

   For more information, see "Establishing a connection to an SFTP server."
2. Display the current working directory on the SFTP server.

   pwd

Displaying files under a directory

1. Enter SFTP client view.

   For more information, see "Establishing a connection to an SFTP server."
2. Display files under a directory.
   - **dir** [**-a** | **-l**] [*remote-path*]
   - **ls** [**-a** | **-l**] [*remote-path*]

   The **dir** command has the same function as the **ls** command.

Changing the name of a directory on the SFTP server

1. Enter SFTP client view.

   For more information, see "Establishing a connection to an SFTP server."
2. Change the name of a directory on the SFTP server.

   rename *oldname newname*

Creating a new directory on the SFTP server

1. Enter SFTP client view.

   For more information, see "Establishing a connection to an SFTP server."
2. Create a new directory on the SFTP server.

   mkdir *remote-path*

Deleting directories on the SFTP server

1. Enter SFTP client view.
   For more information, see "Establishing a connection to an SFTP server."
2. Delete one or more directories from the SFTP server.
   rmdir *remote-path*

Working with SFTP files

About SFTP file operations

After you establish a connection to an SFTP server, you can operate files on the SFTP server.

Changing the name of a file on the SFTP server

1. Enter SFTP client view.
   For more information, see "Establishing a connection to an SFTP server."
2. Change the name of a file on the SFTP server.
   rename *old-name new-name*

Downloading a file from the SFTP server and save it locally

1. Enter SFTP client view.
   For more information, see "Establishing a connection to an SFTP server."
2. Download a file from the SFTP server and save it locally.
   get *remote-file* [*local-file*]

Uploading a local file to the SFTP server

1. Enter SFTP client view.
   For more information, see "Establishing a connection to an SFTP server."
2. Upload a local file to the SFTP server.
   put *local-file* [*remote-file*]

Display files under a directory

1. Enter SFTP client view.
   For more information, see "Establishing a connection to an SFTP server."
2. Display files under a directory.
   - **dir** [**-a** | **-l**] [*remote-path*]
   - **ls** [**-a** | **-l**] [*remote-path*]

   The **dir** command has the same function as the **ls** command.

Deleting a file from the SFTP server

1. Enter SFTP client view.
   For more information, see "Establishing a connection to an SFTP server."
2. Delete a file from the SFTP server.
   - **delete** *remote-file*
   - **remove** *remote-file*

   The **delete** command has the same function as the **remove** command.

Displaying help information

About displaying help information

After you establish a connection to the SFTP server, you can display the help information of SFTP client commands, including the command syntax and parameter configuration.

Procedure

1. Enter SFTP client view.

   For more information, see "Establishing a connection to an SFTP server."
2. Display SFTP client command help information.
   - **`help`**
   - **`?`**

   The **`help`** command has the same function as the **`?`** command.

Terminating the connection with the SFTP server

1. Enter SFTP client view.

   For more information, see "Establishing a connection to an SFTP server."
2. Terminate the connection with the SFTP server and return to user view.
   - **`bye`**
   - **`exit`**
   - **`quit`**

   The three commands have the same function.

Configuring the device as an SCP client

SCP client tasks at a glance

To configure an SCP client, perform the following tasks:

1. Generating local key pairs

   Only required for the **publickey**, **password-publickey**, or **any** authentication method.
2. (Optional.) Specifying the source IP address for outgoing SCP packets
3. Establishing a connection to an SCP server
4. (Optional.) Deleting server public keys saved in the public key file on the SCP client
5. (Optional.) Establishing a connection to an SCP server based on Suite B

Generating local key pairs

About generating local key pairs

You must generate local key pairs on SCP clients when the SCP server uses the **publickey**, **password-publickey**, or **any** authentication method.

Restrictions and guidelines

Local DSA, ECDSA, and RSA key pairs for SSH use default names. You cannot assign names to the key pairs.

The key modulus length must be less than 2048 bits when you generate a DSA key pair.

When you generate an ECDSA key pair, you can generate only a **secp256r1** or **secp384r1** ECDSA key pair.

The SCP client operating in FIPS mode supports only ECDSA and RSA key pairs.

Procedure

1. Enter system view.

   system-view

2. Generate local key pairs.

   public-key local create { **dsa** | **ecdsa** { **secp256r1** | **secp384r1** } | **rsa** }

Specifying the source IP address for outgoing SCP packets

About specifying the source IP address for outgoing SCP packets

After you specify the source IP address for outgoing SCP packets on an SCP client, the client uses the specified IP address to communicate with the SCP server.

Restrictions and guidelines

As a best practice, specify the IP address of a loopback interface as the source address of outgoing SCP packets for the following purposes:

- Ensuring the communication between the SCP client and the SCP server.
- Improving the manageability of SCP clients in authentication service.

Procedure

1. Enter system view.

   system-view

2. Specify the source address for outgoing SCP packets.

   IPv4:

   scp client source { **interface** *interface-type interface-number* | **ip** *ip-address* }

   By default, an SCP client uses the primary IPv4 address of the output interface in the matching route as the source address of the outgoing SCP packets.

   IPv6:

   scp client ipv6 source { **interface** *interface-type interface-number* | **ipv6** *ipv6-address* }

   By default, an SCP client automatically selects an IPv6 address as the source address of the outgoing packets in compliance with RFC 3484.

Establishing a connection to an SCP server

About establishing a connection to an SCP server

Perform this task to enable the SCP client feature on the device, establish a connection to the SCP server, and transfer files with the server. You can specify the public key algorithm and the preferred encryption, HMAC, and key exchange algorithms to be used during the connection.

To access the server, a client must use the server's host public key to authenticate the server. As a best practice, configure the server's host public key on the device in an insecure network. If the server's host public key is not configured on the client, the client will notify you to confirm whether to continue with the access.

- If you choose to continue, the client accesses the server and downloads the server's host public key. The downloaded public key will be used to authenticate the server in subsequent accesses.

  If the server public key is not specified when you connect to the server, the device saves the server public key to the public key file. It does not save the server public key to the configuration file.
- If you choose to not continue, the connection cannot be established.

Restrictions and guidelines for establishing a connection to an SCP server

An SCP client cannot establish connections to both IPv4 and IPv6 SCP servers.

Establishing a connection to an IPv4 SCP server

Execute the following command in user view to connect to an IPv4 SCP server, and transfer files with the server:

In non-FIPS mode:

scp *server* [*port-number*] { **put** | **get** } *source-file-name* [*destination-file-name*] [**identity-key** { **dsa** | **ecdsa-sha2-nistp256** | **ecdsa-sha2-nistp384** | **rsa** | { **x509v3-ecdsa-sha2-nistp256** | **x509v3-ecdsa-sha2-nistp384** } **pki-domain** *domain-name* } | **prefer-compress zlib** | **prefer-ctos-cipher** { **3des-cbc** | **aes128-cbc** | **aes128-ctr** | **aes128-gcm** | **aes192-ctr** | **aes256-cbc** | **aes256-ctr** | **aes256-gcm** | **des-cbc** } | **prefer-ctos-hmac** { **md5** | **md5-96** | **sha1** | **sha1-96** | **sha2-256** | **sha2-512** } | **prefer-kex** { **dh-group-exchange-sha1** | **dh-group1-sha1** | **dh-group14-sha1** | **ecdh-sha2-nistp256** | **ecdh-sha2-nistp384** } | **prefer-stoc-cipher** { **3des-cbc** | **aes128-cbc** | **aes128-ctr** | **aes128-gcm** | **aes192-ctr** | **aes256-cbc** | **aes256-ctr** | **aes256-gcm** | **des-cbc** } | **prefer-stoc-hmac** { **md5** | **md5-96** | **sha1** | **sha1-96** | **sha2-256** | **sha2-512** }] * [{ **public-key** *keyname* | **server-pki-domain** *domain-name* } | **source** { **interface** *interface-type interface-number* | **ip** *ip-address* }] * [**user** *username* [**password** *password*]]

In FIPS mode:

scp *server* [*port-number*] { **put** | **get** } *source-file-name* [*destination-file-name*] [**identity-key** { **ecdsa-sha2-nistp256** | **ecdsa-sha2-nistp384** | **rsa** | { **x509v3-ecdsa-sha2-nistp256** | **x509v3-ecdsa-sha2-nistp384** } **pki-domain** *domain-name* } | **prefer-compress zlib** | **prefer-ctos-cipher** { **aes128-cbc** | **aes128-ctr** | **aes128-gcm** | **aes192-ctr** | **aes256-cbc** | **aes256-ctr** | **aes256-gcm** } | **prefer-ctos-hmac** { **sha1** | **sha1-96** | **sha2-256** | **sha2-512** } | **prefer-kex** { **dh-group14-sha1** | **ecdh-sha2-nistp256** | **ecdh-sha2-nistp384** } | **prefer-stoc-cipher** { **aes128-cbc** | **aes128-ctr** | **aes128-gcm** | **aes192-ctr** | **aes256-cbc** | **aes256-ctr** | **aes256-gcm** } | **prefer-stoc-hmac** { **sha1** | **sha1-96** | **sha2-256** | **sha2-512** }] * [{ **public-key** *keyname* | **server-pki-domain** *domain-name* } | **source** { **interface** *interface-type interface-number* | **ip** *ip-address* }] * [**user** *username* [**password** *password*]]

Establishing a connection to an IPv6 SCP server

Execute the following command in user view to connect to an IPv6 SCP server, and transfer files with the server.

In non-FIPS mode:

scp ipv6 *server* [*port-number*] [**-i** *interface-type interface-number*] { **put** | **get** } *source-file-name* [*destination-file-name*] [**identity-key** { **dsa** | **ecdsa-sha2-nistp256** | **ecdsa-sha2-nistp384** | **rsa** | { **x509v3-ecdsa-sha2-nistp256** | **x509v3-ecdsa-sha2-nistp384** } **pki-domain** *domain-name* } | **prefer-compress zlib** | **prefer-ctos-cipher** { **3des-cbc** |

aes128-cbc | **aes128-ctr** | **aes128-gcm** | **aes192-ctr** | **aes256-cbc** | **aes256-ctr** | **aes256-gcm** | **des-cbc** } | **prefer-ctos-hmac** { **md5** | **md5-96** | **sha1** | **sha1-96** | **sha2-256** | **sha2-512** } | **prefer-kex** { **dh-group-exchange-sha1** | **dh-group1-sha1** | **dh-group14-sha1** | **ecdh-sha2-nistp256** | **ecdh-sha2-nistp384** } | **prefer-stoc-cipher** { **3des-cbc** | **aes128-cbc** | **aes128-ctr** | **aes128-gcm** | **aes192-ctr** | **aes256-cbc** | **aes256-ctr** | **aes256-gcm** | **des-cbc** } | **prefer-stoc-hmac** { **md5** | **md5-96** | **sha1** | **sha1-96** | **sha2-256** | **sha2-512** }] * [{ **public-key** *keyname* | **server-pki-domain** *domain-name* } | **source** { **interface** *interface-type interface-number* | **ipv6** *ipv6-address* }] * [**user** *username* [**password** *password*]]

In FIPS mode:

scp ipv6 *server* [*port-number*] [**-i** *interface-type interface-number*] { **put** | **get** } *source-file-name* [*destination-file-name*] [**identity-key** { **ecdsa-sha2-nistp256** | **ecdsa-sha2-nistp384** | **rsa** | { **x509v3-ecdsa-sha2-nistp256** | **x509v3-ecdsa-sha2-nistp384** } **pki-domain** *domain-name* } | **prefer-compress zlib** | **prefer-ctos-cipher** { **aes128-cbc** | **aes128-ctr** | **aes128-gcm** | **aes192-ctr** | **aes256-cbc** | **aes256-ctr** | **aes256-gcm** } | **prefer-ctos-hmac** { **sha1** | **sha1-96** | **sha2-256** | **sha2-512** } | **prefer-kex** { **dh-group14-sha1** | **ecdh-sha2-nistp256** | **ecdh-sha2-nistp384** } | **prefer-stoc-cipher** { **aes128-cbc** | **aes128-ctr** | **aes128-gcm** | **aes192-ctr** | **aes256-cbc** | **aes256-ctr** | **aes256-gcm** } | **prefer-stoc-hmac** { **sha1** | **sha1-96** | **sha2-256** | **sha2-512** }] * [{ **public-key** *keyname* | **server-pki-domain** *domain-name* } | **source** { **interface** *interface-type interface-number* | **ipv6** *ipv6-address* }] * [**user** *username* [**password** *password*]]

Deleting server public keys saved in the public key file on the SCP client

About deleting server public keys saved in the public key file on the SCP client

When the SCP client switches to FIPS mode but the locally saved server public key does not comply with FIPS, the client cannot connect to the server. To connect to the server, delete the server public key saved on the client and make sure a FIPS-compliant public key has been generated on the server.

Procedure

1. Enter system view.

   system-view

2. Delete server public keys saved in the public key file on the SCP client.

   delete ssh client server-public-key [**server-ip** *ip-address*]

Establishing a connection to an SCP server based on Suite B

Execute the following command in user view to establish a connection to an SCP server based on Suite B:

IPv4:

scp *server* [*port-number*] { **put** | **get** } *source-file-name* [*destination-file-name*] **suite-b** [**128-bit** | **192-bit**] **pki-domain** *domain-name* [**server-pki-domain** *domain-name*] [**prefer-compress zlib**] [**source** { **interface** *interface-type interface-number* | **ip** *ip-address* }] * [**user** *username* [**password** *password*]]

IPv6:

scp ipv6 *server* [*port-number*] [**-i** *interface-type interface-number*] { **put** | **get** } *source-file-name* [*destination-file-name*] **suite-b** [**128-bit** | **192-bit**] **pki-domain** *domain-name* [**server-pki-domain** *domain-name*] [**prefer-compress zlib**] [**source** { **interface** *interface-type interface-number* | **ipv6** *ipv6-address* }] * [**user** *username* [**password** *password*]]

Specifying algorithms for SSH2

About algorithms for SSH2

The SSH2 client and server use the following types of algorithms for algorithm negotiation during the Stelnet, SFTP, or SCP session establishment:

- Key exchange algorithms.
- Public key algorithms.
- Encryption algorithms.
- MAC algorithms.

If you specify algorithms, SSH2 uses only the specified algorithms for algorithm negotiation. The client uses the specified algorithms to initiate the negotiation, and the server uses the matching algorithms to negotiate with the client. If multiple algorithms of the same type are specified, the algorithm specified earlier has a higher priority during negotiation.

Specifying key exchange algorithms for SSH2

1. Enter system view.

   system-view

2. Specify key exchange algorithms for SSH2.

   In non-FIPS mode:

   ssh2 algorithm key-exchange { **dh-group-exchange-sha1** | **dh-group1-sha1** | **dh-group14-sha1** | **ecdh-sha2-nistp256** | **ecdh-sha2-nistp384** } *

   By default, SSH2 uses the **ecdh-sha2-nistp256**, **ecdh-sha2-nistp384**, **dh-group-exchange-sha1**, **dh-group14-sha1**, and **dh-group1-sha1** key exchange algorithms in descending order of priority for algorithm negotiation.

   In FIPS mode:

   ssh2 algorithm key-exchange { **dh-group14-sha1** | **ecdh-sha2-nistp256** | **ecdh-sha2-nistp384** } *

   By default, SSH2 uses the **ecdh-sha2-nistp256**, **ecdh-sha2-nistp384**, and **dh-group14-sha1** key exchange algorithms in descending order of priority for algorithm negotiation.

Specifying public key algorithms for SSH2

1. Enter system view.

   system-view

2. Specify public key algorithms for SSH2.

   In non-FIPS mode:

ssh2 algorithm public-key { **dsa** | **ecdsa-sha2-nistp256** | **ecdsa-sha2-nistp384** | **rsa** | **x509v3-ecdsa-sha2-nistp256** | **x509v3-ecdsa-sha2-nistp384** } *

By default, SSH2 uses the **x509v3-ecdsa-sha2-nistp256**, **x509v3-ecdsa-sha2-nistp384**, **ecdsa-sha2-nistp256**, **ecdsa-sha2-nistp384**, **rsa**, and **dsa** public key algorithms in descending order of priority for algorithm negotiation.

In FIPS mode:

ssh2 algorithm public-key { **ecdsa-sha2-nistp256** | **ecdsa-sha2-nistp384** | **rsa** | **x509v3-ecdsa-sha2-nistp256** | **x509v3-ecdsa-sha2-nistp384** } *

By default, SSH2 uses the **x509v3-ecdsa-sha2-nistp256**, **x509v3-ecdsa-sha2-nistp384**, **ecdsa-sha2-nistp256**, **ecdsa-sha2-nistp384**, and **rsa** public key algorithms in descending order of priority for algorithm negotiation.

Specifying encryption algorithms for SSH2

1. Enter system view.

   system-view

2. Specify encryption algorithms for SSH2.

   In non-FIPS mode:

   ssh2 algorithm cipher { **3des-cbc** | **aes128-cbc** | **aes128-ctr** | **aes128-gcm** | **aes192-ctr** | **aes256-cbc** | **aes256-ctr** | **aes256-gcm** | **des-cbc** } *

   By default, SSH2 uses the **aes128-ctr**, **aes192-ctr**, **aes256-ctr**, **aes128-gcm**, **aes256-gcm**, **aes128-cbc**, **3des-cbc**, **aes256-cbc**, and **des-cbc** encryption algorithms in descending order of priority for algorithm negotiation.

   In FIPS mode:

   ssh2 algorithm cipher { **aes128-cbc** | **aes128-ctr** | **aes128-gcm** | **aes192-ctr** | **aes256-cbc** | **aes256-ctr** | **aes256-gcm** } *

   By default, SSH2 uses the **aes128-ctr**, **aes192-ctr**, **aes256-ctr**, **aes128-gcm**, **aes256-gcm**, **aes128-cbc**, and **aes256-cbc** encryption algorithms in descending order of priority for algorithm negotiation.

Specifying MAC algorithms for SSH2

1. Enter system view.

   system-view

2. Specify MAC algorithms for SSH2.

   In non-FIPS mode:

   ssh2 algorithm mac { **md5** | **md5-96** | **sha1** | **sha1-96** | **sha2-256** | **sha2-512** } *

   By default, SSH2 uses the **sha2-256**, **sha2-512, sha1**, **md5**, **sha1-96**, and **md5-96** MAC algorithms in descending order of priority for algorithm negotiation.

   In FIPS mode:

   ssh2 algorithm mac { **sha1** | **sha1-96** | **sha2-256** | **sha2-512** } *

   By default, SSH2 uses the **sha2-256**, **sha2-512, sha1**, and **sha1-96** MAC algorithms in descending order of priority for algorithm negotiation.

Display and maintenance commands for SSH

Execute **display** commands in any view.

Task	Command
Display the public keys of the local key pairs.	**display public-key local** { **dsa** | **ecdsa** | **rsa** } **public** [**name** *publickey-name*]
Display information about peer public keys.	**display public-key peer** [**brief** | **name** *publickey-name*]
Display the source IP address configuration of the SCP client.	**display scp client source**
Display the source IP address configuration of the SFTP client.	**display sftp client source**
Display server public key information saved in the public key file on the SSH client.	**display ssh client server-public-key** [**server-ip** *ip-address*]
Display the source IP address configuration of the Stelnet client.	**display ssh client source**
Display SSH server status or sessions.	**display ssh server** { **session** | **status** }
Display SSH user information on the SSH server.	**display ssh user-information** [*username*]
Display algorithms used by SSH2 in the algorithm negotiation stage.	**display ssh2 algorithm**

For more information about the **display public-key local** and **display public-key peer** commands, see public key management commands in *Security Command Reference*.

Stelnet configuration examples

Unless otherwise noted, devices in the configuration examples operate in non-FIPS mode.

When the device acts as an Stelnet server operating in FIPS mode, only ECDSA and RSA key pairs are supported. Do not generate a DSA key pair on the Stelnet server.

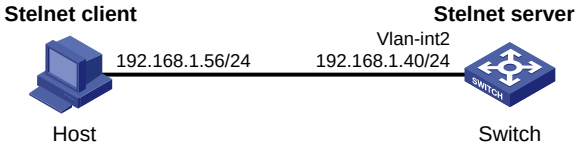
Example: Configuring the device as an Stelnet server (password authentication)

Network configuration

As shown in Figure 1:

- The switch acts as the Stelnet server and uses password authentication to authenticate the Stelnet client. The username and password of the client are saved on the switch.
- The host acts as the Stelnet client, using Stelnet client software (SSH2). After the user on the host logs in to the switch through Stelnet, the user can configure and manage the switch as a network administrator.

Figure 1 Network diagram



Procedure

1. Configure the Stelnet server:

   # Generate RSA key pairs.

```
<Switch> system-view
[Switch] public-key local create rsa
The range of public key modulus is (512 ~ 4096).
If the key modulus is greater than 512, it will take a few minutes.
Press CTRL+C to abort.
Input the modulus length [default = 1024]:
Generating Keys...
.....................++++++
.................++++++
..++++++++
............++++++++
Create the key pair successfully.
```

   # Generate a DSA key pair.

```
[Switch] public-key local create dsa
The range of public key modulus is (512 ~ 2048).
If the key modulus is greater than 512, it will take a few minutes.
Press CTRL+C to abort.
Input the modulus length [default = 1024]:
Generating Keys...
.++++++++++++++++++++++++++++++++++++++++++++++++++*
........+......+.....+.....................................+
...+................+..........+...+.
Create the key pair successfully.
```

   # Generate an ECDSA key pair.

```
[Switch] public-key local create ecdsa secp256r1
Generating Keys...
.
Create the key pair successfully.
```

   # Enable the Stelnet server.

```
[Switch] ssh server enable
```

   # Assign an IP address to VLAN-interface 2. The Stelnet client uses this address as the destination for SSH connection.

```
[Switch] interface vlan-interface 2
[Switch-Vlan-interface2] ip address 192.168.1.40 255.255.255.0
[Switch-Vlan-interface2] quit
```

   # Set the authentication mode to AAA for user lines.

```
[Switch] line vty 0 63
[Switch-line-vty0-63] authentication-mode scheme
```

```
[Switch-line-vty0-63] quit
```

Create a local device management user named **client001**.

```
[Switch] local-user client001 class manage
```

Set the password to **hello12345** in plain text for local user **client001**.

```
[Switch-luser-manage-client001] password simple hello12345
```

Authorize local user **client001** to use the **SSH** service.

```
[Switch-luser-manage-client001] service-type ssh
```

Assign the **network-admin** user role to local user **client001**.

```
[Switch-luser-manage-client001] authorization-attribute user-role network-admin
[Switch-luser-manage-client001] quit
```

Create an SSH user named **client001**. Specify the service type as **stelnet** and the authentication method as **password** for the user.

```
[Switch] ssh user client001 service-type stelnet authentication-type password
```

2. Establish a connection to the Stelnet server:

There are different types of Stelnet client software, such as PuTTY and OpenSSH. This example uses an Stelnet client that runs PuTTY version 0.58.

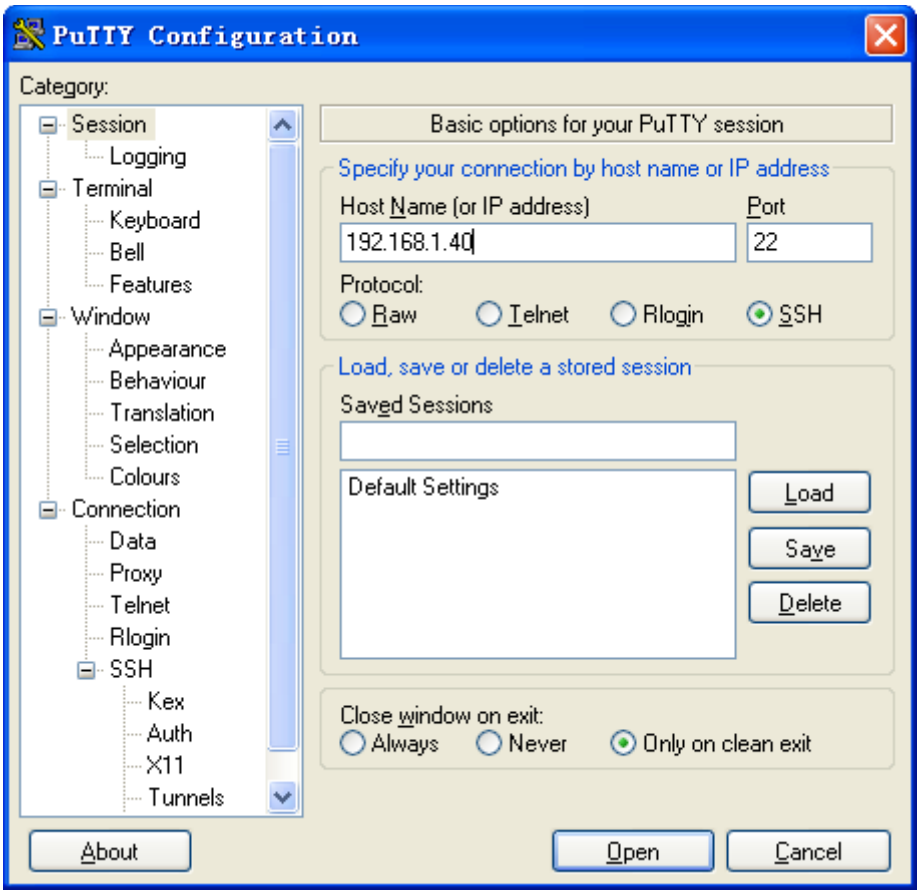
To establish a connection to the Stelnet server:

a. Launch PuTTY.exe to enter the interface shown in Figure 2.

b. In the **Host Name (or IP address)** field, enter IP address **192.168.1.40** of the Stelnet server.

c. Click **Open**.

Figure 2 Specifying the host name (or IP address)



d. Enter username **client001** and password **hello12345** to log in to the Stelnet server.

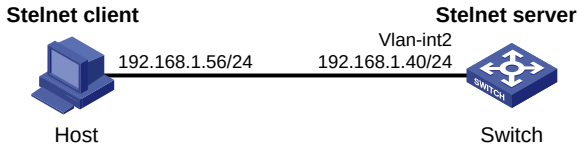
Example: Configuring the device as an Stelnet server (publickey authentication)

Network configuration

As shown in Figure 3:

- The switch acts as the Stelnet server, and it uses publickey authentication and the RSA public key algorithm.
- The host acts as the Stelnet client, using Stelnet client software (SSH2). After the user on the host logs in to the switch through Stelnet, the user can configure and manage the switch as a network administrator.

Figure 3 Network diagram



Procedure

In the server configuration, the client's host public key is required. Use the client software to generate RSA key pairs on the client before configuring the Stelnet server.

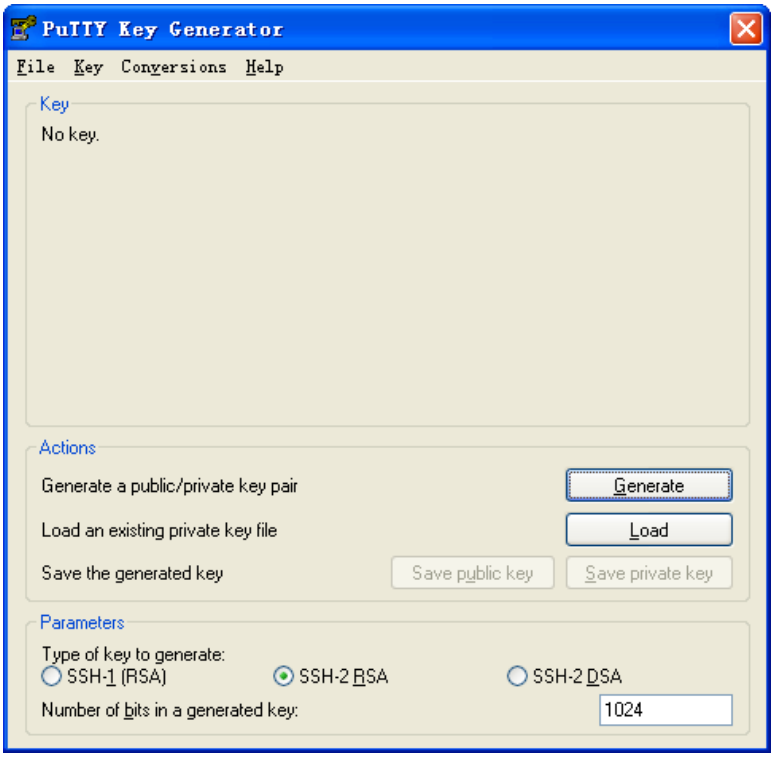
There are different types of Stelnet client software, such as PuTTY and OpenSSH. This example uses an Stelnet client that runs PuTTY version 0.58.

The configuration procedure is as follows:

1. Generate RSA key pairs on the Stelnet client:

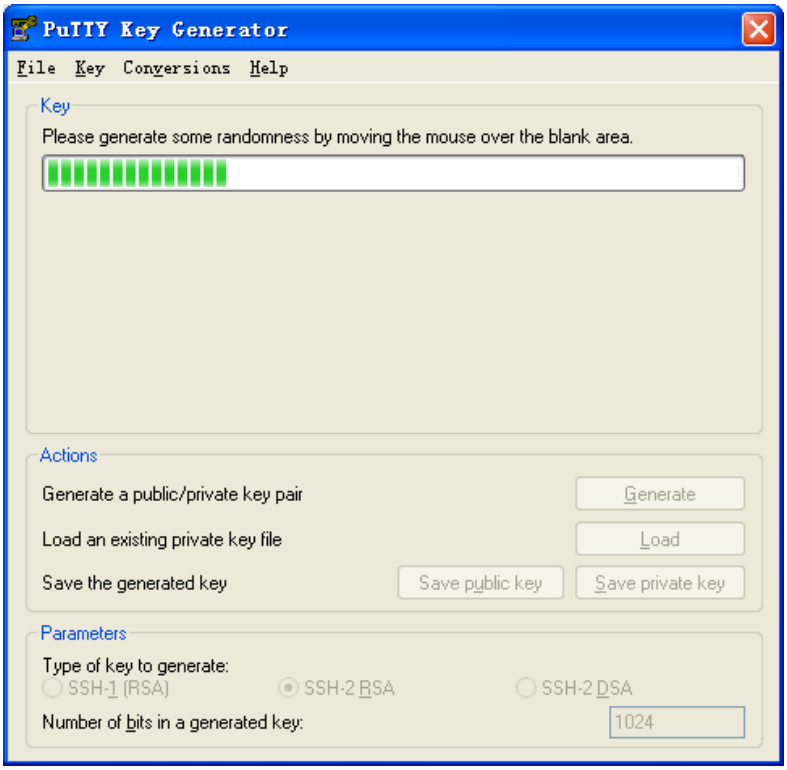
a. Run PuTTYGen.exe on the client, select **SSH-2 RSA** and click **Generate**.

Figure 4 Generating a key pair on the client



b. Continue moving the mouse during the key generating process, but do not place the mouse over the green progress bar shown in Figure 5. Otherwise, the progress bar stops moving and the key pair generating progress stops.

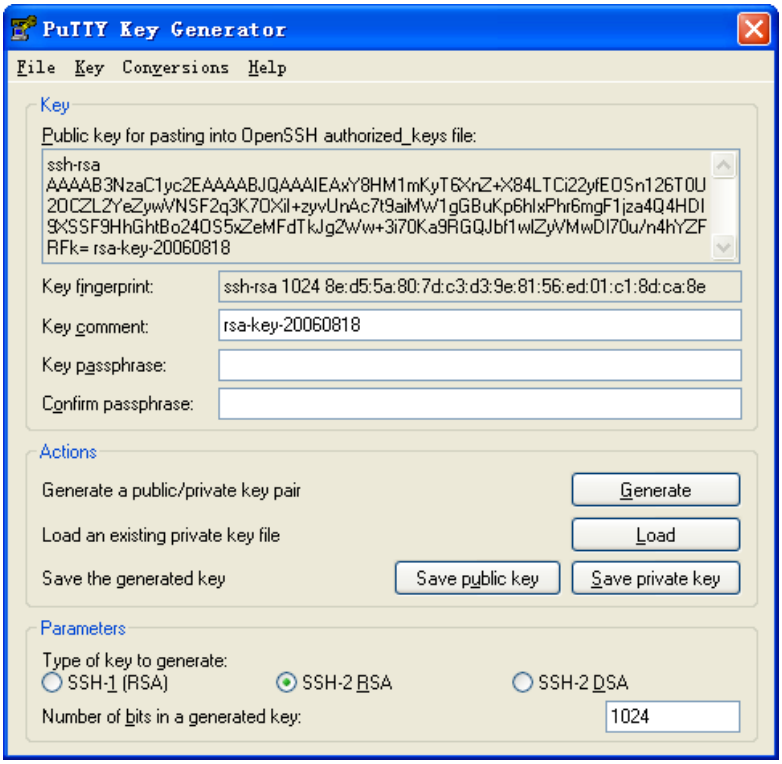
Figure 5 Generating process



c. After the key pair is generated, click **Save public key** to save the public key.

A file saving window appears.

Figure 6 Saving a key pair on the client



d. Enter a file name (**key.pub** in this example), and click **Save**.

e. On the page shown in Figure 6, click **Save private key** to save the private key.

A confirmation dialog box appears.

f. Click **Yes**.

A file saving window appears.

g. Enter a file name (**private.ppk** in this example), and click **Save**.

h. Transmit the public key file to the server through FTP or TFTP. (Details not shown.)

2. Configure the Stelnet server:

Generate RSA key pairs.

```
<Switch> system-view
[Switch] public-key local create rsa
The range of public key modulus is (512 ~ 4096).
If the key modulus is greater than 512, it will take a few minutes.
Press CTRL+C to abort.
Input the modulus length [default = 1024]:
Generating Keys...
.....................++++++
.................++++++
..++++++++
............++++++++
Create the key pair successfully.
```

Generate a DSA key pair.

```
[Switch] public-key local create dsa
```

```
The range of public key modulus is (512 ~ 2048).
If the key modulus is greater than 512, it will take a few minutes.
Press CTRL+C to abort.
Input the modulus length [default = 1024]:
Generating Keys...
.++++++++++++++++++++++++++++++++++++++++++++++++++*
........+......+.....+.....................................+
...+.................+.........+...+
Create the key pair successfully.
```

Generate an ECDSA key pair.

```
[Switch] public-key local create ecdsa secp256r1
Generating Keys...
.
Create the key pair successfully.
```

Enable the Stelnet server.

```
[Switch] ssh server enable
```

Assign an IP address to VLAN-interface 2. The Stelnet client uses this IP address as the destination for SSH connection.

```
[Switch] interface vlan-interface 2
[Switch-Vlan-interface2] ip address 192.168.1.40 255.255.255.0
[Switch-Vlan-interface2] quit
```

Set the authentication mode to AAA for user lines.

```
[Switch] line vty 0 63
[Switch-line-vty0-63] authentication-mode scheme
[Switch-line-vty0-63] quit
```

Import the client's public key from the public key file **key.pub** and name it **switchkey**.

```
[Switch] public-key peer switchkey import sshkey key.pub
```

Create an SSH user named **client002**. Specify the authentication method as **publickey** for the user, and assign the public key **switchkey** to the user.

```
[Switch] ssh user client002 service-type stelnet authentication-type publickey assign
publickey switchkey
```

Create a local device management user named **client002**.

```
[Switch] local-user client002 class manage
```

Authorize local user **client002** to use the **SSH** service.

```
[Switch-luser-manage-client002] service-type ssh
```

Assign the **network-admin** user role to local user **client002**.

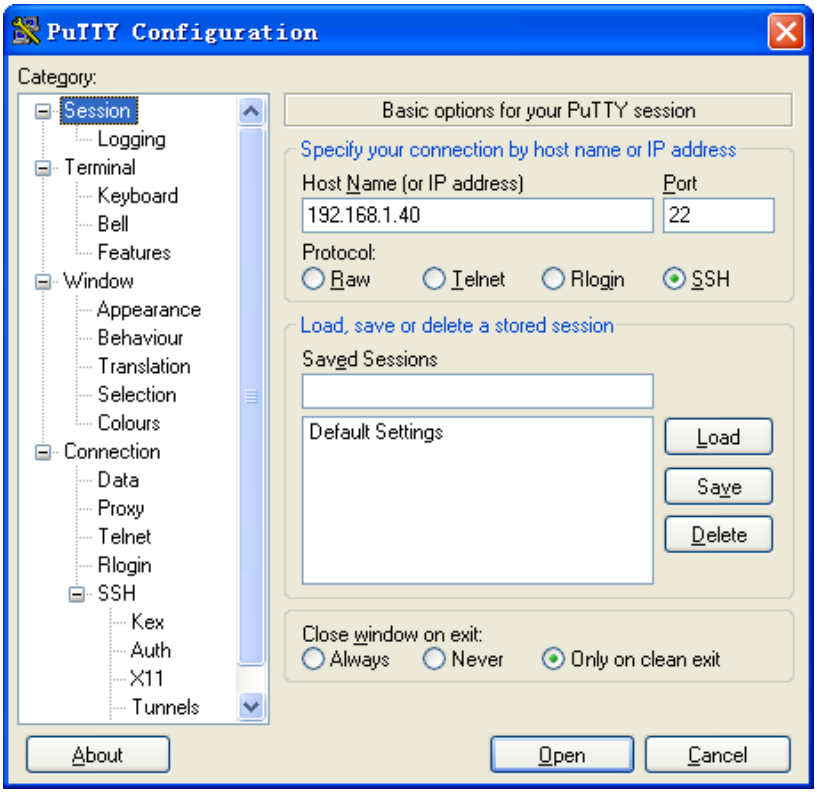
```
[Switch-luser-manage-client002] authorization-attribute user-role network-admin
[Switch-luser-manage-client002] quit
```

3. Specify the private key file and establish a connection to the Stelnet server:

a. Launch PuTTY.exe on the Stelnet client to enter the interface shown in Figure 7.

b. In the **Host Name (or IP address)** field, enter IP address **192.168.1.40** of the Stelnet server.

Figure 7 Specifying the host name (or IP address)

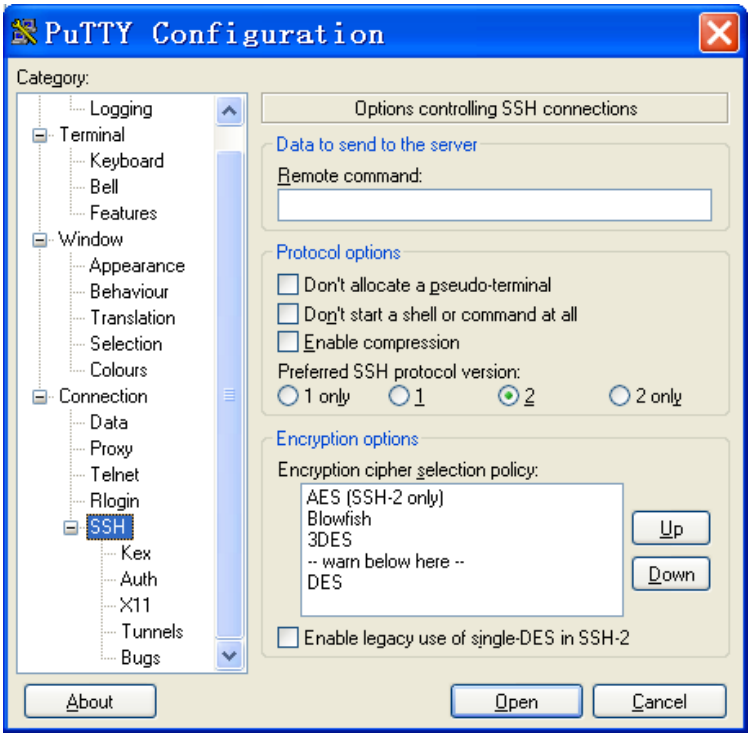


c. From the navigation tree, select **Connection** > **SSH**.

The window shown in Figure 8 appears.

d. Set **Preferred SSH protocol version** to **2**.

Figure 8 Setting the preferred SSH version



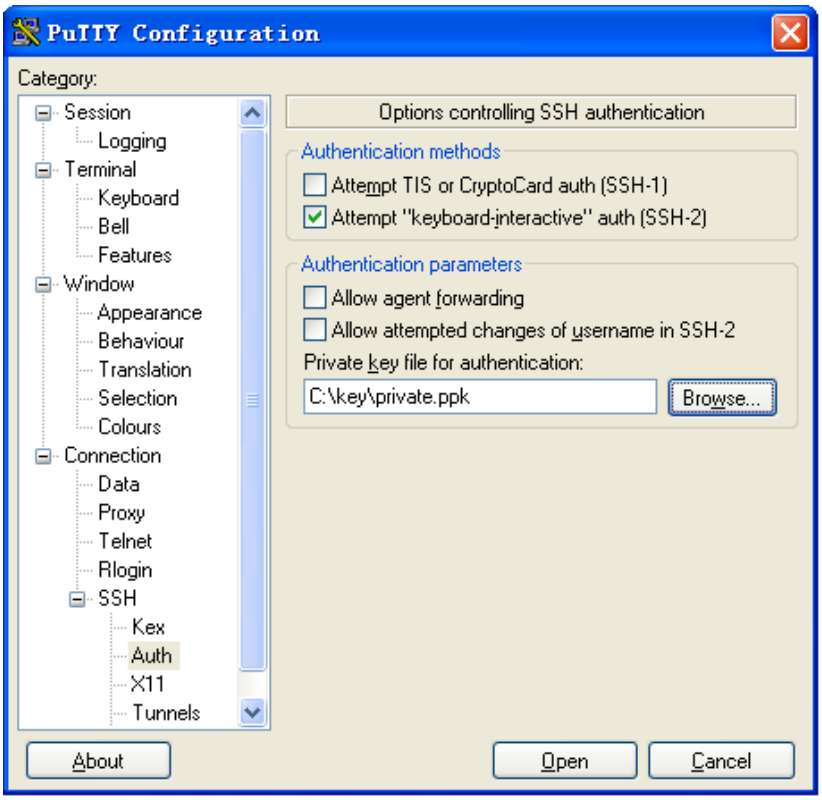
e. From the navigation tree, select **Connection** > **SSH** > **Auth**.

   The window shown in Figure 9 appears.

f. Click **Browse…** to open the file selection window, and then select the private key file (**private.ppk** in this example).

g. Click **Open**.

Figure 9 Specifying the private key file



h. Entering username **client002** to log in to the Stelnet server.

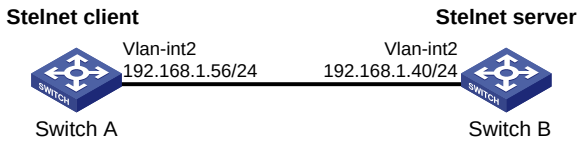
Example: Configuring the device as an Stelnet client (password authentication)

Network configuration

As shown in Figure 10:

- Switch B acts as the Stelnet server and uses password authentication to authenticate the Stelnet client. The username and password of the client are saved on Switch B.
- Switch A acts as the Stelnet client. After the user on Switch A logs in to Switch B through Stelnet, the user can configure and manage Switch B as a network administrator.

Figure 10 Network diagram



Procedure

1. Configure the Stelnet server:

Generate RSA key pairs.

```
<SwitchB> system-view
[SwitchB] public-key local create rsa
The range of public key modulus is (512 ~ 4096).
If the key modulus is greater than 512, it will take a few minutes.
Press CTRL+C to abort.
Input the modulus length [default = 1024]:
Generating Keys...
.....................++++++
.................++++++
..++++++++
............++++++++
Create the key pair successfully.
```

Generate a DSA key pair.

```
[SwitchB] public-key local create dsa
The range of public key modulus is (512 ~ 2048).
If the key modulus is greater than 512, it will take a few minutes.
Press CTRL+C to abort.
Input the modulus length [default = 1024]:
Generating Keys...
.++++++++++++++++++++++++++++++++++++++++++++++++++*
........+......+.....+.................................+
...+.................+..........+...+
Create the key pair successfully.
```

Generate an ECDSA key pair.

```
[SwitchB] public-key local create ecdsa secp256r1
Generating Keys...
.
Create the key pair successfully.
```

Enable the Stelnet server.

```
[SwitchB] ssh server enable
```

Assign an IP address to VLAN-interface 2. The Stelnet client uses this address as the destination address of the SSH connection.

```
[SwitchB] interface vlan-interface 2
[SwitchB-Vlan-interface2] ip address 192.168.1.40 255.255.255.0
[SwitchB-Vlan-interface2] quit
```

Set the authentication mode to AAA for user lines.

```
[SwitchB] line vty 0 63
[SwitchB-line-vty0-63] authentication-mode scheme
[SwitchB-line-vty0-63] quit
```

Create a local device management user named **client001**.

```
[SwitchB] local-user client001 class manage
```

Set the password to **hello12345** in plain text for local user **client001**.

```
[SwitchB-luser-manage-client001] password simple hello12345
```

Authorize local user **client001** to use the **SSH** service.

```
[SwitchB-luser-manage-client001] service-type ssh
```

Assign the **network-admin** user role to local user **client001**.

```
[SwitchB-luser-manage-client001] authorization-attribute user-role network-admin
[SwitchB-luser-manage-client001] quit
```

Create an SSH user named **client001**. Specify the service type as **stelnet** and the authentication method as **password** for the user.

```
[SwitchB] ssh user client001 service-type stelnet authentication-type password
```

2. Establish a connection to the Stelnet server:

Assign an IP address to VLAN-interface 2.

```
<SwitchA> system-view
[SwitchA] interface vlan-interface 2
[SwitchA-Vlan-interface2] ip address 192.168.1.56 255.255.255.0
[SwitchA-Vlan-interface2] quit
[SwitchA] quit
```

Before establishing a connection to the server, you can configure the server's host public key on the client to authenticate the server.

- To configure the server's host public key on the client, perform the following tasks:

  # Use the **display public-key local dsa public** command on the server to display the server's host public key. (Details not shown.)

  # Enter public key view of the client and copy the host public key of the server to the client.

```
[SwitchA] public-key peer key1
Enter public key view. Return to system view with "peer-public-key end" command.
[SwitchA-pkey-public-key-key1]308201B73082012C06072A8648CE3804013082011F028181
0
0D757262C4584C44C211F18BD96E5F0
[SwitchA-pkey-public-key-key1]61C4F0A423F7FE6B6B85B34CEF72CE14A0D3A5222FE08CEC
E
65BE6C265854889DC1EDBD13EC8B274
[SwitchA-pkey-public-key-key1]DA9F75BA26CCB987723602787E922BA84421F22C3C89CB9B
0
6FD60FE01941DDD77FE6B12893DA76E
[SwitchA-pkey-public-key-key1]EBC1D128D97F0678D7722B5341C8506F358214B16A2FAC4B
3
68950387811C7DA33021500C773218C
[SwitchA-pkey-public-key-key1]737EC8EE993B4F2DED30F48EDACE915F0281810082269009
E
14EC474BAF2932E69D3B1F18517AD95
[SwitchA-pkey-public-key-key1]94184CCDFCEAE96EC4D5EF93133E84B47093C52B20CD35D0
2
492B3959EC6499625BC4FA5082E22C5
[SwitchA-pkey-public-key-key1]B374E16DD00132CE71B020217091AC717B612391C76C1FB2
E
88317C1BD8171D41ECB83E210C03CC9
[SwitchA-pkey-public-key-key1]B32E810561C21621C73D6DAAC028F4B1585DA7F42519718C
C
9B09EEF0381840002818000AF995917
[SwitchA-pkey-public-key-key1]E1E570A3F6B1C2411948B3B4FFA256699B3BF871221CC9C5
D
F257523777D033BEE77FC378145F2AD
```

```
[SwitchA-pkey-public-key-key1]D716D7DB9FCABB4ADBF6FB4FDB0CA25C761B308EF53009F7
1
01F7C62621216D5A572C379A32AC290
[SwitchA-pkey-public-key-key1]E55B394A217DA38B65B77F0185C8DB8095522D1EF044B465
E
8716261214A5A3B493E866991113B2D
[SwitchA-pkey-public-key-key1]485348
[SwitchA-pkey-public-key-key1] peer-public-key end
[SwitchA] quit
```

Establish an SSH connection to the server, and specify the host public key of the server.

```
<SwitchA> ssh2 192.168.1.40 public-key key1
Username: client001
Press CTRL+C to abort.
Connecting to 192.168.1.40 port 22.
client001@192.168.1.40's password:
Enter a character ~ and a dot to abort.

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******************************************************************************

<SwitchB>
```

After you enter username **client001** and password **hello12345**, you can successfully log in to Switch B.

- If the client does not have the server's host public key, enter username **client001**, and then enter **y** to access the server and download the server's host public key.

```
<SwitchA> ssh2 192.168.1.40
Username: client001
Press CTRL+C to abort.
Connecting to 192.168.1.40 port 22.
The server is not authenticated. Continue? [Y/N]:y
Do you want to save the server public key? [Y/N]:y
client001@192.168.1.40's password:
Enter a character ~ and a dot to abort.

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******************************************************************************

<SwitchB>
```

After you enter password **hello12345**, you can access Switch B successfully. At the next connection attempt, the client authenticates the server by using the saved server's host public key on the client.

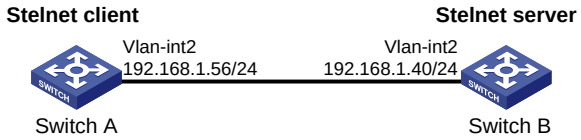
Example: Configuring the device as an Stelnet client (publickey authentication)

Network configuration

As shown in Figure 11:

- Switch B acts as the Stelnet server, and it uses publickey authentication and the DSA public key algorithm.
- Switch A acts as the Stelnet client. After the user on Switch A logs in to Switch B through Stelnet, the user can configure and manage Switch B as a network administrator.

Figure 11 Network diagram



Procedure

In the server configuration, the client's host public key is required. Generate a DSA key pair on the client before configuring the Stelnet server.

1. Configure the Stelnet client:

   # Assign an IP address to VLAN-interface 2.

```
<SwitchA> system-view
[SwitchA] interface vlan-interface 2
[SwitchA-Vlan-interface2] ip address 192.168.1.56 255.255.255.0
[SwitchA-Vlan-interface2] quit
```

   # Generate a DSA key pair.

```
[SwitchA] public-key local create dsa
The range of public key modulus is (512 ~ 2048).
If the key modulus is greater than 512, it will take a few minutes.
Press CTRL+C to abort.
Input the modulus length [default = 1024]:
Generating Keys...
.++++++++++++++++++++++++++++++++++++++++++++++++++*
........+......+.....+.....................................+
...+.................+..........+...+
Create the key pair successfully.
```

   # Export the DSA host public key to a public key file named **key.pub**.

```
[SwitchA] public-key local export dsa ssh2 key.pub
[SwitchA] quit
```

   # Transmit the public key file **key.pub** to the server through FTP or TFTP. (Details not shown.)

2. Configure the Stelnet server:

   # Generate RSA key pairs.

```
<SwitchB> system-view
[SwitchB] public-key local create rsa
The range of public key modulus is (512 ~ 4096)
If the key modulus is greater than 512, it will take a few minutes.
Press CTRL+C to abort.
```

```
Input the modulus length [default = 1024]:
Generating Keys...
.....................++++++
.................++++++
..++++++++
............++++++++
Create the key pair successfully.
```

Generate a DSA key pair.

```
[SwitchB] public-key local create dsa
The range of public key modulus is (512 ~ 2048).
If the key modulus is greater than 512, it will take a few minutes.
Press CTRL+C to abort.
Input the modulus length [default = 1024]:
Generating Keys...
.++++++++++++++++++++++++++++++++++++++++++++++++*
........+......+.....+.................................+
...+.................+..........+...+
Create the key pair successfully.
```

Generate an ECDSA key pair.

```
[SwitchB] public-key local create ecdsa secp256r1
Generating Keys...
.
Create the key pair successfully.
```

Enable the Stelnet server.

```
[SwitchB] ssh server enable
```

Assign an IP address to VLAN-interface 2. The Stelnet client uses this address as the destination address for SSH connection.

```
[SwitchB] interface vlan-interface 2
[SwitchB-Vlan-interface2] ip address 192.168.1.40 255.255.255.0
[SwitchB-Vlan-interface2] quit
```

Set the authentication mode to AAA for user lines.

```
[SwitchB] line vty 0 63
[SwitchB-line-vty0-63] authentication-mode scheme
[SwitchB-line-vty0-63] quit
```

Import the peer public key from the public key file **key.pub**, and name it **switchkey**.

```
[SwitchB] public-key peer switchkey import sshkey key.pub
```

Create an SSH user named **client002**. Specify the authentication method as **publickey** for the user. Assign the public key **switchkey** to the user.

```
[SwitchB] ssh user client002 service-type stelnet authentication-type publickey
assign publickey switchkey
```

Create a local device management user named **client002**.

```
[SwitchB] local-user client002 class manage
```

Authorize local user **client002** to use the **SSH** service.

```
[SwitchB-luser-manage-client002] service-type ssh
```

Assign the **network-admin** user role to local user **client002**.

```
[SwitchB-luser-manage-client002] authorization-attribute user-role network-admin
[SwitchB-luser-manage-client002] quit
```

3. Establish an SSH connection to the Stelnet server.

```
<SwitchA> ssh2 192.168.1.40 identity-key dsa
Username: client002
Press CTRL+C to abort.
Connecting to 192.168.1.40 port 22.
The server is not authenticated. Continue? [Y/N]:y
Do you want to save the server public key? [Y/N]:n
Enter a character ~ and a dot to abort.

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<SwitchB>
```

After you enter username **client002** and then enter **y** to continue accessing the server, you can log in to the server successfully.

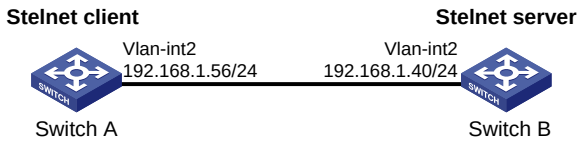
Example: Configuring Stelnet based on 128-bit Suite B algorithms

Network configuration

As shown in Figure 12:

- Switch B acts as the Stelnet Suite B server (SSH2), and it uses publickey authentication to authenticate the Stelnet client.
- Switch A acts as an Stelnet Suite B client (SSH2). After the user on Switch A logs in to Switch B through the Stelnet Suite B client software, the user can configure and manage Switch B as an administrator.

Figure 12 Network diagram



Procedure

1. Generate the client's certificate and the server's certificate. (Details not shown.)

   You must first configure the certificates of the server and the client because they are required for identity authentication between the two parties.

   In this example, the server's certificate file is **ssh-server-ecdsa256.p12** and the client's certificate file is **ssh-client-ecdsa256.p12**.

2. Configure the Stelnet client:

   You can modify the pkix version of the client software OpenSSH to support Suite B. This example uses an H3C switch as an Stelnet client.

   # Upload the server's certificate file **ssh-server-ecdsa256.p12** and the client's certificate file **ssh-client-ecdsa256.p12** to the Stelnet client through FTP or TFTP. (Details not shown.)

   # Create a PKI domain named **server256** for verifying the server's certificate and enter its view.

   ```
   <SwitchA> system-view
   ```

```
[SwitchA] pki domain server256
```

Disable CRL checking.

```
[SwitchA-pki-domain-server256] undo crl check enable
[SwitchA-pki-domain-server256] quit
```

Import local certificate file **ssh-server-ecdsa256.p12** to PKI domain **server256**.

```
[SwitchA] pki import domain server256 p12 local filename ssh-server-ecdsa256.p12
The system is going to save the key pair. You must specify a key pair name, which is
a case-insensitive string of 1 to 64 characters. Valid characters include a to z, A
to Z, 0 to 9, and hyphens (-).
Please enter the key pair name[default name: server256]:
```

Display information about local certificates in PKI domain **server256**.

```
[SwitchA] display pki certificate domain server256 local
Certificate:
    Data:
        Version: 3 (0x2)
        Serial Number: 3 (0x3)
    Signature Algorithm: ecdsa-with-SHA256
        Issuer: C=CN, ST=Beijing, L=Beijing, O=H3C, OU=Software, CN=SuiteB CA
        Validity
            Not Before: Aug 21 08:39:51 2015 GMT
            Not After : Aug 20 08:39:51 2016 GMT
        Subject: C=CN, ST=Beijing, O=H3C, OU=Software, CN=SSH Server secp256
        Subject Public Key Info:
            Public Key Algorithm: id-ecPublicKey
                Public-Key: (256 bit)
                pub:
                    04:a2:b4:b4:66:1e:3b:d5:50:50:0e:55:19:8d:52:
                    6d:47:8c:3d:3d:96:75:88:2f:9a:ba:a2:a7:f9:ef:
                    0a:a9:20:b7:b6:6a:90:0e:f8:c6:de:15:a2:23:81:
                    3c:9e:a2:b7:83:87:b9:ad:28:c8:2a:5e:58:11:8e:
                    c7:61:4a:52:51
                ASN1 OID: prime256v1
                NIST CURVE: P-256
        X509v3 extensions:
            X509v3 Basic Constraints:
                CA:FALSE
            Netscape Comment:
                OpenSSL Generated Certificate
            X509v3 Subject Key Identifier:
                08:C1:F1:AA:97:45:19:6A:DA:4A:F2:87:A1:1A:E8:30:BD:31:30:D7
            X509v3 Authority Key Identifier:
                keyid:5A:BE:85:49:16:E5:EB:33:80:25:EB:D8:91:50:B4:E6:3E:4F:B8:22

    Signature Algorithm: ecdsa-with-SHA256
         30:65:02:31:00:a9:16:e9:c1:76:f0:32:fc:4b:f9:8f:b6:7f:
         31:a0:9f:de:a7:cc:33:29:27:2c:71:2e:f9:0d:74:cb:25:c9:
         00:d2:52:18:7f:58:3f:cc:7e:8b:d3:42:65:00:cb:63:f8:02:
         30:01:a2:f6:a1:51:04:1c:61:78:f6:6b:7e:f9:f9:42:8d:7c:
```

```
        a7:bb:47:7c:2a:85:67:0d:81:12:0b:02:98:bc:06:1f:c1:3c:
        9b:c2:1b:4c:44:38:5a:14:b2:48:63:02:2b
```

Create a PKI domain named **client256** for the client's certificate and enter its view.

```
[SwitchA] pki domain client256
```

Disable CRL checking.

```
[SwitchA-pki-domain-client256] undo crl check enable
[SwitchA-pki-domain-client256] quit
```

Import local certificate file **ssh-client-ecdsa256.p12** to PKI domain **client256**.

```
[SwitchA] pki import domain client256 p12 local filename ssh-client-ecdsa256.p12
The system is going to save the key pair. You must specify a key pair name, which is
a case-insensitive string of 1 to 64 characters. Valid characters include a to z, A
to Z, 0 to 9, and hyphens (-).
Please enter the key pair name[default name: client256]:
```

Display information about local certificates in PKI domain **client256**.

```
[SwitchA] display pki certificate domain client256 local
Certificate:
    Data:
        Version: 3 (0x2)
        Serial Number: 4 (0x4)
    Signature Algorithm: ecdsa-with-SHA256
        Issuer: C=CN, ST=Beijing, L=Beijing, O=H3C, OU=Software, CN=SuiteB CA
        Validity
            Not Before: Aug 21 08:41:09 2015 GMT
            Not After : Aug 20 08:41:09 2016 GMT
        Subject: C=CN, ST=Beijing, O=H3C, OU=Software, CN=SSH Client secp256
        Subject Public Key Info:
            Public Key Algorithm: id-ecPublicKey
                Public-Key: (256 bit)
                pub:
                    04:da:e2:26:45:87:7a:63:20:e7:ca:7f:82:19:f5:
                    96:88:3e:25:46:f8:2f:9a:4c:70:61:35:db:e4:39:
                    b8:38:c4:60:4a:65:28:49:14:32:3c:cc:6d:cd:34:
                    29:83:84:74:a7:2d:0e:75:1c:c2:52:58:1e:22:16:
                    12:d0:b4:8a:92
                ASN1 OID: prime256v1
                NIST CURVE: P-256
        X509v3 extensions:
            X509v3 Basic Constraints:
                CA:FALSE
            Netscape Comment:
                OpenSSL Generated Certificate
            X509v3 Subject Key Identifier:
                1A:61:60:4D:76:40:B8:BA:5D:A1:3C:60:BC:57:98:35:20:79:80:FC
            X509v3 Authority Key Identifier:
                keyid:5A:BE:85:49:16:E5:EB:33:80:25:EB:D8:91:50:B4:E6:3E:4F:B8:22

    Signature Algorithm: ecdsa-with-SHA256
         30:66:02:31:00:9a:6d:fd:7d:ab:ae:54:9a:81:71:e6:bb:ad:
```

```
5a:2e:dc:1d:b3:8a:bf:ce:ee:71:4e:8f:d9:93:7f:a3:48:a1:
5c:17:cb:22:fa:8f:b3:e5:76:89:06:9f:96:47:dc:34:87:02:
31:00:e3:af:2a:8f:d6:8d:1f:3a:2b:ae:2f:97:b3:52:63:b6:
18:67:70:2c:93:2a:41:c0:e7:fa:93:20:09:4d:f4:bf:d0:11:
66:0f:48:56:01:1e:c3:be:37:4e:49:19:cf:c6
```

Assign an IP address to VLAN-interface 2.

```
<SwitchA> system-view
[SwitchA] interface vlan-interface 2
[SwitchA-Vlan-interface2] ip address 192.168.1.56 255.255.255.0
[SwitchA-Vlan-interface2] quit
```

3. Configure the Stelnet server:

Upload the server's certificate file **ssh-server-ecdsa256.p12** and the client's certificate file **ssh-client-ecdsa256.p12** to the Stelnet server through FTP or TFTP. (Details not shown.)

Create a PKI domain named **client256** for verifying the client's certificate and import the file of the client's certificate to this domain. (Details not shown.)

Create a PKI domain named **server256** for the server's certificate and import the file of the server's certificate to this domain. (Details not shown.)

Specify Suite B algorithms for algorithm negotiation.

```
<SwitchB> system-view
[SwitchB] ssh2 algorithm key-exchange ecdh-sha2-nistp256
[SwitchB] ssh2 algorithm cipher aes128-gcm
[SwitchB] ssh2 algorithm public-key x509v3-ecdsa-sha2-nistp256
x509v3-ecdsa-sha2-nistp384
```

Specify **server256** as the PKI domain of the server's certificate.

```
[SwitchB] ssh server pki-domain server256
```

Enable the Stelnet server.

```
[SwitchB] ssh server enable
```

Assign an IP address to VLAN-interface 2.

```
[SwitchB] interface vlan-interface 2
[SwitchB-Vlan-interface2] ip address 192.168.1.40 255.255.255.0
[SwitchB-Vlan-interface2] quit
```

Set the authentication mode to AAA for user lines.

```
[SwitchB] line vty 0 63
[SwitchB-line-vty0-63] authentication-mode scheme
[SwitchB-line-vty0-63] quit
```

Create a local device management user named **client001**. Authorize the user to use the **SSH** service and assign the **network-admin** user role to the user.

```
[SwitchB] local-user client001 class manage
[SwitchB-luser-manage-client001] service-type ssh
[SwitchB-luser-manage-client001] authorization-attribute user-role network-admin
[SwitchB-luser-manage-client001] quit
```

Create an SSH user named **client001**. Specify the **publickey** authentication method for the user and specify **client256** as the PKI domain for verifying the client's certificate.

```
[SwitchB] ssh user client001 service-type stelnet authentication-type publickey
assign pki-domain client256
```

4. Establish an SSH connection to the Stelnet server based on the 128-bit Suite B algorithms:

Establish an SSH connection to the server at 192.168.1.40.

```
<SwitchA>  ssh2 192.168.1.40 suite-b 128-bit pki-domain client256 server-pki-domain
server256
Username: client001
Press CTRL+C to abort.
Connecting to 192.168.1.40 port 22.
Enter a character ~ and a dot to abort.

******************************************************************************
* Copyright (c) 2004-2017 New H3C Technologies Co., Ltd. All rights reserved.*
* Without the owner's prior written consent,                                 *
* no decompiling or reverse-engineering shall be allowed.                    *
******************************************************************************

<SwitchB>
```

SFTP configuration examples

Unless otherwise noted, devices in the configuration examples operate in non-FIPS mode.

When the device acts as an SFTP server operating in FIPS mode, only ECDSA and RSA key pairs are supported. Do not generate a DSA key pair on the SFTP server.

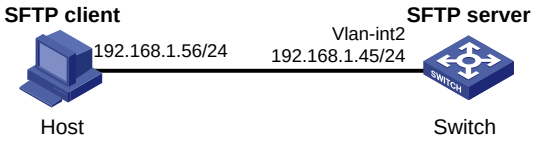
Example: Configuring the device as an SFTP server (password authentication)

Network configuration

As shown in Figure 13:

- The switch acts as the SFTP server and uses password authentication to authenticate the SFTP client. The username and password of the client are saved on the switch.
- The host acts as the SFTP client. After the user on the client logs in to the switch through SFTP, the user can perform file management and transfer operations on the switch as a network administrator.

Figure 13 Network diagram



Procedure

1. Configure the SFTP server:

   # Generate RSA key pairs.

```
<Switch> system-view
[Switch] public-key local create rsa
The range of public key modulus is (512 ~ 4096).
If the key modulus is greater than 512, it will take a few minutes.
Press CTRL+C to abort.
Input the modulus length [default = 1024]:
```

```
Generating Keys...
.....................++++++
.................++++++
..++++++++
............++++++++
Create the key pair successfully.
```

Generate a DSA key pair.

```
[Switch] public-key local create dsa
The range of public key modulus is (512 ~ 2048).
If the key modulus is greater than 512, it will take a few minutes.
Press CTRL+C to abort.
Input the modulus length [default = 1024]:
Generating Keys...
.++++++++++++++++++++++++++++++++++++++++++++++++*
........+......+.....+.................................+
...+.............+.........+...+
Create the key pair successfully.
```

Generate an ECDSA key pair.

```
[Switch] public-key local create ecdsa secp256r1
Generating Keys...
.
Create the key pair successfully.
```

Enable the SFTP server.

```
[Switch] sftp server enable
```

Assign an IP address to VLAN-interface 2. The client uses this address as the destination for SSH connection.

```
[Switch] interface vlan-interface 2
[Switch-Vlan-interface2] ip address 192.168.1.45 255.255.255.0
[Switch-Vlan-interface2] quit
```

Create a local device management user named **client002**.

```
[Switch] local-user client002 class manage
```

Set the password to **hello12345** in plain text for local user **client002**.

```
[Switch-luser-manage-client002] password simple hello12345
```

Authorize local user **client002** to use the **SSH** service.

```
[Switch-luser-manage-client002] service-type ssh
```

Assign the **network-admin** user role and working directory **flash:/** to local user **client002**.

```
[Switch-luser-manage-client002] authorization-attribute user-role network-admin
work-directory flash:/
[Switch-luser-manage-client002] quit
```

Create an SSH user named **client002**. Specify the authentication method as **password** and service type as **sftp** for the user.

```
[Switch] ssh user client002 service-type sftp authentication-type password
```

2. Establish a connection between the SFTP client and the SFTP server:

This example uses an SFTP client that runs PSFTP of PuTTy version 0.58. PSFTP supports only password authentication.

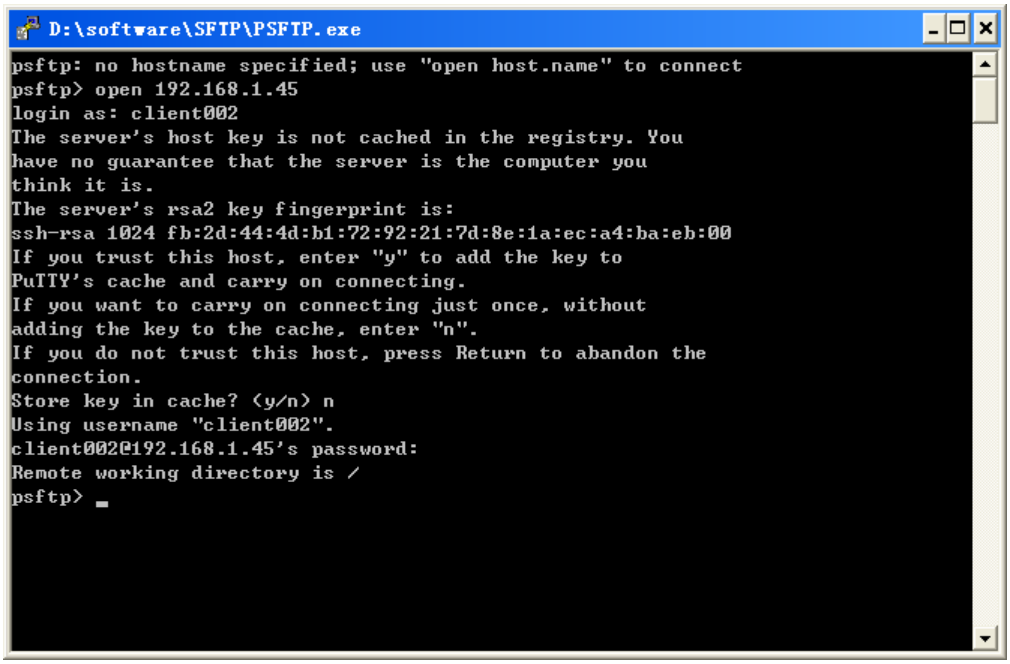
To establish a connection to the SFTP server:

a. Run the **psftp.exe** to launch the client interface shown in Figure 14, and enter the following command:

```
open 192.168.1.45
```

b. Enter username **client002** and password **hello12345** to log in to the SFTP server.

Figure 14 SFTP client interface



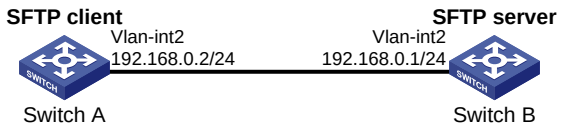
Example: Configuring the device as an SFTP client (publickey authentication)

Network configuration

As shown in Figure 15:

- Switch B acts as the SFTP server, and it uses publickey authentication and the RSA public key algorithm.
- Switch A acts as the SFTP client. After the user on Switch A logs in to Switch B through SFTP, the user can perform file management and transfer operations on Switch B as a network administrator.

Figure 15 Network diagram



Procedure

In the server configuration, the client's host public key is required. Generate RSA key pairs on the client before configuring the SFTP server.

1. Configure the SFTP client:

Assign an IP address to VLAN-interface 2.

```
<SwitchA> system-view
[SwitchA] interface vlan-interface 2
[SwitchA-Vlan-interface2] ip address 192.168.0.2 255.255.255.0
```

```
[SwitchA-Vlan-interface2] quit
```

Generate RSA key pairs.

```
[SwitchA] public-key local create rsa
The range of public key size is (512 ~ 4096).
If the key modulus is greater than 512, it will take a few minutes.
Press CTRL+C to abort.
Input the modulus length [default = 1024]:
Generating Keys...
.....................++++++
.................++++++
..++++++++
............++++++++
Create the key pair successfully.
```

Export the host public key to a public key file named **pubkey**.

```
[SwitchA] public-key local export rsa ssh2 pubkey
[SwitchA] quit
```

Transmit the public key file **pubkey** to the server through FTP or TFTP. (Details not shown.)

2. Configure the SFTP server:

Generate RSA key pairs.

```
<SwitchB> system-view
[SwitchB] public-key local create rsa
The range of public key size is (512 ~ 4096).
If the key modulus is greater than 512, it will take a few minutes.
Press CTRL+C to abort.
Input the modulus length [default = 1024]:
Generating Keys...
.....................++++++
.................++++++
..++++++++
............++++++++
Create the key pair successfully.
```

Generate a DSA key pair.

```
[SwitchB] public-key local create dsa
The range of public key size is (512 ~ 2048).
If the key modulus is greater than 512, it will take a few minutes.
Press CTRL+C to abort.
Input the modulus length [default = 1024]:
Generating Keys...
.++++++++++++++++++++++++++++++++++++++++++++++++++*
........+......+.....+.................................+
...+.................+..........+...+
Create the key pair successfully.
```

Generate an ECDSA key pair.

```
[SwitchB] public-key local create ecdsa secp256r1
Generating Keys...
.
Create the key pair successfully.
```

Enable the SFTP server.

```
[SwitchB] sftp server enable
```

Assign an IP address to VLAN-interface 2. The SSH client uses this address as the destination for SSH connection.

```
[SwitchB] interface vlan-interface 2
[SwitchB-Vlan-interface2] ip address 192.168.0.1 255.255.255.0
[SwitchB-Vlan-interface2] quit
```

Import the peer public key from the public key file **pubkey**, and name it **switchkey**.

```
[SwitchB] public-key peer switchkey import sshkey pubkey
```

Create an SSH user named **client001**. Specify the service type as **sftp** and the authentication method as **publickey** for the user. Assign the public key **switchkey** to the user.

```
[SwitchB] ssh user client001 service-type sftp authentication-type publickey assign
publickey switchkey
```

Create a local device management user named **client001**.

```
[SwitchB] local-user client001 class manage
```

Authorize local user **client001** to use the **SSH** service.

```
[SwitchB-luser-manage-client001] service-type ssh
```

Assign the **network-admin** user role and working directory **flash:/** to local user **client001**.

```
[SwitchB-luser-manage-client001] authorization-attribute user-role network-admin
work-directory flash:/
[SwitchB-luser-manage-client001] quit
```

3. Establish a connection to the SFTP server:

Establish a connection to the SFTP server and enter SFTP client view.

```
<SwitchA> sftp 192.168.0.1 identity-key rsa
Username: client001
Press CTRL+C to abort.
Connecting to 192.168.0.1 port 22.
The server is not authenticated. Continue? [Y/N]:y
Do you want to save the server public key? [Y/N]:n
sftp>
```

Display files under the current directory of the server, delete file **z**, and verify the result.

```
sftp> dir -l
-rwxrwxrwx   1 noone    nogroup      1759 Aug 23 06:52 config.cfg
-rwxrwxrwx   1 noone    nogroup       225 Aug 24 08:01 pubkey2
-rwxrwxrwx   1 noone    nogroup       283 Aug 24 07:39 pubkey
drwxrwxrwx   1 noone    nogroup         0 Sep 01 06:22 new
-rwxrwxrwx   1 noone    nogroup       225 Sep 01 06:55 pub
-rwxrwxrwx   1 noone    nogroup         0 Sep 01 08:00 z
sftp> delete z
Removing /z
sftp> dir -l
-rwxrwxrwx   1 noone    nogroup      1759 Aug 23 06:52 config.cfg
-rwxrwxrwx   1 noone    nogroup       225 Aug 24 08:01 pubkey2
-rwxrwxrwx   1 noone    nogroup       283 Aug 24 07:39 pubkey
drwxrwxrwx   1 noone    nogroup         0 Sep 01 06:22 new
-rwxrwxrwx   1 noone    nogroup       225 Sep 01 06:55 pub
```

Add a directory named **new1** and verify the result.

```
sftp> mkdir new1
sftp> dir -l
```

```
-rwxrwxrwx   1 noone    nogroup      1759 Aug 23 06:52 config.cfg
-rwxrwxrwx   1 noone    nogroup       225 Aug 24 08:01 pubkey2
-rwxrwxrwx   1 noone    nogroup       283 Aug 24 07:39 pubkey
drwxrwxrwx   1 noone    nogroup         0 Sep 01 06:22 new
-rwxrwxrwx   1 noone    nogroup       225 Sep 01 06:55 pub
drwxrwxrwx   1 noone    nogroup         0 Sep 02 06:30 new1
```

Change the name of directory **new1** to **new2** and verify the result.

```
sftp> rename new1 new2
sftp> dir -l
-rwxrwxrwx   1 noone    nogroup      1759 Aug 23 06:52 config.cfg
-rwxrwxrwx   1 noone    nogroup       225 Aug 24 08:01 pubkey2
-rwxrwxrwx   1 noone    nogroup       283 Aug 24 07:39 pubkey
drwxrwxrwx   1 noone    nogroup         0 Sep 01 06:22 new
-rwxrwxrwx   1 noone    nogroup       225 Sep 01 06:55 pub
drwxrwxrwx   1 noone    nogroup         0 Sep 02 06:33 new2
```

Download file **pubkey2** from the server and save it as a local file named **public**.

```
sftp> get pubkey2 public
Fetching / pubkey2 to public
/pubkey2                                      100% 225     1.4KB/s   00:00
```

Upload the local file **pu** to the server, save it as **puk**, and verify the result.

```
sftp> put pu puk
Uploading pu to / puk
sftp> dir -l
-rwxrwxrwx   1 noone    nogroup      1759 Aug 23 06:52 config.cfg
-rwxrwxrwx   1 noone    nogroup       225 Aug 24 08:01 pubkey2
-rwxrwxrwx   1 noone    nogroup       283 Aug 24 07:39 pubkey
drwxrwxrwx   1 noone    nogroup         0 Sep 01 06:22 new
drwxrwxrwx   1 noone    nogroup         0 Sep 02 06:33 new2
-rwxrwxrwx   1 noone    nogroup       283 Sep 02 06:35 pub
-rwxrwxrwx   1 noone    nogroup       283 Sep 02 06:36 puk
sftp>
```

Exit SFTP client view.

```
sftp> quit
<SwitchA>
```

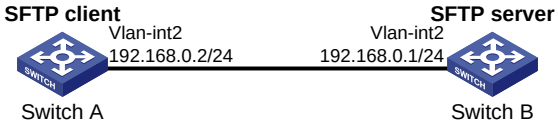
Example: Configuring SFTP based on 192-bit Suite B algorithms

Network configuration

As shown in Figure 16:

- Switch B acts as the SFTP Suite B server (SSH2), and it uses publickey authentication to authenticate the SFTP client.
- Switch A acts as an SFTP Suite B client (SSH2). After the user on Switch A logs in to Switch B based on the SFTP Suite B client software, the user can manage and transfer files on Switch B as an administrator.

Figure 16 Network diagram



Procedure

1. Generate the client's certificate and the server's certificate. (Details not shown.)

   You must first configure the certificates of the server and the client because they are required for identity authentication between the two parties.

   In this example, the server's certificate file is **ssh-server-ecdsa384.p12** and the client's certificate file is **ssh-client-ecdsa384.p12**.

2. Configure the SFTP client:

   You can modify the pkix version of the client software OpenSSH to support Suite B. This example uses an H3C switch as an SFTP client.

   # Upload the server's certificate file **ssh-server-ecdsa384.p12** and the client's certificate file **ssh-client-ecdsa384.p12** to the SFTP client through FTP or TFTP. (Details not shown.)

   # Create a PKI domain named **server384** for verifying the server's certificate and enter its view.

   ```
   <SwitchA> system-view
   [SwitchA] pki domain server384
   ```

   # Disable CRL checking.

   ```
   [SwitchA-pki-domain-server384] undo crl check enable
   [SwitchA-pki-domain-server384] quit
   ```

   # Import local certificate file **ssh-server-ecdsa384.p12** to PKI domain **server384**.

   ```
   [SwitchA] pki import domain server384 p12 local filename ssh-server-ecdsa384.p12
   The system is going to save the key pair. You must specify a key pair name, which is
   a case-insensitive string of 1 to 64 characters. Valid characters include a to z, A
   to Z, 0 to 9, and hyphens (-).
   Please enter the key pair name[default name: server384]:
   ```

   # Display information about local certificates in PKI domain **server384**.

   ```
   [SwitchA] display pki certificate domain server384 local
   Certificate:
       Data:
           Version: 3 (0x2)
           Serial Number: 1 (0x1)
       Signature Algorithm: ecdsa-with-SHA384
           Issuer: C=CN, ST=Beijing, L=Beijing, O=H3C, OU=Software, CN=SuiteB CA
           Validity
               Not Before: Aug 20 10:08:41 2015 GMT
               Not After : Aug 19 10:08:41 2016 GMT
           Subject: C=CN, ST=Beijing, O=H3C, OU=Software, CN=ssh server
           Subject Public Key Info:
               Public Key Algorithm: id-ecPublicKey
                   Public-Key: (384 bit)
                   pub:
                       04:4a:33:e5:99:8d:49:45:a7:a3:24:7b:32:6a:ed:
                       b6:36:e1:4d:cc:8c:05:22:f4:3a:7c:5d:b7:be:d1:
                       e6:9e:f0:ce:95:39:ca:fd:a0:86:cd:54:ab:49:60:
   ```

```
                    10:be:67:9f:90:3a:18:e2:7d:d9:5f:72:27:09:e7:
                    bf:7e:64:0a:59:bb:b3:7d:ae:88:14:94:45:b9:34:
                    d2:f3:93:e1:ba:b4:50:15:eb:e5:45:24:31:10:c7:
                    07:01:f9:dc:a5:6f:81
                ASN1 OID: secp384r1
                NIST CURVE: P-384
        X509v3 extensions:
            X509v3 Basic Constraints:
                CA:FALSE
            Netscape Comment:
                OpenSSL Generated Certificate
            X509v3 Subject Key Identifier:
                10:16:64:2C:DA:C1:D1:29:CD:C0:74:40:A9:70:BD:62:8A:BB:F4:D5
            X509v3 Authority Key Identifier:
                keyid:5A:BE:85:49:16:E5:EB:33:80:25:EB:D8:91:50:B4:E6:3E:4F:B8:22

    Signature Algorithm: ecdsa-with-SHA384
         30:65:02:31:00:80:50:7a:4f:c5:cd:6a:c3:57:13:7f:e9:da:
         c1:72:7f:45:30:17:c2:a7:d3:ec:73:3d:5f:4d:e3:96:f6:a3:
         33:fb:e4:b9:ff:47:f1:af:9d:e3:03:d2:24:53:40:09:5b:02:
         30:45:d1:bf:51:fd:da:22:11:90:03:f9:d4:05:ec:d6:7c:41:
         fc:9d:a1:fd:5b:8c:73:f8:b6:4c:c3:41:f7:c6:7f:2f:05:2d:
         37:f8:52:52:26:99:28:97:ac:6e:f9:c7:01
```

Create a PKI domain named **client384** for the client's certificate and enter its view.

```
[SwitchA] pki domain client384
```

Disable CRL checking.

```
[SwitchA-pki-domain-client384] undo crl check enable
[SwitchA-pki-domain-client384] quit
```

Import local certificate file **ssh-client-ecdsa384.p12** to PKI domain **client384**.

```
[SwitchA] pki import domain client384 p12 local filename ssh-client-ecdsa384.p12
The system is going to save the key pair. You must specify a key pair name, which is
a case-insensitive string of 1 to 64 characters. Valid characters include a to z, A
to Z, 0 to 9, and hyphens (-).
Please enter the key pair name[default name: client384]:
```

Display information about local certificates in PKI domain **client384**.

```
[SwitchA]display pki certificate domain client384 local
Certificate:
    Data:
        Version: 3 (0x2)
        Serial Number: 2 (0x2)
    Signature Algorithm: ecdsa-with-SHA384
        Issuer: C=CN, ST=Beijing, L=Beijing, O=H3C, OU=Software, CN=SuiteB CA
        Validity
            Not Before: Aug 20 10:10:59 2015 GMT
            Not After : Aug 19 10:10:59 2016 GMT
        Subject: C=CN, ST=Beijing, O=H3C, OU=Software, CN=ssh client
        Subject Public Key Info:
            Public Key Algorithm: id-ecPublicKey
```

```
                Public-Key: (384 bit)
                pub:
                    04:85:7c:8b:f4:7a:36:bf:74:f6:7c:72:f9:08:69:
                    d0:b9:ac:89:98:17:c9:fc:89:94:43:da:9a:a6:89:
                    41:d3:72:24:9b:9a:29:a8:d1:ba:b4:e5:77:ba:fc:
                    df:ae:c6:dd:46:72:ab:bc:d1:7f:18:7d:54:88:f6:
                    b4:06:54:7e:e7:4d:49:b4:07:dc:30:54:4b:b6:5b:
                    01:10:51:6b:0c:6d:a3:b1:4b:c9:d9:6c:d6:be:13:
                    91:70:31:2a:92:00:76
                ASN1 OID: secp384r1
                NIST CURVE: P-384
            X509v3 extensions:
                X509v3 Basic Constraints:
                    CA:FALSE
                Netscape Comment:
                    OpenSSL Generated Certificate
                X509v3 Subject Key Identifier:
                    BD:5F:8E:4F:7B:FE:74:03:5A:D1:94:DB:CA:A7:82:D6:F7:78:A1:B0
                X509v3 Authority Key Identifier:
                    keyid:5A:BE:85:49:16:E5:EB:33:80:25:EB:D8:91:50:B4:E6:3E:4F:B8:22

        Signature Algorithm: ecdsa-with-SHA384
             30:66:02:31:00:d2:06:fa:2c:0b:0d:f0:81:90:01:c3:3d:bf:
             97:b3:79:d8:25:a0:e2:0e:ed:00:c9:48:3e:c9:71:43:c9:b4:
             2a:a6:0a:27:80:9e:d4:0f:f2:db:db:5b:40:b1:a9:0a:e4:02:
             31:00:ee:00:e1:07:c0:2f:12:3f:88:ea:fe:19:05:ef:56:ca:
             33:71:75:5e:11:c9:a6:51:4b:3e:7c:eb:2a:4d:87:2b:71:7c:
             30:64:fe:14:ce:06:d5:0a:e2:cf:9a:69:19:ff
```

Assign an IP address to VLAN-interface 2.

```
[SwitchA] interface vlan-interface 2
[SwitchA-Vlan-interface2] ip address 192.168.0.2 255.255.255.0
[SwitchA-Vlan-interface2] quit
[SwitchA] quit
```

3. Configure the SFTP server:

Upload the server's certificate file **ssh-server-ecdsa384.p12** and the client's certificate file **ssh-client-ecdsa384.p12** to the SFTP server through FTP or TFTP. (Details not shown.)

Create a PKI domain named **client384** for verifying the client's certificate and import the file of the client's certificate to this domain. (Details not shown.)

Create a PKI domain named **server384** for the server's certificate and import the file of the server's certificate to this domain. (Details not shown.)

Specify Suite B algorithms for algorithm negotiation.

```
[SwitchB] ssh2 algorithm key-exchange ecdh-sha2-nistp384
[SwitchB] ssh2 algorithm cipher aes256-gcm
[SwitchB] ssh2 algorithm public-key x509v3-ecdsa-sha2-nistp384
```

Specify **server384** as the PKI domain of the server's certificate.

```
[SwitchB] ssh server pki-domain server384
```

Enable the SFTP server.

```
[SwitchB] sftp server enable
```

Assign an IP address to VLAN-interface 2.

```
[SwitchB] interface vlan-interface 2
[SwitchB-Vlan-interface2] ip address 192.168.0.1 255.255.255.0
[SwitchB-Vlan-interface2] quit
```

Set the authentication mode to AAA for user lines.

```
[SwitchB] line vty 0 63
[SwitchB-line-vty0-63] authentication-mode scheme
[SwitchB-line-vty0-63] quit
```

Create a local device management user named **client001**. Authorize the user to use the **SSH** service and assign the **network-admin** user role to the user.

```
[SwitchB] local-user client001 class manage
[SwitchB-luser-manage-client001] service-type ssh
[SwitchB-luser-manage-client001] authorization-attribute user-role network-admin
[SwitchB-luser-manage-client001] quit
```

Create an SSH user named **client001**. Specify the **publickey** authentication method for the user and specify **client384** as the PKI domain for verifying the client's certificate.

```
[SwitchB] ssh user client001 service-type sftp authentication-type publickey assign
pki-domain client384
```

4. Establish an SFTP connection to the SFTP server based on the 192-bit Suite B algorithms:

Establish an SFTP connection to the server at 192.168.0.1.

```
<SwitchA> sftp 192.168.0.1 suite-b 192-bit pki-domain client384 server-pki-domain
server384
Username: client001
Press CTRL+C to abort.
Connecting to 192.168.0.1 port 22.
sftp>
```

SCP configuration examples

Unless otherwise noted, devices in the configuration examples operate in non-FIPS mode.

When the device acts as an SCP server operating in FIPS mode, only ECDSA and RSA key pairs are supported. Do not generate a DSA key pair on the SCP server.

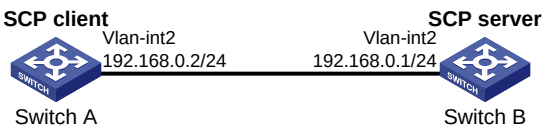
Example: Configuring SCP with password authentication

Network configuration

As shown in Figure 17:

- Switch B acts as the SCP server and uses password authentication to authenticate the SCP client. The client's username and password are saved on Switch B.
- Switch A acts as the SCP client. After the user on Switch A logs in to Switch B through SCP, the user can transfer files between switches as a network administrator.

Figure 17 Network diagram



Procedure

1. Configure the SCP server:

Generate RSA key pairs.

```
<SwitchB> system-view
[SwitchB] public-key local create rsa
The range of public key modulus is (512 ~ 4096).
If the key modulus is greater than 512, it will take a few minutes.
Press CTRL+C to abort.
Input the modulus length [default = 1024]:
Generating Keys...
.....................++++++
.................++++++
..++++++++
............++++++++
Create the key pair successfully.
```

Generate a DSA key pair.

```
[SwitchB] public-key local create dsa
The range of public key modulus is (512 ~ 2048).
If the key modulus is greater than 512, it will take a few minutes.
Press CTRL+C to abort.
Input the modulus length [default = 1024]:
Generating Keys...
.++++++++++++++++++++++++++++++++++++++++++++++++++*
........+......+.....+.................................+
...+.................+..........+...+.
Create the key pair successfully.
```

Generate an ECDSA key pair.

```
[SwitchB] public-key local create ecdsa secp256r1
Generating Keys...
.
Create the key pair successfully.
```

Enable the SCP server.

```
[SwitchB] scp server enable
```

Configure an IP address for VLAN-interface 2. The client uses this address as the destination for SCP connection.

```
[SwitchB] interface vlan-interface 2
[SwitchB-Vlan-interface2] ip address 192.168.0.1 255.255.255.0
[SwitchB-Vlan-interface2] quit
```

Create a local device management user named **client001**.

```
[SwitchB] local-user client001 class manage
```

Set the password to **hello12345** in plain text for local user **client001**.

```
[SwitchB-luser-manage-client001] password simple hello12345
```

Authorize local user **client001** to use the **SSH** service.

```
[SwitchB-luser-manage-client001] service-type ssh
```

Assign the **network-admin** user role to local user **client001**.

```
[SwitchB-luser-manage-client001] authorization-attribute user-role network-admin
[SwitchB-luser-manage-client001] quit
```

Create an SSH user named **client001**. Specify the service type as **scp** and the authentication method as **password** for the user.

```
[SwitchB] ssh user client001 service-type scp authentication-type password
```

2. Configure an IP address for VLAN-interface 2 on the SCP client.

```
<SwitchA> system-view
[SwitchA] interface vlan-interface 2
[SwitchA-Vlan-interface2] ip address 192.168.0.2 255.255.255.0
[SwitchA-Vlan-interface2] quit
[SwitchA] quit
```

3. Connect to the SCP server, download file **remote.bin** from the server, and save it as a local file named **local.bin**.

```
<SwitchA> scp 192.168.0.1 get remote.bin local.bin
Username: client001
Press CTRL+C to abort.
Connecting to 192.168.0.1 port 22.
The server is not authenticated. Continue? [Y/N]:y
Do you want to save the server public key? [Y/N]:n
client001@192.168.0.1's password:
remote.bin                                        100% 2875     2.8KB/s   00:00
```

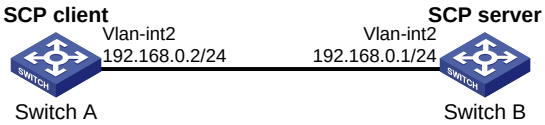
Example: Configuring SCP based on Suite B algorithms

Network configuration

As shown in Figure 18:

- Switch B acts as the SCP Suite B server (SSH2), and it uses publickey authentication to authenticate the SCP client.
- Switch A acts as an SCP Suite B client (SSH2). After the user on Switch A logs in to Switch B through the SCP Suite B client software, the user can transfer files between switches as a network administrator.

Figure 18 Network diagram



Procedure

1. Generate the client's certificates and the server's certificates. (Details not shown.)

   You must first configure the certificates of the server and the client because they are required for identity authentication between the two parties.

   In this example, the server's certificate files are **ssh-server-ecdsa256.p12** and **ssh-server-ecdsa384.p12**. The client's certificate files are **ssh-client-ecdsa256.p12** and **ssh-client-ecdsa384.p12**.

2. Configure the SCP client:

   You can modify the pkix version of the client software OpenSSH to support Suite B. This example uses an H3C switch as an SCP client.

   # Upload the server's certificate files (**ssh-server-ecdsa256.p12** and **ssh-server-ecdsa384.p12**) and the client's certificate files (**ssh-client-ecdsa256.p12** and **ssh-client-ecdsa384.p12**) to the SCP client through FTP or TFTP. (Details not shown.)

Create a PKI domain named **server256** for verifying the server's certificate **ecdsa256** and enter its view.

```
<SwitchA> system-view
[SwitchA] pki domain server256
```

Disable CRL checking.

```
[SwitchA-pki-domain-server256] undo crl check enable
[SwitchA-pki-domain-server256] quit
```

Import local certificate file **ssh-server-ecdsa256.p12** to PKI domain **server256**.

```
[SwitchA] pki import domain server256 p12 local filename ssh-server-ecdsa256.p12
The system is going to save the key pair. You must specify a key pair name, which is
a case-insensitive string of 1 to 64 characters. Valid characters include a to z, A
to Z, 0 to 9, and hyphens (-).
Please enter the key pair name[default name: server256]:
```

Display information about local certificates in PKI domain **server256**.

```
[SwitchA] display pki certificate domain server256 local
Certificate:
    Data:
        Version: 3 (0x2)
        Serial Number: 3 (0x3)
    Signature Algorithm: ecdsa-with-SHA256
        Issuer: C=CN, ST=Beijing, L=Beijing, O=H3C, OU=Software, CN=SuiteB CA
        Validity
            Not Before: Aug 21 08:39:51 2015 GMT
            Not After : Aug 20 08:39:51 2016 GMT
        Subject: C=CN, ST=Beijing, O=H3C, OU=Software, CN=SSH Server secp256
        Subject Public Key Info:
            Public Key Algorithm: id-ecPublicKey
                Public-Key: (256 bit)
                pub:
                    04:a2:b4:b4:66:1e:3b:d5:50:50:0e:55:19:8d:52:
                    6d:47:8c:3d:3d:96:75:88:2f:9a:ba:a2:a7:f9:ef:
                    0a:a9:20:b7:b6:6a:90:0e:f8:c6:de:15:a2:23:81:
                    3c:9e:a2:b7:83:87:b9:ad:28:c8:2a:5e:58:11:8e:
                    c7:61:4a:52:51
                ASN1 OID: prime256v1
                NIST CURVE: P-256
        X509v3 extensions:
            X509v3 Basic Constraints:
                CA:FALSE
            Netscape Comment:
                OpenSSL Generated Certificate
            X509v3 Subject Key Identifier:
                08:C1:F1:AA:97:45:19:6A:DA:4A:F2:87:A1:1A:E8:30:BD:31:30:D7
            X509v3 Authority Key Identifier:
                keyid:5A:BE:85:49:16:E5:EB:33:80:25:EB:D8:91:50:B4:E6:3E:4F:B8:22

    Signature Algorithm: ecdsa-with-SHA256
         30:65:02:31:00:a9:16:e9:c1:76:f0:32:fc:4b:f9:8f:b6:7f:
         31:a0:9f:de:a7:cc:33:29:27:2c:71:2e:f9:0d:74:cb:25:c9:
```

```
        00:d2:52:18:7f:58:3f:cc:7e:8b:d3:42:65:00:cb:63:f8:02:
        30:01:a2:f6:a1:51:04:1c:61:78:f6:6b:7e:f9:f9:42:8d:7c:
        a7:bb:47:7c:2a:85:67:0d:81:12:0b:02:98:bc:06:1f:c1:3c:
        9b:c2:1b:4c:44:38:5a:14:b2:48:63:02:2b
```

Create a PKI domain named **client256** for the client's certificate **ecdsa256** and enter its view.

```
[SwitchA] pki domain client256
```

Disable CRL checking.

```
[SwitchA-pki-domain-client256] undo crl check enable
[SwitchA-pki-domain-client256] quit
```

Import local certificate file **ssh-client-ecdsa256.p12** to PKI domain **client256**.

```
[SwitchA] pki import domain client256 p12 local filename ssh-client-ecdsa256.p12
The system is going to save the key pair. You must specify a key pair name, which is
a case-insensitive string of 1 to 64 characters. Valid characters include a to z, A
to Z, 0 to 9, and hyphens (-).
Please enter the key pair name[default name: client256]:
```

Display information about local certificates in PKI domain **client256**.

```
[SwitchA] display pki certificate domain client256 local
Certificate:
    Data:
        Version: 3 (0x2)
        Serial Number: 4 (0x4)
    Signature Algorithm: ecdsa-with-SHA256
        Issuer: C=CN, ST=Beijing, L=Beijing, O=H3C, OU=Software, CN=SuiteB CA
        Validity
            Not Before: Aug 21 08:41:09 2015 GMT
            Not After : Aug 20 08:41:09 2016 GMT
        Subject: C=CN, ST=Beijing, O=H3C, OU=Software, CN=SSH Client secp256
        Subject Public Key Info:
            Public Key Algorithm: id-ecPublicKey
                Public-Key: (256 bit)
                pub:
                    04:da:e2:26:45:87:7a:63:20:e7:ca:7f:82:19:f5:
                    96:88:3e:25:46:f8:2f:9a:4c:70:61:35:db:e4:39:
                    b8:38:c4:60:4a:65:28:49:14:32:3c:cc:6d:cd:34:
                    29:83:84:74:a7:2d:0e:75:1c:c2:52:58:1e:22:16:
                    12:d0:b4:8a:92
                ASN1 OID: prime256v1
                NIST CURVE: P-256
        X509v3 extensions:
            X509v3 Basic Constraints:
                CA:FALSE
            Netscape Comment:
                OpenSSL Generated Certificate
            X509v3 Subject Key Identifier:
                1A:61:60:4D:76:40:B8:BA:5D:A1:3C:60:BC:57:98:35:20:79:80:FC
            X509v3 Authority Key Identifier:
                keyid:5A:BE:85:49:16:E5:EB:33:80:25:EB:D8:91:50:B4:E6:3E:4F:B8:22
```

```
    Signature Algorithm: ecdsa-with-SHA256
         30:66:02:31:00:9a:6d:fd:7d:ab:ae:54:9a:81:71:e6:bb:ad:
         5a:2e:dc:1d:b3:8a:bf:ce:ee:71:4e:8f:d9:93:7f:a3:48:a1:
         5c:17:cb:22:fa:8f:b3:e5:76:89:06:9f:96:47:dc:34:87:02:
         31:00:e3:af:2a:8f:d6:8d:1f:3a:2b:ae:2f:97:b3:52:63:b6:
         18:67:70:2c:93:2a:41:c0:e7:fa:93:20:09:4d:f4:bf:d0:11:
         66:0f:48:56:01:1e:c3:be:37:4e:49:19:cf:c6
```

Create a PKI domain named **server384** for verifying the server's certificate **ecdsa384** and enter its view.

```
[SwitchA] pki domain server384
```

Disable CRL checking.

```
[SwitchA-pki-domain-server384] undo crl check enable
[SwitchA-pki-domain-server384] quit
```

Import local certificate file **ssh-server-ecdsa384.p12** to PKI domain **server384**.

```
[SwitchA] pki import domain server384 p12 local filename ssh-server-ecdsa384.p12
The system is going to save the key pair. You must specify a key pair name, which is
a case-insensitive string of 1 to 64 characters. Valid characters include a to z, A
to Z, 0 to 9, and hyphens (-).
Please enter the key pair name[default name: server384]:
```

Display information about local certificates in PKI domain **server384**.

```
[SwitchA] display pki certificate domain server384 local
Certificate:
    Data:
        Version: 3 (0x2)
        Serial Number: 1 (0x1)
    Signature Algorithm: ecdsa-with-SHA384
        Issuer: C=CN, ST=Beijing, L=Beijing, O=H3C, OU=Software, CN=SuiteB CA
        Validity
            Not Before: Aug 20 10:08:41 2015 GMT
            Not After : Aug 19 10:08:41 2016 GMT
        Subject: C=CN, ST=Beijing, O=H3C, OU=Software, CN=ssh server
        Subject Public Key Info:
            Public Key Algorithm: id-ecPublicKey
                Public-Key: (384 bit)
                pub:
                    04:4a:33:e5:99:8d:49:45:a7:a3:24:7b:32:6a:ed:
                    b6:36:e1:4d:cc:8c:05:22:f4:3a:7c:5d:b7:be:d1:
                    e6:9e:f0:ce:95:39:ca:fd:a0:86:cd:54:ab:49:60:
                    10:be:67:9f:90:3a:18:e2:7d:d9:5f:72:27:09:e7:
                    bf:7e:64:0a:59:bb:b3:7d:ae:88:14:94:45:b9:34:
                    d2:f3:93:e1:ba:b4:50:15:eb:e5:45:24:31:10:c7:
                    07:01:f9:dc:a5:6f:81
                ASN1 OID: secp384r1
                NIST CURVE: P-384
        X509v3 extensions:
            X509v3 Basic Constraints:
                CA:FALSE
            Netscape Comment:
```

```
                OpenSSL Generated Certificate
            X509v3 Subject Key Identifier:
                10:16:64:2C:DA:C1:D1:29:CD:C0:74:40:A9:70:BD:62:8A:BB:F4:D5
            X509v3 Authority Key Identifier:
                keyid:5A:BE:85:49:16:E5:EB:33:80:25:EB:D8:91:50:B4:E6:3E:4F:B8:22

    Signature Algorithm: ecdsa-with-SHA384
         30:65:02:31:00:80:50:7a:4f:c5:cd:6a:c3:57:13:7f:e9:da:
         c1:72:7f:45:30:17:c2:a7:d3:ec:73:3d:5f:4d:e3:96:f6:a3:
         33:fb:e4:b9:ff:47:f1:af:9d:e3:03:d2:24:53:40:09:5b:02:
         30:45:d1:bf:51:fd:da:22:11:90:03:f9:d4:05:ec:d6:7c:41:
         fc:9d:a1:fd:5b:8c:73:f8:b6:4c:c3:41:f7:c6:7f:2f:05:2d:
         37:f8:52:52:26:99:28:97:ac:6e:f9:c7:01
```

Create a PKI domain named **client384** for the client's certificate **ecdsa384** and enter its view.

```
[SwitchA] pki domain client384
```

Disable CRL checking.

```
[SwitchA-pki-domain-client384] undo crl check enable
[SwitchA-pki-domain-client384] quit
```

Import local certificate file **ssh-client-ecdsa384.p12** to PKI domain **client384**.

```
[SwitchA] pki import domain client384 p12 local filename ssh-client-ecdsa384.p12
The system is going to save the key pair. You must specify a key pair name, which is
a case-insensitive string of 1 to 64 characters. Valid characters include a to z, A
to Z, 0 to 9, and hyphens (-).
Please enter the key pair name[default name: client384]:
```

Display information about local certificates in PKI domain **client384**.

```
[SwitchA] display pki certificate domain client384 local
Certificate:
    Data:
        Version: 3 (0x2)
        Serial Number: 2 (0x2)
    Signature Algorithm: ecdsa-with-SHA384
        Issuer: C=CN, ST=Beijing, L=Beijing, O=H3C, OU=Software, CN=SuiteB CA
        Validity
            Not Before: Aug 20 10:10:59 2015 GMT
            Not After : Aug 19 10:10:59 2016 GMT
        Subject: C=CN, ST=Beijing, O=H3C, OU=Software, CN=ssh client
        Subject Public Key Info:
            Public Key Algorithm: id-ecPublicKey
                Public-Key: (384 bit)
                pub:
                    04:85:7c:8b:f4:7a:36:bf:74:f6:7c:72:f9:08:69:
                    d0:b9:ac:89:98:17:c9:fc:89:94:43:da:9a:a6:89:
                    41:d3:72:24:9b:9a:29:a8:d1:ba:b4:e5:77:ba:fc:
                    df:ae:c6:dd:46:72:ab:bc:d1:7f:18:7d:54:88:f6:
                    b4:06:54:7e:e7:4d:49:b4:07:dc:30:54:4b:b6:5b:
                    01:10:51:6b:0c:6d:a3:b1:4b:c9:d9:6c:d6:be:13:
                    91:70:31:2a:92:00:76
                ASN1 OID: secp384r1
```

```
                NIST CURVE: P-384
            X509v3 extensions:
                X509v3 Basic Constraints:
                    CA:FALSE
                Netscape Comment:
                    OpenSSL Generated Certificate
                X509v3 Subject Key Identifier:
                    BD:5F:8E:4F:7B:FE:74:03:5A:D1:94:DB:CA:A7:82:D6:F7:78:A1:B0
                X509v3 Authority Key Identifier:
                    keyid:5A:BE:85:49:16:E5:EB:33:80:25:EB:D8:91:50:B4:E6:3E:4F:B8:22

        Signature Algorithm: ecdsa-with-SHA384
             30:66:02:31:00:d2:06:fa:2c:0b:0d:f0:81:90:01:c3:3d:bf:
             97:b3:79:d8:25:a0:e2:0e:ed:00:c9:48:3e:c9:71:43:c9:b4:
             2a:a6:0a:27:80:9e:d4:0f:f2:db:db:5b:40:b1:a9:0a:e4:02:
             31:00:ee:00:e1:07:c0:2f:12:3f:88:ea:fe:19:05:ef:56:ca:
             33:71:75:5e:11:c9:a6:51:4b:3e:7c:eb:2a:4d:87:2b:71:7c:
             30:64:fe:14:ce:06:d5:0a:e2:cf:9a:69:19:ff
```

Assign an IP address to VLAN-interface 2.

```
[SwitchA] interface vlan-interface 2
[SwitchA-Vlan-interface2] ip address 192.168.0.2 255.255.255.0
[SwitchA-Vlan-interface2] quit
```

3. Configure the SCP server:

Upload the server's certificate files (**ssh-server-ecdsa256.p12** and **ssh-server-ecdsa384.p12**) and the client's certificate files (**ssh-client-ecdsa256.p12** and **ssh-client-ecdsa384.p12**) to the SCP server through FTP or TFTP. (Details not shown.)

Create a PKI domain named **client256** for verifying the client's certificate **ecdsa256** and import the file of this certificate to this domain. Create a PKI domain named **server256** for the server's certificate **ecdsa256** and import the file of this certificate to this domain. (Details not shown.)

Create a PKI domain named **client384** for verifying the client's certificate **ecdsa384** and import the file of this certificate to this domain. Create a PKI domain named **server384** for the server's certificate **ecdsa384** and import the file of this certificate to this domain. (Details not shown.)

Specify Suite B algorithms for algorithm negotiation.

```
<SwitchB> system-view
[SwitchB] ssh2 algorithm key-exchange ecdh-sha2-nistp256 ecdh-sha2-nistp384
[SwitchB] ssh2 algorithm cipher aes128-gcm aes256-gcm
[SwitchB] ssh2 algorithm public-key x509v3-ecdsa-sha2-nistp256
x509v3-ecdsa-sha2-nistp384
```

Enable the SCP server.

```
[SwitchB] scp server enable
```

Assign an IP address to VLAN-interface 2.

```
[SwitchB] interface vlan-interface 2
[SwitchB-Vlan-interface2] ip address 192.168.0.1 255.255.255.0
[SwitchB-Vlan-interface2] quit
```

Set the authentication mode to AAA for user lines.

```
[SwitchB] line vty 0 63
[SwitchB-line-vty0-63] authentication-mode scheme
```

```
[SwitchB-line-vty0-63] quit
```

Create a local device management user named **client001**. Authorize the user to use the **SSH** service and assign the **network-admin** user role to the user.

```
[SwitchB] local-user client001 class manage
[SwitchB-luser-manage-client001] service-type ssh
[SwitchB-luser-manage-client001] authorization-attribute user-role network-admin
[SwitchB-luser-manage-client001] quit
```

Create a local device management user named **client002**. Authorize the user to use the **SSH** service and assign the **network-admin** user role to the user.

```
[SwitchB] local-user client002 class manage
[SwitchB-luser-manage-client002] service-type ssh
[SwitchB-luser-manage-client002] authorization-attribute user-role network-admin
[SwitchB-luser-manage-client002] quit
```

4. Establish an SCP connection to the SCP server:

- Based on the 128-bit Suite B algorithms:

  # Specify **server256** as the PKI domain of the server's certificate.

  ```
  [SwitchB]ssh server pki-domain server256
  ```

  # Create an SSH user **client001**. Specify the **publickey** authentication method for the user and specify **client256** as the PKI domain for verifying the client's certificate.

  ```
  [SwitchB] ssh user client001 service-type scp authentication-type publickey assign pki-domain client256
  ```

  # Establish an SCP connection to the SCP server at 192.168.0.1 based on the 128-bit Suite B algorithms.

  ```
  <SwitchA> scp 192.168.0.1 get src.cfg suite-b 128-bit pki-domain client256 server-pki
  -domain server256
  Username: client001
  Press CTRL+C to abort.
  Connecting to 192.168.0.1 port 22.
  src.cfg                                       100% 4814     4.7KB/s   00:00
  <SwitchA>
  ```

- Based on the 192-bit Suite B algorithms:

  # Specify **server384** as the PKI domain of the server's certificate.

  ```
  [SwitchB] ssh server pki-domain server384
  ```

  # Create an SSH user **client002**. Specify the **publickey** authentication method for the user and specify **client384** as the PKI domain for verifying the client's certificate.

  ```
  [Switch] ssh user client002 service-type scp authentication-type publickey assign pki-domain client384
  ```

  # Establish an SCP connection to the SCP server at 192.168.0.1 based on the 192-bit Suite B algorithms.

  ```
  <SwitchA> scp 192.168.0.1 get src.cfg suite-b 192-bit pki-domain client384 server-pki
  -domain server384
  Username: client002
  Press CTRL+C to abort.
  Connecting to 192.168.0.1 port 22.
  src.cfg                                       100% 4814     4.7KB/s   00:00
  <SwitchA>
  ```

NETCONF over SSH configuration examples

Unless otherwise noted, devices in the configuration examples are in non-FIPS mode.

When the device acts as a NETCONF-over-SSH server operating in FIPS mode, only ECDSA and RSA key pairs are supported. Do not generate a DSA key pair on the NETCONF-over-SSH server.

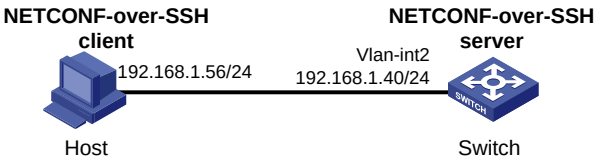
Example: Configuring NETCONF over SSH with password authentication

Network configuration

As shown in Figure 19:

- The switch acts as the NETCONF-over-SSH server and uses password authentication to authenticate the client. The client's username and password are saved on the switch.
- The host acts as the NETCONF-over-SSH client, using SSH2 client software. After the user on the host logs in to the switch through NETCONF over SSH, the user can perform NETCONF operations on the switch as a network administrator.

Figure 19 Network diagram



Procedure

Generate RSA key pairs.

```
<Switch> system-view
[Switch] public-key local create rsa
The range of public key modulus is (512 ~ 4096).
If the key modulus is greater than 512, it will take a few minutes.
Press CTRL+C to abort.
Input the modulus length [default = 1024]:
Generating Keys...
.....................++++++
.................++++++
..++++++++
............++++++++
Create the key pair successfully.
```

Generate a DSA key pair.

```
[Switch] public-key local create dsa
The range of public key modulus is (512 ~ 2048).
If the key modulus is greater than 512, it will take a few minutes.
Press CTRL+C to abort.
Input the modulus length [default = 1024]:
Generating Keys...
.++++++++++++++++++++++++++++++++++++++++++++++++++*
........+......+.....+.....................................+
```

```
...+.................+.........+...+.
Create the key pair successfully.
```

Generate an ECDSA key pair.

```
[Switch] public-key local create ecdsa secp256r1
Generating Keys...
.
Create the key pair successfully.
```

Enable NETCONF over SSH.

```
[Switch] netconf ssh server enable
```

Configure an IP address for VLAN-interface 2. The client uses this address as the destination for NETCONF-over-SSH connection.

```
[Switch] interface vlan-interface 2
[Switch-Vlan-interface2] ip address 192.168.1.40 255.255.255.0
[Switch-Vlan-interface2] quit
```

Set the authentication mode to AAA for user lines.

```
[Switch] line vty 0 63
[Switch-line-vty0-63] authentication-mode scheme
[Switch-line-vty0-63] quit
```

Create a local device management user named **client001**.

```
[Switch] local-user client001 class manage
```

Set the password to **hello12345** in plain text for local user **client001**.

```
[Switch-luser-manage-client001] password simple hello12345
```

Authorize local user **client001** to use the **SSH** service.

```
[Switch-luser-manage-client001] service-type ssh
```

Assign the **network-admin** user role to local user **client001**.

```
[Switch-luser-manage-client001] authorization-attribute user-role network-admin
[Switch-luser-manage-client001] quit
```

Create an SSH user named **client001**. Specify the service type as **NETCONF** and the authentication method as **password** for the user.

```
[Switch] ssh user client001 service-type netconf authentication-type password
```

Verifying the configuration

Verify that you can perform NETCONF operations after logging in to the switch. (Details not shown.)

Contents

Configuring SSL

About SSL

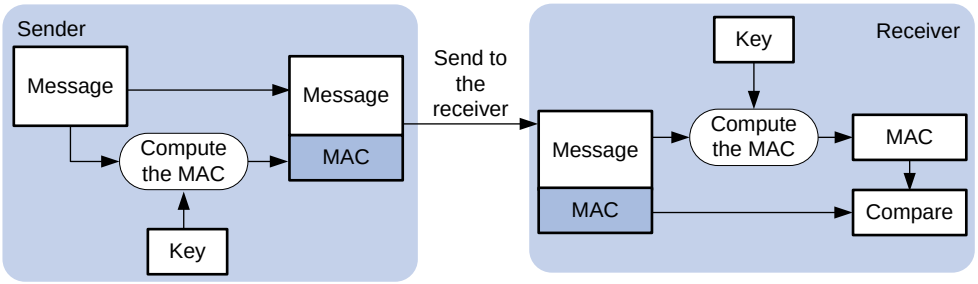
Secure Sockets Layer (SSL) is a cryptographic protocol that provides communication security for TCP-based application layer protocols such as HTTP. SSL has been widely used in applications such as e-business and online banking to provide secure data transmission over the Internet.

SSL security services

SSL provides the following security services:

- **Privacy**—SSL uses a symmetric encryption algorithm to encrypt data. It uses the asymmetric key algorithm of RSA to encrypt the key used by the symmetric encryption algorithm. For more information about RSA, see "Managing public keys."
- **Authentication**—SSL uses certificate-based digital signatures to authenticate the SSL server and client. The SSL server and client obtain digital certificates through PKI. For more information about PKI and digital certificates, see "Configuring PKI."
- **Integrity**—SSL uses the message authentication code (MAC) to verify message integrity. It uses a MAC algorithm and a key to transform a message of any length to a fixed-length message. Any change to the original message will result in a change to the calculated fixed-length message. As shown in Figure 1, the message integrity verification process is as follows:
  - **a.** The sender uses a MAC algorithm and a key to calculate a MAC value for a message. Then, it appends the MAC value to the message and sends the message to the receiver.
  - **b.** The receiver uses the same key and MAC algorithm to calculate a MAC value for the received message, and compares it with the MAC value appended to the message.
  - **c.** If the two MAC values match, the receiver considers the message intact. Otherwise, the receiver considers that the message was tampered with and it discards the message.

Figure 1 MAC algorithm diagram

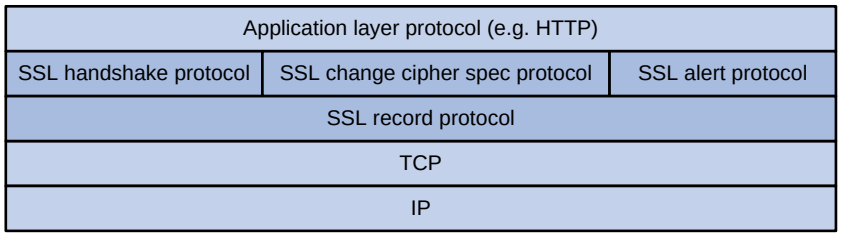


SSL protocol stack

The SSL protocol stack includes the following protocols:

- SSL record protocol at the lower layer.
- SSL handshake protocol, SSL change cipher spec protocol, and SSL alert protocol at the upper layer.

Figure 2 SSL protocol stack



The following describes the major functions of SSL protocols:

- **SSL record protocol**—Fragments data received from the upper layer, computes and adds MAC to the data, and encrypts the data.
- **SSL handshake protocol**—Negotiates the cipher suite used for secure communication, authenticates the server and client, and securely exchanges the keys between the server and client. The cipher suite that needs to be negotiated includes the symmetric encryption algorithm, key exchange algorithm, and MAC algorithm.
- **SSL change cipher spec protocol**—Notifies the receiver that subsequent packets are to be protected based on the negotiated cipher suite and key.
- **SSL alert protocol**—Sends alert messages to the receiving party. An alert message contains the alert severity level and a description.

SSL protocol versions

SSL protocol versions include SSL 2.0, SSL 3.0, TLS 1.0 (or SSL 3.1), TLS 1.1, and TLS 1.2. Because SSL 3.0 is known to be insecure, you can disable SSL 3.0 for the SSL server to ensure security.

FIPS compliance

The device supports the FIPS mode that complies with NIST FIPS 140-2 requirements. Support for features, commands, and parameters might differ in FIPS mode (see "Configuring FIPS") and non-FIPS mode.

Restrictions and guidelines: SSL configuration

By default, the SSL server can communicate with clients running all SSL protocol versions. When the server receives an SSL 2.0 Client Hello message from a client, it notifies the client to use a later version for communication.

SSL tasks at a glance

Configuring the SSL server

- Configuring an SSL server policy
- (Optional.) Disabling SSL protocol versions for the SSL server
- (Optional.) Disabling SSL session renegotiation

Configuring the SSL client

Configuring an SSL server policy

About SSL server policies

An SSL server policy is a set of SSL parameters used by the device when the device acts as the SSL server. An SSL server policy takes effect only after it is associated with an application such as HTTPS.

Procedure

1. Enter system view.

   system-view

2. Create an SSL server policy and enter its view.

   ssl server-policy *policy-name*

3. Specify a PKI domain for the SSL server policy.

   pki-domain *domain-name*

   By default, no PKI domain is specified for an SSL server policy.

   If SSL server authentication is required, you must specify a PKI domain and request a local certificate for the SSL server in the domain.

   For information about configuring a PKI domain, see "Configuring PKI."

4. Specify the cipher suites that the SSL server policy supports.

   In non-FIPS mode:

   ciphersuite { **dhe_rsa_aes_128_cbc_sha** | **dhe_rsa_aes_128_cbc_sha256** | **dhe_rsa_aes_256_cbc_sha** | **dhe_rsa_aes_256_cbc_sha256** | **ecdhe_ecdsa_aes_128_cbc_sha256** | **ecdhe_ecdsa_aes_128_gcm_sha256** | **ecdhe_ecdsa_aes_256_cbc_sha384** | **ecdhe_ecdsa_aes_256_gcm_sha384** | **ecdhe_rsa_aes_128_cbc_sha256** | **ecdhe_rsa_aes_128_gcm_sha256** | **ecdhe_rsa_aes_256_cbc_sha384** | **ecdhe_rsa_aes_256_gcm_sha384** | **exp_rsa_des_cbc_sha** | **exp_rsa_rc2_md5** | **exp_rsa_rc4_md5** | **rsa_3des_ede_cbc_sha** | **rsa_aes_128_cbc_sha** | **rsa_aes_128_cbc_sha256** | **rsa_aes_256_cbc_sha** | **rsa_aes_256_cbc_sha256** | **rsa_des_cbc_sha** | **rsa_rc4_128_md5** | **rsa_rc4_128_sha** } *

   In FIPS mode:

   ciphersuite { **ecdhe_ecdsa_aes_128_cbc_sha256** | **ecdhe_ecdsa_aes_256_cbc_sha384** | **ecdhe_ecdsa_aes_128_gcm_sha256** | **ecdhe_ecdsa_aes_256_gcm_sha384** | **ecdhe_rsa_aes_128_cbc_sha256** | **ecdhe_rsa_aes_128_gcm_sha256** | **ecdhe_rsa_aes_256_cbc_sha384** | **ecdhe_rsa_aes_256_gcm_sha384** | **rsa_aes_128_cbc_sha** | **rsa_aes_128_cbc_sha256** | **rsa_aes_256_cbc_sha** | **rsa_aes_256_cbc_sha256** } *

   By default, an SSL server policy supports all cipher suites.

5. (Optional.) Set the maximum number of sessions that the SSL server can cache and the session cache timeout time.

   session { **cachesize** *size* | **timeout** *time* } *

   By default, the SSL server can cache a maximum of 500 sessions, and the session cache timeout time is 3600 seconds.

6. Enable mandatory or optional SSL client authentication.

client-verify { **enable** | **optional** }

By default, SSL client authentication is disabled. The SSL server does not perform digital certificate-based authentication on SSL clients.

When authenticating a client by using the digital certificate, the SSL server verifies the certificate chain presented by the client. It also verifies that the certificates in the certificate chain (except the root CA certificate) are not revoked.

7. (Optional.) Enable the SSL server to send the complete certificate chain to the client during SSL negotiation.

   certificate-chain-sending enable

   By default, the SSL server sends the server certificate rather than the complete certificate chain to the client during negotiation.

Configuring an SSL client policy

About SSL client policies

An SSL client policy is a set of SSL parameters used by the device when the device acts as the SSL client. The SSL client uses the settings in the client policy to establish a connection to the server. An SSL client policy takes effect only after it is associated with an application.

Restrictions and guidelines

As a best practice to enhance system security, do not specify SSL 3.0 for the SSL client policy.

Procedure

1. Enter system view.

   system-view

2. Create an SSL client policy and enter its view.

   ssl client-policy *policy-name*

3. Specify a PKI domain for the SSL client policy.

   pki-domain *domain-name*

   By default, no PKI domain is specified for an SSL client policy.

   If SSL client authentication is required, you must specify a PKI domain and request a local certificate for the SSL client in the PKI domain.

   For information about configuring a PKI domain, see "Configuring PKI."

4. Specify the preferred cipher suite for the SSL client policy.

   In non-FIPS mode:

   prefer-cipher { **dhe_rsa_aes_128_cbc_sha** | **dhe_rsa_aes_128_cbc_sha256** | **dhe_rsa_aes_256_cbc_sha** | **dhe_rsa_aes_256_cbc_sha256** | **ecdhe_ecdsa_aes_128_cbc_sha256** | **ecdhe_ecdsa_aes_128_gcm_sha256** | **ecdhe_ecdsa_aes_256_cbc_sha384** | **ecdhe_ecdsa_aes_256_gcm_sha384** | **ecdhe_rsa_aes_128_cbc_sha256** | **ecdhe_rsa_aes_128_gcm_sha256** | **ecdhe_rsa_aes_256_cbc_sha384** | **ecdhe_rsa_aes_256_gcm_sha384** | **exp_rsa_des_cbc_sha** | **exp_rsa_rc2_md5** | **exp_rsa_rc4_md5** | **rsa_3des_ede_cbc_sha** | **rsa_aes_128_cbc_sha** | **rsa_aes_128_cbc_sha256** | **rsa_aes_256_cbc_sha** | **rsa_aes_256_cbc_sha256** | **rsa_des_cbc_sha** | **rsa_rc4_128_md5** | **rsa_rc4_128_sha** }

   The default preferred cipher suite in non-FIPS mode is **rsa_rc4_128_md5**.

   In FIPS mode:

   prefer-cipher { **ecdhe_ecdsa_aes_128_cbc_sha256** | **ecdhe_ecdsa_aes_128_gcm_sha256** | **ecdhe_ecdsa_aes_256_cbc_sha384** |

ecdhe_ecdsa_aes_256_gcm_sha384 | **ecdhe_rsa_aes_128_cbc_sha256** | **ecdhe_rsa_aes_128_gcm_sha256** | **ecdhe_rsa_aes_256_cbc_sha384** | **ecdhe_rsa_aes_256_gcm_sha384** | **rsa_aes_128_cbc_sha** | **rsa_aes_128_cbc_sha256** | **rsa_aes_256_cbc_sha** | **rsa_aes_256_cbc_sha256** }

The default preferred cipher suite in FIPS mode is **rsa_aes_128_cbc_sha**.

5. Specify the SSL protocol version for the SSL client policy.

   In non-FIPS mode:

   version { **ssl3.0** | **tls1.0** | **tls1.1** | **tls1.2** }

   In FIPS mode:

   version { **tls1.0** | **tls1.1** | **tls1.2** }

   By default, an SSL client policy uses TLS 1.0.

6. Enable the SSL client to authenticate servers through digital certificates.

   server-verify enable

   By default, SSL server authentication is enabled.

Disabling SSL protocol versions for the SSL server

About disabling SSL protocol versions for the SSL server

To enhance system security, you can disable the SSL server from using specific SSL protocol versions (SSL 3.0, TLS 1.0, and TLS 1.1) for session negotiation.

Restrictions and guidelines

Disabling an SSL protocol version does not affect the availability of earlier SSL protocol versions. For example, if you execute the **ssl version tls1.1 disable** command, TLS 1.1 is disabled but TLS 1.0 is still available for the SSL server.

Procedure

1. Enter system view.

   system-view

2. Disable SSL protocol versions for the SSL server.

   In non-FIPS mode:

   ssl version { **ssl3.0** | **tls1.0** | **tls1.1** } * **disable**

   By default, the SSL server supports SSL 3.0, TLS 1.0, TLS 1.1, and TLS 1.2.

   In FIPS mode:

   ssl version { **tls1.0** | **tls1.1** } * **disable**

   By default, the SSL server supports TLS 1.0, TLS 1.1, and TLS 1.2.

Disabling SSL session renegotiation

About disabling SSL session renegotiation

The SSL session renegotiation feature enables the SSL client and server to reuse a previously negotiated SSL session for an abbreviated handshake.

Disabling session renegotiation causes more computational overhead to the system but it can avoid potential risks.

Restrictions and guidelines

Disable SSL session renegotiation only when explicitly required.

Procedure

1. Enter system view.
   `system-view`
2. Disable SSL session renegotiation.
   `ssl renegotiation disable`
   By default, SSL session renegotiation is enabled.

Display and maintenance commands for SSL

Execute **`display`** commands in any view.

Task	Command
Display SSL client policy information.	**`display ssl client-policy`** [*`policy-name`*]
Display SSL server policy information.	**`display ssl server-policy`** [*`policy-name`*]

SSL server policy configuration examples

Example: Configuring an SSL server policy

Network configuration

As shown in Figure 3, users need to access and manage the device through the Web page.

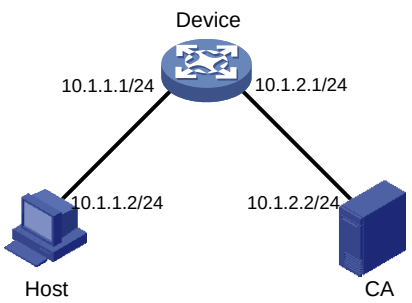
To protect the device and prevent data from being eavesdropped or tampered with, configure the device to be accessible through HTTPS only.

In this example, the CA server runs Windows Server and has the SCEP plug-in installed.

To meet the network requirements, perform the following tasks:

- Configure the device as the HTTPS server and request a server certificate for the device. For more information about HTTPS, see *Fundamentals Configuration Guide*.
- Request a client certificate for the host so that the device can authenticate the identity of the host.

Figure 3 Network diagram



Procedure

1. Make sure the device, the host, and the CA server can reach each other. (Details not shown.)
2. Configure the HTTPS server on the device:

   # Create a PKI entity named **en**. Set the common name and FQDN for the entity.

```
<Device> system-view
[Device] pki entity en
[Device-pki-entity-en] common-name http-server1
[Device-pki-entity-en] fqdn ssl.security.com
[Device-pki-entity-en] quit
```

   # Create PKI domain **1** and specify **CA server** as the name of the trusted CA. Set the URL of the registration server to **http://10.1.2.2/certsrv/mscep/mscep.dll**, the authority for certificate request to **RA**, and the entity for certificate request to **en**. Set the URL of the CRL repository to **http://10.1.2.2/CertEnroll/caserver.crl**.

```
[Device] pki domain 1
[Device-pki-domain-1] ca identifier CA server
[Device-pki-domain-1] certificate request url
http://10.1.2.2/certsrv/mscep/mscep.dll
[Device-pki-domain-1] certificate request from ra
[Device-pki-domain-1] certificate request entity en
[Device-pki-domain-1] crl url http://10.1.2.2/CertEnroll/caserver.crl
```

   # Configure a general-purpose RSA key pair named **abc** and set the key modulus length to 1024 bits.

```
[Device-pki-domain-1] public-key rsa general name abc length 1024
[Device-pki-domain-1] quit
```

   # Generate RSA key pair **abc**.

```
[Device] public-key local create rsa name abc
The range of public key size is (512 ~ 4096).
If the key modulus is greater than 512,it will take a few minutes.
Press CTRL+C to abort.
Input the modulus length [default = 1024]:
Generating Keys...
.........................++++++
.....................................++++++
Create the key pair successfully.
```

   # Obtain the CA certificate.

```
[Device] pki retrieve-certificate domain 1 ca
The trusted CA's finger print is:
    MD5  fingerprint:7682 5865 ACC2 7B16 6F52 D60F D998 4484
    SHA1 fingerprint:DF6B C53A E645 5C81 D6FC 09B0 3459 DFD1 94F6 3DDE
Is the finger print correct?(Y/N):y
Retrieved the certificates successfully.
```

   # Request a server certificate for the device.

```
[Device] pki request-certificate domain 1
Start to request general certificate ...
Certificate requested successfully.
```

   # Create an SSL server policy named **myssl**.

```
[Device] ssl server-policy myssl
```

   # Specify PKI domain **1** for the SSL server policy.

```
[Device-ssl-server-policy-myssl] pki-domain 1
```

Enable client authentication.

```
[Device-ssl-server-policy-myssl] client-verify enable
[Device-ssl-server-policy-myssl] quit
```

Configure the HTTPS service to use SSL server policy **myssl**.

```
[Device] ip https ssl-server-policy myssl
```

Enable the HTTPS service.

```
[Device] ip https enable
```

Create a local user named **usera**. Set the password to **hello12345**, service type to **https**, and user role to **network-admin**.

```
[Device] local-user usera
[Device-luser-usera] password simple hello12345
[Device-luser-usera] service-type https
[Device-luser-usera] authorization-attribute user-role network-admin
```

3. Request a client certificate for the host:
   a. Launch IE on the host, and then enter **http://10.1.2.2/certsrv** in the address bar.
   b. Request a client certificate for the host. (Details not shown.)

Verifying the configuration

Perform the following tasks on the host:

1. Launch IE and enter **https://10.1.1.1** in the address bar.
2. Select the certificate issued by the CA server to the host.

   The login page of the device should appear.
3. Enter username **usera** and password **123**.

   Verify that now you can log in to the Web interface to access and manage the device.

Contents

Configuring attack detection and prevention

Overview

Attack detection and prevention enables a device to detect attacks by inspecting arriving packets, and to take prevention actions (such as packet dropping) to protect a private network.

Attacks that the device can prevent

This section describes the attacks that the device can detect and prevent.

TCP fragment attack

An attacker launches TCP fragment attacks by sending attack TCP fragments defined in RFC 1858:

- First fragments in which the TCP header is smaller than 20 bytes.
- Non-first fragments with a fragment offset of 8 bytes (FO=1).

Typically, packet filter detects the source and destination IP addresses, source and destination ports, and transport layer protocol of the first fragment of a TCP packet. If the first fragment passes the detection, all subsequent fragments of the TCP packet are allowed to pass through.

Because the first fragment of attack TCP packets does not hit any match in the packet filter, the subsequent fragments can all pass through. After the receiving host reassembles the fragments, a TCP fragment attack occurs.

To prevent TCP fragment attacks, enable TCP fragment attack prevention to drop attack TCP fragments.

Login dictionary attack

The login dictionary attack is an automated process to attempt to log in by trying all possible passwords from a pre-arranged list of values (the dictionary). Multiple login attempts can occur in a short period of time.

You can configure the login delay feature to slow down the login dictionary attacks. This feature enables the device to delay accepting another login request after detecting a failed login attempt for a user.

Configuring TCP fragment attack prevention

About TCP fragment attack prevention

The TCP fragment attack prevention feature detects the length and fragment offset of received TCP fragments and drops attack TCP fragments.

Restrictions and guidelines

TCP fragment attack prevention takes precedence over single-packet attack prevention. When both are used, incoming TCP packets are processed first by TCP fragment attack prevention and then by the single-packet attack defense policy.

Procedure

1. Enter system view.

   system-view

2. Enable TCP fragment attack prevention.

   attack-defense tcp fragment enable

   By default, TCP fragment attack prevention is enabled.

Enabling login delay

About login delay

The login delay feature delays the device from accepting a login request from a user after the user fails a login attempt. This feature can slow down login dictionary attacks.

The login delay feature is independent of the login attack prevention feature.

Procedure

1. Enter system view.

   system-view

2. Enable the login delay feature.

   attack-defense login reauthentication-delay *seconds*

   By default, the login delay feature is disabled. The device does not delay accepting a login request from a user who has failed a login attempt.

Contents

Configuring TCP attack prevention

About TCP attack prevention

TCP attack prevention can detect and prevent attacks that exploit the TCP connection establishment process.

Configuring Naptha attack prevention

About Naptha attack prevention

Naptha is a DDoS attack that targets operating systems. It exploits the resources consuming vulnerability in TCP/IP stack and network application process. The attacker establishes a large number of TCP connections in a short period of time and leaves them in certain states without requesting any data. These TCP connections starve the victim of system resources, resulting in a system breakdown.

After you enable Naptha attack prevention, the device periodically checks the number of TCP connections in each state (CLOSING, ESTABLISHED, FIN_WAIT_1, FIN_WAIT_2, and LAST_ACK). If the number of TCP connections in a state exceeds the limit, the device will accelerate the aging of the TCP connections in that state to mitigate the Naptha attack.

Procedure

1. Enter system view.

   system-view

2. Enable Naptha attack prevention.

   tcp anti-naptha enable

   By default, Naptha attack prevention is disabled.

3. (Optional.) Set the maximum number of TCP connections in a state.

   tcp state { **closing** | **established** | **fin-wait-1** | **fin-wait-2** | **last-ack** } **connection-limit** *number*

   By default, the maximum number of TCP connections in each state (CLOSING, ESTABLISHED, FIN_WAIT_1, FIN_WAIT_2, and LAST_ACK) is 50.

   To disable the device from accelerating the aging of the TCP connections in a state, set the value to 0.

4. (Optional.) Set the interval for checking the number of TCP connections in each state.

   tcp check-state interval *interval*

   By default, the interval for checking the number of TCP connections in each state is 30 seconds.

Contents

Configuring IP source guard

About IPSG

IP source guard (IPSG) prevents spoofing attacks by using an IPSG binding table to filter out illegitimate packets. This feature is typically configured on user-side interfaces.

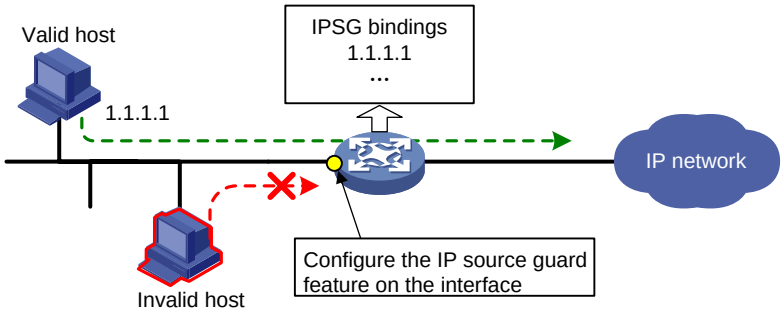
IPSG operating mechanism

The IPSG binding table contains bindings that bind IP address, MAC address, VLAN, or any combinations. IPSG uses the bindings to match an incoming packet. If a match is found, the packet is forwarded. If no match is found, the packet is discarded.

IPSG bindings can be static or dynamic.

As shown in Figure 1, IPSG forwards only the packets that match an IPSG binding.

Figure 1 IPSG application



Static IPSG bindings

Static IPSG bindings are configured manually. They are suitable for scenarios where few hosts exist on a LAN and their IP addresses are manually configured. For example, you can configure a static IPSG binding on an interface that connects to a server. This binding allows the interface to receive packets only from the server.

Static IPSG bindings on an interface implement the following functions:

- Filter incoming IPv4 or IPv6 packets on the interface.
- Cooperate with ARP attack detection in IPv4 for user validity checking. For information about ARP attack detection, see "Configuring ARP attack protection."
- Cooperate with ND attack detection in IPv6 for user validity checking. For information about ND attack detection, see "Configuring ND attack defense."

Static IPSG bindings can be global or interface-specific.

- **Global static binding**—Binds the IP address and MAC address in system view. The binding takes effect on all interfaces to filter packets for user spoofing attack prevention.
- **Interface-specific static binding**—Binds the IP address, MAC address, VLAN, or any combination of the items in interface view. The binding takes effect only on the interface to check the validity of users who are attempting to access the interface.

Dynamic IPSG bindings

IPSG automatically obtains user information from other modules to generate dynamic bindings. A dynamic IPSG binding can contain MAC address, IPv4 or IPv6 address, VLAN tag, ingress interface, and binding type. The binding type identifies the source module for the binding, such as DHCP snooping, DHCPv6 snooping, DHCP relay agent, or DHCPv6 relay agent.

For example, DHCP-based IPSG bindings are suitable for scenarios where hosts on a LAN obtain IP addresses through DHCP. IPSG is configured on the DHCP server, the DHCP snooping device, or the DHCP relay agent. It generates dynamic bindings based on the client bindings on the DHCP server, the DHCP snooping entries, or the DHCP relay entries. IPSG allows only packets from the DHCP clients to pass through.

Dynamic IPv4SG

Dynamic bindings generated based on different source modules are for different usages:

Interface types	Source modules	Binding usage
Layer 2 Ethernet port	DHCP snooping 802.1X	Packet filtering.
	ARP snooping	For cooperation with modules (such as the MFF module) to provide security services.
VLAN interface	DHCP relay agent	Packet filtering.
	DHCP server	For cooperation with modules (such as the authorized ARP module) to provide security services.

For more information about 802.1X, see "Configuring 802.1X." For information about ARP snooping, DHCP snooping, DHCP relay, and DHCP server, see *Layer 3—IP Services Configuration Guide*.

Dynamic IPv6SG

Dynamic IPv6SG bindings generated based on different source modules are for different usages:

Interface types	Source modules	Binding usage
Layer 2 Ethernet port	DHCPv6 snooping ND snooping 802.1X	Packet filtering.
VLAN interface	DHCPv6 relay agent	Packet filtering.

For more information about DHCPv6 snooping, see *Layer 3—IP Services Configuration Guide*. For more information about ND snooping, see IPv6 basics configuration in *Layer 3—IP Services Configuration Guide*. For more information about ND RA prefix entry recording, see IPv6 neighbor discovery in *Layer 3—IP Services Configuration Guide.* For more information about DHCPv6 relay agent, see *Layer 3—IP Services Configuration Guide*. For more information about DHCPv6 server, see *Layer 3—IP Services Configuration Guide.*

IPSG tasks at a glance

To configure IPv4SG, perform the following tasks:

1. Enabling IPv4SG
2. (Optional.) Configuring a static IPv4SG binding
3. (Optional.) Excluding IPv4 packets from IPSG filtering

To configure IPv6SG, perform the following tasks:

1. Enabling IPv6SG
2. (Optional.) Configuring a static IPv6SG binding

Configuring the IPv4SG feature

Enabling IPv4SG

About the IPv4SG feature on an interface

When you enable IPSG on an interface, the static and dynamic IPSG are both enabled.

- Static IPv4SG uses static bindings configured by using the **ip source binding** command. For more information, see "Configuring a static IPv4SG binding."
- Dynamic IPv4SG generates dynamic bindings from related source modules. IPv4SG uses the bindings to filter incoming IPv4 packets based on the matching criteria specified in the **ip verify source** command.

Restrictions and guidelines

To implement dynamic IPv4SG, make sure 802.1X, ARP snooping, DHCP snooping, DHCP relay agent, or DHCP server operates correctly on the network.

Enabling IPv4SG on an interface

1. Enter system view.
   system-view
2. Enter interface view.
   interface *interface-type interface-number*
   The following interface types are supported:
   - Layer 2 Ethernet interface.
   - VLAN interface.
3. Enable IPv4SG on the interface.
   ip verify source { **ip-address** | **ip-address mac-address** | **mac-address** }
   By default, IPv4SG is disabled on an interface.
   ip verify source trust

Configuring a static IPv4SG binding

About static IPv4SG bindings

You can configure global static and interface-specific static IPv4SG bindings. Global static bindings take priority over interface-specific static and dynamic bindings. An interface first uses global static bindings to match packets. If no match is found, the interface uses the static and dynamic bindings on the interface to match packets.

Restrictions and guidelines

Global static bindings take effect on all interfaces on the device.

To configure a static IPv4SG binding for the ARP attack detection feature, make sure the following conditions are met:

- The **ip-address** *ip-address* option, the **mac-address** *mac-address* option, and the **vlan** *vlan-id* option must be specified.

- ARP attack detection must be enabled for the specified VLAN.

Configuring a global static IPv4SG binding

1. Enter system view.
   system-view
2. Configure a global static IPv4SG binding.
   ip source binding ip-address *ip-address* **mac-address** *mac-address*

Configuring a static IPv4SG binding on an interface

1. Enter system view.
   system-view
2. Enter interface view.
   interface *interface-type interface-number*
   The following interface types are supported:
   - Layer 2 Ethernet interface.
   - VLAN interface.
3. Configure a static IPv4SG binding.
   ip source binding { **ip-address** *ip-address* | **ip-address** *ip-address* **mac-address** *mac-address* | **mac-address** *mac-address* } [**vlan** *vlan-id*]
   You can configure the same static IPv4SG binding on different interfaces.

Excluding IPv4 packets from IPSG filtering

About excluding IPv4 packets from IPSG filtering

By default, IPv4SG processes all incoming IPv4 packets on an interface and discards the packets that do not match IPSG bindings. To allow specific IPv4 packets that do not match any IPSG binding to pass through the interface, you can specify source items of the packets for IPSG filtering exemption. All IPv4 packets with the specified source items are forwarded without being processed by IPSG.

Procedure

1. Enter system view.
   system-view
2. Exclude IPv4 packets with the specified source items from IPSG filtering.
   ip verify source exclude vlan *start-vlan-id* [to *end-vlan-id*]
   By default, no excluded source items are configured.
   You can execute this command multiple times to specify multiple excluded VLANs. The specified excluded VLANs cannot overlap.

Configuring the IPv6SG feature

Enabling IPv6SG

About the IPv6SG feature on an interface

When you enable IPv6SG on an interface, the static and dynamic IPv6SG are both enabled.

- Static IPv6SG uses static bindings configured by using the **ipv6 source binding** command. For more information, see "Configuring a static IPv6SG binding."

- Dynamic IPv6SG generates dynamic bindings from related source modules. IPv6SG uses the bindings to filter incoming IPv6 packets based on the matching criteria specified in the **ipv6 verify source** command.

Restrictions and guidelines

To implement dynamic IPv6SG, make sure DHCPv6 snooping, DHCPv6 relay agent, or ND snooping operates correctly on the network.

Enabling IPv6SG on an interface

1. Enter system view.
   system-view
2. Enter interface view.
   interface *interface-type interface-number*
   The following interface types are supported:
   - Layer 2 Ethernet interface.
   - VLAN interface.
3. Enable IPv6SG on the interface.
   ipv6 verify source { **ip-address** | **ip-address mac-address** | **mac-address** }
   By default, IPv6SG is disabled on an interface.

Configuring a static IPv6SG binding

About static IPv6SG bindings

You can configure global static and interface-specific static IPv6SG bindings. Global static bindings take priority over interface-specific static and dynamic bindings. An interface first uses global static bindings to match packets. If no match is found, the interface uses the static and dynamic bindings on the interface to match packets.

Restrictions and guidelines

Global static bindings take effect on all interfaces on the device.

To configure a static IPv6SG binding for the ND attack detection feature, the **vlan** *vlan-id* option must be specified, and ND attack detection must be enabled for the specified VLAN.

Configuring a global static IPv6SG binding

1. Enter system view.
   system-view
2. Configure a global static IPv6SG binding.
   ipv6 source binding ip-address *ipv6-address* **mac-address** *mac-address*

Configuring a static IPv6SG binding on an interface

1. Enter system view.
   system-view
2. Enter interface view.
   interface *interface-type interface-number*
   The following interface types are supported:
   - Layer 2 Ethernet interface.
   - VLAN interface.
3. Configure a static IPv6SG binding.

ipv6 source binding { **ip-address** *ipv6-address* | **ip-address** *ipv6-address* **mac-address** *mac-address* | **mac-address** *mac-address* } [**vlan** *vlan-id*]

You can configure the same static IPv6SG binding on different interfaces.

Display and maintenance commands for IPSG

Execute **display** commands in any view and **reset** commands in user view.

Task	Command
Display IPv4SG bindings.	**display ip source binding** [**static** | [**arp-snooping-vlan** | **dhcp-relay** | **dhcp-server** | **dhcp-snooping** | **dot1x**]] [**ip-address** *ip-address*] [**mac-address** *mac-address*] [**vlan** *vlan-id*] [**interface** *interface-type interface-number*] [**slot** *slot-number*]
Display source items that have been configured to be excluded from IPSG filtering.	**display ip verify source excluded** [**vlan** *start-vlan-id* [**to** *end-vlan-id*]] [**slot** *slot-number*]
Display IPv6SG address bindings.	**display ipv6 source binding** [**static** | [**dhcpv6-server** | **dhcpv6-snooping** | **dot1x**]] [**ip-address** *ipv6-address*] [**mac-address** *mac-address*] [**vlan** *vlan-id*] [**interface** *interface-type interface-number*] [**slot** *slot-number*]
Display IPv6SG prefix bindings.	**display ipv6 source binding pd** [**prefix** *prefix/prefix-length*] [**mac-address** *mac-address*] [**vlan** *vlan-id*] [**interface** *interface-type interface-number*] [**slot** *slot-number*]

IPSG configuration examples

Example: Configuring static IPv4SG

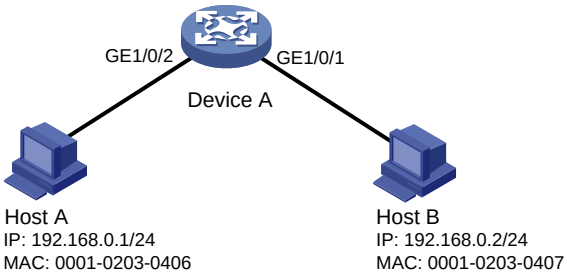
Network configuration

As shown in Figure 2, all hosts use static IP addresses.

Configure static IPv4SG bindings on Device A and Device B to meet the following requirements:

- All interfaces of Device A allow IP packets from Host A to pass.
- GigabitEthernet 1/0/1 of Device A allows IP packets from Host B to pass.

Figure 2 Network diagram



Procedure

Configure IP addresses for the interfaces. (Details not shown.)

Enable IPv4SG on GigabitEthernet 1/0/2.

```
<DeviceA> system-view
[DeviceA] interface gigabitethernet 1/0/2
[DeviceA-GigabitEthernet1/0/2] ip verify source ip-address mac-address
[DeviceA-GigabitEthernet1/0/2] quit
```

Configure a static IPv4SG binding for Host A.

```
[DeviceA] ip source binding ip-address 192.168.0.1 mac-address 0001-0203-0406
```

Enable IPv4SG on GigabitEthernet 1/0/1.

```
[DeviceA] interface gigabitethernet 1/0/1
[DeviceA-GigabitEthernet1/0/1] ip verify source ip-address mac-address
```

On GigabitEthernet 1/0/1, configure a static IPv4SG binding for Host B.

```
[DeviceA-GigabitEthernet1/0/1] ip source binding mac-address 0001-0203-0407
[DeviceA-GigabitEthernet1/0/1] quit
```

Verifying the configuration

Verify that the static IPv4SG bindings are configured successfully on Device A.

```
<DeviceA> display ip source binding static
Total entries found: 2
IP Address      MAC Address    Interface              VLAN Type
192.168.0.1     0001-0203-0406 N/A                    N/A  Static
N/A             0001-0203-0407 GE1/0/1                N/A  Static
```

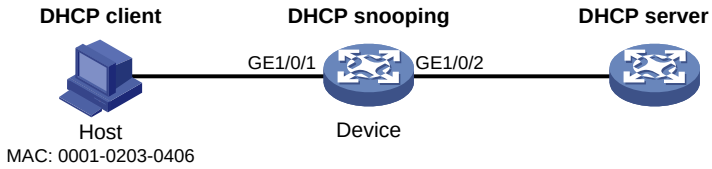
Example: Configuring DHCP snooping-based dynamic IPv4SG

Network configuration

As shown in Figure 3, the host (the DHCP client) obtains an IP address from the DHCP server. Perform the following tasks:

- Enable DHCP snooping on the device to make sure the DHCP client obtains an IP address from the authorized DHCP server. To generate a DHCP snooping entry for the DHCP client, enable recording of client information in DHCP snooping entries.
- Enable dynamic IPv4SG on GigabitEthernet 1/0/1 to filter incoming packets by using the IPv4SG bindings generated based on DHCP snooping entries. Only packets from the DHCP client are allowed to pass.

Figure 3 Network diagram



Procedure

1. Configure the DHCP server.

   For information about DHCP server configuration, see *Layer 3—IP Services Configuration Guide*.

2. Configure the device:

   # Configure IP addresses for the interfaces. (Details not shown.)

   # Enable DHCP snooping.

   ```
   <Device> system-view
   [Device] dhcp snooping enable
   ```

   # Configure GigabitEthernet 1/0/2 as a trusted interface.

   ```
   [Device] interface gigabitethernet 1/0/2
   [Device-GigabitEthernet1/0/2] dhcp snooping trust
   [Device-GigabitEthernet1/0/2] quit
   ```

   # Enable IPv4SG on GigabitEthernet 1/0/1 and verify the source IP address and MAC address for dynamic IPSG.

   ```
   [Device] interface gigabitethernet 1/0/1
   [Device-GigabitEthernet1/0/1] ip verify source ip-address mac-address
   ```

   # Enable recording of client information in DHCP snooping entries on GigabitEthernet 1/0/1.

   ```
   [Device-GigabitEthernet1/0/1] dhcp snooping binding record
   [Device-GigabitEthernet1/0/1] quit
   ```

Verifying the configuration

Display dynamic IPv4SG bindings generated based on DHCP snooping entries.

```
[Device] display ip source binding dhcp-snooping
Total entries found: 1
IP Address      MAC Address    Interface               VLAN Type
192.168.0.1     0001-0203-0406 GE1/0/1                 1    DHCP snooping
```

GigabitEthernet 1/0/1 will filter packets based on the IPv4SG binding.

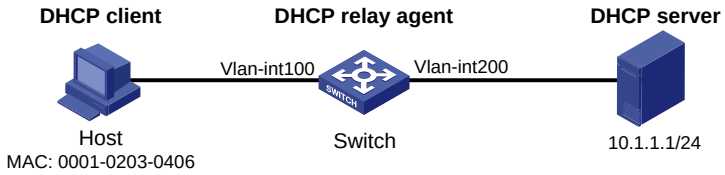
Example: Configuring DHCP relay agent-based dynamic IPv4SG

Network configuration

As shown in Figure 4, DHCP relay agent is enabled on the switch. The host obtains an IP address from the DHCP server through the DHCP relay agent.

Enable dynamic IPv4SG on VLAN-interface 100 to filter incoming packets by using the IPv4SG bindings generated based on DHCP relay entries.

Figure 4 Network diagram



Procedure

1. Configure dynamic IPv4SG:

   # Configure IP addresses for the interfaces. (Details not shown.)

   # Enable IPv4SG on VLAN-interface 100 and verify the source IP address and MAC address for dynamic IPSG.

   ```
   <Switch> system-view
   [Switch] interface vlan-interface 100
   [Switch-Vlan-interface100] ip verify source ip-address mac-address
   [Switch-Vlan-interface100] quit
   ```

2. Configure the DHCP relay agent:

   # Enable the DHCP service.

   ```
   [Switch] dhcp enable
   ```

   # Enable recording DHCP relay entries.

   ```
   [Switch] dhcp relay client-information record
   ```

   # Configure VLAN-interface 100 to operate in DHCP relay mode.

   ```
   [Switch] interface vlan-interface 100
   [Switch-Vlan-interface100] dhcp select relay
   ```

   # Specify the IP address of the DHCP server.

   ```
   [Switch-Vlan-interface100] dhcp relay server-address 10.1.1.1
   [Switch-Vlan-interface100] quit
   ```

Verifying the configuration

Display dynamic IPv4SG bindings generated based on DHCP relay entries.

```
[Switch] display ip source binding dhcp-relay
Total entries found: 1
IP Address      MAC Address    Interface               VLAN Type
192.168.0.1     0001-0203-0406 Vlan100                 100  DHCP relay
```

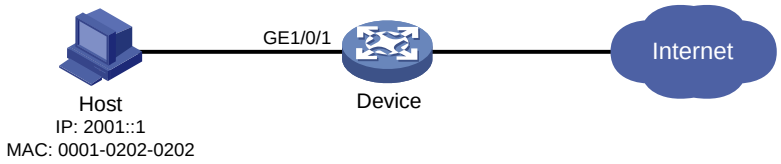
VLAN-interface 100 will filter packets based on the IPv4SG binding.

Example: Configuring static IPv6SG

Network configuration

As shown in Figure 5, configure a static IPv6SG binding on GigabitEthernet 1/0/1 of the device to allow only IPv6 packets from the host to pass.

Figure 5 Network diagram



Procedure

Enable IPv6SG on GigabitEthernet 1/0/1.

```
<Device> system-view
[Device] interface gigabitethernet 1/0/1
[Device-GigabitEthernet1/0/1] ipv6 verify source ip-address mac-address
```

On GigabitEthernet 1/0/1, configure a static IPv6SG binding for the host.

```
[Device-GigabitEthernet1/0/1] ipv6 source binding ip-address 2001::1 mac-address
0001-0202-0202
[Device-GigabitEthernet1/0/1] quit
```

Verifying the configuration

Verify that the static IPv6SG binding is configured successfully on the device.

```
[Device] display ipv6 source binding static
Total entries found: 1
IPv6 Address         MAC Address    Interface             VLAN Type
2001::1              0001-0202-0202 GE1/0/1               N/A  Static
```

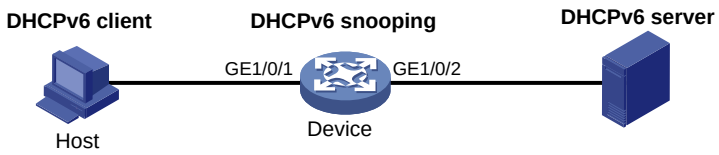
Example: Configuring DHCPv6 snooping-based dynamic IPv6SG address bindings

Network configuration

As shown in Figure 6, the host (the DHCPv6 client) obtains an IP address from the DHCPv6 server. Perform the following tasks:

- Enable DHCPv6 snooping on the device to make sure the DHCPv6 client obtains an IPv6 address from the authorized DHCPv6 server. To generate a DHCPv6 snooping entry for the DHCPv6 client, enable recording of client information in DHCPv6 snooping entries.
- Enable dynamic IPv6SG on GigabitEthernet 1/0/1 to filter incoming packets by using the IPv6SG bindings generated based on DHCPv6 snooping entries. Only packets from the DHCPv6 client are allowed to pass.

Figure 6 Network diagram



Procedure

1. Configure DHCPv6 snooping:

   # Enable DHCPv6 snooping globally.

   ```
   <Device> system-view
   [Device] ipv6 dhcp snooping enable
   ```

Configure GigabitEthernet 1/0/2 as a trusted interface.

```
[Device] interface gigabitethernet 1/0/2
[Device-GigabitEthernet1/0/2] ipv6 dhcp snooping trust
[Device-GigabitEthernet1/0/2] quit
```

2. Enable IPv6SG:

   # Enable IPv6SG on GigabitEthernet 1/0/1 and verify the source IP address and MAC address for dynamic IPv6SG.

```
[Device] interface gigabitethernet 1/0/1
[Device-GigabitEthernet1/0/1] ipv6 verify source ip-address mac-address
```

   # Enable recording of client information in DHCPv6 snooping entries on GigabitEthernet 1/0/1.

```
[Device-GigabitEthernet1/0/1] ipv6 dhcp snooping binding record
[Device-GigabitEthernet1/0/1] quit
```

Verifying the configuration

Display dynamic IPv6SG bindings generated based on DHCPv6 snooping entries.

```
[Device] display ipv6 source binding dhcpv6-snooping
Total entries found: 1
IPv6 Address         MAC Address    Interface              VLAN Type
2001::1              040a-0000-0001 GE1/0/1                1    DHCPv6 snooping
```

GigabitEthernet 1/0/1 will filter packets based on the IPv6SG binding.

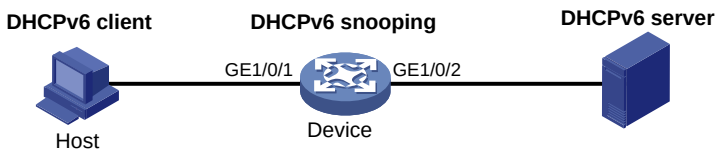
Example: Configuring DHCPv6 snooping-based dynamic IPv6SG prefix bindings

Network configuration

As shown in Figure 7, the host (the DHCPv6 client) obtains an IPv6 prefix from the DHCPv6 server. Perform the following tasks:

- Enable DHCPv6 snooping on the device to make sure the DHCPv6 client obtains an IPv6 prefix from the authorized DHCPv6 server. To generate a DHCPv6 snooping prefix entry for the DHCPv6 client, enable recording IPv6 prefix information in DHCPv6 snooping entries.
- Enable dynamic IPv6SG on GigabitEthernet 1/0/1 to filter incoming packets by using the IPv6SG bindings generated based on DHCPv6 snooping prefix entries. Only packets from the DHCPv6 client are allowed to pass.

Figure 7 Network diagram



Procedure

1. Configure DHCPv6 snooping.

   # Enable DHCPv6 snooping globally.

```
<Device> system-view
[Device] ipv6 dhcp snooping enable
```

   # Configure GigabitEthernet 1/0/2 as a trusted interface.

```
[Device] interface gigabitethernet 1/0/2
[Device-GigabitEthernet1/0/2] ipv6 dhcp snooping trust
```

```
[Device-GigabitEthernet1/0/2] quit
```

Enable recording DHCPv6 snooping prefix entries on GigabitEthernet 1/0/1.

```
[Device] interface gigabitethernet 1/0/1
[Device-GigabitEthernet1/0/1] ipv6 dhcp snooping pd binding record
```

2. Enable IPv6SG.

Enable IPv6SG on GigabitEthernet 1/0/1 and verify the source IP address and MAC address for dynamic IPv6SG.

```
[Device-GigabitEthernet1/0/1] ipv6 verify source ip-address mac-address
[Device-GigabitEthernet1/0/1] quit
```

Verifying the configuration

Display dynamic IPv6SG bindings generated based on DHCPv6 snooping entries.

```
[Device] display ipv6 source binding pd
Total entries found: 1
IPv6 prefix          MAC address    Interface              VLAN
2001:410:1::/48      0010-9400-0004 GE1/0/1                1
```

GigabitEthernet 1/0/1 will filter packets based on the IPv6SG binding.

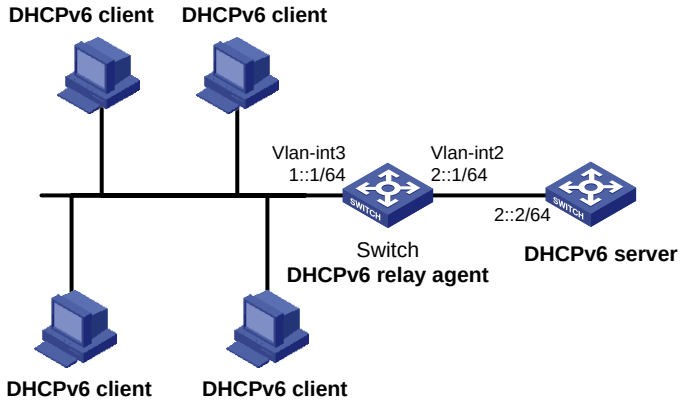
Example: Configuring DHCPv6 relay agent-based dynamic IPv6SG

Network configuration

As shown in Figure 8, DHCPv6 relay agent is enabled on the switch. The clients obtain IPv6 addresses from the DHCPv6 server through the DHCPv6 relay agent.

Enable dynamic IPv6SG on VLAN-interface 3 to filter incoming packets by using the IPv6SG bindings generated based on DHCPv6 relay entries.

Figure 8 Network diagram



Procedure

1. Configure the DHCPv6 relay agent:

Create VLAN 2 and VLAN 3, assign interfaces to the VLANs, and specify IP addresses for VLAN-interface 2 and VLAN-interface 3. (Details not shown.)

Enable the DHCPv6 relay agent on VLAN-interface 3.

```
[Switch] interface vlan-interface 3
[Switch-Vlan-interface3] ipv6 dhcp select relay
```

Enable recording of DHCPv6 relay entries on the interface.

```
[Switch-Vlan-interface3] ipv6 dhcp relay client-information record
```

Specify the DHCPv6 server address 2::2 on the relay agent.

```
[Switch-Vlan-interface3] ipv6 dhcp relay server-address 2::2
[Switch-Vlan-interface3] quit
```

2. Enable IPv6SG on VLAN-interface 3 and verify the source IP address and MAC address for dynamic IPv6SG.

```
<Switch> system-view
[Switch] interface vlan-interface 3
[Switch-Vlan-interface3] ipv6 verify source ip-address mac-address
[Switch-Vlan-interface3] quit
```

Verifying the configuration

Display dynamic IPv6SG bindings generated based on DHCPv6 relay entries.

```
[Switch] display ipv6 source binding dhcpv6-relay
Total entries found: 1
IP Address      MAC Address    Interface               VLAN Type
1::2            0001-0203-0406 Vlan3                   3    DHCPv6 relay
```

VLAN-interface 3 will filter packets based on the IPv6SG binding.

Configuring ARP attack protection

About ARP attack protection

The device can provide multiple features to detect and prevent ARP attacks and viruses in the LAN. An attacker can exploit ARP vulnerabilities to attack network devices in the following ways:

- Sends a large number of unresolvable IP packets to have the receiving device busy with resolving IP addresses until its CPU is overloaded. Unresolvable IP packets refer to IP packets for which ARP cannot find corresponding MAC addresses.
- Sends a large number of ARP packets to overload the CPU of the receiving device.
- Acts as a trusted user or gateway to send ARP packets so the receiving devices obtain incorrect ARP entries.

ARP attack protection tasks at a glance

All ARP attack protection tasks are optional.

- Preventing flood attacks
  - Configuring unresolvable IP attack protection
  - Configuring ARP packet rate limit
  - Configuring source MAC-based ARP attack detection
- Preventing user and gateway spoofing attacks
  - Configuring ARP packet source MAC consistency check
  - Configuring ARP active acknowledgement
  - Configuring authorized ARP
  - Configuring ARP attack detection
  - Configuring ARP packet validity check
  - Configuring ARP restricted forwarding
  - Ignoring ingress ports of ARP packets during user validity check
  - Enabling ARP attack detection logging
  - Configuring ARP scanning and fixed ARP
  - Configuring ARP gateway protection
  - Example: Configuring ARP gateway protection
  - Configuring ARP filtering

Configuring unresolvable IP attack protection

About unresolvable IP attack protection

If a device receives a large number of unresolvable IP packets from a host, the following situations can occur:

- The device sends a large number of ARP requests, overloading the target subnets.
- The device keeps trying to resolve the destination IP addresses, overloading its CPU.

To protect the device from such IP attacks, you can configure the following features:

- **ARP source suppression**—Stops resolving packets from an IP address if the number of unresolvable IP packets from the IP address exceeds the upper limit within 5 seconds. The device continues ARP resolution when the interval elapses. This feature is applicable if the attack packets have the same source addresses.
- **ARP blackhole routing**—Creates a blackhole route destined for an unresolved IP address. The device drops all matching packets until the blackhole route is deleted. A blackhole route is deleted when its aging timer is reached or the route becomes reachable.

  After a blackhole route is created for an unresolved IP address, the device immediately starts the first ARP blackhole route probe by sending an ARP request. If the resolution fails, the device continues probing according to the probe settings. If the IP address resolution succeeds in a probe, the device converts the blackhole route to a normal route. If an ARP blackhole route ages out before the device finishes all probes, the device deletes the blackhole route and does not perform the remaining probes.

  This feature is applicable regardless of whether the attack packets have the same source addresses.

Configuring ARP source suppression

1. Enter system view.

   system-view
2. Enable ARP source suppression.

   arp source-suppression enable

   By default, ARP source suppression is disabled.
3. Set the maximum number of unresolvable packets that the device can process per source IP address within 5 seconds.

   arp source-suppression limit *limit-value*

   By default, the maximum number is 10.

Configuring ARP blackhole routing

Restrictions and guidelines

Set the ARP blackhole route probe count to a big value, for example, 25. If the device fails to reach the destination IP address temporarily and the probe count is too small, all probes might finish before the problem is resolved. As a result, non-attack packets will be dropped. This setting can avoid such situation.

Procedure

1. Enter system view.

   system-view
2. Enable ARP blackhole routing.

   arp resolving-route enable

   By default, ARP blackhole routing is enabled.
3. (Optional.) Set the number of ARP blackhole route probes for each unresolved IP address.

   arp resolving-route probe-count *count*

   The default setting is three probes.
4. (Optional.) Set the interval at which the device probes ARP blackhole routes.

   arp resolving-route probe-interval *interval*

   The default setting is 1 second.

Display and maintenance commands for unresolvable IP attack protection

Execute **display** commands in any view.

Task	Command
Display ARP source suppression configuration information.	**display arp source-suppression**

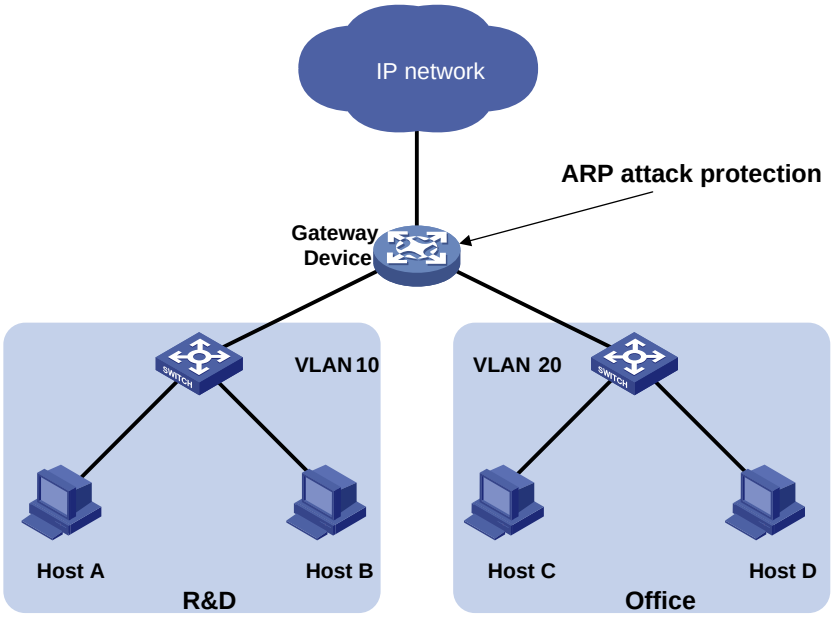
Example: Configuring unresolvable IP attack protection

Network configuration

As shown in Figure 1, a LAN contains two areas: an R&D area in VLAN 10 and an office area in VLAN 20. Each area connects to the gateway (Device) through an access switch.

A large number of ARP requests are detected in the office area and are considered an attack caused by unresolvable IP packets. To prevent the attack, configure ARP source suppression or ARP blackhole routing.

Figure 1 Network diagram



Procedure

- If the attack packets have the same source address, configure ARP source suppression:

  # Enable ARP source suppression.

  ```
  <Device> system-view
  [Device] arp source-suppression enable
  ```

  # Configure the device to process a maximum of 100 unresolvable packets per source IP address within 5 seconds.

  ```
  [Device] arp source-suppression limit 100
  ```

- If the attack packets have different source addresses, configure ARP blackhole routing:

  # Enable ARP blackhole routing.

```
[Device] arp resolving-route enable
```

Configuring ARP packet rate limit

About ARP packet rate limit

The ARP packet rate limit feature allows you to limit the rate of ARP packets delivered to the CPU. An ARP attack detection-enabled device will send all received ARP packets to the CPU for inspection. Processing excessive ARP packets will make the device malfunction or even crash. To solve this problem, configure ARP packet rate limit. When the receiving rate of ARP packets on the interface exceeds the rate limit, those packets are discarded.

You can enable sending notifications to the SNMP module or enable logging for ARP packet rate limit.

- If notification sending is enabled, the device sends the highest threshold-crossed ARP packet rate within the sending interval in a notification to the SNMP module. You must use the **snmp-agent target-host** command to set the notification type and target host. For more information about notifications, see *Network Management and Monitoring Command Reference*.
- If logging for ARP packet rate limit is enabled, the device sends the highest threshold-crossed ARP packet rate within the sending interval in a log message to the information center. You can configure the information center module to set the log output rules. For more information about information center, see *Network Management and Monitoring Configuration Guide*.

Restrictions and guidelines

As a best practice, configure this feature when ARP attack detection, ARP snooping, or MFF is enabled, or when ARP flood attacks are detected.

If excessive notifications and log messages are sent for ARP packet rate limit, you can increase notification and log message sending interval.

If you enable notification sending and logging for ARP packet rate limit on a Layer 2 aggregate interface, the features apply to all aggregation member ports.

Procedure

1. Enter system view.
   system-view
2. (Optional.) Enable SNMP notifications for ARP packet rate limit.
   snmp-agent trap enable arp [**rate-limit**]
   By default, SNMP notifications for ARP packet rate limit are disabled.
3. (Optional.) Enable logging for ARP packet rate limit.
   arp rate-limit log enable
   By default, logging for ARP packet rate limit is disabled.
4. (Optional.) Set the notification and log message sending interval.
   arp rate-limit log interval *interval*
   By default, the device sends notifications and log messages every 60 seconds.
5. Enter interface view.
   interface *interface-type interface-number*
   Supported interface types include Layer 2 Ethernet interface and Layer 2 aggregate interface.
6. Enable ARP packet rate limit.
   arp rate-limit [*pps*]
   By default, ARP packet rate limit is enabled.

Configuring source MAC-based ARP attack detection

About source MAC-based ARP attack detection

This feature checks the number of ARP packets delivered to the CPU. If the number of packets from the same MAC address within 5 seconds exceeds a threshold, the device generates an ARP attack entry for the MAC address. If the ARP logging feature is enabled, the device handles the attack by using either of the following methods before the ARP attack entry ages out:

- **Monitor**—Only generates log messages.
- **Filter**—Generates log messages and filters out subsequent ARP packets from the MAC address and data packets sourced from or destined for the MAC address.

To enable the ARP logging feature, use the **arp source-mac log enable** command. For information about the ARP logging feature, see ARP in *Layer 3—IP Services Configuration Guide*.

When an ARP attack entry ages out, ARP packets sourced from the MAC address in the entry can be processed correctly.

Restrictions and guidelines

When you change the handling method from monitor to filter, the configuration takes effect immediately. When you change the handling method from filter to monitor, the device continues filtering packets that match existing attack entries.

You can exclude the MAC addresses of some gateways and servers from this detection. This feature does not inspect ARP packets from those devices even if they are attackers.

Procedure

1. Enter system view.
   system-view
2. Enable source MAC-based ARP attack detection and specify the handling method.
   arp source-mac { **filter** | **monitor** }
   By default, this feature is disabled.
3. Set the threshold.
   arp source-mac threshold *threshold-value*
   By default, the threshold is 30.
4. Set the aging timer for ARP attack entries.
   arp source-mac aging-time *time*
   By default, the lifetime is 300 seconds.
5. (Optional.) Exclude specific MAC addresses from this detection.
   arp source-mac exclude-mac *mac-address*&<1-10>
   By default, no MAC address is excluded.
6. Enable logging for source MAC-based ARP attack detection.
   arp source-mac log enable
   By default, logging for source MAC-based ARP attack detection is disabled.

Display and maintenance commands for source MAC-based ARP attack detection

Execute **display** commands in any view.

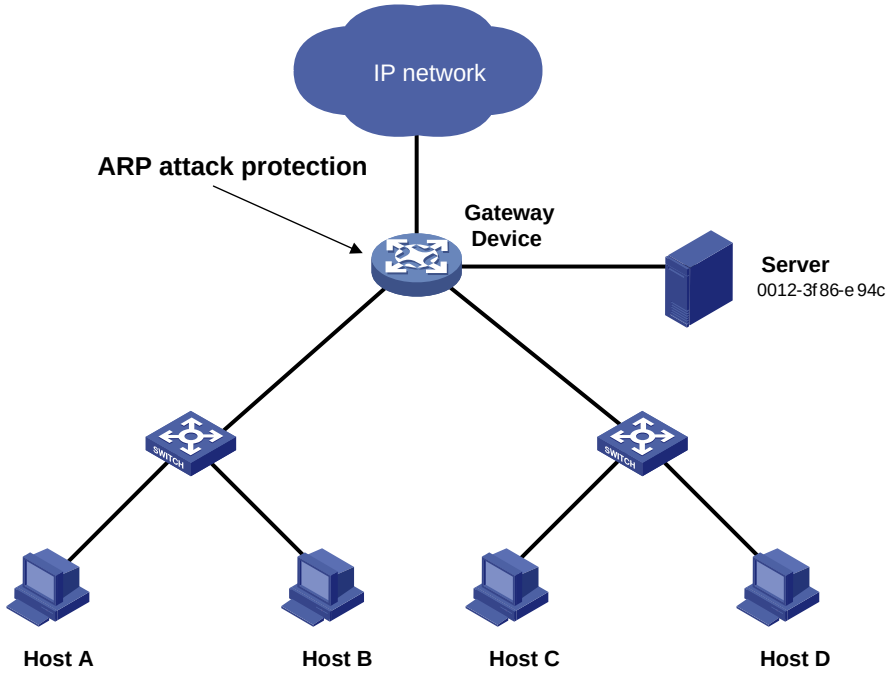
Task	Command
Display ARP attack entries detected by source MAC-based ARP attack detection.	**display arp source-mac** { **interface** *interface-type interface-number* [**slot** *slot-number*] | **slot** *slot-number* }

Example: Configuring source MAC-based ARP attack detection

Network configuration

As shown in Figure 2, the hosts access the Internet through a gateway (Device). If malicious users send a large number of ARP requests to the gateway, the gateway might crash and cannot process requests from the clients. To solve this problem, configure source MAC-based ARP attack detection on the gateway.

Figure 2 Network diagram



Procedure

Enable source MAC-based ARP attack detection, and specify the handling method as filter.

```
<Device> system-view
[Device] arp source-mac filter
```

Set the threshold to 30.

```
[Device] arp source-mac threshold 30
```

Set the lifetime for ARP attack entries to 60 seconds.

```
[Device] arp source-mac aging-time 60
```

Exclude MAC address 0012-3f86-e94c from this detection.

```
[Device] arp source-mac exclude-mac 0012-3f86-e94c
```

Configuring ARP packet source MAC consistency check

About ARP packet source MAC consistency check

This feature enables a gateway to filter out ARP packets whose source MAC address in the Ethernet header is different from the sender MAC address in the message body. This feature allows the gateway to learn correct ARP entries.

Procedure

1. Enter system view.
   system-view
2. Enable ARP packet source MAC address consistency check.
   arp valid-check enable
   By default, ARP packet source MAC address consistency check is disabled.

Configuring ARP active acknowledgement

About ARP active acknowledgement

Configure this feature on gateways to prevent user spoofing.

ARP active acknowledgement prevents a gateway from generating incorrect ARP entries.

In strict mode, a gateway performs more strict validity checks before creating an ARP entry:

- Upon receiving an ARP request destined for the gateway, the gateway sends an ARP reply but does not create an ARP entry.
- Upon receiving an ARP reply, the gateway determines whether it has resolved the sender IP address:
  - If yes, the gateway performs active acknowledgement. When the ARP reply is verified as valid, the gateway creates an ARP entry.
  - If no, the gateway discards the packet.

Procedure

1. Enter system view.
   system-view
2. Enable the ARP active acknowledgement feature.
   arp active-ack [**strict**] **enable**
   By default, this feature is disabled.
   For ARP active acknowledgement to take effect in strict mode, make sure ARP blackhole routing is enabled.

Configuring authorized ARP

About authorized ARP

Authorized ARP entries are generated based on the DHCP clients' address leases on the DHCP server or dynamic client entries on the DHCP relay agent. For more information about DHCP server and DHCP relay agent, see *Layer 3—IP Services Configuration Guide*.

Use this feature to prevent user spoofing and to allow only authorized clients to access network resources.

Procedure

1. Enter system view.
   `system-view`
2. Enter interface view.
   `interface` *`interface-type interface-number`*
   Only VLAN interfaces are supported.
3. Enable authorized ARP on the interface.
   `arp authorized enable`
   By default, authorized ARP is disabled.

Configuring ARP attack detection

About ARP attack detection

ARP attack detection enables access devices to block ARP packets from unauthorized clients to prevent user spoofing and gateway spoofing attacks.

ARP attack detection provides the following features:

- User validity check.
- ARP packet validity check.
- ARP restricted forwarding.
- ARP packet ingress port ignoring during user validity check
- ARP attack detection logging.

If both ARP packet validity check and user validity check are enabled, the former one applies first, and then the latter applies.

Do not configure ARP attack detection together with ARP snooping. Otherwise, ARP snooping entries cannot be generated.

Configuring user validity check

About user validity check

User validity check does not check ARP packets received on ARP trusted interfaces. This feature compares the sender IP and sender MAC in the ARP packet received on an ARP untrusted interface with the matching criteria in the following order:

1. User validity check rules.

- If a match is found, the device processes the ARP packet according to the rule.
- If no match is found or no user validity check rule is configured, proceeds to step 2.

2. Static IPSG bindings, 802.1X security entries, and DHCP snooping entries.
   - If a match is found, the device determines that the ARP packet is valid. Then, the device forwards the packet by searching for an entry that contains the target IP address.
     - If a match is found and the receiving interface is the same as the interface in the entry with a matching sender IP address, the device performs Layer 3 forwarding.
     - If a match is found but the receiving interface is different from the interface in the entry with a matching sender IP address, the device performs Layer 2 forwarding.
     - If no match is found, the device performs Layer 2 forwarding.
   - If no match is found, the device discards the ARP packet.

Static IP source guard bindings are created by using the **ip source binding** command. For more information, see "Configuring IP source guard."

DHCP snooping entries are automatically generated by DHCP snooping. For more information, see *Layer 3—IP Services Configuration Guide*.

802.1X security entries record the IP-to-MAC mappings for 802.1X clients. After a client passes 802.1X authentication and uploads its IP address to an ARP attack detection enabled device, the device automatically generates an 802.1X security entry. The 802.1X client must be enabled to upload its IP address to the device. For more information, see "Configuring 802.1X."

Restrictions and guidelines

When you configure user validity check, make sure one or more of the following items are configured:

- User validity check rules.
- Static IP source guard bindings.
- DHCP snooping.
- 802.1X.

If none of the items is configured, the device does not perform user validity check and cannot correctly forward all incoming ARP packets on ARP untrusted interfaces.

Specify an IP address, a MAC address, and a VLAN where ARP attack detection is enabled for an IP source guard binding. Otherwise, no ARP packets can match the IP source guard binding.

Configuring user validity check rules

1. Enter system view.

   system-view

2. Configure a user validity check rule.

   arp detection rule *rule-id* { **deny** | **permit** } **ip** { *ip-address* [*mask*] | **any** } **mac** { *mac-address* [*mask*] | **any** } [**vlan** *vlan-id*]

   By default, no user validity check rules are configured.

Enabling ARP attack detection in a VLAN

1. Enter system view.

   system-view

2. Enter VLAN view.

   vlan *vlan-id*

3. Enable ARP attack detection.

   arp detection enable

   By default, ARP attack detection is disabled. The device does not perform user validity check.

4. (Optional.) Configure an interface that does not require ARP user validity check as a trusted interface.
   a. Return to system view.
      quit
   b. Enter interface view.
      interface *interface-type interface-number*
      Supported interface types include Layer 2 Ethernet interface and Layer 2 aggregate interface.
   c. Configure the interface as a trusted interface excluded from ARP attack detection.
      arp detection trust
      By default, an interface is untrusted.

Configuring ARP packet validity check

About ARP packet validity check

ARP packet validity check does not check ARP packets received on ARP trusted interfaces. To check ARP packets received on untrusted interfaces, you can specify the following objects to be checked:

- **src-mac**—Checks whether the sender MAC address in the message body is identical to the source MAC address in the Ethernet header. If they are identical, the packet is forwarded. Otherwise, the packet is discarded.
- **dst-mac**—Checks the target MAC address of ARP replies. If the target MAC address is all-zero, all-one, or inconsistent with the destination MAC address in the Ethernet header, the packet is considered invalid and discarded.
- **ip**—Checks the sender and target IP addresses of ARP replies, and the sender IP address of ARP requests. All-one or multicast IP addresses are considered invalid and the corresponding packets are discarded.

Prerequisites

Before you configure ARP packet validity check, you must first configure user validity check. For more information about user validity check configuration, see "Configuring user validity check."

Enabling ARP packet validity check

1. Enter system view.
   system-view
2. Enable ARP packet validity check and specify the objects to be checked.
   arp detection validate { **dst-mac** | **ip** | **src-mac** } *
   By default, ARP packet validity check is disabled.

Enabling ARP attack detection in a VLAN

1. Enter system view.
   system-view
2. Enter VLAN view.
   vlan *vlan-id*
3. Enable ARP attack detection.
   arp detection enable
   By default, ARP attack detection is disabled. The device does not perform ARP packet validity check.

4. (Optional.) Execute the following commands in sequence to configure the interface that does not require ARP packet validity check as a trusted interface:
   a. Return to system view.
      quit
   b. Enter interface view.
      interface *interface-type interface-number*
      Supported interface types include Layer 2 Ethernet interface and Layer 2 aggregate interface.
   c. Configure the interface as a trusted interface excluded from ARP attack detection.
      arp detection trust
      By default, an interface is untrusted.

Configuring ARP restricted forwarding

About ARP restricted forwarding

ARP restricted forwarding does not take effect on ARP packets received on ARP trusted interfaces and forwards the ARP packets correctly. This feature controls the forwarding of ARP packets that are received on untrusted interfaces and have passed user validity check as follows:

- If the packets are ARP requests, they are forwarded through the trusted interface.
- If the packets are ARP replies, they are forwarded according to their destination MAC address. If no match is found in the MAC address table, they are forwarded through the trusted interface.

Restrictions and guidelines

ARP restricted forwarding does not apply to ARP packets that use multiport destination MAC addresses.

Prerequisites

Configure user validity check before you configure ARP restricted forwarding. For information about user validity check configuration, see "Configuring user validity check."

Procedure

1. Enter system view.
   system-view
2. Enter VLAN view.
   vlan *vlan-id*
3. Enable ARP restricted forwarding.
   arp restricted-forwarding enable
   By default, ARP restricted forwarding is disabled.

Ignoring ingress ports of ARP packets during user validity check

About ignoring ingress ports of ARP packets during user validity check

ARP attack detection performs user validity check on ARP packets from ARP untrusted interfaces. The sender IP and sender MAC in the received ARP packet are compared with the entries used for user validity check. In addition, user validity check compares the ingress port of the ARP packet with the port in the entries. If no matching port is found, the ARP packet is discarded. For more information about user validity check, see "Configuring user validity check."

You can configure the device to ignore the ingress ports of ARP packets during user validity check. If an ARP packet passes user validity check, the device directly performs Layer 2 forwarding for the packet. It no longer searches for a matching static IPSG binding, 802.1X security entry, or DHCP snooping entry by the target IP address of the ARP packet.

Procedure

1. Enter system view.
   system-view
2. Ignore ingress ports of ARP packets during user validity check.
   arp detection port-match-ignore
   By default, ingress ports of ARP packets are checked during user invalidity.

Enabling ARP attack detection logging

About ARP attack detection logging

The ARP attack detection logging feature enables a device to generate ARP attack detection log messages when illegal ARP packets are detected. An ARP attack detection log message contains the following information:

- Receiving interface of the ARP packets.
- Sender IP address.
- Total number of dropped ARP packets.

Procedure

1. Enter system view.
   system-view
2. Enable ARP attack detection logging.
   arp detection log enable [**interval** *interval* | **number** *number*]
   By default, ARP attack detection logging is disabled.

Display and maintenance commands for ARP attack detection

Execute **display** commands in any view and **reset** commands in user view.

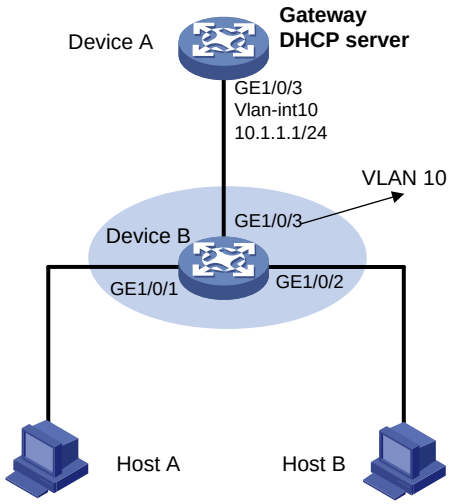
Task	Command
Display the VLANs enabled with ARP attack detection.	**display arp detection**
Display ARP attack source statistics.	**display arp detection statistics attack-source slot** *slot-number*
Display statistics for packets dropped by ARP attack detection.	**display arp detection statistics packet-drop** [**interface** *interface-type interface-number*]
Clear ARP attack source statistics.	**reset arp detection statistics attack-source** [**slot** *slot-number*]
Clear statistics for packets dropped by ARP attack detection.	**reset arp detection statistics packet-drop** [**interface** *interface-type interface-number*]

Example: Configuring user validity check

Network configuration

As shown in Figure 3, configure Device B to perform user validity check based on 802.1X security entries for connected hosts.

Figure 3 Network diagram



Procedure

1. Add all interfaces on Device B to VLAN 10, and specify the IP address of VLAN-interface 10 on Device A. (Details not shown.)
2. Configure the DHCP server on Device A, and configure DHCP address pool 0.

```
<DeviceA> system-view
[DeviceA] dhcp enable
[DeviceA] dhcp server ip-pool 0
[DeviceA-dhcp-pool-0] network 10.1.1.0 mask 255.255.255.0
```

3. Configure Host A and Host B as 802.1X clients and configure them to upload IP addresses for ARP attack detection. (Details not shown.)
4. Configure Device B:

   # Enable 802.1X.

```
<DeviceB> system-view
[DeviceB] dot1x
[DeviceB] interface gigabitethernet 1/0/1
[DeviceB-GigabitEthernet1/0/1] dot1x
[DeviceB-GigabitEthernet1/0/1] quit
[DeviceB] interface gigabitethernet 1/0/2
[DeviceB-GigabitEthernet1/0/2] dot1x
[DeviceB-GigabitEthernet1/0/2] quit
```

   # Add a local user **test**.

```
[DeviceB] local-user test
[DeviceB-luser-test] service-type lan-access
[DeviceB-luser-test] password simple test
[DeviceB-luser-test] quit
```

   # Enable ARP attack detection for VLAN 10 to check user validity based on 802.1X entries.

```
[DeviceB] vlan 10
[DeviceB-vlan10] arp detection enable
```

Configure the upstream interface as an ARP trusted interface. By default, an interface is an untrusted interface.

```
[DeviceB-vlan10] interface gigabitethernet 1/0/3
[DeviceB-GigabitEthernet1/0/3] arp detection trust
[DeviceB-GigabitEthernet1/0/3] quit
```

Verifying the configuration

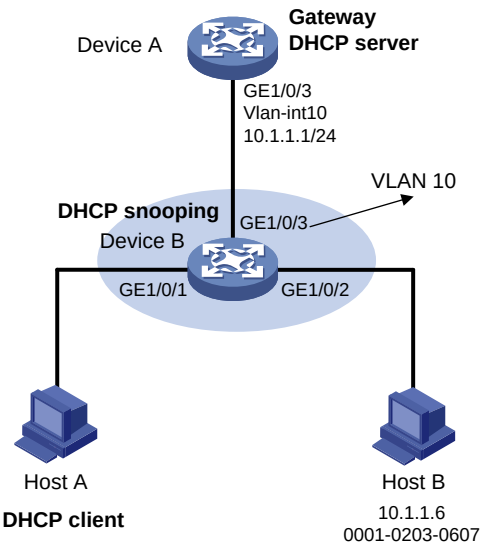
Verify that ARP packets received on interfaces GigabitEthernet 1/0/1 and GigabitEthernet 1/0/2 are checked against 802.1X entries.

Example: Configuring user validity check and ARP packet validity check

Network configuration

As shown in Figure 4, configure Device B to perform ARP packet validity check and user validity check based on static IP source guard bindings and DHCP snooping entries for connected hosts.

Figure 4 Network diagram



Procedure

1. Add all interfaces on Device B to VLAN 10, and specify the IP address of VLAN-interface 10 on Device A. (Details not shown.)
2. Configure the DHCP server on Device A, and configure DHCP address pool 0.

```
<DeviceA> system-view
[DeviceA] dhcp enable
[DeviceA] dhcp server ip-pool 0
[DeviceA-dhcp-pool-0] network 10.1.1.0 mask 255.255.255.0
```

3. Configure Host A (DHCP client) and Host B. (Details not shown.)
4. Configure Device B:

Enable DHCP snooping.

```
<DeviceB> system-view
```

```
[DeviceB] dhcp snooping enable
[DeviceB] interface gigabitethernet 1/0/3
[DeviceB-GigabitEthernet1/0/3] dhcp snooping trust
[DeviceB-GigabitEthernet1/0/3] quit
```

Enable recording of client information in DHCP snooping entries on GigabitEthernet 1/0/1.

```
[DeviceB] interface gigabitethernet 1/0/1
[DeviceB-GigabitEthernet1/0/1] dhcp snooping binding record
[DeviceB-GigabitEthernet1/0/1] quit
```

Enable ARP attack detection for VLAN 10.

```
[DeviceB] vlan 10
[DeviceB-vlan10] arp detection enable
```

Configure the upstream interface as a trusted interface. By default, an interface is an untrusted interface.

```
[DeviceB-vlan10] interface gigabitethernet 1/0/3
[DeviceB-GigabitEthernet1/0/3] arp detection trust
[DeviceB-GigabitEthernet1/0/3] quit
```

Configure a static IP source guard binding entry on interface GigabitEthernet 1/0/2 for user validity check.

```
[DeviceB] interface gigabitethernet 1/0/2
[DeviceB-GigabitEthernet1/0/2] ip source binding ip-address 10.1.1.6 mac-address
0001-0203-0607 vlan 10
[DeviceB-GigabitEthernet1/0/2] quit
```

Enable ARP packet validity check by checking the MAC addresses and IP addresses of ARP packets.

```
[DeviceB] arp detection validate dst-mac ip src-mac
```

Verifying the configuration

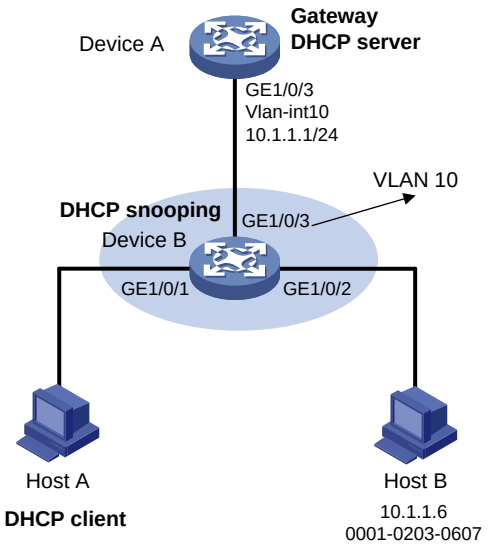
Verify that Device B first checks the validity of ARP packets received on GigabitEthernet 1/0/1 and GigabitEthernet 1/0/2. If the ARP packets are confirmed valid, Device B performs user validity check by using the static IP source guard bindings and finally DHCP snooping entries.

Example: Configuring ARP restricted forwarding

Network configuration

As shown in Figure 5, configure ARP restricted forwarding on Device B where ARP attack detection is configured. Port isolation configured on Device B can take effect for broadcast ARP requests.

Figure 5 Network diagram



Procedure

1. Configure VLAN 10, add interfaces to VLAN 10, and specify the IP address of VLAN-interface 10 on Device A. (Details not shown.)
2. Configure the DHCP server on Device A, and configure DHCP address pool 0.

```
<DeviceA> system-view
[DeviceA] dhcp enable
[DeviceA] dhcp server ip-pool 0
[DeviceA-dhcp-pool-0] network 10.1.1.0 mask 255.255.255.0
```

3. Configure Host A (DHCP client) and Host B. (Details not shown.)
4. Configure Device B:

   # Enable DHCP snooping, and configure GigabitEthernet 1/0/3 as a DHCP trusted interface.

```
<DeviceB> system-view
[DeviceB] dhcp snooping enable
[DeviceB] interface gigabitethernet 1/0/3
[DeviceB-GigabitEthernet1/0/3] dhcp snooping trust
[DeviceB-GigabitEthernet1/0/3] quit
```

   # Enable ARP attack detection for user validity check.

```
[DeviceB] vlan 10
[DeviceB-vlan10] arp detection enable
```

   # Configure GigabitEthernet 1/0/3 as an ARP trusted interface.

```
[DeviceB-vlan10] interface gigabitethernet 1/0/3
[DeviceB-GigabitEthernet1/0/3] arp detection trust
[DeviceB-GigabitEthernet1/0/3] quit
```

   # Configure a static IP source guard entry on interface GigabitEthernet 1/0/2.

```
[DeviceB] interface gigabitethernet 1/0/2
[DeviceB-GigabitEthernet1/0/2] ip source binding ip-address 10.1.1.6 mac-address
0001-0203-0607 vlan 10
[DeviceB-GigabitEthernet1/0/2] quit
```

   # Enable ARP packet validity check by checking the MAC addresses and IP addresses of ARP packets.

```
[DeviceB] arp detection validate dst-mac ip src-mac
```

Configure port isolation.

```
[DeviceB] port-isolate group 1
[DeviceB] interface gigabitethernet 1/0/1
[DeviceB-GigabitEthernet1/0/1] port-isolate enable group 1
[DeviceB-GigabitEthernet1/0/1] quit
[DeviceB] interface gigabitethernet 1/0/2
[DeviceB-GigabitEthernet1/0/2] port-isolate enable group 1
[DeviceB-GigabitEthernet1/0/2] quit
```

After the configurations are completed, Device B first checks the validity of ARP packets received on GigabitEthernet 1/0/1 and GigabitEthernet 1/0/2. If the ARP packets are confirmed valid, Device B performs user validity check by using the static IP source guard bindings and finally DHCP snooping entries. However, ARP broadcast requests sent from Host A can pass the check on Device B and reach Host B. Port isolation fails.

Enable ARP restricted forwarding.

```
[DeviceB] vlan 10
[DeviceB-vlan10] arp restricted-forwarding enable
[DeviceB-vlan10] quit
```

Verifying the configuration

Verify that Device B forwards ARP broadcast requests from Host A to Device A through the trusted interface GigabitEthernet 1/0/3. Host B cannot receive such packets. Port isolation operates correctly.

Configuring ARP scanning and fixed ARP

About ARP scanning and fixed ARP

ARP scanning is typically used together with the fixed ARP feature in small-scale and stable networks.

ARP scanning automatically creates ARP entries for devices in an address range. The device performs ARP scanning in the following steps:

1. Sends ARP requests for each IP address in the address range.
2. Obtains their MAC addresses through received ARP replies.
3. Creates dynamic ARP entries.

Fixed ARP converts existing dynamic ARP entries (including those generated through ARP scanning) to static ARP entries. These static ARP entries are of the same attributes as the ARP entries that are manually configured. This feature prevents ARP entries from being modified by attackers.

You can set the ARP packet sending rate if the scanning range has a large number of IP addresses. This setting can avoid high CPU usage and heavy network load caused by a burst of ARP traffic.

Restrictions and guidelines

IP addresses in existing ARP entries are not scanned.

Due to the limit on the total number of static ARP entries, some dynamic ARP entries might fail the conversion.

The **arp fixup** command is a one-time operation. You can use this command again to convert the dynamic ARP entries learned later to static.

To delete a static ARP entry converted from a dynamic one, use the **undo arp** *ip-address* command. You can also use the **reset arp all** command to delete all ARP entries or the **reset arp static** command to delete all static ARP entries.

Procedure

1. Enter system view.
   system-view
2. Enter interface view.
   interface *interface-type interface-number*
3. Trigger an ARP scanning.
   arp scan [*start-ip-address* **to** *end-ip-address*] [**send-rate** *pps*]

   CAUTION:
   ARP scanning will take some time. To stop an ongoing scan, press **Ctrl** + **C**. Dynamic ARP entries are created based on ARP replies received before the scan is terminated.
4. Return to system view.
   quit
5. Convert existing dynamic ARP entries to static ARP entries.
   arp fixup

Configuring ARP gateway protection

About ARP gateway protection

Configure this feature on interfaces not connected with a gateway to prevent gateway spoofing attacks.

When such an interface receives an ARP packet, it checks whether the sender IP address in the packet is consistent with that of any protected gateway. If yes, it discards the packet. If not, it handles the packet correctly.

Restrictions and guidelines

You can enable ARP gateway protection for a maximum of eight gateways on an interface.

Do not configure both the **arp filter source** and **arp filter binding** commands on an interface.

If ARP gateway protection works with ARP attack detection, MFF, and ARP snooping, ARP gateway protection applies first.

Procedure

1. Enter system view.
   system-view
2. Enter interface view.
   interface *interface-type interface-number*

   Supported interface types include Layer 2 Ethernet interface and Layer 2 aggregate interface.
3. Enable ARP gateway protection for the specified gateway.
   arp filter source *ip-address*

   By default, ARP gateway protection is disabled.

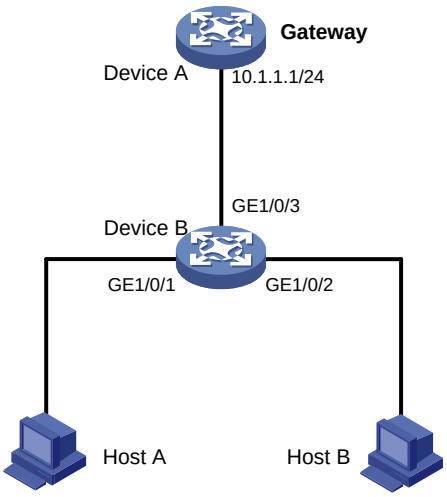
Example: Configuring ARP gateway protection

Network configuration

As shown in Figure 6, Host B launches gateway spoofing attacks to Device B. As a result, traffic that Device B intends to send to Device A is sent to Host B.

Configure Device B to block such attacks.

Figure 6 Network diagram



Procedure

Configure ARP gateway protection on Device B.

```
<DeviceB> system-view
[DeviceB] interface gigabitethernet 1/0/1
[DeviceB-GigabitEthernet1/0/1] arp filter source 10.1.1.1
[DeviceB-GigabitEthernet1/0/1] quit
[DeviceB] interface gigabitethernet 1/0/2
[DeviceB-GigabitEthernet1/0/2] arp filter source 10.1.1.1
```

Verifying the configuration

Verify that GigabitEthernet 1/0/1 and GigabitEthernet 1/0/2 discard the incoming ARP packets whose sender IP address is the IP address of the gateway.

Configuring ARP filtering

ARP filtering

The ARP filtering feature can prevent gateway spoofing and user spoofing attacks.

An interface enabled with this feature checks the sender IP and MAC addresses in a received ARP packet against permitted entries. If a match is found, the packet is handled correctly. If not, the packet is discarded.

Restrictions and guidelines

You can configure a maximum of eight permitted entries on an interface.

Do not configure both the **arp filter source** and **arp filter binding** commands on an interface.

If ARP filtering works with ARP attack detection, MFF, and ARP snooping, ARP filtering applies first.

Procedure

1. Enter system view.
   system-view
2. Enter interface view.
   interface *interface-type interface-number*
   Supported interface types include Ethernet interface and Layer 2 aggregate interface.
3. Enable ARP filtering and configure a permitted entry.
   arp filter binding *ip-address mac-address*
   By default, ARP filtering is disabled.

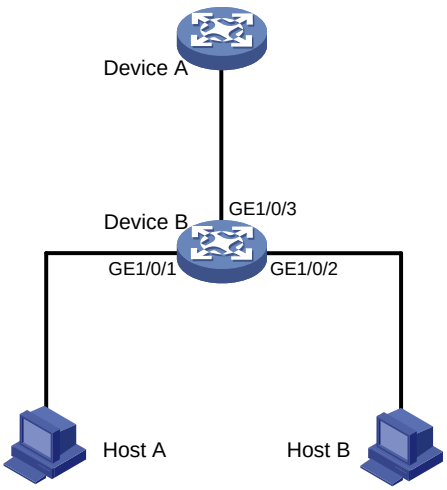
Example: Configuring ARP filtering

Network configuration

As shown in Figure 7, the IP and MAC addresses of Host A are 10.1.1.2 and 000f-e349-1233, respectively. The IP and MAC addresses of Host B are 10.1.1.3 and 000f-e349-1234, respectively.

Configure ARP filtering on GigabitEthernet 1/0/1 and GigabitEthernet 1/0/2 of Device B to permit ARP packets from only Host A and Host B.

Figure 7 Network diagram



Procedure

Configure ARP filtering on Device B.

```
<DeviceB> system-view
[DeviceB] interface gigabitethernet 1/0/1
[DeviceB-GigabitEthernet1/0/1] arp filter binding 10.1.1.2 000f-e349-1233
[DeviceB-GigabitEthernet1/0/1] quit
[DeviceB] interface gigabitethernet 1/0/2
[DeviceB-GigabitEthernet1/0/2] arp filter binding 10.1.1.3 000f-e349-1234
```

Verifying the configuration

Verify that GigabitEthernet 1/0/1 permits ARP packets from Host A and discards other ARP packets.

Verify that GigabitEthernet 1/0/2 permits ARP packets from Host B and discards other ARP packets.

Contents

Configuring ND attack defense

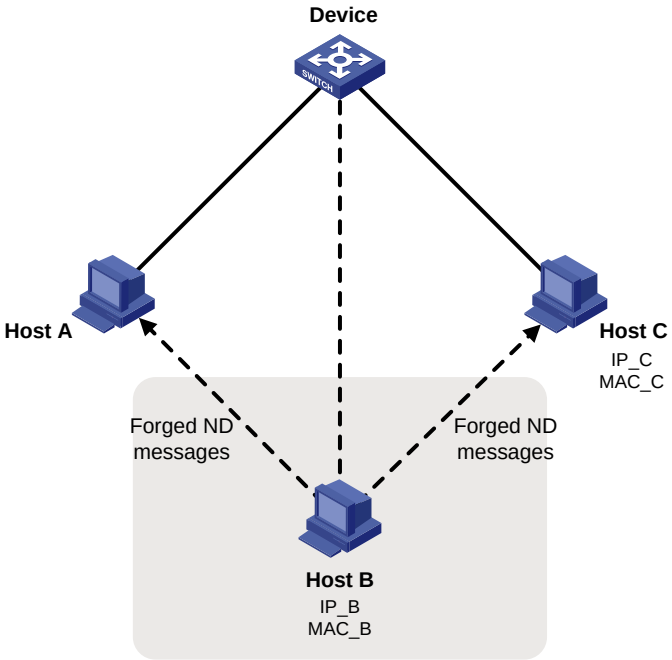
About ND attack defense

IPv6 Neighbor Discovery (ND) attack defense is able to identify forged ND messages to prevent ND attacks.

The IPv6 ND protocol does not provide any security mechanisms and is vulnerable to network attacks. As shown in Figure 1, an attacker can send the following forged ICMPv6 messages to perform ND attacks:

- Forged NS/NA/RS messages with an IPv6 address of a victim host. The gateway and other hosts update the ND entry for the victim with incorrect address information. As a result, all packets intended for the victim are sent to the attacking terminal.
- Forged RA messages with the IPv6 address of a victim gateway. As a result, all hosts attached to the victim gateway maintain incorrect IPv6 configuration parameters and ND entries.

Figure 1 ND attack diagram



ND attack defense tasks at a glance

All ND attack defense tasks are optional.

- Enabling source MAC consistency check for ND messages
- Configuring ND attack detection
- Configuring RA guard

Enabling source MAC consistency check for ND messages

About source MAC consistency check

The source MAC consistency check feature is typically configured on gateways to prevent ND attacks.

This feature checks the source MAC address and the source link-layer address for consistency for each arriving ND message.

- If the source MAC address and the source link-layer address are not the same, the device drops the packet.
- If the addresses are the same, the device continues learning ND entries.

The ND logging feature logs source MAC inconsistency events, and it sends the log messages to the information center. The information center can then output log messages from different source modules to different destinations. For more information about the information center, see *Network Management and Monitoring Configuration Guide*.

Procedure

1. Enter system view.

   `system-view`
2. Enable source MAC consistency check for ND messages.

   `ipv6 nd mac-check enable`

   By default, source MAC consistency check is disabled for ND messages.
3. (Optional.) Enable the ND logging feature.

   `ipv6 nd check log enable`

   By default, the ND logging feature is disabled.

   As a best practice, disable the ND logging feature to avoid excessive ND logs.

Configuring ND attack detection

About ND attack detection

ND attack detection checks incoming ND messages for user validity to prevent spoofing attacks. It is typically configured on access devices. It supports the following features:

- User validity check.
- ND attack detection logging.

ND attack detection defines the following types of interfaces:

- **ND trusted interface**—The device directly forwards ND messages or data packets received by ND trusted interfaces. It does not perform user validity check.
- **ND untrusted interface**—The device discards RA and redirect messages received by ND untrusted interfaces. For other types of ND messages received by the ND untrusted interfaces, the device checks the user validity.

ND attack detection compares the source IPv6 address and the source MAC address in an incoming ND message against security entries from other modules.

- If a match is found, the device verifies the user as legal in the receiving VLAN, and it forwards the packet.

- If no match is found, the device verifies the user as illegal, and it discards the ND message.

ND attack detection uses static IPv6 source guard binding entries, ND snooping entries, and DHCPv6 snooping entries for user validity check.

Static IPv6 source guard binding entries are created by using the **ipv6 source binding** command. For information about IPv6 source guard, see "Configuring IP source guard." For information about DHCPv6 snooping, see *Layer 3–IP Services Configuration Guide*. For information about ND snooping, see *Layer 3–IP Services Configuration Guide*.

Restrictions and guidelines

When you configure ND attack detection, follow these restrictions and guidelines:

- To prevent ND untrusted interfaces from dropping all received ND messages, make sure one or more of the these features are configured: IPv6 source guard static bindings, DHCPv6 snooping, and ND snooping.
- To make the IPv6 source guard static bindings effective for ND attack detection, you must perform the following operations:
  - Specify the **vlan** *vlan-id* option in the **ipv6 source binding** command.
  - Enable ND attack detection for the same VLAN.

Enabling ND detection in a VLAN

1. Enter system view.
   system-view
2. Enter VLAN view.
   vlan *vlan-id*
3. Enable ND attack detection.
   ipv6 nd detection enable
   By default, ND attack detection is disabled.
4. (Optional.) Configure the interface as ND trusted interface:
   a. Return to system view.
      quit
   b. Enter Layer 2 Ethernet or aggregate interface view.
      interface *interface-type interface-number*
   c. Configure the interface as ND trusted interface.
      ipv6 nd detection trust
      By default, all interfaces are ND untrusted interfaces.

Enabling ND attack detection logging

About ND attack detection logging

This feature allows a device to generate logs when it detects invalid ND packets. The log information helps administrators locate and solve problems. Each log records the following information:

- Victim port numbers in a VLAN.
- Source IP address of the invalid ND packets.
- Source MAC address of the invalid ND packets.
- VLAN ID of the invalid ND packets.

- Total number of dropped ND packets.

Procedure

1. Enter system view.
   `system-view`
2. Enable ND attack detection logging.
   `ipv6 nd detection log enable`
   By default, ND attack detection logging is disabled.

Display and maintenance commands for ND attack detection

Execute **`display`** commands in any view and **`reset`** commands in user view.

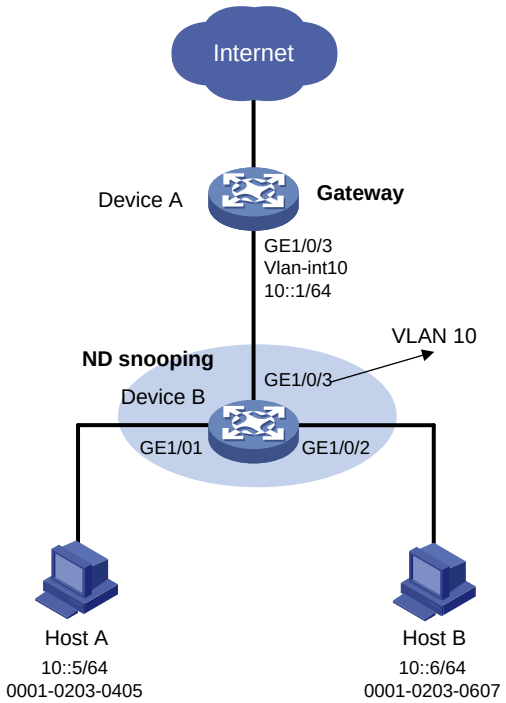
Task	Command
Display statistics for ND messages dropped by ND attack detection.	**`display ipv6 nd detection statistics`** [**`interface`** *`interface-type interface-number`*]
Clear ND attack detection statistics.	**`reset ipv6 nd detection statistics`** [**`interface`** *`interface-type interface-number`*]

Example: Configuring ND attack detection

Network configuration

As shown in Figure 2, configure ND attack detection on Device B to check user validity for ND messages from Host A and Host B.

Figure 2 Network diagram



Procedure

1. Configure Device A:

   # Create VLAN 10.

```
<DeviceA> system-view
[DeviceA] vlan 10
[DeviceA-vlan10] quit
```

   # Configure GigabitEthernet 1/0/3 to trunk VLAN 10.

```
[DeviceA] interface gigabitethernet 1/0/3
[DeviceA-GigabitEthernet1/0/3] port link-type trunk
[DeviceA-GigabitEthernet1/0/3] port trunk permit vlan 10
[DeviceA-GigabitEthernet1/0/3] quit
```

   # Assign IPv6 address 10::1/64 to VLAN-interface 10.

```
[DeviceA] interface vlan-interface 10
[DeviceA-Vlan-interface10] ipv6 address 10::1/64
[DeviceA-Vlan-interface10] quit
```

2. Configure Device B:

   # Create VLAN 10.

```
<DeviceB> system-view
[DeviceB] vlan 10
[DeviceB-vlan10] quit
```

   # Configure GigabitEthernet 1/0/1, GigabitEthernet 1/0/2, and GigabitEthernet 1/0/3 to trunk VLAN 10.

```
[DeviceB] interface gigabitethernet 1/0/1
[DeviceB-GigabitEthernet1/0/1] port link-type access
[DeviceB-GigabitEthernet1/0/1] port access vlan 10
[DeviceB-GigabitEthernet1/0/1] quit
[DeviceB] interface gigabitethernet 1/0/2
[DeviceB-GigabitEthernet1/0/2] port link-type access
[DeviceB-GigabitEthernet1/0/2] port access vlan 10
[DeviceB-GigabitEthernet1/0/2] quit
[DeviceB] interface gigabitethernet 1/0/3
[DeviceB-GigabitEthernet1/0/3] port link-type trunk
[DeviceB-GigabitEthernet1/0/3] port trunk permit vlan 10
[DeviceB-GigabitEthernet1/0/3] quit
```

   # Enable ND attack detection for VLAN 10.

```
[DeviceB] vlan 10
[DeviceB-vlan10] ipv6 nd detection enable
```

   # Enable ND snooping for IPv6 global unicast addresses and ND snooping for IPv6 link-local addresses in VLAN 10.

```
[DeviceB-vlan10] ipv6 nd snooping enable global
[DeviceB-vlan10] ipv6 nd snooping enable link-local
[DeviceB-vlan10] quit
```

   # Configure GigabitEthernet 1/0/3 as ND trusted interface.

```
[DeviceB] interface gigabitethernet 1/0/3
[DeviceB-GigabitEthernet1/0/3] ipv6 nd detection trust
```

Verifying the configuration

Verify that Device B inspects all ND messages received by GigabitEthernet 1/0/1 and GigabitEthernet 1/0/2 based on the ND snooping entries. (Details not shown.)

Configuring RA guard

About RA guard

RA guard allows Layer 2 access devices to analyze and block unwanted and forged RA messages.

Upon receiving an RA message, the device makes the forwarding or dropping decision based on the role of the attached device or the RA guard policy.

1. If the role of the device attached to the receiving interface is **router**, the device forwards the RA message. If the role is **host**, the device drops the RA message.
2. If no attached device role is set, the device uses the RA guard policy applied to the VLAN of the receiving interface to match the RA message.
   - If the policy does not contain match criteria, the policy will not take effect and the device forwards the RA message.
   - If the RA message content matches every criterion in the policy, the device forwards the message. Otherwise, the device drops the message.

Specifying the role of the attached device

Restrictions and guidelines

Make sure your setting is consistent with the type of the attached device. If you are not aware of the device type, do not specify a role for the device.

Procedure

1. Enter system view.

   system-view
2. Enter interface view.
   - Enter Layer 2 Ethernet interface view.

     interface *interface-type interface-number*
   - Enter aggregate interface view.

     interface bridge-aggregation *interface-number*
3. Specify the role of the device attached to the interface.

   ipv6 nd raguard role { **host** | **router** }

   By default, the role of the device attached to the interface is not specified.

Configuring and applying an RA guard policy

About RA guard policy configuration

Configure an RA guard policy if you do not specify a role for the attached device or if you want to filter the RA messages sent by a router.

Procedure

1. Enter system view.

   system-view

2. Create an RA guard policy and enter its view.
   ipv6 nd raguard policy *policy-name*
3. Configure the RA guard policy.
   Choose the following tasks as needed:
   - Specify an ACL match criterion.
     if-match acl { *ipv6-acl-number* | **name** *ipv6-acl-name* }
   - Specify a prefix match criterion.
     if-match prefix acl { *ipv6-acl-number* | **name** *ipv6-acl-name* }
   - Specify a router preference match criterion.
     if-match router-preference maximum { **high** | **low** | **medium** }
   - Specify an M flag match criterion.
     if-match autoconfig managed-address-flag { **off** | **on** }
   - Specify an O flag match criterion.
     if-match autoconfig other-flag { **off** | **on** }
   - Specify a maximum or minimum hop limit match criterion.
     if-match hop-limit { **maximum** | **minimum** } *limit*

   By default, the RA guard policy is not configured.
4. Quit RA guard policy view.
   quit
5. Enter VLAN view.
   vlan *vlan-number*
6. Apply an RA guard policy to the VLAN.
   ipv6 nd raguard apply policy [*policy-name*]
   By default, no RA guard policy is applied to the VLAN.

Enabling the RA guard logging feature

About RA guard logging

This feature allows a device to generate logs when it detects forged RA messages. The log information helps administrators locate and solve problems. Each log records the following information:

- Name of the interface that received the forged RA message.
- Source IP address of the forged RA message.
- Number of RA messages dropped on the interface.

The RA guard logging feature sends the log messages to the information center. The information center can then output log messages from different source modules to different destinations. For more information about the information center, see *Network Management and Monitoring Configuration Guide*.

Procedure

1. Enter system view.
   system-view
2. Enable the RA guard logging feature.
   ipv6 nd raguard log enable
   By default, the RA guard logging feature is disabled.

Display and maintenance commands for RA guard

Execute **display** commands in any view.

Task	Command
Display the RA guard policy configuration.	**display ipv6 nd raguard policy** [*policy-name*]
Display RA guard statistics.	**display ipv6 nd raguard statistics** [**interface** *interface-type interface-number*]
Clear RA guard statistics.	**reset ipv6 nd raguard statistics** [**interface** *interface-type interface-number*]

Example: Configuring RA guard

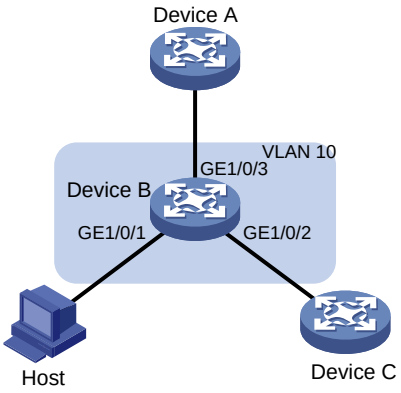
Network configuration

As shown in Figure 3, GigabitEthernet 1/0/1, GigabitEthernet 1/0/2, and GigabitEthernet 1/0/3 of Device B are in VLAN 10.

Configure RA guard on Device B to filter forged and unwanted RA messages.

- Configure an RA policy in VLAN 10 for GigabitEthernet 1/0/2 to filter all RA messages received from the unknown device.
- Specify **host** as the role of the host. All RA messages received on GigabitEthernet 1/0/1 are dropped.
- Specify **router** as the role of the Device A. All RA messages received on GigabitEthernet 1/0/3 are forwarded.

Figure 3 Network diagram



Procedure

Create an RA guard policy named **policy1**.

```
<DeviceB> system-view
[DeviceB] ipv6 nd raguard policy policy1
```

Set the maximum router preference to **high** for the RA guard policy.

```
[DeviceB-raguard-policy-policy1] if-match router-preference maximum high
```

Specify **on** as the M flag match criterion for the RA guard policy.

```
[DeviceB-raguard-policy-policy1] if-match autoconfig managed-address-flag on
```

Specify **on** as the O flag match criterion for the RA guard policy.

```
[DeviceB-raguard-policy-policy1] if-match autoconfig other-flag on
```

Set the maximum advertised hop limit to 120 for the RA guard policy.

```
[DeviceB-raguard-policy-policy1] if-match hop-limit maximum 120
```

Set the minimum advertised hop limit to 100 for the RA guard policy.

```
[DeviceB-raguard-policy-policy1] if-match hop-limit minimum 100
[DeviceB-raguard-policy-policy1] quit
```

Assign GigabitEthernet 1/0/1 and GigabitEthernet 1/0/2 to VLAN 10.

```
[DeviceB] interface gigabitethernet 1/0/1
[DeviceB-GigabitEthernet1/0/1] port link-type access
[DeviceB-GigabitEthernet1/0/1] port access vlan 10
[DeviceB-GigabitEthernet1/0/1] quit
[DeviceB] interface gigabitethernet 1/0/2
[DeviceB-GigabitEthernet1/0/2] port link-type access
[DeviceB-GigabitEthernet1/0/2] port access vlan 10
[DeviceB-GigabitEthernet1/0/2] quit
```

Configure GigabitEthernet 1/0/3 to trunk VLAN 10.

```
[DeviceB] interface gigabitethernet 1/0/3
[DeviceB-GigabitEthernet1/0/3] port link-type trunk
[DeviceB-GigabitEthernet1/0/3] port trunk permit vlan 10
[DeviceB-GigabitEthernet1/0/3] quit
```

Apply the RA guard policy **policy1** to VLAN 10.

```
[DeviceB] vlan 10
[DeviceB-vlan10] ipv6 nd raguard apply policy policy1
[DeviceB-vlan10] quit
```

Specify **host** as the role of the device attached to GigabitEthernet 1/0/1.

```
[DeviceB] interface gigabitethernet 1/0/1
[DeviceB-GigabitEthernet1/0/1] ipv6 nd raguard role host
[DeviceB-GigabitEthernet1/0/1] quit
```

Specify **router** as the role of the device attached to GigabitEthernet 1/0/3.

```
[DeviceB] interface gigabitethernet 1/0/3
[DeviceB-GigabitEthernet1/0/3] ipv6 nd raguard role router
[DeviceB-GigabitEthernet1/0/3] quit
```

Verifying the configuration

Verify that the device forwards or drops RA messages received on GigabitEthernet 1/0/2 based on the RA guard policy. (Details not shown.)

Verify that the device drops RA messages received on GigabitEthernet 1/0/1. (Details not shown.)

Verify that the device forwards RA messages received on GigabitEthernet 1/0/3 to other interfaces in VLAN 10. (Details not shown.)

Contents

Configuring SAVI

About SAVI

Source Address Validation Improvement (SAVI) checks the validity of the source addresses of global unicast IPv6 packets. It implements the validity check by using the ND snooping, DHCPv6 snooping, ND attack detection, and IP source guard features. SAVI checks only global unicast addresses and forwards the packets that pass the validity check. Packets sourced from an invalid address are dropped.

SAVI application scenarios

DHCPv6-only

The hosts connected to the SAVI-enabled device obtain addresses only through DHCPv6. DHCPv6 messages, ND messages (RA and RR messages excluded), and IPv6 data packets are checked based on DHCPv6 snooping entries and static IPv6 source guard binding entries.

SLAAC-only

The hosts connected to the SAVI-enabled device obtain addresses only through Stateless Address Autoconfiguration (SLAAC). In this scenario, SAVI drops all DHCPv6 messages. Only ND messages and IPv6 data packets are checked based on DHCPv6 snooping entries and static IPv6 source guard binding entries.

DHCPv6+SLAAC

The hosts connected to the SAVI-enabled device obtain addresses through DHCPv6 and SLAAC. In this scenario, SAVI checks all DHCPv6 messages, ND messages, and IPv6 data packets based on DHCPv6 snooping entries, ND snooping entries, and static IPv6 source guard binding entries.

SAVI tasks at a glance

To configure SAVI, perform the following tasks:

1. Enabling SAVI
2. Configuring IPv6 source guard
3. Configuring DHCPv6 snooping
4. Configuring ND parameters
5. (Optional.) Setting the entry deletion delay
6. (Optional.) Enabling packet spoofing logging and filtering entry logging

Enabling SAVI

1. Enter system view.
   `system-view`
2. Enable SAVI.
   `ipv6 savi strict`
   By default, SAVI is disabled.

Configuring IPv6 source guard

1. Enable IPv6 source guard on an interface.
2. (Optional.) Configure static IPv6SG bindings.

For more information about IPv6 source guard configuration, see "Configuring IP source guard."

Configuring DHCPv6 snooping

Restrictions and guidelines

Enable only DHCPv6 snooping for the SLAAC-only scenario.

Procedure

1. Enable DHCPv6 snooping.
2. Specify DHCPv6 snooping trusted ports.
3. Enable recording client information in DHCPv6 snooping entries.

For more information about DHCPv6 snooping configuration, see *Layer 3—IP Services Configuration Guide*.

Configuring ND parameters

Restrictions and guidelines

Enable only ND attack detection for the DHCPv6-only scenario.

Procedure

1. Enable ND snooping for global unicast addresses.

   For more information about ND snooping, see IPv6 basics in *Layer 3—IP Services Configuration Guide*.
2. Enable ND attack detection.

   For more information about ND attack detection, see "Configuring ND attack defense."
3. Specify ND trusted ports.

   For more information about ND trusted ports, see "Configuring ND attack defense."

Setting the entry deletion delay

About the entry deletion delay

The entry deletion delay is the period of time that the device waits before deleting the DHCPv6 snooping entries and ND snooping entries for a down port.

Procedure

1. Enter system view.

   system-view
2. Set the entry deletion delay.

   ipv6 savi down-delay *delay-time*

   By default, the entry deletion delay is 30 seconds.

Enabling packet spoofing logging and filtering entry logging

About this task

Packet spoofing logging enables the device to generate log messages for the spoofed packets detected by SAVI.

Filtering entries are effective bindings used for filtering IPv6 packets by the source IPv6 address. Filtering entry logging enables the device to generate log messages for filtering entries. A log message contains the IPv6 address, MAC address, VLAN, and interface of a filtering entry.

The device sends packet spoofing and filtering entry log messages to the information center. With the information center, you can set log message filtering and output rules, including output destinations. For more information about using the information center, see *Network Management and Monitoring Configuration Guide*.

Software version and feature compatibility

This feature is supported only in Release 6328 and later.

Procedure

1. Enter system view.

   system-view

2. Enable packet spoofing logging.

   ipv6 savi log enable spoofing-packet [**interval** *interval* | **total-number** *number*] *

   By default, packet spoofing logging is disabled.

3. Enable filtering entry logging.

   ipv6 savi log enable filter-entry

   By default, filtering entry logging is disabled.

SAVI configuration examples

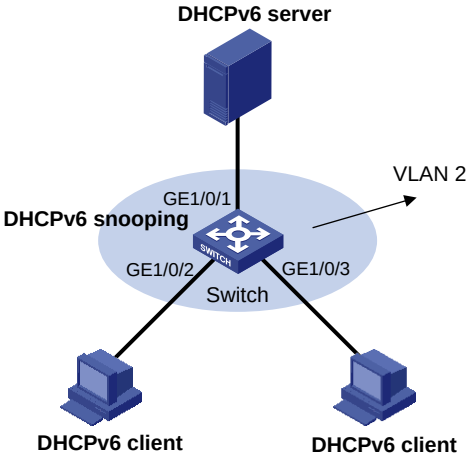
Example: Configuring DHCPv6-only SAVI

Network configuration

As shown in Figure 1, configure SAVI on the switch to meet the following requirements:

- Clients obtain IPv6 addresses only through DHCPv6.
- SAVI checks the source addresses of DHCPv6 messages, ND messages (RA and RR messages excluded), and IPv6 data packets on GigabitEthernet 1/0/2 and GigabitEthernet 1/0/3.

Figure 1 Network diagram



Procedure

Enable SAVI.

```
<Switch> system-view
[Switch] ipv6 savi strict
```

Assign GigabitEthernet 1/0/1 through GigabitEthernet 1/0/3 to VLAN 2.

```
[Switch] vlan 2
[Switch-vlan2] port gigabitethernet 1/0/1 gigabitethernet 1/0/2 gigabitethernet 1/0/3
[Switch-vlan2] quit
```

Enable DHCPv6 snooping.

```
[Switch] ipv6 dhcp snooping enable
```

Configure GigabitEthernet 1/0/1 as a DHCPv6 snooping trusted port.

```
[Switch] interface gigabitethernet 1/0/1
[Switch-GigabitEthernet1/0/1] ipv6 dhcp snooping trust
[Switch-GigabitEthernet1/0/1] quit
```

Enable recording DHCPv6 snooping entries on GigabitEthernet 1/0/2 and GigabitEthernet 1/0/3.

```
[Switch] interface gigabitethernet 1/0/2
[Switch-GigabitEthernet1/0/2] ipv6 dhcp snooping binding record
[Switch-GigabitEthernet1/0/2] quit
[Switch] interface gigabitethernet 1/0/3
[Switch-GigabitEthernet1/0/3] ipv6 dhcp snooping binding record
[Switch-GigabitEthernet1/0/3] quit
```

Enable ND attack detection.

```
[Switch] vlan 2
[Switch-vlan2] ipv6 nd detection enable
[Switch-vlan2] quit
```

Enable IPv6 source guard on GigabitEthernet 1/0/2 and GigabitEthernet 1/0/3.

```
[Switch] interface gigabitethernet 1/0/2
[Switch-GigabitEthernet1/0/2] ipv6 verify source ip-address mac-address
[Switch-GigabitEthernet1/0/2] quit
[Switch] interface gigabitethernet 1/0/3
[Switch-GigabitEthernet1/0/3] ipv6 verify source ip-address mac-address
[Switch-GigabitEthernet1/0/3] quit
```

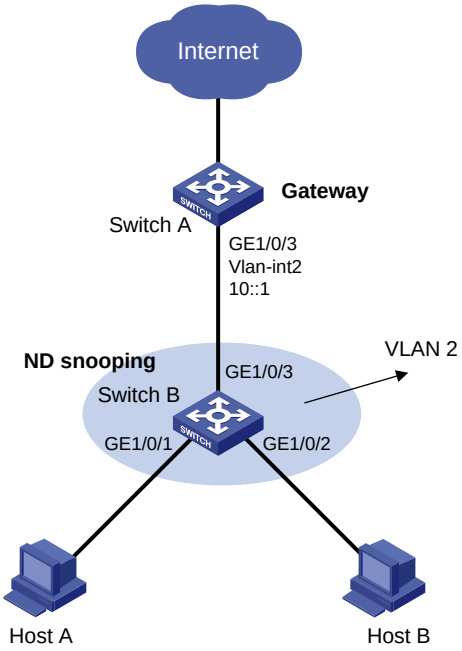
Example: Configuring SLAAC-only SAVI

Network configuration

As shown in Figure 2, configure SAVI on Switch B to meet the following requirements:

- Hosts obtain IPv6 addresses only through SLAAC.
- DHCPv6 messages are dropped on GigabitEthernet 1/0/1 through GigabitEthernet 1/0/3 in VLAN 2.
- SAVI checks the source addresses of ND messages and IPv6 data packets on GigabitEthernet 1/0/1 and GigabitEthernet 1/0/2.

Figure 2 Network diagram



Procedure

Enable SAVI.

```
<SwitchB> system-view
[SwitchB] ipv6 savi strict
```

Assign GigabitEthernet 1/0/1 through GigabitEthernet 1/0/3 to VLAN 2.

```
[SwitchB] vlan 2
[SwitchB-vlan2] port gigabitethernet 1/0/1 gigabitethernet 1/0/2 gigabitethernet 1/0/3
[SwitchB-vlan2] quit
```

Enable ND snooping for global unicast addresses in VLAN 2.

```
[SwitchB] vlan 2
[SwitchB-vlan2] ipv6 nd snooping enable global
```

Enable ND attack detection for VLAN 2.

```
[SwitchB-vlan2] ipv6 nd detection enable
[SwitchB-vlan2] quit
```

Enable DHCPv6 snooping.

```
[SwitchB] ipv6 dhcp snooping enable
```

Configure GigabitEthernet 1/0/3 as an ND trusted port.

```
[SwitchB] interface gigabitethernet 1/0/3
[SwitchB-GigabitEthernet1/0/3] ipv6 nd detection trust
[SwitchB-GigabitEthernet1/0/3] quit
```

Enable IPv6 source guard on GigabitEthernet 1/0/1 and GigabitEthernet 1/0/2.

```
[SwitchB] interface gigabitethernet 1/0/1
[SwitchB-GigabitEthernet1/0/1] ipv6 verify source ip-address mac-address
[SwitchB-GigabitEthernet1/0/1] quit
[SwitchB] interface gigabitethernet 1/0/2
[SwitchB-GigabitEthernet1/0/2] ipv6 verify source ip-address mac-address
[SwitchB-GigabitEthernet1/0/2] quit
```

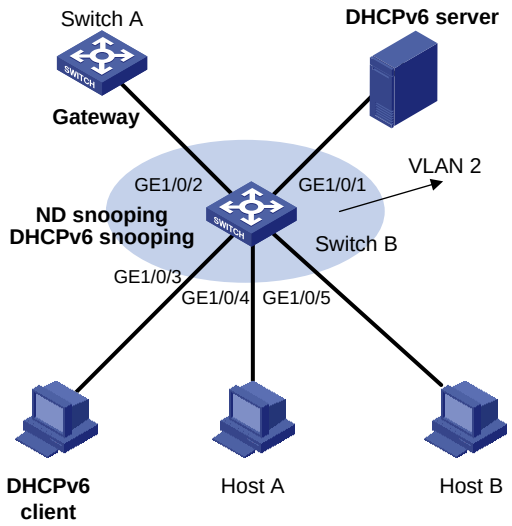
Example: Configuring DHCPv6+SLAAC SAVI

Network configuration

As shown in Figure 3, configure SAVI on Switch B to meet the following requirements:

- Hosts obtain IP addresses through DHCPv6 or SLAAC.
- SAVI checks the source addresses of DHCPv6 messages, ND messages, and IPv6 data packets on GigabitEthernet 1/0/3 through GigabitEthernet 1/0/5.

Figure 3 Network diagram



Procedure

Enable SAVI.

```
<SwitchB> system-view
[SwitchB] ipv6 savi strict
```

Assign GigabitEthernet 1/0/1 through GigabitEthernet 1/0/5 to VLAN 2.

```
[SwitchB] vlan 2
[SwitchB-vlan2] port gigabitethernet 1/0/1 gigabitethernet 1/0/2 gigabitethernet 1/0/3
gigabitethernet 1/0/4 gigabitethernet 1/0/5
```

Enable DHCPv6 snooping.

```
[SwitchB] ipv6 dhcp snooping enable
```

Enable recording DHCPv6 snooping entries on GigabitEthernet 1/0/3 through GigabitEthernet 1/0/5.

```
[SwitchB] interface gigabitethernet 1/0/3
[SwitchB-GigabitEthernet1/0/3] ipv6 dhcp snooping binding record
[SwitchB-GigabitEthernet1/0/3] quit
[SwitchB] interface gigabitethernet 1/0/4
[SwitchB-GigabitEthernet1/0/4] ipv6 dhcp snooping binding record
[SwitchB-GigabitEthernet1/0/4] quit
[SwitchB] interface gigabitethernet 1/0/5
[SwitchB-GigabitEthernet1/0/5] ipv6 dhcp snooping binding record
[SwitchB-GigabitEthernet1/0/5] quit
```

Configure GigabitEthernet 1/0/1 as a DHCPv6 snooping trusted port.

```
[SwitchB] interface gigabitethernet 1/0/1
[SwitchB-GigabitEthernet1/0/1] ipv6 dhcp snooping trust
[SwitchB-GigabitEthernet1/0/1] quit
```

Enable ND snooping for global unicast addresses in VLAN 2.

```
[SwitchB] vlan 2
[SwitchB-vlan2] ipv6 nd snooping enable global
```

Enable ND attack detection for VLAN 2.

```
[SwitchB-vlan2] ipv6 nd detection enable
[SwitchB-vlan2] quit
```

Configure GigabitEthernet 1/0/2 as an ND trusted port.

```
[SwitchB] interface gigabitethernet 1/0/2
[SwitchB-GigabitEthernet1/0/2] ipv6 nd detection trust
[SwitchB-GigabitEthernet1/0/2] quit
```

Enable IPv6 source guard on GigabitEthernet 1/0/3 through GigabitEthernet 1/0/5.

```
[SwitchB] interface gigabitethernet 1/0/3
[SwitchB-GigabitEthernet1/0/3] ipv6 verify source ip-address mac-address
[SwitchB-GigabitEthernet1/0/3] quit
[SwitchB] interface gigabitethernet 1/0/4
[SwitchB-GigabitEthernet1/0/4] ipv6 verify source ip-address mac-address
[SwitchB-GigabitEthernet1/0/4] quit
[SwitchB] interface gigabitethernet 1/0/5
[SwitchB-GigabitEthernet1/0/5] ipv6 verify source ip-address mac-address
```

Contents

Configuring MFF

About MFF

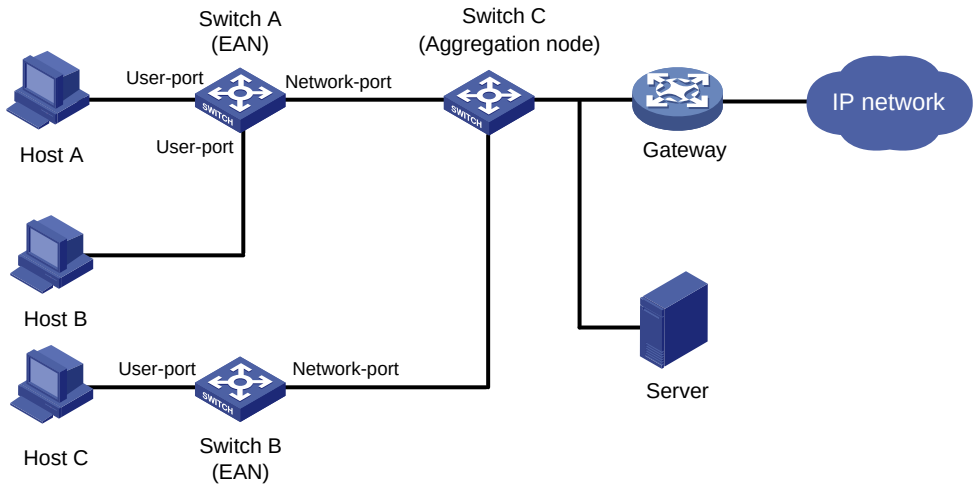
MAC-forced forwarding (MFF) implements Layer 2 isolation and Layer 3 communication between hosts in the same broadcast domain.

An MFF-enabled device intercepts ARP requests and returns the MAC address of a gateway (or server) to the senders. In this way, the senders are forced to send packets to the gateway for traffic monitoring and attack prevention.

MFF network model

As shown in Figure 1, hosts are connected to Switch C through Switch A and Switch B, which are called Ethernet access nodes (EANs). The MFF-enabled EANs forward packets from hosts to the gateway for further forwarding. The hosts are isolated at Layer 2, but they can communicate at Layer 3.

Figure 1 Network diagram for MFF



MFF works with any of the following features to implement traffic filtering and Layer 2 isolation on the EANs:

- ARP snooping (see *Layer 3—IP Services Configuration Guide*).
- IP source guard (see "Configuring IP source guard").
- ARP detection (see "Configuring ARP attack protection").
- VLAN mapping (see *Layer 2—LAN Switching Configuration Guide*).

Port roles

Two types of ports, user port and network port, exist in an MFF-enabled VLAN.

User port

An MFF user port is directly connected to a host and processes the following packets differently:

- Allows multicast packets to pass.
- Delivers ARP packets to the CPU.

- Processes unicast packets as follows:
  - If gateways' MAC addresses have been learned, the user port allows only the unicast packets with the gateways' MAC addresses as the destination MAC addresses to pass.
  - If no gateways' MAC addresses have been learned, the user port discards all received unicast packets.

Network port

An MFF network port is connected to any of the following networking devices:

- An access switch.
- A distribution switch.
- A gateway.
- A server.

A network port processes the following packets differently:

- Allows multicast packets to pass.
- Delivers ARP packets to the CPU.
- Denies broadcast packets other than DHCP and ARP packets.

Processing of ARP packets in MFF

An MFF-enabled device implements Layer 3 communication between hosts by intercepting ARP requests from the hosts and replies with the MAC address of a gateway. This mechanism helps reduce the number of broadcast messages.

The MFF device processes ARP packets as follows:

- After receiving an ARP request from a host, the MFF device sends the MAC address of the corresponding gateway to the host. In this way, hosts in the network have to communicate at Layer 3 through a gateway.
- After receiving an ARP request from a gateway, the MFF device sends the requested host's MAC address to the gateway if the corresponding entry is available. If the entry is not available, the MFF device forwards the ARP request.
- The MFF device forwards ARP replies between hosts and gateways.
- If the source MAC addresses of ARP requests from gateways are different from those recorded, the MFF device updates and broadcasts the IP and MAC addresses of the gateways.

MFF default gateway

MFF applies to only networks where the hosts' IP addresses are manually configured. Because the hosts cannot obtain the gateway information through DHCP, the default gateway must be specified by the **`mac-forced-forwarding default-gateway`** command. MFF maintains only one default gateway for each VLAN. MFF updates the MAC address of the default gateway upon receiving an ARP packet with a different sender MAC address from the default gateway.

Protocols and standards

RFC 4562, *MAC-Forced Forwarding*

MFF tasks at a glance

To configure MFF, perform the following tasks:

1. Enabling MFF
2. Configuring a network port
3. (Optional.) Enabling periodic gateway probe
4. Specifying the IP addresses of servers

   If servers exist in the network, you must perform this task to ensure communication between the servers and hosts.

Enabling MFF

Restrictions and guidelines

- An MFF-enabled device and a host cannot ping each other.
- When MFF works with static IP source guard bindings, you must configure VLAN IDs in the static bindings. Otherwise, IP packets allowed by IP source guard are permitted even if their destination MAC addresses are not the MAC address of the gateway.
- MFF is not supported in a network where VRRP load balancing mode is configured.

Prerequisites

For MFF to take effect, make sure ARP snooping is enabled on the VLAN where MFF is enabled.

Procedure

1. Enter system view.

   system-view
2. Enter VLAN view.

   vlan *vlan-id*
3. Enable MFF.

   mac-forced-forwarding default-gateway *gateway-ip*

   By default, MFF is disabled.

Configuring a network port

Restrictions and guidelines

In a VLAN with MFF enabled, you need to configure the following ports as network ports:

- Upstream ports connected to the gateway.
- Ports connected to other MFF devices.

Link aggregation is supported by network ports in an MFF-enabled VLAN, but it is not supported by user ports in the VLAN. You can add the network ports to link aggregation groups, but cannot add the user ports to link aggregation groups. For more information about link aggregation, see *Layer 2—LAN Switching Configuration Guide*.

Procedure

1. Enter system view.

   system-view
2. Enter interface view.

   interface *interface-type interface-number*
3. Configure the port as a network port.

   mac-forced-forwarding network-port

   By default, the port is a user port.

Enabling periodic gateway probe

About periodic gateway probe

You can configure the MFF device to detect gateways every 30 seconds for the change of MAC addresses by sending forged ARP packets. The ARP packets use 0.0.0.0 as the sender IP address and bridge MAC address as the sender MAC address.

Procedure

1. Enter system view.
   system-view
2. Enter VLAN view.
   vlan *vlan-id*
3. Enable periodic gateway probe.
   mac-forced-forwarding gateway probe
   By default, this feature is disabled.

Specifying the IP addresses of servers

About server IP address

Server IP addresses can be those of the interfaces on a router in a VRRP group and those of the servers collaborating with MFF, such as a RADIUS server.

When the MFF device receives an ARP request from a server, the device searches IP-to-MAC address entries it has stored. Then the device replies with the requested MAC address to the server.

As a result, packets from a host to a server are forwarded by the gateway. However, packets from a server to a host are not forwarded by the gateway.

MFF does not check whether the IP address of a server is on the same network segment as that of a gateway. Instead, it checks whether the IP address of a server is all-zero or all-one. An all-zero or all-one server IP address is invalid.

Restrictions and guidelines

If the server's interface connecting to the MFF device uses secondary IP addresses to send ARP packets, include all these IP addresses in the server IP address list.

Procedure

1. Enter system view.
   system-view
2. Enter VLAN view.
   vlan *vlan-id*
3. Specify the IP addresses of servers.
   mac-forced-forwarding server *server-ip*&<1-10>
   By default, no server IP address is specified.

Display and maintenance commands for MFF

Execute **display** commands in any view.

Task	Command
Display MFF port configuration.	**display mac-forced-forwarding interface**
Display the MFF configuration for a VLAN.	**display mac-forced-forwarding vlan** *vlan-id*

MFF configuration examples

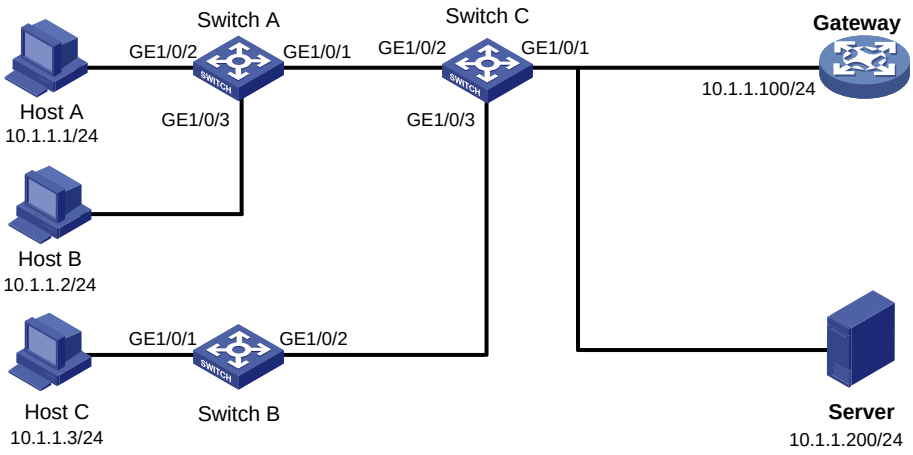
Example: Configuring MFF in a tree network

Network configuration

As shown in Figure 2, all the devices are in VLAN 100. Hosts A, B, and C are assigned IP addresses manually.

Configure MFF to isolate the hosts at Layer 2 and allow them to communicate with each other through the gateway at Layer 3.

Figure 2 Network diagram



Procedure

1. Configure the IP addresses of the hosts and the gateway, as shown in Figure 2.
2. Configure Switch A:

   # Configure MFF on VLAN 100.

   ```
   [SwitchA] vlan 100
   [SwitchA-vlan100] mac-forced-forwarding default-gateway 10.1.1.100
   ```

   # Specify the IP address of the server.

   ```
   [SwitchA-vlan100] mac-forced-forwarding server 10.1.1.200
   ```

   # Enable ARP snooping on VLAN 100.

   ```
   [SwitchA-vlan100] arp snooping enable
   [SwitchA-vlan100] quit
   ```

   # Configure GigabitEthernet 1/0/1 as a network port.

   ```
   [SwitchA] interface gigabitethernet 1/0/1
   [SwitchA-GigabitEthernet1/0/1] mac-forced-forwarding network-port
   ```
3. Configure Switch B:

Configure MFF on VLAN 100.

```
[SwitchB] vlan 100
[SwitchB-vlan100] mac-forced-forwarding default-gateway 10.1.1.100
```

Specify the IP address of the server.

```
[SwitchB-vlan100] mac-forced-forwarding server 10.1.1.200
```

Enable ARP snooping on VLAN 100.

```
[SwitchB-vlan100] arp snooping enable
[SwitchB-vlan100] quit
```

Configure GigabitEthernet 1/0/2 as a network port.

```
[SwitchB] interface gigabitethernet 1/0/2 1/0/6
[SwitchB-GigabitEthernet1/0/2] mac-forced-forwarding network-port
```

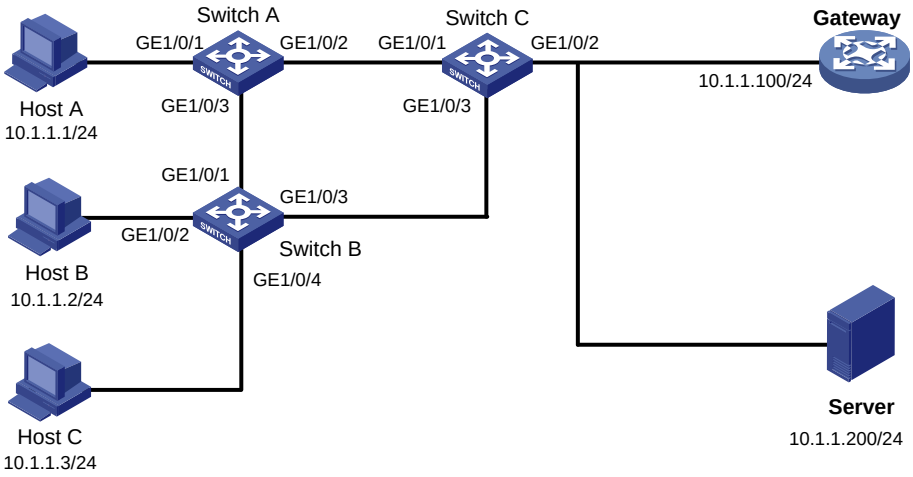
Example: Configuring MFF in a ring network

Network configuration

As shown in Figure 3, all the devices are in VLAN 100, and the switches form a ring. Hosts A, B, and C are assigned IP addresses manually.

Configure MFF to isolate the hosts at Layer 2 and allow them to communicate with each other through the gateway at Layer 3.

Figure 3 Network diagram



Procedure

1. Configure the IP addresses of the hosts and the gateway, as in shown in Figure 3.
2. Configure Switch A:

   # Enable STP globally to make sure STP is enabled on interfaces.

   ```
   [SwitchA] stp global enable
   ```

   # Configure MFF on VLAN 100.

   ```
   [SwitchA] vlan 100
   [SwitchA-vlan100] mac-forced-forwarding default-gateway 10.1.1.100
   ```

   # Specify the IP address of the server.

   ```
   [SwitchA-vlan100] mac-forced-forwarding server 10.1.1.200
   ```

   # Enable ARP snooping on VLAN 100.

   ```
   [SwitchA-vlan100] arp snooping enable
   ```

```
[SwitchA-vlan100] quit
```

Configure GigabitEthernet 1/0/2 and GigabitEthernet 1/0/3 as network ports.

```
[SwitchA] interface gigabitethernet 1/0/2
[SwitchA-GigabitEthernet1/0/2] mac-forced-forwarding network-port
[SwitchA-GigabitEthernet1/0/2] quit
[SwitchA] interface gigabitethernet 1/0/3
[SwitchA-GigabitEthernet1/0/3] mac-forced-forwarding network-port
```

3. Configure Switch B:

Enable STP globally to make sure STP is enabled on interfaces.

```
[SwitchB] stp global enable
```

Configure MFF on VLAN 100.

```
[SwitchB] vlan 100
[SwitchB-vlan100] mac-forced-forwarding default-gateway 10.1.1.100
```

Specify the IP address of the server.

```
[SwitchB-vlan100] mac-forced-forwarding server 10.1.1.200
```

Enable ARP snooping on VLAN 100.

```
[SwitchB-vlan100] arp snooping enable
[SwitchB-vlan100] quit
```

Configure GigabitEthernet 1/0/1 and GigabitEthernet 1/0/3 as network ports.

```
[SwitchB] interface gigabitethernet 1/0/1
[SwitchB-GigabitEthernet1/0/1] mac-forced-forwarding network-port
[SwitchB-GigabitEthernet1/0/1] quit
[SwitchB] interface gigabitethernet 1/0/3
[SwitchB-GigabitEthernet1/0/3] mac-forced-forwarding network-port
```

4. Enable STP on Switch C globally to make sure STP is enabled on interfaces.

```
<SwitchC> system-view
[SwitchC] stp global enable
```

Contents

Configuring crypto engines

About crypto engines

Crypto engines encrypt and decrypt data for service modules.

The device supports only one software crypto engine, which is a set of software encryption algorithms. The software crypto engine is always enabled.

When a service module requires data encryption/decryption, it sends the desired data to the crypto engine. After the crypto engine completes data encryption/decryption, it sends the data back to the service module.

Display and maintenance commands for crypto engines

Execute **display** commands in any view and **reset** commands in user view.

Task	Command
Display crypto engine information.	**display crypto-engine**
Display crypto engine statistics.	**display crypto-engine statistics** [**engine-id** *engine-id* **slot** *slot-number*]
Clear crypto engine statistics.	**reset crypto-engine statistics** [**engine-id** *engine-id* **slot** *slot-number*]

Contents

Configuring FIPS

About FIPS

Federal Information Processing Standards (FIPS) was developed by the National Institute of Standards and Technology (NIST) of the United States. FIPS specifies the requirements for cryptographic modules.

FIPS security levels

FIPS 140-2 defines four levels of security, named Level 1 to Level 4, from low to high. The device supports Level 2.

Unless otherwise noted, the term "FIPS" refers to Level-2 FIPS 140-2 in this document.

FIPS functionality

In FIPS mode, the device has strict security requirements. It performs self-tests on cryptography modules to verify that the modules are operating correctly.

A FIPS device also meets the functionality requirements defined in Network Device Protection Profile (NDPP) of Common Criteria (CC).

FIPS self-tests

To ensure correct operation of cryptography modules, FIPS provides self-test mechanisms, including power-up self-tests and conditional self-tests.

If a power-up self-test fails, the device where the self-test process exists reboots. If a conditional self-test fails, the system outputs a self-test failure message.

NOTE:

If a self-test fails, contact H3C Support.

Power-up self-tests

The power-up self-test examines the availability of FIPS-allowed cryptographic algorithms.

The device supports the following types of power-up self-tests:

- Known-answer test (KAT)

  A cryptographic algorithm is run on data for which the correct output is already known. The calculated output is compared with the known answer. If they are not identical, the KAT test fails.

- Pairwise conditional test (PWCT)
  - **Signature and authentication test**—The test is run when a DSA, RSA, or ECDSA asymmetrical key pair is generated. The system uses the private key to sign the specific data, and then uses the public key to authenticate the signed data. If the authentication is successful, the test succeeds.
  - **Encryption and decryption test**—The test is run when an RSA asymmetrical key pair is generated. The system uses the public key to encrypt a plain text string, and then uses the private key to decrypt the encrypted text. If the decryption result is the same as the original plain text string, the test succeeds.

The power-up self-test examines the cryptographic algorithms listed in Table 1.

Table 1 Power-up self-tests list

Type	Operations
KAT	Tests the following algorithms: • SHA1, SHA224, SHA256, SHA384, and SHA512. • HMAC-SHA1, HMAC-SHA224, HMAC-SHA256, HMAC-SHA384, and HMAC-SHA512. • AES. • RSA (signature and authentication). • ECDH. • DRBG. • GCM. • GMAC.
PWCT	Tests the following algorithms: • RSA (signature and authentication). • RSA (encryption and decryption). • DSA (signature and authentication). • ECDSA (signature and authentication).

Conditional self-tests

A conditional self-test runs when an asymmetrical cryptographic module or a random number generator module is invoked. Conditional self-tests include the following types:

- **PWCT signature and authentication**—This test is run when a DSA or RSA asymmetrical key pair is generated. The system uses the private key to sign the specific data, and then uses the public key to authenticate the signed data. If the authentication is successful, the test succeeds.
- **Continuous random number generator test**—Runs when a random number is generated. The system compares the generated random number with the previously generated random number. If the two numbers are the same, the test fails. This test also runs when a DSA or RSA asymmetrical key pair is generated.

Restrictions and guidelines: FIPS

Requirements for key pairs and passwords

Before you reboot the device to enter FIPS mode, the system automatically removes all key pairs configured in non-FIPS mode and all FIPS-incompliant digital certificates. FIPS-incompliant digital certificates are MD5-based certificates with a key modulus length less than 2048 bits. You cannot log in to the device through SSH after the device enters FIPS mode. To log in to the device in FIPS mode through SSH, log in to the device through a console port and create a key pair for the SSH server.

The password for entering the device in FIPS mode must comply with the password control policies, such as password length, complexity, and aging policy. When the aging timer for a password expires, the system prompts you to change the password. If you adjust the system time after the device enters FIPS mode, the login password might expire before the next login, because the original system time is typically much earlier than the actual time.

Configuration rollback guidelines

Configuration rollback is supported in FIPS mode and also during a switch between FIPS mode and non-FIPS mode. After a configuration rollback between FIPS mode and non-FIPS mode, perform the following tasks:

1. Delete the local user and configure a new local user. Local user attributes include password, user role, and service type.

2. Save the current configuration file.
3. Specify the current configuration file as the startup configuration file.
4. Reboot the device. The new configuration takes effect after the reboot. During this process, do not exit the system or perform other operations.

If a device enters FIPS or non-FIPS mode through automatic reboot, configuration rollback fails. To support configuration rollback, you must execute the **save** command after the device enters FIPS or non-FIPS mode.

IRF compatibility

All devices in an IRF fabric must be operating in the same mode, whether in FIPS mode or non-FIPS mode.

To enable FIPS mode for an IRF fabric, you must reboot the entire IRF fabric.

Feature changes in FIPS mode

After the system enters FIPS mode, the following feature changes occur:

- The user login authentication mode can only be scheme.
- The FTP/TFTP server and client are disabled.
- The Telnet server and client are disabled.
- The HTTP server is disabled.
- SNMPv1 and SNMPv2c are disabled. Only SNMPv3 is available.
- The SSL server supports only TLS1.0, TLS1.1, and TLS1.2.
- The SSH server does not support SSHv1 clients or DSA key pairs.
- The generated RSA and DSA key pairs must have a modulus length of 2048 bits.

  When the device acts as a server to authenticate a client through the public key, the key pair for the client must also have a modulus length of 2048 bits.
- The generated ECDSA key pairs must have a modulus length of more than 256 bits.

  When the device acts as a server to authenticate a client through the public key, the key pair for the client must also have a modulus length of more than 256 bits.
- SSH, SNMPv3, IPsec, and SSL do not support DES, 3DES, RC4, or MD5.
- The password control feature cannot be disabled globally. The **undo password-control enable** command does not take effect.
- An AAA shared key, IKE pre-shared key, or SNMPv3 authentication key must have at least 15 characters and must contain uppercase and lowercase letters, digits, and special characters.
- The password for a device management local user and password for switching user roles must comply with the password control policies. By default, the password must have at least 15 characters and must contain uppercase and lowercase letters, digits, and special characters.

Entering FIPS mode

About entering FIPS mode

For the device to enter FIPS mode, you can use one of the following methods:

- **Automatic reboot**—The system automatically performs the following operations:
  a. Prompts you to specify the username and password for the next login.
  b. Creates a default FIPS configuration file named **fips-startup.cfg**.
  c. Specifies the default FIPS configuration file as the startup configuration file.
  d. Reboots and loads the default FIPS configuration file to enter the FIPS mode.

- **Manual reboot**—You must complete the required configuration tasks and reboot the device manually.

Restrictions and guidelines

After you execute the **`fips mode enable`** command, the system prompts you to choose a reboot method.

- If you do not make a choice within 30 seconds or press **Ctrl**+**C**, the system enables FIPS mode and waits for you to manually complete the FIPS mode configuration tasks.
- If you select the automatic reboot method, you can press **Ctrl**+**C** to abort both the interactive FIPS mode configuration process and the **`fips mode enable`** command.

Using the automatic reboot method to enter FIPS mode

Prerequisites

To ensure login password effectiveness under the password control policies, set the correct system time.

Procedure

1. Enter system view.

   ```
   system-view
   ```

2. Enable FIPS mode.

   ```
   fips mode enable
   ```

   By default, the FIPS mode is disabled.

3. After the reboot method choice prompt appears, enter **Y** within 30 minutes.

   The system starts the interactive FIPS mode configuration process.

CAUTION:

System reboot might interrupt ongoing services. Please perform the previous operations with caution.

4. Enter the login username and password as prompted.

   The password must have a minimum of 15 characters and must contain uppercase and lowercase letters, digits, and special characters. After you enter the username and password, the device performs the following operations:

   - Creates a device management local user that uses the entered username and password.
   - Assigns the user the terminal service and the network-admin user role.
   - Saves the running configuration and specifies the configuration file as the startup configuration file.
   - Reboots, loads the startup configuration file, and enters FIPS mode.

To log in to the device, you must enter the configured username and password. After login, you are identified as the FIPS mode crypto officer.

Using the manual reboot method to enter FIPS mode

Prerequisites

1. To ensure login password effectiveness under the password control policies, set the correct system time.

2. Configure the password control feature.
   a. Enable the password control feature globally.
   b. Configure password control policies.
      - Set the number of character types a password must contain to 4.
      - Set the minimum number of characters for each type to one character.
      - Set the minimum length for a user password to 15 characters.

   For more information about the password control feature, see password control in *Security Configuration Guide*.
3. Configure a local user.
   - Create a device management local user.
   - Specify a password that complies with the password control policies.
   - Assign the terminal service to the user.
   - Assign the network-admin user role to the user.

Procedure

1. Enter system view.

   `system-view`
2. Enable FIPS mode.

   `fips mode enable`

   By default, the FIPS mode is disabled.
3. After the reboot method choice prompt appears, enter **N**.

   The system enables FIPS mode and waits for you to complete the FIPS mode configuration tasks. Before rebooting the device to enter FIPS mode, do not execute any commands except for **`save`** and commands used to prepare for entering FIPS mode. If you execute any other commands, the commands might not take effect.

   CAUTION:
   - System reboot might interrupt ongoing services. Please perform the previous operations with caution.
   - If you select the manual reboot method to enter FIPS mode, you must manually complete the configurations for entering FIPS mode. If you fail to do so, the device enters FIPS mode after startup but you cannot log in to the device.
4. Save the running configuration and specify the configuration file as the startup configuration file.
5. Delete the .mdb startup configuration file.

   When loading a .mdb configuration file, the device loads all settings in the file. The settings that are not supported in FIPS mode might affect device operation.
6. Reboot the device.

   The device reboots, loads the startup configuration file, and enters FIPS mode. To log in to the device, you must enter the configured username and password. After login, you are identified as the FIPS mode crypto officer.

Manually triggering self-tests

About triggering self-tests

You can manually trigger FIPS self-tests to verify operation of cryptography modules anytime as required. The triggered self-tests are the same as the power-up self-tests.

Procedure

1. Enter system view.
   ```
   system-view
   ```
2. Trigger self-tests.
   ```
   fips self-test
   ```

CAUTION:

A successful self-test requires that all cryptographic algorithms pass the self-test. If the self-test fails, the device where the self-test process exists reboots.

Exiting FIPS mode

About exiting FIPS mode

After you disable FIPS mode and reboot the device, the device operates in non-FIPS mode.

For the device to exit FIPS mode, you can use one of the following reboot methods:

- **Automatic reboot**—The system automatically creates a default non-FIPS configuration file named **non-fips-startup.cfg**, specifies the file as the startup configuration file, and reboots to enter non-FIPS mode. You can log in to the device without providing username or password.
- **Manual reboot**—You must manually complete the configuration tasks for entering non-FIPS mode, and then reboot the device. To log in to the device after the reboot, you must enter user information as required by the authentication mode settings.

  The following are the default authentication mode settings:
  - **VTY line**—Password authentication.
  - **AUX line**—Authentication is disabled.

  You can modify the authentication settings as needed.

Using the automatic reboot method to exit FIPS mode

1. Enter system view.
   ```
   system-view
   ```
2. Disable FIPS mode.
   ```
   undo fips mode enable
   ```
   By default, the FIPS mode is disabled.
3. Select the automatic reboot method.

CAUTION:

System reboot might interrupt ongoing services. Please perform the previous operations with caution.

Using the manual reboot method to exit FIPS mode

1. Enter system view.
   ```
   system-view
   ```
2. Disable FIPS mode.
   ```
   undo fips mode enable
   ```
   By default, the FIPS mode is disabled.
3. Select the manual reboot method.

CAUTION:

System reboot might interrupt ongoing services. Please perform the previous operations with caution.

4. Configure login authentication settings.
   - If you logged in to the device through SSH, perform the following tasks without disconnecting the current user line:
     - Set the authentication mode to **scheme** for VTY lines.
     - Specify the username and password. If you do not specify the username or password, the device uses the current username and password.
   - If you logged in to the device through a console port, configure login authentication settings for the current type of user lines as described in the following table:

Current login method	Login authentication requirements
Scheme	Set the authentication to scheme and specify the username and password. If you do not specify the username or password, the device uses the current username and password.
Password	Set the authentication to password and specify the password. If you do not specify the password, the device uses the current password.
None	Set the authentication to none.

5. Save the running configuration and specify the file as the startup configuration file.
6. Delete the .mdb startup configuration file.
7. Reboot the device.

Display and maintenance commands for FIPS

Execute **display** commands in any view.

Task	Command
Display the version number of the device algorithm base.	**display crypto version**
Display the FIPS mode state.	**display fips status**

FIPS configuration examples

Example: Entering FIPS mode through automatic reboot

Network configuration

Use the automatic reboot method to enter FIPS mode, and use a console port to log in to the device in FIPS mode.

Procedure

If you want to save the current configuration, execute the **save** command before you enable FIPS mode.

Enable FIPS mode and choose the automatic reboot method to enter FIPS mode. Set the username to **root** and the password to **12345zxcvb!@#$%ZXCVB**.

```
<Sysname> system-view
[Sysname] fips mode enable
FIPS mode change requires a device reboot. Continue? [Y/N]:y
Reboot the device automatically? [Y/N]:y
The system will create a new startup configuration file for FIPS mode. After you set the login username and password for FIPS mode, the device will reboot automatically.
Enter username(1-55 characters):root
Enter password(15-63 characters):
Confirm password:
Waiting for reboot... After reboot, the device will enter FIPS mode.
```

Verifying the configuration

After the device reboots, enter a username of **root** and a password of **12345zxcvb!@#$%ZXCVB**. The system prompts you to configure a new password. After you configure the new password, the device enters FIPS mode. The new password must be different from the previous password. It must include at least 15 characters, and contain uppercase and lowercase letters, digits, and special characters. For more information about the requirements for the password, see the system output.

```
Press ENTER to get started.
login: root
Password:
First login or password reset. For security reason, you need to change your password. Please enter your password.
old password:
new password:
confirm:
Updating user information. Please wait ... ...
…
<Sysname>
```

Display the FIPS mode state.

```
<Sysname> display fips status
FIPS mode is enabled.
```

Display the default configuration file.

```
<Sysname> more fips-startup.cfg
#
 password-control enable
#
local-user root class manage
 service-type terminal
 authorization-attribute user-role network-admin
#
 fips mode enable
#
return

<Sysname>
```

Example: Entering FIPS mode through manual reboot

Network configuration

Use the manual reboot method to enter FIPS mode, and use a console port to log in to the device in FIPS mode.

Procedure

Enable the password control feature globally.

```
<Sysname> system-view
[Sysname] password-control enable
```

Set the number of character types a password must contain to 4, and set the minimum number of characters for each type to one character.

```
[Sysname] password-control composition type-number 4 type-length 1
```

Set the minimum length of user passwords to 15 characters.

```
[Sysname] password-control length 15
```

Add a local user account for device management, including a username of **test**, a password of **12345zxcvb!@#$%ZXCVB**, a user role of **network-admin**, and a service type of **terminal**.

```
[Sysname] local-user test class manage
[Sysname-luser-manage-test] password simple 12345zxcvb!@#$%ZXCVB
[Sysname-luser-manage-test] authorization-attribute user-role network-admin
[Sysname-luser-manage-test] service-type terminal
[Sysname-luser-manage-test] quit
```

Enable FIPS mode, and choose the manual reboot method to enter FIPS mode.

```
[Sysname] fips mode enable
FIPS mode change requires a device reboot. Continue? [Y/N]:y
Reboot the device automatically? [Y/N]:n
Change the configuration to meet FIPS mode requirements, save the configuration to the
next-startup configuration file, and then reboot to enter FIPS mode.
```

Save the current configuration to the root directory of the storage medium, and specify it as the startup configuration file.

```
[Sysname] save
The current configuration will be written to the device. Are you sure? [Y/N]:y
Please input the file name(*.cfg)[flash:/startup.cfg]
(To leave the existing filename unchanged, press the enter key):
flash:/startup.cfg exists, overwrite? [Y/N]:y
Validating file. Please wait...
Saved the current configuration to mainboard device successfully.
[Sysname] quit
```

Delete the startup configuration file in binary format.

```
<Sysname> delete flash:/startup.mdb
Delete flash:/startup.mdb?[Y/N]:y
Deleting file flash:/startup.mdb...Done.
```

Reboot the device.

```
<Sysname> reboot
```

Verifying the configuration

After the device reboots, enter a username of **test** and a password of **12345zxcvb!@#$%ZXCVB**. The system prompts you to configure a new password. After you configure the new password, the

device enters FIPS mode. The new password must be different from the previous password. It must include at least 15 characters, and contain uppercase and lowercase letters, digits, and special characters. For more information about the requirements for the password, see the system output.

```
Press ENTER to get started.
login: test
Password:
First login or password reset. For security reason, you need to change your pass
word. Please enter your password.
old password:
new password:
confirm:
Updating user information. Please wait ... ...
…
<Sysname>
```

Display the FIPS mode state.

```
<Sysname> display fips status
FIPS mode is enabled.
```

Example: Exiting FIPS mode through automatic reboot

Network configuration

After logging in to the device in FIPS mode through a console port, use the automatic reboot method to exit FIPS mode.

Procedure

Disable FIPS mode.

```
[Sysname] undo fips mode enable
FIPS mode change requires a device reboot. Continue? [Y/N]:y
The system will create a new startup configuration file for non-FIPS mode and then reboot
automatically. Continue? [Y/N]:y
Waiting for reboot... After reboot, the device will enter non-FIPS mode.
```

Verifying the configuration

After the device reboots, you can enter the system.

```
<Sysname>
```

Display the FIPS mode state.

```
<Sysname> display fips status
FIPS mode is disabled.
```

Example: Exiting FIPS mode through manual reboot

Network configuration

After logging in to the device in FIPS mode through the console port with username **test** and password **12345zxcvb!@#$%ZXCVB**, use the manual reboot method to exit FIPS mode.

Procedure

Disable FIPS mode.

```
[Sysname] undo fips mode enable
FIPS mode change requires a device reboot. Continue? [Y/N]:y
```

```
The system will create a new startup configuration file for non-FIPS mode, and then reboot automatically. Continue? [Y/N]:n
Change the configuration to meet non-FIPS mode requirements, save the configuration to the next-startup configuration file, and then reboot to enter non-FIPS mode.
```

Save the current configuration to the root directory of the storage medium, and specify it as the startup configuration file.

```
[Sysname] save
The current configuration will be written to the device. Are you sure? [Y/N]:y
Please input the file name(*.cfg)[flash:/startup.cfg]
(To leave the existing filename unchanged, press the enter key):
flash:/startup.cfg exists, overwrite? [Y/N]:y
Validating file. Please wait...
Saved the current configuration to mainboard device successfully.
[Sysname] quit
```

Delete the startup configuration file in binary format.

```
<Sysname> delete flash:/startup.mdb
Delete flash:/startup.mdb?[Y/N]:y
Deleting file flash:/startup.mdb...Done.
```

Reboot the device.

```
<Sysname> reboot
```

Verifying the configuration

After the device reboots, authentication is disabled for console login by default. You can press **Enter** to enter non-FIPS mode without authentication.

```
Press ENTER to get started.
login: test
Password:
Last successfully login time:…
…
<Sysname>
```

Display the FIPS mode state.

```
<Sysname> display fips status
FIPS mode is disabled.
```

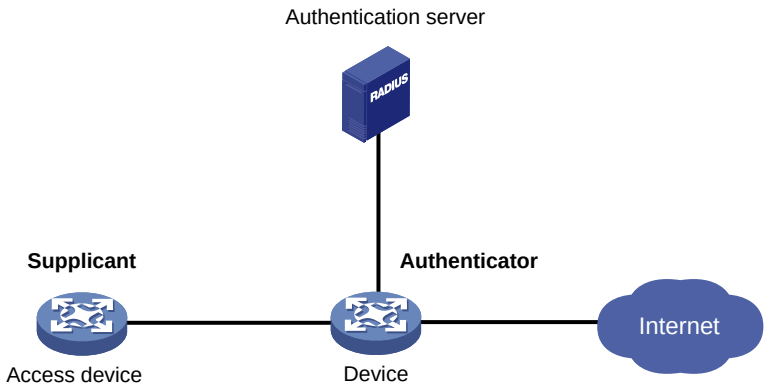
Contents

Configuring an 802.1X client

About 802.1X clients

As shown in Figure 1, the 802.1X client feature allows the access device to act as the supplicant in the 802.1X architecture. For information about the 802.1X architecture, see "802.1X overview."

Figure 1 802.1X client network diagram



802.1X client tasks at a glance

To configure an 802.1X client, perform the following tasks:

1. Enabling the 802.1X client feature
2. Configuring an 802.1X client username and password
3. Specifying an 802.1X client EAP authentication method
4. (Optional.) Configuring an 802.1X client MAC address
5. (Optional.) Specifying an 802.1X client mode for sending EAP-Response and EAPOL-Logoff packets
6. (Optional.) Configuring an 802.1X client anonymous identifier
7. Specifying an SSL client policy

   This task is required when you specify PEAP-MSCHAPv2, PEAP-GTC, TTLS-MSCHAPv2, or TTLS-GTC authentication as the 802.1X client EAP authentication method.

Enabling the 802.1X client feature

1. Enter system view.

   `system-view`
2. Enter Ethernet interface view.

   `interface` *`interface-type interface-number`*
3. Enable the 802.1X client feature.

   `dot1x supplicant enable`

   By default, the 802.1X client feature is disabled.

Configuring an 802.1X client username and password

Restrictions and guidelines

To ensure successful authentication, make sure the username and password configured on the device is consistent with the username and password configured on the authentication server.

Procedure

1. Enter system view.
   system-view
2. Enter Ethernet interface view.
   interface *interface-type interface-number*
3. Configure an 802.1X client username.
   dot1x supplicant username *username*
   By default, no 802.1X client username is configured.
4. Set an 802.1X client password.
   dot1x supplicant password { **cipher** | **simple** } *string*
   By default, no 802.1X client password is configured.

Specifying an 802.1X client EAP authentication method

About 802.1X client EAP authentication methods

The 802.1X clients on the device support the following EAP authentication methods:

- MD5-Challenge.
- PEAP-MSCHAPv2.
- PEAP-GTC.
- TTLS-MSCHAPv2.
- TTLS-GTC.

Restrictions and guidelines

The following matrix shows the restrictions for the selection of authentication methods on the 802.1X client and the authenticator:

Authentication method specified on the 802.1X client	Packet exchange method specified on the authenticator
MD5-Challenge	• EAP relay • EAP termination
• PEAP-MSCHAPv2 • PEAP-GTC • TTLS-MSCHAPv2 • TTLS-GTC	EAP relay

For information about 802.1X packet exchange methods, see "Configuring 802.1X."

Make sure the specified 802.1X client EAP authentication method is supported by the authentication server.

Procedure

1. Enter system view.

   system-view

2. Enter Ethernet interface view.

   interface *interface-type interface-number*

3. Specify an 802.1X client EAP authentication method.

   dot1x supplicant eap-method { **md5** | **peap-gtc** | **peap-mschapv2** | **ttls-gtc** | **ttls-mschapv2** }

   By default, an 802.1X client-enabled interface uses the MD5-Challenge EAP authentication.

Configuring an 802.1X client MAC address

About 802.1X client MAC addresses

The authenticator adds the MAC address of an authenticated 802.1X client to the MAC address table and then assigns access rights to the client.

If multiple Ethernet interfaces on the device act as 802.1X clients, configure a unique MAC address for each interface to ensure successful 802.1X authentication.

You can use either of the following methods to configure a unique MAC address for each interface:

- Execute the **mac-address** command in Ethernet interface view. For information about this command, see *Layer 2—LAN Switching Command Reference*.
- Configure an 802.1X client MAC address.

Procedure

1. Enter system view.

   system-view

2. Enter Ethernet interface view.

   interface *interface-type interface-number*

3. Configure an 802.1X client MAC address.

   dot1x supplicant mac-address *mac-address*

   By default, the 802.1X client on an Ethernet interface uses the interface's MAC address for 802.1X authentication. If the interface's MAC address is unavailable, the 802.1X client uses the device's MAC address for 802.1X authentication.

Specifying an 802.1X client mode for sending EAP-Response and EAPOL-Logoff packets

About specifying an 802.1X client mode for sending EAP-Response and EAPOL-Logoff packets

802.1X authentication supports unicast and multicast modes to send EAP-Response and EAPOL-Logoff packets. As a best practice, use multicast mode to avoid 802.1X authentication failures if the NAS device in the network does not support receiving unicast EAP-Response or EAPOL-Logoff packets.

Procedure

1. Enter system view.
   system-view
2. Enter Ethernet interface view.
   interface *interface-type interface-number*
3. Specify a mode for 802.1X authentication to send EAP-Response and EAPOL-Logoff packets.
   dot1x supplicant transmit-mode { **multicast** | **unicast** }
   By default, 802.1X authentication uses unicast mode to send EAP-Response and EAPOL-Logoff packets.

Configuring an 802.1X client anonymous identifier

About 802.1X client anonymous identifiers

At the first authentication phase, packets sent to the authenticator are not encrypted. The use of an 802.1X client anonymous identifier prevents the 802.1X client username from being disclosed at the first phase. The 802.1X client-enabled device sends the anonymous identifier to the authenticator instead of the 802.1X client username. The 802.1X client username will be sent to the authenticator in encrypted packets at the second phase.

If no 802.1X client anonymous identifier is configured, the device sends the 802.1X client username at the first authentication phase.

The configured 802.1X client anonymous identifier takes effect only if one of the following EAP authentication methods is used:

- PEAP-MSCHAPv2.
- PEAP-GTC.
- TTLS-MSCHAPv2.
- TTLS-GTC.

If the MD5-Challenge EAP authentication is used, the configured 802.1X client anonymous identifier does not take effect. The device uses the 802.1X client username at the first authentication phase.

Restrictions and guidelines

Do not configure the 802.1X client anonymous identifier if the vendor-specific authentication server cannot identify anonymous identifiers.

Procedure

1. Enter system view.
   system-view
2. Enter Ethernet interface view.
   interface *interface-type interface-number*
3. Configure an 802.1X client anonymous identifier.
   dot1x supplicant anonymous identify *identifier*
   By default, no 802.1X client anonymous identifier is configured.

Specifying an SSL client policy

About SSL client policies

If the PEAP-MSCHAPv2, PEAP-GTC, TTLS-MSCHAPv2, or TTLS-GTC authentication is used, the 802.1X authentication process is as follows:

- **The first phase**—The device acts as an SSL client to negotiate with the SSL server.

  The SSL client uses the SSL parameters defined in the specified SSL client policy to establish a connection with the SSL server for negotiation. The SSL parameters include a PKI domain, supported cipher suites, and the SSL version. For information about SSL client policy configuration, see "Configuring SSL."
- **The second phase**—The device uses the negotiated result to encrypt and transmit the interchanged authentication packets.

If the MD5-Challenge authentication is used, the device does not use an SSL client policy during the authentication process.

Procedure

1. Enter system view.

   system-view
2. Enter Ethernet interface view.

   interface *interface-type interface-number*
3. Specify an SSL client policy.

   dot1x supplicant ssl-client-policy *policy-name*

   By default, an 802.1X client-enabled interface uses the default SSL client policy.

Display and maintenance commands for 802.1X client

Execute **display** commands in any view.

Task	Command
Display 802.1X client information.	**display dot1x supplicant** [**interface** *interface-type interface-number*]

High Availability Configuration Guide

This command reference is applicable to the following switches and software versions:

H3C S5120V2-LI switch series (Release 6308P01 and later)
H3C S3100V3-SI switch series (Release 6309P01 and later)
H3C S5110V2 switch series (Release 6310 and later)
H3C S5110V2-SI switch series (Release 6310 and later)
H3C S5000V3-EI switch series (Release 6310 and later)
H3C S5000V5-EI switch series (Release 6319P01 and later)
H3C S5000E-X switch series (Release 6310 and later)
H3C S5130S-LI switch series (Release 6310 and later)
H3C MS4320V2 switch series (Release 6308P01 and later)
H3C MS4320 switch series (Release 6308P01 and later)
H3C MS4300V2 switch series (Release 6308P01 and later)
H3C MS4200 switch series (Release 6310 and later)
H3C WS5810-WiNet switch series (Release 6308P01 and later)
H3C WS5820-WiNet switch series (Release 6308P01 and later)
H3C WAS6000 switch series (Release 6308P01 and later)
H3C S5000X-EI switch series (Release 6329 and later)
H3C MS4320V3 switch series (Release 6329 and later)
H3C S5120V3-SI switch series (Release 6329 and later)
H3C S5120V3-LI switch series (Release 6329 and later)

New H3C Technologies Co., Ltd.
http://www.h3c.com

Software version: Release 63xx
Document version: 6W105-20230524

Preface

This configuration guide describes the high availability fundamentals and configuration procedures. The high availability technologies include fault detection and fault failover. Failure detection technologies focus on fault detection and isolation. Failover technologies focus on network recovery.

This preface includes the following topics about the documentation:

Audience

This documentation is intended for:

- Network planners.
- Field technical support and servicing engineers.
- Network administrators.

Conventions

The following information describes the conventions used in the documentation.

Command conventions

Convention	Description
Boldface	**Bold** text represents commands and keywords that you enter literally as shown.
Italic	*Italic* text represents arguments that you replace with actual values.
[ ]	Square brackets enclose syntax choices (keywords or arguments) that are optional.
{ x | y | ... }	Braces enclose a set of required syntax choices separated by vertical bars, from which you select one.
[x | y | ...]	Square brackets enclose a set of optional syntax choices separated by vertical bars, from which you select one or none.
{ x | y | ... } *	Asterisk marked braces enclose a set of required syntax choices separated by vertical bars, from which you select a minimum of one.
[x | y | ...] *	Asterisk marked square brackets enclose optional syntax choices separated by vertical bars, from which you select one choice, multiple choices, or none.
&<1-n>	The argument or keyword and argument combination before the ampersand (&) sign can be entered 1 to n times.
#	A line that starts with a pound (#) sign is comments.

GUI conventions

Convention	Description
Boldface	Window names, button names, field names, and menu items are in Boldface. For example, the **New User** window opens; click **OK**.
>	Multi-level menus are separated by angle brackets. For example, **File** > **Create** >

Convention	Description
	Folder.

Symbols

Convention	Description
⚠ **WARNING!**	An alert that calls attention to important information that if not understood or followed can result in personal injury.
△ **CAUTION:**	An alert that calls attention to important information that if not understood or followed can result in data loss, data corruption, or damage to hardware or software.
ⓘ **IMPORTANT:**	An alert that calls attention to essential information.
NOTE:	An alert that contains additional or supplementary information.
TIP:	An alert that provides helpful information.

Network topology icons

Convention	Description
	Represents a generic network device, such as a router, switch, or firewall.
	Represents a routing-capable device, such as a router or Layer 3 switch.
	Represents a generic switch, such as a Layer 2 or Layer 3 switch, or a router that supports Layer 2 forwarding and other Layer 2 features.
	Represents an access controller, a unified wired-WLAN module, or the access controller engine on a unified wired-WLAN switch.
	Represents an access point.
	Represents a wireless terminator unit.
	Represents a wireless terminator.
	Represents a mesh access point.
	Represents omnidirectional signals.
	Represents directional signals.
	Represents a security product, such as a firewall, UTM, multiservice security gateway, or load balancing device.
	Represents a security module, such as a firewall, load balancing, NetStream, SSL VPN, IPS, or ACG module.

Examples provided in this document

Examples in this document might use devices that differ from your device in hardware model, configuration, or software version. It is normal that the port numbers, sample output, screenshots, and other information in the examples differ from what you have on your device.

Documentation feedback

You can e-mail your comments about product documentation to info@h3c.com.

We appreciate your comments.

Contents

Configuring Ethernet OAM

About Ethernet OAM

Ethernet Operation, Administration, and Maintenance (OAM) is a tool that monitors Layer 2 link status and addresses common link-related issues on the "last mile." Ethernet OAM improves Ethernet management and maintainability. You can use it to monitor the status of the point-to-point link between two directly connected devices.

Major functions of Ethernet OAM

Ethernet OAM provides the following functions:

- **Link performance monitoring**—Monitors the performance indices of a link, including packet loss, delay, and jitter, and collects traffic statistics of various types.
- **Fault detection and alarm**—Checks the connectivity of a link by sending OAM protocol data units (OAMPDUs) and reports to the network administrators when a link error occurs.
- **Remote loopback**—Checks link quality and locates link errors by looping back OAMPDUs.

Ethernet OAMPDUs

Ethernet OAM operates on the data link layer. Ethernet OAM reports the link status by periodically exchanging OAMPDUs between devices, so that the administrator can effectively manage the network.

Ethernet OAMPDUs include the following types shown in Table 1.

Table 1 Functions of different types of OAMPDUs

OAMPDU type	Function
Information OAMPDU	Used for transmitting state information of an Ethernet OAM entity, including the information about the local device and remote devices, and customized information, to the remote Ethernet OAM entity, and maintaining OAM connections.
Event Notification OAMPDU	Used by link monitoring to notify the remote OAM entity when it detects problems on the link in between.
Loopback Control OAMPDU	Used for remote loopback control. By inserting the information used to enable/disable loopback to a loopback control OAMPDU, you can enable/disable loopback on a remote OAM entity.

NOTE:

Throughout this document, an Ethernet OAM-enabled port is called an Ethernet OAM entity or an OAM entity.

How Ethernet OAM works

This section describes the working procedures of Ethernet OAM.

Ethernet OAM connection establishment

OAM connection establishment is also known as the Discovery phase, where an Ethernet OAM entity discovers the remote OAM entity to establish a session.

In this phase, two connected OAM entities exchange Information OAMPDUs to advertise their OAM configuration and capabilities to each other for a comparison. If their Loopback, link detection, and link event settings match, the OAM entities establish an OAM connection.

An OAM entity operates in active mode or passive mode. OAM entities in active mode initiate OAM connections, and OAM entities in passive mode wait and respond to the OAM connection requests. To set up an OAM connection between two OAM entities, you must set at least one entity to operate in active mode.

Table 2 shows the actions that a device can perform in different modes.

Table 2 Active Ethernet OAM mode and passive Ethernet OAM mode

Item	Active Ethernet OAM mode	Passive Ethernet OAM mode
Initiating OAM Discovery	Available	Unavailable
Responding to OAM Discovery	Available	Available
Transmitting Information OAMPDUs	Available	Available
Transmitting Event Notification OAMPDUs	Available	Available
Transmitting Information OAMPDUs without any TLV	Available	Available
Transmitting Loopback Control OAMPDUs	Available	Unavailable
Responding to Loopback Control OAMPDUs	Available	Available

After an Ethernet OAM connection is established, the Ethernet OAM entities exchange Information OAMPDUs at the handshake packet transmission interval to detect the availability of the Ethernet OAM connection. If an Ethernet OAM entity receives no Information OAMPDU within the Ethernet OAM connection timeout time, the Ethernet OAM connection is considered disconnected.

Link monitoring

Error detection in an Ethernet is difficult, especially when the physical connection in the network is not disconnected, but network performance is degrading gradually.

Link monitoring detects link faults in various environments. Ethernet OAM entities monitor link status by exchanging Event Notification OAMPDUs. When detecting one of the link error events listed in Table 3, an OAM entity sends an Event Notification OAMPDU to its peer OAM entity. The network administrator can keep track of network status changes by retrieving the log.

Table 3 Ethernet OAM link error events

Ethernet OAM link events	Description
Errored frame event	An errored frame event occurs when the number of detected error frames in the detection window (specified detection interval) exceeds the predefined threshold.
Errored frame period event	An errored frame period event occurs when the number of frame errors in the detection window (specified number of received frames) exceeds the predefined threshold.
Errored frame seconds event	An errored frame seconds event occurs when the number of errored frame seconds (the second in which an errored frame appears is called an errored frame second) detected on a port in the detection window (specified detection interval) reaches the predefined threshold.

Remote fault detection

Information OAMPDUs are exchanged periodically among Ethernet OAM entities across established OAM connections. When traffic is interrupted due to device failure or unavailability, the Ethernet OAM entity at the faulty end sends error information to its peer. The Ethernet OAM entity uses the flag field in Information OAMPDUs to indicate the error information (any critical link event type as shown in Table 4). You can use the log information to track ongoing link status and troubleshoot problems promptly.

Table 4 Critical link events

Type	Description	OAMPDU transmission frequencies
Link Fault	Peer link signal is lost.	Once per second.
Dying Gasp	An unexpected fault, such as power failure, occurred.	Non-stop.
Critical Event	An undetermined critical event happened.	Non-stop.

Remote loopback

Remote loopback is available only after the Ethernet OAM connection is established. With remote loopback enabled, the Ethernet OAM entity in active mode sends non-OAMPDUs to its peer. After receiving these frames, the peer does not forward them according to their destination addresses. Instead, it returns them to the sender along the original path.

Remote loopback enables you to check the link status and locate link failures. Performing remote loopback periodically helps to detect network faults promptly. Furthermore, performing remote loopback by network segments helps to locate network faults.

Protocols and standards

IEEE 802.3ah, *Carrier Sense Multiple Access with Collision Detection (CSMA/CD) Access Method and Physical Layer Specifications*

Restrictions and guidelines: Ethernet OAM configuration

The device's support for sending and receiving Information OAMPDUs carrying critical link events is as follows:

- Can receive Information OAMPDUs carrying the critical link events listed in Table 4.
- Can send Information OAMPDUs carrying Link Fault events.
- Can send Information OAMPDUs carrying Dying Gasp events when the device is rebooted or relevant ports are manually shut down. Physical IRF ports, however, are unable to send this type of OAMPDUs.
- Cannot send Information OAMPDUs carrying Critical Events.

Ethernet OAM tasks at a glance

To configure Ethernet OAM, perform the following tasks:

1. Configuring basic Ethernet OAM functions
2. (Optional.) Configuring the Ethernet OAM connection detection timers

3. (Optional.) Configuring link event detection
   - Configuring errored symbol event detection
   - Configuring errored frame event detection
   - Configuring errored frame period event detection
   - Configuring errored frame seconds event detection
4. (Optional.) Configuring the action a port takes after it receives an Ethernet OAM event from the remote end
5. (Optional.) Configuring Ethernet OAM remote loopback
   - Enabling Ethernet OAM remote loopback for a port
   - Rejecting the Ethernet OAM remote loopback request from a remote port

Configuring basic Ethernet OAM functions

About Ethernet OAM modes

To set up an Ethernet OAM connection between two Ethernet OAM entities, you must set at least one entity to operate in active mode. An Ethernet OAM entity can initiate OAM connection only in active mode.

Restrictions and guidelines

To change the Ethernet OAM mode on an Ethernet OAM-enabled port, first disable Ethernet OAM on the port.

Procedure

1. Enter system view.
   `System-view`
2. Enter Layer 2 Ethernet port view.
   `interface` *`interface-type interface-number`*
3. Set the Ethernet OAM mode.
   `oam mode` { **`active`** | **`passive`** }
   The default is active Ethernet OAM mode.
4. Enable Ethernet OAM.
   `oam enable`
   Ethernet OAM is disabled by default.

Configuring the Ethernet OAM connection detection timers

About the Ethernet OAM connection detection timers

After an Ethernet OAM connection is established, the Ethernet OAM entities exchange Information OAMPDUs at the handshake packet transmission interval to detect the availability of the Ethernet OAM connection. If an Ethernet OAM entity receives no Information OAMPDU within the Ethernet OAM connection timeout time, the Ethernet OAM connection is considered disconnected.

By adjusting the handshake packet transmission interval and the connection timeout timer, you can change the detection time resolution for Ethernet OAM connections.

Restrictions and guidelines for configuring Ethernet OAM connection detection timers

When you configure Ethernet OAM, follow these restrictions and guidelines:

- You can configure this command in system view or port view. The configuration in system view takes effect on all ports, and the configuration in port view takes effect on the specified port. For a port, the configuration in port view takes precedence.
- After the timeout timer of an Ethernet OAM connection expires, the local OAM entity ages out and terminates its connection with the peer OAM entity. To keep the Ethernet OAM connections stable, set the connection timeout timer to be at least five times the handshake packet transmission interval.

Configuring the Ethernet OAM connection detection timers globally

1. Enter system view.
   System-view
2. Configure the Ethernet OAM handshake packet transmission interval.
   oam global timer hello *interval*
   The default is 1000 milliseconds.
3. Configure the Ethernet OAM connection timeout timer.
   oam global timer keepalive *interval*
   The default is 5000 milliseconds.

Configuring the Ethernet OAM connection detection timers on a port

1. Enter system view.
   System-view
2. Enter Layer 2 Ethernet port view.
   interface *interface-type interface-number*
3. Configure the Ethernet OAM handshake packet transmission interval.
   oam timer hello *interval*
   By default, an interface uses the value configured globally.
4. Configure the Ethernet OAM connection timeout timer.
   oam timer keepalive *interval*
   By default, an interface uses the value configured globally.

Configuring errored symbol event detection

Restrictions and guidelines for configuring errored symbol event detection

You can configure this function in system view or port view. The configuration in system view takes effect on all ports, and the configuration in port view takes effect on the specified port. For a port, the configuration in port view takes precedence.

Configuring errored symbol event detection globally

1. Enter system view.
   system-view
2. Configure the errored symbol event detection window.
   oam global errored-symbol-period window *window-value*
   By default, the errored symbol event detection window is 100000000.
3. Configure the errored symbol event triggering threshold.
   oam global errored-symbol-period threshold *threshold-value*
   By default, the errored symbol event triggering threshold is 1.

Configuring errored symbol event detection on a port

1. Enter system view.
   system-view
2. Enter Layer 2 Ethernet port view.
   interface *interface-type interface-number*
3. Configure the errored symbol event detection window.
   oam errored-symbol-period window *window-value*
   By default, an interface uses the value configured globally.
4. Configure the errored symbol event triggering threshold.
   oam errored-symbol-period threshold *threshold-value*
   By default, an interface uses the value configured globally.

Configuring errored frame event detection

Restrictions and guidelines for configuring errored frame event detection

You can configure this function in system view or port view. The configuration in system view takes effect on all ports, and the configuration in port view takes effect on the specified port. For a port, the configuration in port view takes precedence.

Configuring errored frame event detection globally

1. Enter system view.

system-view

2. Configure the errored frame event detection window.
   oam global errored-frame window *window-value*
   By default, the errored frame event detection window is 1000 milliseconds.
3. Configure the errored frame event triggering threshold.
   oam global errored-frame threshold *threshold-value*
   By default, the errored frame event triggering threshold is 1.

Configuring errored frame event detection on a port

1. Enter system view.
   system-view
2. Enter Layer 2 Ethernet port view.
   interface *interface-type interface-number*
3. Configure the errored frame event detection window.
   oam errored-frame window *window-value*
   By default, an interface uses the value configured globally.
4. Configure the errored frame event triggering threshold.
   oam errored-frame threshold *threshold-value*
   By default, an interface uses the value configured globally.

Configuring errored frame period event detection

Restrictions and guidelines for configuring errored frame period event detection

You can configure this function in system view or port view. The configuration in system view takes effect on all ports, and the configuration in port view takes effect on the specified port. For a port, the configuration in port view takes precedence.

Configuring errored frame period event detection globally

1. Enter system view.
   system-view
2. Configure the errored frame period event detection window.
   oam global errored-frame-period window *window-value*
   By default, the errored frame period event detection window is 10000000.
3. Configure the errored frame period event triggering threshold.
   oam global errored-frame-period threshold *threshold-value*
   By default, the errored frame period event triggering threshold is 1.

Configuring errored frame period event detection on a port

1. Enter system view.
   system-view

2. Enter Layer 2 Ethernet port view.
   interface *interface-type interface-number*
3. Configure the errored frame period event detection window.
   oam errored-frame-period window *window-value*
   By default, an interface uses the value configured globally.
4. Configure the errored frame period event triggering threshold.
   oam errored-frame-period threshold *threshold-value*
   By default, an interface uses the value configured globally.

Configuring errored frame seconds event detection

Restrictions and guidelines for configuring errored frame seconds event detection

- You can configure this function in system view or port view. The configuration in system view takes effect on all ports, and the configuration in port view takes effect on the specified port. For a port, the configuration in port view takes precedence.
- Make sure the errored frame seconds triggering threshold is less than the errored frame seconds detection window. Otherwise, no errored frame seconds event can be generated.

Configuring errored frame seconds event detection globally

1. Enter system view.
   system-view
2. Configure the errored frame seconds event detection window.
   oam global errored-frame-seconds window *window-value*
   By default, the errored frame seconds event detection window is 60000 milliseconds.
3. Configure the errored frame seconds event triggering threshold.
   oam global errored-frame-seconds threshold *threshold-value*
   By default, the errored frame seconds event triggering threshold is 1.

Configuring errored frame seconds event detection on a port

1. Enter system view.
   system-view
2. Enter Layer 2 Ethernet port view.
   interface *interface-type interface-number*
3. Configure the errored frame seconds event detection window.
   oam errored-frame-seconds window *window-value*
   By default, an interface uses the value configured globally.
4. Configure the errored frame seconds event triggering threshold.
   oam errored-frame-seconds threshold *threshold-value*
   By default, an interface uses the value configured globally.

Configuring the action a port takes after it receives an Ethernet OAM event from the remote end

About this feature

This feature enables a port to log events and automatically terminate the OAM connection and set the link state to down.

Procedure

1. Enter system view.

   system-view

2. Enter Layer 2 Ethernet port view.

   interface *interface-type interface-number*

3. Configure the action the port takes after it receives an Ethernet OAM event from the remote end.

   oam remote-failure { **connection-expired** | **critical-event** | **dying-gasp** | **link-fault** } **action error-link-down**

   By default, the port only logs the Ethernet OAM event it receives from the remote end.

Enabling Ethernet OAM remote loopback for a port

△ **CAUTION:**

Use this feature with caution, because enabling Ethernet OAM remote loopback impacts other services.

About Ethernet OAM remote loopback

When you enable Ethernet OAM remote loopback on a port, the port sends Loopback Control OAMPDUs to a remote port. After receiving the Loopback Control OAMPDUs, the remote port enters the loopback state. The remote port then returns any packets sent from the local port except OAMPDUs. By observing how many of these packets return, you can calculate the packet loss ratio on the link and evaluate the link performance.

Restrictions and guidelines for enabling Ethernet OAM remote loopback

- Ethernet OAM remote loopback is available only after the Ethernet OAM connection is established. It can be performed only by Ethernet OAM entities operating in active Ethernet OAM mode.
- Remote loopback is available only on full-duplex links that support remote loopback at both ends.
- Ethernet OAM remote loopback must be supported by both the remote port and the sending port.
- Enabling Ethernet OAM remote loopback interrupts data communications. After Ethernet OAM remote loopback is disabled, all the ports involved will go down and then come up. Ethernet OAM remote loopback can be disabled by any of the following events:

  - Disabling Ethernet OAM.
  - Disabling Ethernet OAM remote loopback.
  - Timeout of the Ethernet OAM connection.
- Enabling internal loopback test on a port in remote loopback test can terminate the remote loopback test. For more information about loopback test, see *Layer 2—LAN Switching Configuration Guide*.
- You can enable Ethernet OAM remote loopback on a specific port in user view, system view, or Ethernet port view. The configuration effects are the same.

Enabling Ethernet OAM remote loopback for a port in system view

1. (Optional.) Enter system view.
   `system-view`
   You can also perform this task in user view.
2. Enable Ethernet OAM remote loopback for a port.
   `oam remote-loopback start interface` *`interface-type interface-number`*
   By default, Ethernet OAM remote loopback is disabled.

Enabling Ethernet OAM remote loopback for a port in interface view

1. Enter system view.
   `system-view`
2. Enter Layer 2 Ethernet port view.
   `interface` *`interface-type interface-number`*
3. Enable Ethernet OAM remote loopback on the port.
   `oam remote-loopback start`
   By default, Ethernet OAM remote loopback is disabled.

Rejecting the Ethernet OAM remote loopback request from a remote port

About this feature

The Ethernet OAM remote loopback feature impacts other services. To solve this problem, you can disable a port from being controlled by the Loopback Control OAMPDUs sent by a remote port. The local port then rejects the Ethernet OAM remote loopback request from the remote port.

Restrictions and guidelines

This feature does not affect the ongoing remote loopback test on the port. It takes effect when the next remote loopback starts on the port.

Procedure

1. Enter system view.
   `system-view`
2. Enter Layer 2 Ethernet port view.

interface *interface-type interface-number*

3. Reject the Ethernet OAM remote loopback request from a remote port.

   oam remote-loopback reject-request

   By default, a port does not reject the Ethernet OAM remote loopback request from a remote port.

Display and maintenance commands for Ethernet OAM

Execute **display** commands in any view and **reset** commands in user view:

Task	Command
Display information about an Ethernet OAM connection.	**display oam** { **local** | **remote** } [**interface** *interface-type interface-number*]
Display Ethernet OAM configuration.	**display oam configuration** [**interface** *interface-type interface-number*]
Display the statistics on critical events after an Ethernet OAM connection is established.	**display oam critical-event** [**interface** *interface-type interface-number*]
Display the statistics on Ethernet OAM link error events after an Ethernet OAM connection is established.	**display oam link-event** { **local** | **remote** } [**interface** *interface-type interface-number*]
Clear statistics on Ethernet OAM packets and Ethernet OAM link error events.	**reset oam** [**interface** *interface-type interface-number*]

Ethernet OAM configuration examples

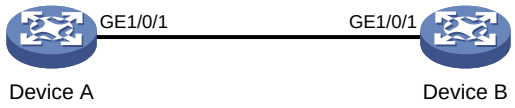
Example: Configuring Ethernet OAM

Network configuration

On the network shown in Figure 1, perform the following operations:

- Enable Ethernet OAM on Device A and Device B to auto-detect link errors between the two devices
- Determine the performance of the link between Device A and Device B by collecting statistics about the error frames received by Device A

Figure 1 Network diagram



Procedure

1. Configure Device A:

Configure GigabitEthernet 1/0/1 to operate in active Ethernet OAM mode, and enable Ethernet OAM for it.

```
<DeviceA> system-view
[DeviceA] interface gigabitethernet 1/0/1
[DeviceA-GigabitEthernet1/0/1] oam mode active
[DeviceA-GigabitEthernet1/0/1] oam enable
```

Set the errored frame event detection window to 20000 milliseconds, and set the errored frame event triggering threshold to 10.

```
[DeviceA-GigabitEthernet1/0/1] oam errored-frame window 200
[DeviceA-GigabitEthernet1/0/1] oam errored-frame threshold 10
[DeviceA-GigabitEthernet1/0/1] quit
```

2. Configure Device B:

Configure GigabitEthernet 1/0/1 to operate in passive Ethernet OAM mode (the default), and enable Ethernet OAM for it.

```
<DeviceB> system-view
[DeviceB] interface gigabitethernet 1/0/1
[DeviceB-GigabitEthernet1/0/1] oam mode passive
[DeviceB-GigabitEthernet1/0/1] oam enable
[DeviceB-GigabitEthernet1/0/1] quit
```

Verifying the configuration

Use the **display oam critical-event** command to display the statistics of Ethernet OAM critical link events. For example:

Display the statistics of Ethernet OAM critical link events on all the ports of Device A.

```
[DeviceA] display oam critical-event
-----------[GigabitEthernet1/0/1] -----------
 Local link status   : UP
 Event statistics
   Link fault        : Not occurred
   Dying gasp        : Not occurred
   Critical event    : Not occurred
```

The output shows that no critical link event occurred on the link between Device A and Device B.

Use the **display oam link-event** command to display the statistics of Ethernet OAM link events. For example:

Display Ethernet OAM link event statistics of the local end of Device A.

```
[DeviceA] display oam link-event local
------------ [GigabitEthernet1/0/1] -----------
 Link status: UP
 OAM local errored frame event
   Event time stamp        : 5789 x 100 milliseconds
   Errored frame window    : 200 x 100 milliseconds
   Errored frame threshold : 10 error frames
   Errored frame           : 13 error frames
   Error running total     : 350 error frames
   Event running total     : 17 events
```

The output shows the following:

- 350 errors occurred after Ethernet OAM is enabled on Device A.

- 17 errors were caused by error frames.
- The link is unstable.

Contents

Configuring CFD

About CFD

Connectivity Fault Detection (CFD), which conforms to IEEE 802.1ag Connectivity Fault Management (CFM) and ITU-T Y.1731, is an end-to-end per-VLAN link layer OAM mechanism. CFD is used for link connectivity detection, fault verification, and fault location.

Basic CFD concepts

Maintenance domain

A maintenance domain (MD) defines the network or part of the network where CFD plays its role. An MD is identified by its MD name.

Maintenance association

A maintenance association (MA) is a part of an MD. You can configure multiple MAs in an MD as needed. An MA is identified by the MD name + MA name.

An MA serves the specified VLAN or no VLAN. An MA that serves a VLAN is considered to be carrying VLAN attribute. An MA that serves no VLAN is considered to be carrying no VLAN attribute.

Maintenance point

An MP is configured on a port and belongs to an MA. MPs include the following types: maintenance association end points (MEPs) and maintenance association intermediate points (MIPs).

MEPs define the boundary of the MA. Each MEP is identified by a MEP ID.

MEPs include inward-facing MEPs and outward-facing MEPs:

- An outward-facing MEP sends packets to its host port.
- An inward-facing MEP does not send packets to its host port. Rather, it sends packets to other ports on the device.

A MIP is internal to an MA. It cannot send CFD packets actively, but it can handle and respond to CFD packets. MIPs are automatically created by the device. By cooperating with MEPs, a MIP can perform a function similar to ping and traceroute.

MEP list

A MEP list is a collection of local MEPs allowed to be configured and the remote MEPs to be monitored in the same MA. It lists all the MEPs configured on different devices in the same MA. The MEPs all have unique MEP IDs. When a MEP receives from a remote device a continuity check message (CCM) carrying a MEP ID not in the MEP list of the MA, it drops the message.

The local device must send CCM messages carrying the Remote Defect Indication (RDI) flag bits. Otherwise, the peer device cannot sense certain failures. When a local MEP has not learned all remote MEPs in the MEP list, the MEPs in the MA might not carry the RDI flag bits in CCMs.

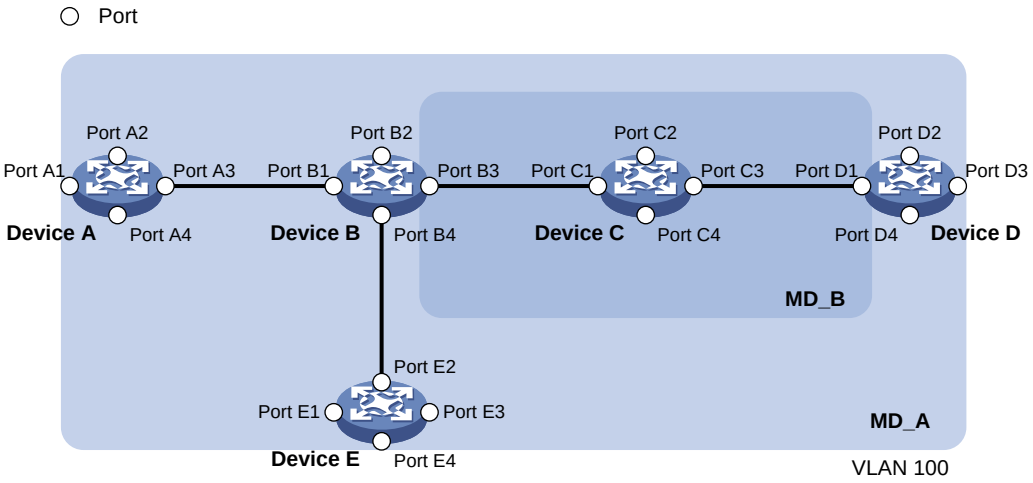
CFD levels

MD levels

To accurately locate faults, CFD introduces eight levels (from 0 to 7) to MDs. The bigger the number, the higher the level and the larger the area covered. Domains can touch or nest (if the outer domain has a higher level than the nested one) but cannot intersect or overlap.

MD levels facilitate fault location and make fault location more accurate. As shown in Figure 1, MD_A in light blue nests MD_B in dark blue. If a connectivity fault is detected at the boundary of MD_A, any of the devices in MD_A, including Device A through Device E, might fail. If a connectivity fault is also detected at the boundary of MD_B, the failure points can be any of Device B through Device D. If the devices in MD_B can operate correctly, at least Device C is operational.

Figure 1 Two nested MDs



CFD exchanges messages and performs operations on a per-domain basis. By planning MDs correctly in a network, you can use CFD to rapidly locate failure points.

MA and MP levels

The level of an MA equals the level of the MD to which the MA belongs.

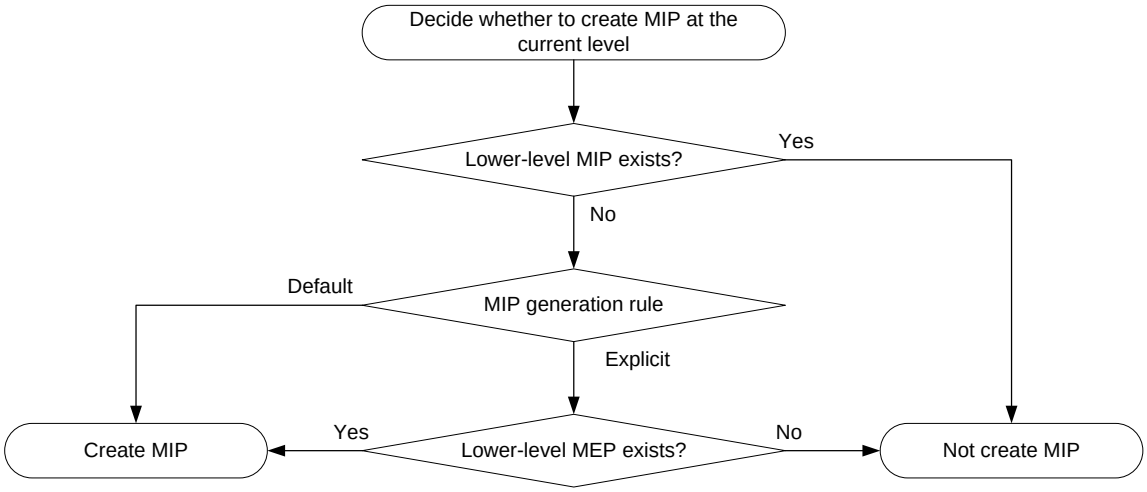
The level of a MEP equals the level of the MD to which the MEP belongs.

The level of a MIP is defined by its generation rule and the MD to which the MIP belongs. MIPs are generated on each port automatically according to the following MIP generation rules:

- **Default rule**—If no lower-level MIP exists on an interface, a MIP is created on the current level. A MIP can be created even if no MEP is configured on the interface.
- **Explicit rule**—If no lower-level MIP exists and a lower-level MEP exists on an interface, a MIP is created on the current level. A MIP can be created only when a lower-level MEP is created on the interface.

If a port has no MIP, the system will check the MAs in each MD (from low to high levels), and follow the procedure as described in Figure 2 to create or not to create MIPs at the current level.

Figure 2 Procedure of creating MIPs

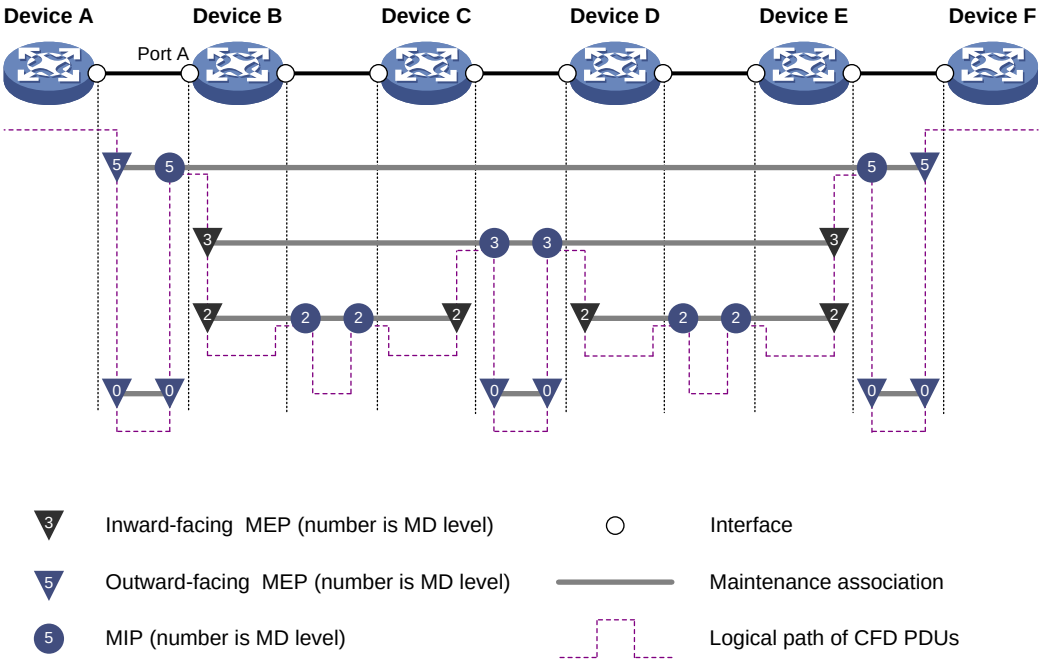


CFD grading example

Figure 3 demonstrates a grading example of the CFD module. Four levels of MDs (0, 2, 3, and 5) are designed. The bigger the number, the higher the level and the larger the area covered. MPs are configured on the ports of Device A through Device F. Port A of Device B is configured with the following MPs:

- A level 5 MIP.
- A level 3 inward-facing MEP.
- A level 2 inward-facing MEP.
- A level 0 outward-facing MEP.

Figure 3 CFD grading example



Packet processing of MPs

For an MA carrying VLAN attribute, MPs of the MA send packets only in the VLAN that the MA serves. The level of packets sent by an MP equals the level of the MD to which the MP belongs.

For an MA not carrying VLAN attribute, MPs of the MA can only be outward-facing MEPs. The level of packets sent by an outward-facing MEP equals the level of the MD to which the MEP belongs.

A MEP forwards packets at a higher level without any processing and only processes packets of its level or lower.

A MIP forwards packets of a different level without any processing and only processes packets of its level.

CFD functions

CFD functions, which are implemented through the MPs, include:

- Continuity check (CC).
- Loopback (LB).
- Linktrace (LT).
- Alarm indication signal (AIS).
- Loss measurement (LM).
- Delay measurement (DM).
- Test (TST).

Continuity check

Connectivity faults are usually caused by device faults or configuration errors. Continuity check examines the connectivity between MEPs. This function is implemented through periodic sending of CCMs by the MEPs. A CCM sent by one MEP is intended to be received by all the other MEPs in the same MA. If a MEP fails to receive the CCMs within 3.5 times the sending interval, the link is considered as faulty and a log is generated. When multiple MEPs send CCMs at the same time, the multipoint-to-multipoint link check is achieved. CCM frames are multicast frames.

Loopback

Similar to ping at the IP layer, loopback verifies the connectivity between a source device and a target device. To implement this function, the source MEP sends loopback messages (LBMs) to the target MEP. Depending on whether the source MEP can receive a loopback reply message (LBR) from the target MEP, the link state between the two can be verified.

LBM frames are multicast and unicast frames. The device can send and receive unicast LBM frames, and can receive multicast LBM frames but cannot send multicast LBM frames. LBR frames are unicast frames.

Linktrace

Linktrace is similar to traceroute. It identifies the path between the source MEP and the target MP. The source MEP sends the linktrace messages (LTMs) to the target MP. After receiving the messages, the target MP and the MIPs that the LTM frames pass send back linktrace reply messages (LTRs) to the source MEP. Based on the reply messages, the source MEP can identify the path to the target MP. LTM frames are multicast frames and LTRs are unicast frames.

AIS

The AIS function suppresses the number of error alarms reported by MEPs. If a local MEP does not receive any CCM frames from its peer MEP within 3.5 times the CCM transmission interval, it immediately starts sending AIS frames. The AIS frames are sent periodically in the opposite direction of CCM frames. When the peer MEP receives the AIS frames, it suppresses the error alarms locally, and continues to send the AIS frames. If the local MEP receives CCM frames within 3.5 times the

CCM transmission interval, it stops sending AIS frames and restores the error alarm function. AIS frames are multicast frames.

LM

The LM function measures the frame loss in a certain direction between a pair of MEPs. The source MEP sends loss measurement messages (LMMs) to the target MEP. The target MEP responds with loss measurement replies (LMRs). The source MEP calculates the number of lost frames according to the counter values of the two consecutive LMRs (the current LMR and the previous LMR). LMMs and LMRs are unicast frames.

DM

The DM function measures frame delays between two MEPs, including the following types:

- One-way frame delay measurement

  The source MEP sends a one-way delay measurement (1DM) frame, which carries the transmission time, to the target MEP. When the target MEP receives the 1DM frame, it does the following:

  - Records the reception time.
  - Calculates and records the link transmission delay and jitter (delay variation) according to the transmission time and reception time.

  1DM frames are unicast frames.

- Two-way frame delay measurement

  The source MEP sends a delay measurement message (DMM), which carries the transmission time, to the target MEP. When the target MEP receives the DMM, it responds with a delay measurement reply (DMR). The DMR carries the reception time and transmission time of the DMM and the transmission time of the DMR. When the source MEP receives the DMR, it does the following:

  - Records the DMR reception time.
  - Calculates the link transmission delay and jitter according to the DMR reception time and DMM transmission time.

  DMM frames and DMR frames are unicast frames.

TST

The TST function tests the bit errors between two MEPs. The source MEP sends a TST frame, which carries the test pattern, such as pseudo random bit sequence (PRBS) or all-zero, to the target MEP. When the target MEP receives the TST frame, it determines the bit errors by calculating and comparing the content of the TST frame. TST frames are unicast frames.

EAIS

Ethernet Alarm Indication Signal (EAIS) enables collaboration between the Ethernet port status and the AIS function. When a port on the device (not necessarily an MP) goes down, it immediately starts to send EAIS frames periodically to suppress the error alarms. When the port goes up again, it immediately stops sending EAIS frames. When the MEP receives the EAIS frames, it suppresses the error alarms locally, and continues to send the EAIS frames. If a MEP receives no EAIS frames within 3.5 times the EAIS frame transmission interval, the fault is considered cleared. The port stops sending EAIS frames and restores the error alarm function. EAIS frames are multicast frames.

Protocols and standards

- IEEE 802.1ag, *Virtual Bridged Local Area Networks Amendment 5: Connectivity Fault Management*
- ITU-T Y.1731, *OAM functions and mechanisms for Ethernet based networks*

Restrictions and guidelines: CFD configuration

When you configure CFD, follow these restrictions and guidelines:

- Configure CC before you use the MEP ID of the remote MEP to configure other CFD functions. This restriction does not apply when you use the MAC address of the remote MEP to configure other CFD functions.
- Do not configure a Layer 2 aggregate interface as an IPP if the following conditions exist:
  - The Layer 2 aggregate interface exists between an inward-facing MEP and a remote MEP.
  - The MAC address of the remote MEP is used for CFD functions.

  For information about IPPs, see DRNI configuration in *Layer 2—LAN Switching Configuration Guide*.
- Typically, a port blocked by the spanning tree feature cannot receive or send CFD messages except in the following cases:
  - The port is configured as an outward-facing MEP.
  - The port is configured as a MIP or inward-facing MEP, which can still receive and send CFD messages except CCM messages.

  For more information about the spanning tree feature, see *Layer 2—LAN Switching Configuration Guide*.

CFD tasks at a glance

To configure CFD, perform the following tasks:

1. Configuring basic CFD settings
   a. Enabling CFD
   b. Configuring service instances
   c. Configuring MEPs
   d. Configuring MIP auto-generation rules
2. Configuring CFD functions
   a. Configuring CC
   b. (Optional.) Configuring LB
   c. (Optional.) Configuring LT
   d. (Optional.) Configuring AIS
   e. (Optional.) Configuring LM
   f. (Optional.) Configuring one-way DM
   g. (Optional.) Configuring two-way DM
   h. (Optional.) Configuring TST
3. (Optional.) Configuring EAIS

Prerequisites for CFD

For CFD to work correctly, design the network by performing the following tasks:

- Grade the MDs in the entire network, and define the boundary of each MD.
- Assign a name for each MD. Make sure the devices in the same MD use the same MD name.
- Define the MA in each MD according to the VLAN you want to monitor.

- Assign a name for each MA. Make sure that the devices in the same MA in the same MD use the same MA name.
- Determine the MEP list of each MA in each MD. Make sure devices in the same MA maintain the same MEP list.
- At the edges of MD and MA, MEPs must be designed at the device port. MIPs can be designed on devices or ports that are not at the edges.

Configuring basic CFD settings

Enabling CFD

1. Enter system view.
   system-view
2. Enable CFD.
   cfd enable
   By default, CFD is disabled.

Configuring service instances

About service instances

Before configuring the MEPs and MIPs, you must first configure service instances. A service instance is a set of service access points (SAPs), and belongs to an MA in an MD.

The MD and MA define the level attribute and VLAN attribute of the messages handled by the MPs in a service instance. The MPs of the MA that carries no VLAN attribute do not belong to any VLAN.

Procedure

1. Enter system view.
   system-view
2. Create an MD.
   cfd md *md-name* [**index** *index-value*] **level** *level-value* [**md-id** { **dns** *dns-name* | **mac** *mac-address subnumber* | **none** }]
3. Create a service instance.
   cfd service-instance *instance-id* **ma-id** { **icc-based** *ma-name* | **integer** *ma-num* | **string** *ma-name* | **vlan-based** [*vlan-id*] } [**ma-index** *index-value*] **md** *md-name* [**vlan** *vlan-id*]

Configuring MEPs

About MEPs

CFD is implemented through various operations on MEPs. As a MEP is configured on a service instance, the MD level and VLAN attribute of the service instance become the attribute of the MEP.

Restrictions and guidelines

- You can specify an interface as the MEP for only one of the non-VLAN-specific MAs at the same level. In addition, the MEP must be outward facing.
- If a MEP in a non-VLAN-specific MA does not receive a CCM message within 3.5 CCM intervals from a remote MEP, the local MEP sets its interface to link down state. This behavior of the local MEP facilitates fast switchover for RRPP or Smart Link.

Prerequisites

Before you configure MEPs, you must configure service instances.

Procedure

1. Enter system view.
   system-view
2. Configure a MEP list.
   cfd meplist *mep-list* **service-instance** *instance-id*
   The created MEP must be included in the configured MEP list.
3. Enter Layer 2 Ethernet interface view or Layer 2 aggregate interface view.
   interface *interface-type interface-number*
4. Create a MEP.
   cfd mep *mep-id* **service-instance** *instance-id* { **inbound** | **outbound** }

Configuring MIP auto-generation rules

About MIP auto-generation rules

As functional entities in a service instance, MIPs respond to various CFD frames, such as LTM and LBM frames. You can configure MIP auto-generation rules for the system to automatically create MIPs.

Any of the following events can cause MIPs to be created or deleted after you have configured the **cfd mip-rule** command:

- Enabling or disabling CFD.
- Creating or deleting MEPs on a port.
- Changes occur to the VLAN attribute of a port.
- The rule specified in the **cfd mip-rule** command changes.

Restrictions and guidelines

- An MA carrying no VLAN attribute is typically used to detect direct link status. The system cannot generate MIPs for such MAs.
- For an MA carrying VLAN attribute, the system does not generate MIPs if the same or a higher level MEP exists on the interface.

Procedure

1. Enter system view.
   system-view
2. Configure MIP auto-generation rules.
   cfd mip-rule { **default** | **explicit** } **service-instance** *instance-id*
   By default, no rules for generating MIPs are configured, and the system does not automatically create any MIP.

Configuring CFD functions

Configuring CC

About CC

After the CC function is configured, MEPs in an MA can periodically send CCM frames to maintain connectivity.

You must configure CC before you use the MEP ID of the remote MEP to configure other CFD functions. This restriction does not apply when you use the MAC address of the remote MEP to configure other CFD functions.

When the lifetime of a CCM frame expires, the link to the sending MEP is considered disconnected. When setting the CCM interval, use the settings described in Table 1.

Table 1 CCM interval field encoding

CCM interval field	Transmission interval	Maximum CCM lifetime
1	10/3 milliseconds	35/3 milliseconds
2	10 milliseconds	35 milliseconds
3	100 milliseconds	350 milliseconds
4	1 second	3.5 seconds
5	10 seconds	35 seconds
6	60 seconds	210 seconds
7	600 seconds	2100 seconds

NOTE:

- The value range for the interval field is 1 to 7. If you set the value to 1 or 2, the continuity check might work incorrectly due to hardware restrictions.
- The CCM messages with an interval field value of 1 to 3 are short-interval CCM messages. The CCM messages with an interval field value of 4 to 7 are long-interval CCM messages.

Restrictions and guidelines

When you configure the CCM interval, follow these restrictions and guidelines:

- Configure the same CCM interval field value for all MEPs in the same MA.
- After the CCM interval field is modified, the MEP must wait for another CCM interval before sending CCMs.
- If the device cannot process short-interval CCM messages, setting the CCM interval field value to smaller than 4 might cause the CC function to operate unsteadily.

Procedure

1. Enter system view.
   `system-view`
2. (Optional.) Set the CCM interval field.
   `cfd cc interval` *`interval-value`* **`service-instance`** *`instance-id`*
   By default, the interval field value is 4.
3. Enter Layer 2 Ethernet interface view or Layer 2 aggregate interface view.
   `interface` *`interface-type interface-number`*

4. Enable CCM sending on a MEP.

   cfd cc service-instance *instance-id* **mep** *mep-id* **enable**

   By default, CCM sending is disabled on a MEP.

Configuring LB

To verify the link state between the local MEP and the remote MEP, execute the following command in any view:

cfd loopback service-instance *instance-id* **mep** *mep-id* { **target-mac** *mac-address* | **target-mep** *target-mep-id* } [**number** *number*]

Configuring LT

About LT

LT can trace the path between source and target MEPs, and can locate link faults by automatically sending LT messages. The two functions are implemented in the following way:

- **Tracing path**—The source MEP first sends LTM messages to the target MEP. Based on the LTR messages in response to the LTM messages, the path between the two MEPs is identified.
- **LT messages automatic sending**—If the source MEP fails to receive CCM frames from the target MEP within 3.5 times the transmission interval, it considers the link faulty. The source MEP then sends LTM frames, with the TTL field set to the maximum value 255, to the target MEP. Based on the returned LTRs, the fault source is located.

Prerequisites

Before you configure LT on a MEP in an MA carrying VLAN attribute, create the VLAN to which the MA belongs.

Procedure

1. Identify the path between a source MEP and a target MEP.

   cfd linktrace service-instance *instance-id* **mep** *mep-id* { **target-mac** *mac-address* | **target-mep** *target-mep-id* } [**ttl** *ttl-value*] [**hw-only**]

   This command is available in any view.

2. Enter system view.

   system-view

3. Enable LT messages automatic sending.

   cfd linktrace auto-detection [**size** *size-value*]

   By default, LT messages automatic sending is disabled.

Configuring AIS

About AIS

The AIS function suppresses the number of error alarms reported by MEPs.

Restrictions and guidelines

If you enable AIS, the MEPs in a service instance cannot send AIS frames in the following conditions:

- No AIS frame transmission level is configured.
- The AIS frame transmission level is lower than the MD level of the service instance.

If you enable AIS and configure an AIS frame transmission level equal to the MD level of a service instance, the MEPs in the service instance:

- Can suppress error alarms.
- Cannot send AIS frames to MDs with higher level.

Procedure

1. Enter system view.
   system-view
2. Enable AIS.
   cfd ais enable
   By default, AIS is disabled.
3. Configure the AIS frame transmission level.
   cfd ais level *level-value* **service-instance** *instance-id*
   By default, the AIS frame transmission level is not configured.
   The AIS frame transmission level must be higher than the MD level of the service instance.
4. Configure the AIS frame transmission interval.
   cfd ais period *period-value* **service-instance** *instance-id*
   By default, the AIS frame transmission interval is 1 second.

Configuring LM

About LM

The LM function measures frame loss between MEPs. Frame loss statistics include the number of lost frames, the frame loss ratio, and the average number of lost frames for the source and target MEPs.

Procedure

To configure LM, execute the following command in any view:

cfd slm service-instance *instance-id* **mep** *mep-id* { **target-mac** *mac-address* | **target-mep** *target-mep-id* } [**dot1p** *dot1p-value*] [**number** *number*] [**interval** *interval*]

Configuring one-way DM

About one-way DM

The one-way DM function measures the one-way frame delay between two MEPs, and monitors and manages the link transmission performance.

Restrictions and guidelines

Follow these guidelines when you configure one-way DM on a MEP:

- One-way DM requires that the time setting at the transmitting MEP and the receiving MEP be the same. For the purpose of frame delay variation measurement, the requirement can be relaxed.
- To view the test result, use the **display cfd dm one-way history** command on the target MEP.

Procedure

To configure one-way DM, execute the following command in any view:

cfd dm one-way service-instance *instance-id* **mep** *mep-id* { **target-mac** *mac-address* | **target-mep** *target-mep-id* } [**number** *number*]

Configuring two-way DM

About two-way DM

The two-way DM function measures the two-way frame delay, average two-way frame delay, and two-way frame delay variation between two MEPs. It also monitors and manages the link transmission performance.

Procedure

To configure two-way DM, execute the following command in any view:

cfd dm two-way service-instance *instance-id* **mep** *mep-id* { **target-mac** *mac-address* | **target-mep** *target-mep-id* } **dot1p** *dot1p-value*] [**number** *number*] [**interval** *interval*]

Configuring TST

About TST

The TST function detects bit errors on a link, and monitors and manages the link transmission performance.

Restrictions and guidelines

To view the test result, use the **display cfd tst** command on the target MEP.

Procedure

To configure TST, execute the following command in any view:

cfd tst service-instance *instance-id* **mep** *mep-id* { **target-mac** *mac-address* | **target-mep** *target-mep-id* } [**number** *number*] [**length-of-test** *length*] [**pattern-of-test** { **all-zero** | **prbs** } [**with-crc**]]

Configuring EAIS

Restrictions and guidelines

Follow these guidelines when you configure EAIS on a MEP:

- You can configure EAIS on a device that does not support or is not configured with CFD. However, EAIS must collaborate with the CFD function in the network, so you must configure CFD in the network.
- You can configure EAIS on the member port of an aggregation group, but the configuration does not take effect. If you configure EAIS on the port and then add it to an aggregation group, the EAIS configuration immediately fails to take effect. After the port leaves the aggregation group, the EAIS configuration takes effect.
- If the intersection of the configured VLANs where the EAIS frames can be transmitted and the VLANs to which the port belongs is empty, no EAIS frame is sent. If the intersection contains more than 70 VLANs and the EAIS frame transmission interval is 1 second, the CPU usage will be too high. As a best practice, set the EAIS frame transmission interval to 60 seconds in this case.

Procedure

1. Enter system view.

   system-view

2. Enable port status-AIS collaboration.

   cfd ais-track link-status global

By default, port status-AIS collaboration is disabled.

3. Enter Layer 2 Ethernet interface view or Layer 2 aggregate interface view.
   interface *interface-type interface-number*
4. Configure the EAIS frame transmission level.
   cfd ais-track link-status level *level-value*
   By default, the EAIS frame transmission level is not configured.
5. Configure the EAIS frame transmission interval.
   cfd ais-track link-status period *period-value*
   By default, the EAIS frame transmission interval is not configured.
6. Specify the VLANs where the EAIS frames can be transmitted.
   cfd ais-track link-status vlan *vlan-list*
   By default, the EAIS frames can only be transmitted within the default VLAN of the port.
   The EAIS frames are transmitted within the intersection of the VLANs specified with this command and the existing VLANs on the device.

Display and maintenance commands for CFD

Execute **display** commands in any view and **reset** commands in user view.

Task	Command
Display the AIS configuration and information on the specified MEP.	**display cfd ais** [**service-instance** *instance-id* [**mep** *mep-id*]]
Display the AIS configuration and information associated with the status of the specified port.	**display cfd ais-track link-status** [**interface** *interface-type interface-number*]
Display the one-way DM result on the specified MEP.	**display cfd dm one-way history** [**service-instance** *instance-id* [**mep** *mep-id*]]
Display LTR information received by a MEP.	**display cfd linktrace-reply** [**service-instance** *instance-id* [**mep** *mep-id*]]
Display the content of the LTR messages received as responses to the automatically sent LTMs.	**display cfd linktrace-reply auto-detection** [**size** *size-value*]
Display MD configuration information.	**display cfd md**
Display the attribute and running information of the MEPs.	**display cfd mep** *mep-id* **service-instance** *instance-id*
Display MEP lists in a service instance.	**display cfd meplist** [**service-instance** *instance-id*]
Display MP information.	**display cfd mp** [**interface** *interface-type interface-number*]
Display information about a remote MEP.	**display cfd remote-mep service-instance** *instance-id* **mep** *mep-id*
Display service instance configuration.	**display cfd service-instance** [*instance-id*]

Task	Command
Display CFD status.	**display cfd status**
Display the TST result on the specified MEP.	**display cfd tst** [**service-instance** *instance-id* [**mep** *mep-id*]]
Clear the one-way DM result on the specified MEP.	**reset cfd dm one-way history** [**service-instance** *instance-id* [**mep** *mep-id*]]
Clear the TST result on the specified MEP.	**reset cfd tst** [**service-instance** *instance-id* [**mep** *mep-id*]]

CFD configuration examples

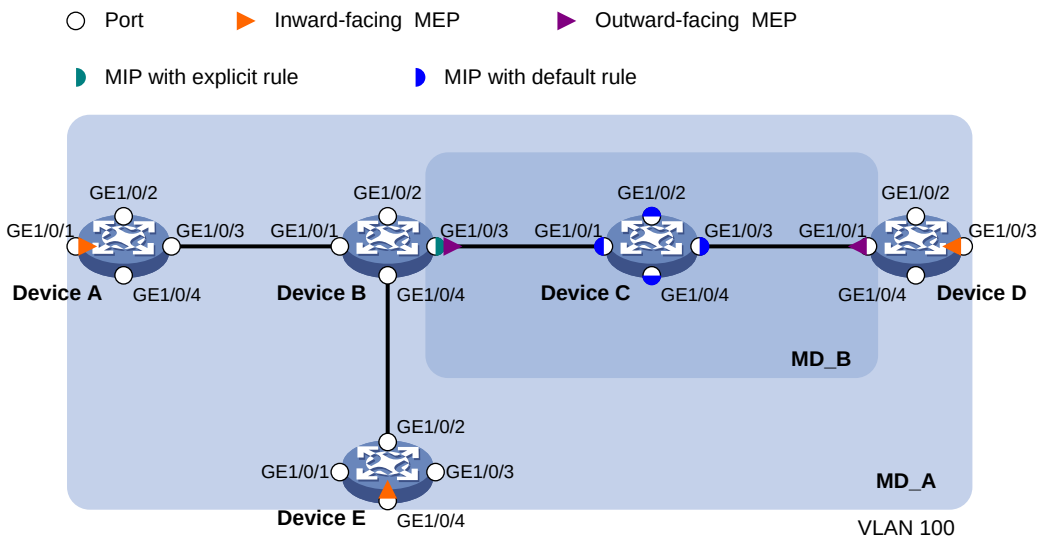
Example: Configuring CFD

Network configuration

As shown in Figure 4:

- The network comprises five devices and is divided into two MDs: MD_A (level 5) and MD_B (level 3). All ports belong to VLAN 100, and the MAs in the two MDs all serve VLAN 100. Assume that the MAC addresses of Device A through Device E are 0010-FC01-6511, 0010-FC02-6512, 0010-FC03-6513, 0010-FC04-6514, and 0010-FC05-6515, respectively.
- MD_A has three edge ports: GigabitEthernet 1/0/1 on Device A, GigabitEthernet 1/0/3 on Device D, and GigabitEthernet 1/0/4 on Device E. They are all inward-facing MEPs. MD_B has two edge ports: GigabitEthernet 1/0/3 on Device B and GigabitEthernet 1/0/1 on Device D. They are both outward-facing MEPs.
- In MD_A, Device B is designed to have MIPs when its port is configured with low level MEPs. Port GigabitEthernet 1/0/3 is configured with MEPs of MD_B, and the MIPs of MD_A can be configured on this port. You must configure the MIP generation rule of MD_A as explicit.
- The MIPs of MD_B are designed on Device C, and are configured on all ports. You must configure the MIP generation rule as default.
- Configure CC to monitor the connectivity among all the MEPs in MD_A and MD_B. Configure LB to locate link faults, and use the AIS and EAIS functions to suppress the error alarms that are reported.
- After the status information of the entire network is obtained, use LT, LM, one-way DM, two-way DM, and TST to detect link faults.

Figure 4 Network diagram



Procedure

1. Configure a VLAN and assign ports to it:

   On each device shown in Figure 4, create VLAN 100 and assign ports GigabitEthernet 1/0/1 through GigabitEthernet 1/0/4 to VLAN 100.

2. Enable CFD:

   # Enable CFD on Device A.

   ```
   <DeviceA> system-view
   [DeviceA] cfd enable
   ```

   # Configure Device B through Device E in the same way Device A is configured. (Details not shown.)

3. Configure service instances:

   # Create MD_A (level 5) on Device A, and create service instance 1 (in which the MA is identified by a VLAN and serves VLAN 100).

   ```
   [DeviceA] cfd md MD_A level 5
   [DeviceA] cfd service-instance 1 ma-id vlan-based md MD_A vlan 100
   ```

   # Configure Device E in the same way Device A is configured. (Details not shown.)

   # Create MD_A (level 5) on Device B, and create service instance 1 (in which the MA is identified by a VLAN and serves VLAN 100).

   ```
   [DeviceB] cfd md MD_A level 5
   [DeviceB] cfd service-instance 1 ma-id vlan-based md MD_A vlan 100
   ```

   # Create MD_B (level 3), and create service instance 2 (in which the MA is identified by a VLAN and serves VLAN 100).

   ```
   [DeviceB] cfd md MD_B level 3
   [DeviceB] cfd service-instance 2 ma-id vlan-based md MD_B vlan 100
   ```

   # Configure Device D in the same way Device B is configured. (Details not shown.)

   # Create MD_B (level 3) on Device C, and create service instance 2 (in which the MA is identified by a VLAN and serves VLAN 100).

   ```
   [DeviceC] cfd md MD_B level 3
   [DeviceC] cfd service-instance 2 ma-id vlan-based md MD_B vlan 100
   ```

4. Configure MEPs:

On Device A, configure a MEP list in service instance 1, and create inward-facing MEP 1001 in service instance 1 on GigabitEthernet 1/0/1.

```
[DeviceA] cfd meplist 1001 4002 5001 service-instance 1
[DeviceA] interface gigabitethernet 1/0/1
[DeviceA-GigabitEthernet1/0/1] cfd mep 1001 service-instance 1 inbound
[DeviceA-GigabitEthernet1/0/1] quit
```

On Device B, configure a MEP list in service instances 1 and 2.

```
[DeviceB] cfd meplist 1001 4002 5001 service-instance 1
[DeviceB] cfd meplist 2001 4001 service-instance 2
```

Create outward-facing MEP 2001 in service instance 2 on GigabitEthernet 1/0/3.

```
[DeviceB] interface gigabitethernet 1/0/3
[DeviceB-GigabitEthernet1/0/3] cfd mep 2001 service-instance 2 outbound
[DeviceB-GigabitEthernet1/0/3] quit
```

On Device D, configure a MEP list in service instances 1 and 2.

```
[DeviceD] cfd meplist 1001 4002 5001 service-instance 1
[DeviceD] cfd meplist 2001 4001 service-instance 2
```

Create outward-facing MEP 4001 in service instance 2 on GigabitEthernet 1/0/1.

```
[DeviceD] interface gigabitethernet 1/0/1
[DeviceD-GigabitEthernet1/0/1] cfd mep 4001 service-instance 2 outbound
[DeviceD-GigabitEthernet1/0/1] quit
```

Create inward-facing MEP 4002 in service instance 1 on GigabitEthernet 1/0/3.

```
[DeviceD] interface gigabitethernet 1/0/3
[DeviceD-GigabitEthernet1/0/3] cfd mep 4002 service-instance 1 inbound
[DeviceD-GigabitEthernet1/0/3] quit
```

On Device E, configure a MEP list in service instance 1.

```
[DeviceE] cfd meplist 1001 4002 5001 service-instance 1
```

Create inward-facing MEP 5001 in service instance 1 on GigabitEthernet 1/0/4.

```
[DeviceE] interface gigabitethernet 1/0/4
[DeviceE-GigabitEthernet1/0/4] cfd mep 5001 service-instance 1 inbound
[DeviceE-GigabitEthernet1/0/4] quit
```

5. Configure MIPs:

Configure the MIP generation rule in service instance 1 on Device B as **`explicit`**.

```
[DeviceB] cfd mip-rule explicit service-instance 1
```

Configure the MIP generation rule in service instance 2 on Device C as **`default`**.

```
[DeviceC] cfd mip-rule default service-instance 2
```

6. Configure CC:

On Device A, enable the sending of CCM frames for MEP 1001 in service instance 1 on GigabitEthernet 1/0/1.

```
[DeviceA] interface gigabitethernet 1/0/1
[DeviceA-GigabitEthernet1/0/1] cfd cc service-instance 1 mep 1001 enable
[DeviceA-GigabitEthernet1/0/1] quit
```

On Device B, enable the sending of CCM frames for MEP 2001 in service instance 2 on GigabitEthernet 1/0/3.

```
[DeviceB] interface gigabitethernet 1/0/3
[DeviceB-GigabitEthernet1/0/3] cfd cc service-instance 2 mep 2001 enable
[DeviceB-GigabitEthernet1/0/3] quit
```

On Device D, enable the sending of CCM frames for MEP 4001 in service instance 2 on GigabitEthernet 1/0/1.

```
[DeviceD] interface gigabitethernet 1/0/1
[DeviceD-GigabitEthernet1/0/1] cfd cc service-instance 2 mep 4001 enable
[DeviceD-GigabitEthernet1/0/1] quit
```

Enable the sending of CCM frames for MEP 4002 in service instance 1 on GigabitEthernet 1/0/3.

```
[DeviceD] interface gigabitethernet 1/0/3
[DeviceD-GigabitEthernet1/0/3] cfd cc service-instance 1 mep 4002 enable
[DeviceD-GigabitEthernet1/0/3] quit
```

On Device E, enable the sending of CCM frames for MEP 5001 in service instance 1 on GigabitEthernet 1/0/4.

```
[DeviceE] interface gigabitethernet 1/0/4
[DeviceE-GigabitEthernet1/0/4] cfd cc service-instance 1 mep 5001 enable
[DeviceE-GigabitEthernet1/0/4] quit
```

7. Configure AIS:

Enable AIS on Device B. Configure the AIS frame transmission level as 5 and AIS frame transmission interval as 1 second in service instance 2.

```
[DeviceB] cfd ais enable
[DeviceB] cfd ais level 5 service-instance 2
[DeviceB] cfd ais period 1 service-instance 2
```

8. Configure EAIS:

Enable port status-AIS collaboration on Device B.

```
[DeviceB] cfd ais-track link-status global
```

On GigabitEthernet 1/0/3 of Device B, configure the EAIS frame transmission level as 5 and the EAIS frame transmission interval as 60 seconds. Specify the VLANs where the EAIS frames can be transmitted as VLAN 100.

```
[DeviceB] interface gigabitethernet 1/0/3
[DeviceB-GigabitEthernet1/0/3] cfd ais-track link-status level 5
[DeviceB-GigabitEthernet1/0/3] cfd ais-track link-status period 60
[DeviceB-GigabitEthernet1/0/3] cfd ais-track link-status vlan 100
[DeviceB-GigabitEthernet1/0/3] quit
```

Verifying the configuration

1. Verify the LB function when the CC function detects a link fault:

Enable LB on Device A to check the status of the link between MEP 1001 and MEP 5001 in service instance 1.

```
[DeviceA] cfd loopback service-instance 1 mep 1001 target-mep 5001
Loopback to MEP 5001 with the sequence number start from 1001-43404:
Reply from 0010-fc05-6515: sequence number=1001-43404 time=5ms
Reply from 0010-fc05-6515: sequence number=1001-43405 time=5ms
Reply from 0010-fc05-6515: sequence number=1001-43406 time=5ms
Reply from 0010-fc05-6515: sequence number=1001-43407 time=5ms
Reply from 0010-fc05-6515: sequence number=1001-43408 time=5ms
Sent: 5        Received: 5        Lost: 0
```

2. Verify the LT function after the CC function obtains the status information of the entire network:

Identify the path between MEP 1001 and MEP 5001 in service instance 1 on Device A.

```
[DeviceA] cfd linktrace service-instance 1 mep 1001 target-mep 5001
Linktrace to MEP 5001 with the sequence number 1001-43462:
MAC address               TTL     Last MAC         Relay action
0010-fc05-6515            63      0010-fc02-6512   Hit
```

3. Verify the LM function after the CC function obtains the status information of the entire network:

Test the frame loss from MEP 1001 to MEP 4002 in service instance 1 on Device A.

```
[DeviceA] cfd slm service-instance 1 mep 1001 target-mep 4002
Reply from 0010-fc04-6514
Far-end frame loss: 10    Near-end frame loss: 20
Reply from 0010-fc04-6514
Far-end frame loss: 40    Near-end frame loss: 40
Reply from 0010-fc04-6514
Far-end frame loss: 0     Near-end frame loss: 10
Reply from 0010-fc04-6514
Far-end frame loss: 30    Near-end frame loss: 30

Average
Far-end frame loss: 20    Near-end frame loss: 25
Far-end frame loss rate: 25.00%    Near-end frame loss rate: 32.00%
Send LMMs: 5        Received: 5        Lost: 0
```

4. Verify the one-way DM function after the CC function obtains the status information of the entire network:

Test the one-way frame delay from MEP 1001 to MEP 4002 in service instance 1 on Device A.

```
[DeviceA] cfd dm one-way service-instance 1 mep 1001 target-mep 4002
5 1DMs have been sent. Please check the result on the remote device.
```

Display the one-way DM result on MEP 4002 in service instance 1 on Device D.

```
[DeviceD] display cfd dm one-way history service-instance 1 mep 4002
Service instance: 1
MEP ID: 4002
Sent 1DM total number: 0
Received 1DM total number: 5
Frame delay: 10ms 9ms 11ms 5ms 5ms
Delay average: 8ms
Delay variation: 5ms 4ms 6ms 0ms 0ms
Variation average: 3ms
```

5. Verify the two-way DM function after the CC function obtains the status information of the entire network:

Test the two-way frame delay from MEP 1001 to MEP 4002 in service instance 1 on Device A.

```
[DeviceA] cfd dm two-way service-instance 1 mep 1001 target-mep 4002
Frame delay:
Reply from 0010-fc04-6514: 2406us
Reply from 0010-fc04-6514: 2215us
Reply from 0010-fc04-6514: 2112us
Reply from 0010-fc04-6514: 1812us
Reply from 0010-fc04-6514: 2249us
Average: 2158us
Sent DMMs: 5        Received: 5        Lost: 0

Frame delay variation: 191us 103us 300us 437us
Average: 257us
```

6. Verify the TST function after the CC function obtains the status information of the entire network:

Test the bit errors on the link from MEP 1001 to MEP 4002 in service instance 1 on Device A.

```
[DeviceA] cfd tst service-instance 1 mep 1001 target-mep 4002
5 TSTs have been sent. Please check the result on the remote device.
```

Display the TST result on MEP 4002 in service instance 1 on Device D.

```
[DeviceD] display cfd tst service-instance 1 mep 4002
Service instance: 1
MEP ID: 4002
Sent TST total number: 0
Received TST total number: 5
Received from 0010-fc01-6511, Bit True,  sequence number 0
Received from 0010-fc01-6511, Bit True,  sequence number 1
Received from 0010-fc01-6511, Bit True,  sequence number 2
Received from 0010-fc01-6511, Bit True,  sequence number 3
Received from 0010-fc01-6511, Bit True,  sequence number 4
```

Contents

Configuring DLDP

About DLDP

Physical layer detection mechanisms, such as auto-negotiation, can detect physical signals and faults. However, they cannot detect communication failures for unidirectional links where the physical layer is in connected state.

As a data link layer protocol, the Device Link Detection Protocol (DLDP) can do the following:

- Monitor status of the fiber link or twisted-pair link at the link layer.
- Cooperate with physical layer protocols to detect whether the link is correctly connected and whether the two ends of the link can exchange packets correctly.

When DLDP detects unidirectional links, it can automatically shut down the faulty port to avoid network problems. Alternatively, a user can manually shut down the faulty port.

Application scenario

A link becomes unidirectional when only one end of the link can receive packets from the other end.

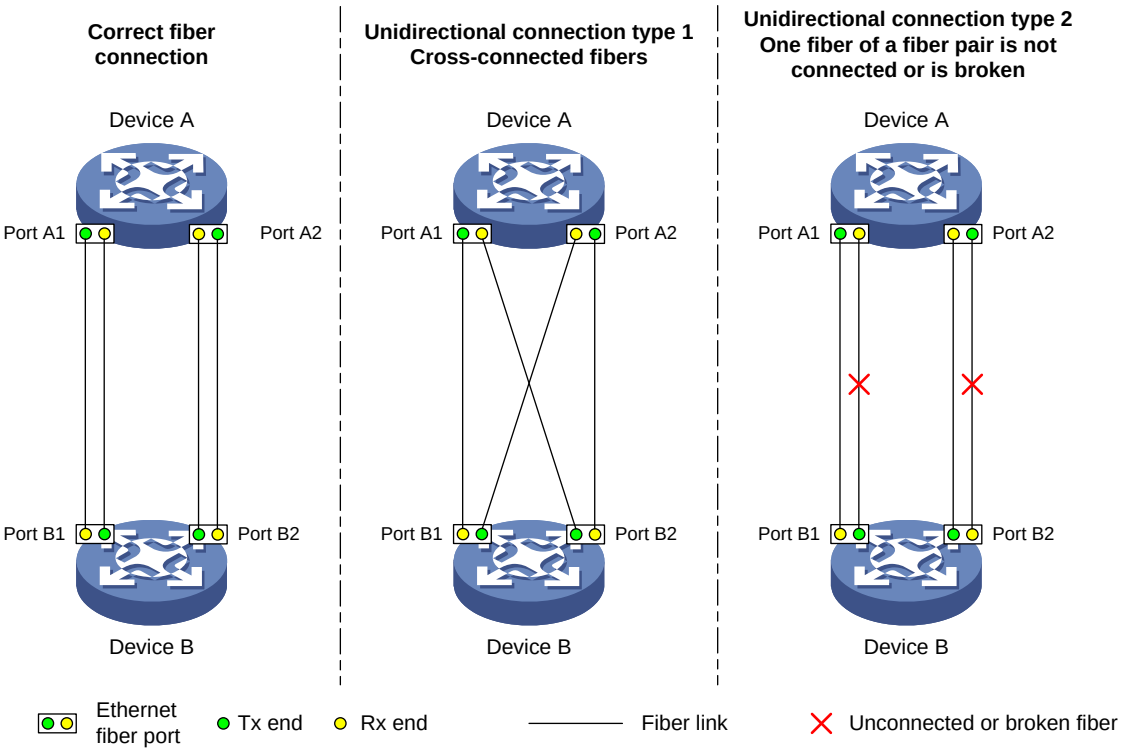
Unidirectional fiber links occur in the following cases:

- Fibers are cross-connected.
- A fiber is not connected at one end or one fiber of a fiber pair is broken.

Figure 1 shows a correct fiber connection and two types of unidirectional fiber connections.

When DLDP detects unidirectional links, it can automatically shut down the faulty port to avoid network problems. Alternatively, a user can manually shut down the faulty port.

Figure 1 Correct and incorrect fiber connections



Basic concepts

DLDP neighbor states

If port A can receive link-layer packets from port B on the same link, port B is a DLDP neighbor of port A. Two ports that can exchange packets are neighbors.

Table 1 DLDP neighbor states

DLDP timer	Description
Confirmed	The link to a DLDP neighbor is bidirectional.
Unconfirmed	The state of the link to a newly discovered neighbor is not determined.

DLDP port states

A DLDP-enabled port is called a DLDP port. A DLDP port can have multiple neighbors, and its state varies by the DLDP neighbor state.

Table 2 DLDP port states

State	Description
Initial	DLDP is enabled on the port, but is disabled globally.
Inactive	DLDP is enabled on the port and globally, and the link is physically down.
Bidirectional	DLDP is enabled on the port and globally, and at least one neighbor in Confirmed state exists.
Unidirectional	DLDP is enabled on the port and globally, and no neighbor in Confirmed state exists. In this state, a port does not send or receive packets other than DLDP packets any more.

DLDP timers

Table 3 DLDP timers

DLDP timer	Description
Advertisement timer	Advertisement packet sending interval (the default is 5 seconds and is configurable).
Probe timer	Probe packet sending interval. This timer is set to 1 second.
Echo timer	The Echo timer is triggered when a probe is launched for a new neighbor. The neighbor information is deleted when the timer expires. This timer is set to 10 seconds.
Entry timer	When a new neighbor joins, a neighbor entry is created and the corresponding Entry timer is triggered if the neighbor is in Confirmed state. When an Advertisement is received, the device updates the corresponding neighbor entry and the Entry timer. When the Entry timer expires, the Enhanced timer and Echo timer are triggered for the neighbor. The value of an Entry timer is three times that of the Advertisement timer.
Enhanced timer	Probe packet sending interval. This timer is set to 1 second. When the Entry timer expires, the Enhanced timer is triggered and probe packets are sent. At the same time, the Echo timer is triggered.
DelayDown timer	If a port is physically down, the device triggers the DelayDown timer, rather than removing the corresponding neighbor entry. The default DelayDown timer is 1 second and is configurable. When the DelayDown timer expires, the device removes the corresponding DLDP neighbor information if the port is down, and does not perform any

DLDP timer	Description
	operation if the port is up.
RecoverProbe timer	This timer is set to 2 seconds. A port in unidirectional state regularly sends RecoverProbe packets to detect whether a unidirectional link has been restored to bidirectional.

DLDP authentication mode

You can use DLDP authentication to prevent network attacks and illegal detecting.

Table 4 DLDP authentication mode

Authentication mode	Processing at the DLDP packet sending side	Processing at the DLDP packet receiving side
Non-authentication	The sending side sets the Authentication field of DLDP packets to 0.	The receiving side examines the authentication information of received DLDP packets and drops packets where the authentication information conflicts with the local configuration.
Plaintext authentication	The sending side sets the Authentication field to the password configured in plain text.	
MD5 authentication	The sending side encrypts the user configured password by using MD5 algorithm, and assigns the digest to the Authentication field.	

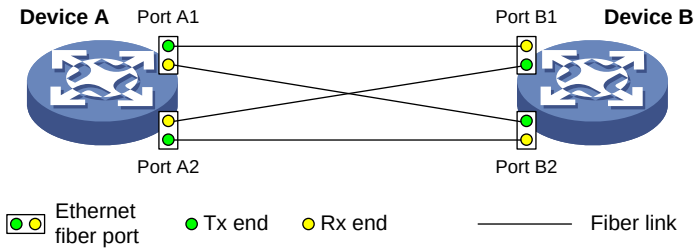
How DLDP works

Detecting one neighbor

When two devices are connected through an optical fiber or a network cable, enable DLDP to detect unidirectional links to the neighbor. The following illustrates the unidirectional link detection process in two cases:

- Unidirectional links occur before you enable DLDP.

  Figure 2 Cross-connected fibers



  As shown in Figure 2, before you enable DLDP, the optical fibers between Device A and Device B are cross-connected. After you enable DLDP, the four ports are all up and in unidirectional state, and they send RecoverProbe packets. Take Port A1 as an example to illustrate the unidirectional link detection process.

  a. Port A1 receives the RecoverProbe packet from Port B2, and returns a RecoverEcho packet.

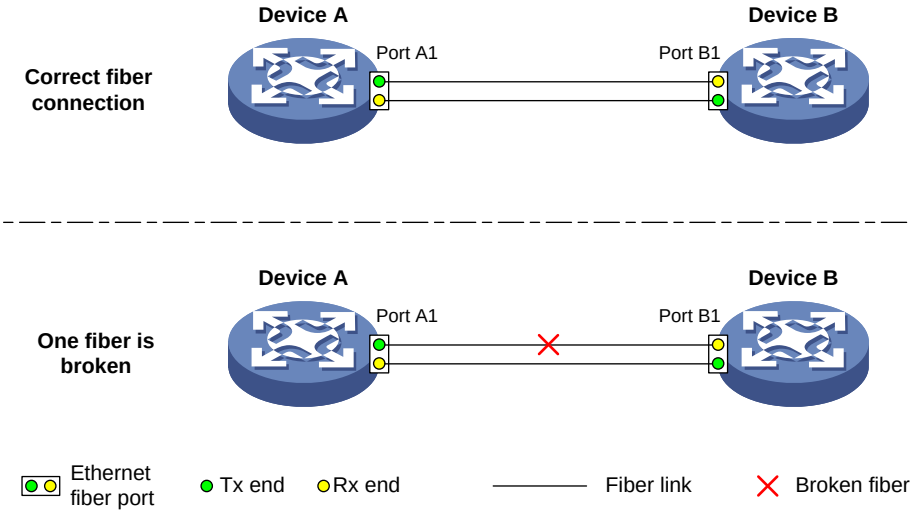
  b. Port B2 cannot receive any RecoverEcho packet from Port A1, so Port B2 cannot become the neighbor of Port A1.

  c. Port B1 can receive the RecoverEcho packet from Port A1, but Port B1 is not the intended destination, so Port B1 cannot become the neighbor of Port A1.

  The same process occurs on the other three ports. The four ports are all in unidirectional state.

- Unidirectional links occur after you enable DLDP.

Figure 3 Broken fiber



As shown in Figure 3, Device A and Device B are connected through an optical fiber. After you enable DLDP, Port A1 and Port B1 establish the bidirectional neighborship in the following way:

a. Port A1 that is physically up enters the unidirectional state and sends a RecoverProbe packet.

b. After receiving the RecoverProbe packet, Port B1 returns a RecoverEcho packet.

c. After Port A1 receives the RecoverEcho packet, it examines the neighbor information in the packet. If the neighbor information matches the local information, Port A1 establishes the neighborship with Port B1 and transits to bidirectional state. Port A1 then starts the Entry timer and periodically sends Advertisement packets.

d. After Port B1 receives the Advertisement packet, it establishes the Unconfirmed neighborship with Port A1. Port B1 then starts the Echo timer and Probe timer, and periodically sends Probe packets.

e. After receiving the Probe packet, Port A1 returns an Echo packet.

f. After Port B1 receives the Echo packet, it examines the neighbor information in the packet. If the neighbor information matches the local information, the neighbor state of Port A1 becomes Confirmed. Port B1 then transits to bidirectional state, starts the Entry timer, and periodically sends Advertisement packets.

The bidirectional neighborship between Port A1 and Port B1 is now established.

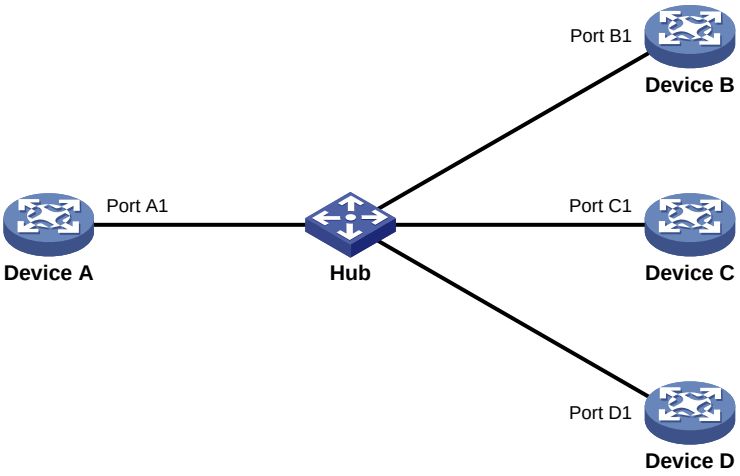
After that, when Port B1's Rx end fails to receive signals, Port B1 is physically down and enters the Inactive state. Because Port B1's Tx end can still send signals to Port A1, Port A1 stays up. After the Entry timer for Port B1 expires, Port A1 starts the Enhanced timer and Echo timer, and sends a probe packet to Port B1. Because Port A1's Tx line is broken, Port A1 cannot receive the Echo packet from Port B1 after the Echo timer expires. Port A1 then enters the unidirectional state, and sends a Disable packet to Port B1. At the same time, Port A1 deletes the neighborship with Port B1, and starts the RecoverProbe timer. Port B1 stays in Inactive state during this process.

When an interface is physically down, but the Tx end of the interface is still operating, DLDP sends a LinkDown packet to inform the peer to delete the relevant neighbor entry.

Detecting multiple neighbors

When multiple devices are connected through a hub, enable DLDP on all interfaces connected to the hub to detect unidirectional links among the neighbors. When no Confirmed neighbor exists, an interface enters the unidirectional state.

Figure 4 Network diagram



As shown in Figure 4, Device A through Device D are connected through a hub, and enabled with DLDP. When Port A1, Port B1, and Port C1 detect that the link to Port D1 fails, they delete the neighborship with Port D1, but stay in bidirectional state.

Restrictions and guidelines: DLDP configuration

When you configure DLDP, follow these configuration restrictions and guidelines:

- For DLDP to operate correctly, enable DLDP on both sides and make sure the following settings are consistent:
  - Interval to send Advertisement packets.
  - DLDP authentication mode.
  - Password.
- For DLDP to operate correctly, configure the full duplex mode for the ports at the two ends of the link, and configure the same speed for the two ports.

DLDP tasks at a glance

To configure DLDP, perform the following tasks:

1. Enabling DLDP
2. (Optional.) Setting the interval to send advertisement packets
3. (Optional.) Setting the DelayDown timer
4. (Optional.) Setting the port shutdown mode
5. (Optional.) Configuring DLDP authentication

Enabling DLDP

About enabling DLDP

After a port is enabled with DLDP, the port enters Initial state and then transitions to Unidirectional state. By default, DLDP blocks a port immediately when the port transitions to Unidirectional state. This behavior causes a traffic disruption that lasts until the port enters Bidirectional state when establishing a Confirmed neighbor.

You can set the delay time for DLDP to block a port upon an Initial-to-Unidirectional state transition. DLDP does not block the port until the delay time expires.

Procedure

1. Enter system view.

   system-view

2. Enable DLDP globally.

   dldp global enable

   By default, DLDP is globally disabled.

3. Enter Ethernet interface view.

   interface *interface-type interface-number*

4. Enable DLDP and set the delay time for DLDP to block the port upon an Initial-to-Unidirectional state transition.

   dldp enable [**initial-unidirectional-delay** *time*]

   By default, DLDP is disabled on a port, and when DLDP is enabled, a port is blocked immediately upon an Initial-to-Unidirectional state transition.

Setting the interval to send advertisement packets

About setting the interval to send advertisement packets

To make sure DLDP can detect unidirectional links before network performance deteriorates, set the advertisement interval appropriate for your network environment. As a best practice, use the default interval.

Procedure

1. Enter system view.

   system-view

2. Set the interval to send Advertisement packets.

   dldp interval *interval*

   By default, the interval is 5 seconds.

Setting the DelayDown timer

About setting the DelayDown timer

When the Tx line fails, some ports might go down and then come up again, causing optical signal jitters on the Rx line. To prevent the device from removing neighbor entries in such cases, set the DelayDown timer for the device. The device starts the DelayDown timer when a port goes down due to a Tx line failure. If the port remains down when the timer expires, the device removes the DLDP neighbor information. If the port comes up, the device takes no action.

Procedure

1. Enter system view.

   system-view

2. Set the DelayDown timer.

   dldp delaydown-timer *time*

   The default is 1 second.

   The DelayDown timer setting applies to all DLDP-enabled ports.

Setting the port shutdown mode

About port shutdown modes

On detecting a unidirectional link, DLDP shuts down the ports in one of the following modes:

- **Auto mode**—When DLDP detects a unidirectional link, it shuts down the unidirectional port. When the link becomes bidirectional, DLDP brings up the port that was shut down.
- **Manual mode**—When DLDP detects a unidirectional link, it does not shut down the port. You need to manually shut it down. To verify the link status, use the **undo shutdown** command to bring up the port. If the link becomes bidirectional, the port becomes bidirectional. Use this mode to prevent normal links from being shut down because of false unidirectional link reports in the following cases:
  - The network performance is low.
  - The device is busy.
  - The CPU usage is high.
- **Hybrid mode**—When DLDP detects a unidirectional link, it shuts down the unidirectional port and stops link detection. To verify the link status, use the **undo shutdown** command to bring up the port. If the link becomes bidirectional, the port becomes bidirectional.

Restrictions and guidelines

You can set the port shutdown mode for all interfaces in system view or for a single interface in interface view. The setting in interface view takes precedence over the setting in system view.

To enable remote OAM loopback on a DLDP port, set the port shutdown mode to **manual**. Otherwise, DLDP automatically shuts down the port when it receives a packet sent by itself. This causes remote OAM loopback failure. For more information about Ethernet OAM, see "Configuring Ethernet OAM."

Setting the global port shutdown mode

1. Enter system view.
   system-view
2. Set the global port shutdown mode.
   dldp unidirectional-shutdown { **auto** | **hybrid** | **manual** }
   The default mode is **auto**.

Setting the port shutdown mode for an interface

1. Enter system view.
   system-view
2. Enter Ethernet interface view.
   interface *interface-type interface-number*
3. Set the the port shutdown mode for the interface.
   dldp port unidirectional-shutdown { **auto** | **hybrid** | **manual** }
   By default, the global setting is used.

Configuring DLDP authentication

About DLDP authentication

You can guard your network against attacks and malicious probes by configuring an appropriate DLDP authentication mode, which can be plain text authentication or MD5 authentication. If your network is safe, you can choose not to authenticate.

Procedure

1. Enter system view.
   system-view
2. Configure a DLDP authentication mode.
   dldp authentication-mode { **md5** | **none** | **simple** }
   The default authentication mode is **none**.
3. Configure the password for DLDP authentication.
   dldp authentication-password { **cipher** | **simple** } *string*
   By default, no password is configured for DLDP authentication.
   If you do not configure the authentication password after you configure the authentication mode, the authentication mode is **none** no matter which authentication mode you configure.

Display and maintenance commands for DLDP

Execute **display** commands in any view and the **reset** command in user view.

Task	Command
Display the DLDP configuration globally and of a port.	**display dldp** [**interface** *interface-type interface-number*]
Display the statistics on DLDP packets passing through a port.	**display dldp statistics** [**interface** *interface-type interface-number*]
Clear the statistics on DLDP packets passing through a port.	**reset dldp statistics** [**interface** *interface-type interface-number*]

DLDP configuration examples

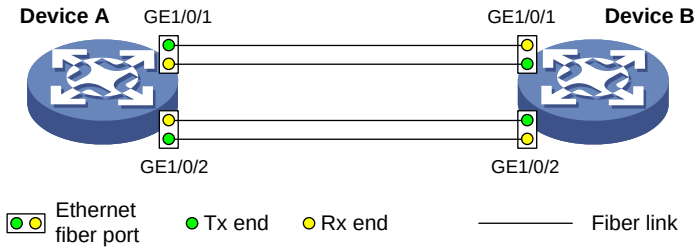
Example: Configuring the auto port shutdown mode

Network configuration

As shown in Figure 5, Device A and Device B are connected through two fiber pairs.

Configure DLDP to automatically shut down the faulty port upon detecting a unidirectional link, and automatically bring up the port after you clear the fault.

Figure 5 Network diagram



Procedure

1. Configure Device A:

Enable DLDP globally.

```
<DeviceA> system-view
[DeviceA] dldp global enable
```

Configure GigabitEthernet 1/0/1 to operate in full duplex mode and at 1000 Mbps, and enable DLDP on the port.

```
[DeviceA] interface gigabitethernet 1/0/1
[DeviceA-GigabitEthernet1/0/1] duplex full
[DeviceA-GigabitEthernet1/0/1] speed 1000
[DeviceA-GigabitEthernet1/0/1] dldp enable
[DeviceA-GigabitEthernet1/0/1] quit
```

Configure GigabitEthernet 1/0/2 to operate in full duplex mode and at 1000 Mbps, and enable DLDP on the port.

```
[DeviceA] interface gigabitethernet 1/0/2
[DeviceA-GigabitEthernet1/0/2] duplex full
[DeviceA-GigabitEthernet1/0/2] speed 1000
[DeviceA-GigabitEthernet1/0/2] dldp enable
[DeviceA-GigabitEthernet1/0/2] quit
```

Set the global port shutdown mode to auto.

```
[DeviceA] dldp unidirectional-shutdown auto
```

2. Configure Device B:

Enable DLDP globally.

```
<DeviceB> system-view
[DeviceB] dldp global enable
```

Configure GigabitEthernet 1/0/1 to operate in full duplex mode and at 1000 Mbps, and enable DLDP on it.

```
[DeviceB] interface gigabitethernet 1/0/1
[DeviceB-GigabitEthernet1/0/1] duplex full
[DeviceB-GigabitEthernet1/0/1] speed 1000
[DeviceB-GigabitEthernet1/0/1] dldp enable
[DeviceB-GigabitEthernet1/0/1] quit
```

Configure GigabitEthernet 1/0/2 to operate in full duplex mode and at 1000 Mbps, and enable DLDP on it.

```
[DeviceB] interface gigabitethernet 1/0/2
[DeviceB-GigabitEthernet1/0/2] duplex full
[DeviceB-GigabitEthernet1/0/2] speed 1000
[DeviceB-GigabitEthernet1/0/2] dldp enable
[DeviceB-GigabitEthernet1/0/2] quit
```

Set the global port shutdown mode to auto.

```
[DeviceB] dldp unidirectional-shutdown auto
```

Verifying the configuration

Display the DLDP configuration globally and on all the DLDP-enabled ports of Device A.

```
[DeviceA] display dldp
 DLDP global status: Enabled
 DLDP advertisement interval: 5s
 DLDP authentication-mode: None
 DLDP unidirectional-shutdown mode: Auto
 DLDP delaydown-timer value: 1s
 Number of enabled ports: 2
```

```
Interface GigabitEthernet1/0/1
 DLDP port state: Bidirectional
 DLDP port unidirectional-shutdown mode: None
 DLDP initial-unidirectional-delay: 0s
 Number of the port’s neighbors: 1
  Neighbor MAC address: 0023-8956-3600
  Neighbor port index: 1
  Neighbor state: Confirmed
  Neighbor aged time: 11s
  Neighbor echo time: -

Interface GigabitEthernet1/0/2
 DLDP port state: Bidirectional
 DLDP port unidirectional-shutdown mode: None
 DLDP initial-unidirectional-delay: 0s
 Number of the port’s neighbors: 1
  Neighbor MAC address: 0023-8956-3600
  Neighbor port index: 2
  Neighbor state: Confirmed
  Neighbor aged time: 12s
  Neighbor echo time: -
```

The output shows that both GigabitEthernet 1/0/1 and GigabitEthernet 1/0/2 are bidirectional.

Enable the monitoring of logs on the current terminal on Device A. Set the lowest level of the logs that can be output to the current terminal to 6.

```
[DeviceA] quit
<DeviceA> terminal monitor
The current terminal is enabled to display logs.
<DeviceA> terminal logging level 6
```

The following log information is displayed on Device A:

```
<DeviceA>%Jul 11 17:40:31:089 2012 DeviceA IFNET/3/PHY_UPDOWN: Physical state on the interface Physical state on the interface GigabitEthernet1/0/1 changed to down.
%Jul 11 17:40:31:091 2012 DeviceA IFNET/5/LINK_UPDOWN: Line protocol state on the interface GigabitEthernet1/0/1 changed to down.
%Jul 11 17:40:31:677 2012 DeviceA IFNET/3/PHY_UPDOWN: Physical state on the interface Physical state on the interface GigabitEthernet1/0/2 changed to down.
%Jul 11 17:40:31:678 2012 DeviceA IFNET/5/LINK_UPDOWN: Line protocol state on the interface GigabitEthernet1/0/2 changed to down.
%Jul 11 17:40:38:544 2012 DeviceA IFNET/3/PHY_UPDOWN: Physical state on the interface Physical state on the interface GigabitEthernet1/0/1 l changed to up.
%Jul 11 17:40:38:836 2012 DeviceA IFNET/3/PHY_UPDOWN: Physical state on the interface Physical state on the interface GigabitEthernet1/0/2 changed to up.
```

The output shows the following:

- The port status of both GigabitEthernet 1/0/1 and GigabitEthernet 1/0/2 is down and then up.
- The link status of both GigabitEthernet 1/0/1 and GigabitEthernet 1/0/2 is always down.

Display the DLDP configuration globally and of all the DLDP-enabled ports.

```
<DeviceA> display dldp
 DLDP global status: Enabled
```

```
 DLDP advertisement interval: 5s
 DLDP authentication-mode: None
 DLDP unidirectional-shutdown mode: Auto
 DLDP delaydown-timer value: 1s
 Number of enabled ports: 2

Interface GigabitEthernet1/0/1
 DLDP port state: Unidirectional
 DLDP port unidirectional-shutdown mode: None
 DLDP initial-unidirectional-delay: 0s
 Number of the port’s neighbors: 0 (Maximum number ever detected: 1)

Interface GigabitEthernet1/0/2
 DLDP port state: Unidirectional
 DLDP port unidirectional-shutdown mode: None
 DLDP initial-unidirectional-delay: 0s
 Number of the port’s neighbors: 0 (Maximum number ever detected: 1)
```

The output shows that the DLDP port status of both GigabitEthernet 1/0/1 and GigabitEthernet 1/0/2 is unidirectional. DLDP detects unidirectional links on them and automatically shuts down the two ports.

The unidirectional links are caused by cross-connected fibers. Correct the fiber connections. As a result, the ports shut down by DLDP automatically recover, and Device A displays the following log information:

```
<DeviceA>%Jul 11 17:42:57:709 2012 DeviceA IFNET/3/PHY_UPDOWN: Physical state on the interface GigabitEthernet1/0/1 changed to down.
%Jul 11 17:42:58:603 2012 DeviceA IFNET/3/PHY_UPDOWN: Physical state on the interface GigabitEthernet1/0/2 changed to down.
%Jul 11 17:43:02:342 2012 DeviceA IFNET/3/PHY_UPDOWN: Physical state on the interface GigabitEthernet1/0/1 changed to up.
%Jul 11 17:43:02:343 2012 DeviceA DLDP/6/DLDP_NEIGHBOR_CONFIRMED: A neighbor was confirmed on interface GigabitEthernet1/0/1. The neighbor's system MAC is 0023-8956-3600, and the port index is 1.
%Jul 11 17:43:02:344 2012 DeviceA DLDP/6/DLDP_LINK_BIDIRECTIONAL: DLDP detected a bidirectional link on interface GigabitEthernet1/0/1.
%Jul 11 17:43:02:353 2012 DeviceA IFNET/5/LINK_UPDOWN: Line protocol state on the interface GigabitEthernet1/0/1 changed to up.
%Jul 11 17:43:02:357 2012 DeviceA IFNET/3/PHY_UPDOWN: Physical state on the interface GigabitEthernet1/0/2 changed to up.
%Jul 11 17:43:02:362 2012 DeviceA DLDP/6/DLDP_NEIGHBOR_CONFIRMED: A neighbor was confirmed on interface GigabitEthernet1/0/2. The neighbor's system MAC is 0023-8956-3600, and the port index is 2.
%Jul 11 17:43:02:362 2012 DeviceA DLDP/6/DLDP_LINK_BIDIRECTIONAL: DLDP detected a bidirectional link on interface GigabitEthernet1/0/2.
%Jul 11 17:43:02:368 2012 DeviceA IFNET/5/LINK_UPDOWN: Line protocol state on the interface GigabitEthernet1/0/2 changed to up.
```

The output shows that the port status and link status of both GigabitEthernet 1/0/1 and GigabitEthernet 1/0/2 are now up and their DLDP neighbors are determined.

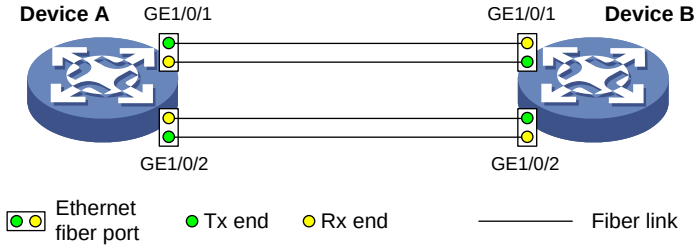
Example: Configuring the manual port shutdown mode

Network configuration

As shown in Figure 6, Device A and Device B are connected through two fiber pairs.

Configure DLDP to detect unidirectional links. When a unidirectional link is detected, the administrator must manually shut down the port.

Figure 6 Network diagram



Procedure

1. Configure Device A:

   # Enable DLDP globally.

   ```
   <DeviceA> system-view
   [DeviceA] dldp enable
   ```

   # Configure GigabitEthernet 1/0/1 to operate in full duplex mode and at 1000 Mbps, and enable DLDP on the port.

   ```
   [DeviceA] interface gigabitethernet 1/0/1
   [DeviceA-GigabitEthernet1/0/1] duplex full
   [DeviceA-GigabitEthernet1/0/1] speed 1000
   [DeviceA-GigabitEthernet1/0/1] dldp enable
   [DeviceA-GigabitEthernet1/0/1] quit
   ```

   # Configure GigabitEthernet 1/0/2 to operate in full duplex mode and at 1000 Mbps, and enable DLDP on the port.

   ```
   [DeviceA] interface gigabitethernet 1/0/2
   [DeviceA-GigabitEthernet1/0/2] duplex full
   [DeviceA-GigabitEthernet1/0/2] speed 1000
   [DeviceA-GigabitEthernet1/0/2] dldp enable
   [DeviceA-GigabitEthernet1/0/2] quit
   ```

   # Set the global port shutdown mode to manual.

   ```
   [DeviceA] dldp unidirectional-shutdown manual
   ```

2. Configure Device B:

   # Enable DLDP globally.

   ```
   <DeviceB> system-view
   [DeviceB] dldp global enable
   ```

   # Configure GigabitEthernet 1/0/1 to operate in full duplex mode and at 1000 Mbps, and enable DLDP on it.

   ```
   [DeviceB] interface gigabitethernet 1/0/1
   [DeviceB-GigabitEthernet1/0/1] duplex full
   [DeviceB-GigabitEthernet1/0/1] speed 1000
   [DeviceB-GigabitEthernet1/0/1] dldp enable
   [DeviceB-GigabitEthernet1/0/1] quit
   ```

Configure GigabitEthernet 1/0/2 to operate in full duplex mode and at 1000 Mbps, and enable DLDP on it.

```
[DeviceB] interface gigabitethernet 1/0/2
[DeviceB-GigabitEthernet1/0/2] duplex full
[DeviceB-GigabitEthernet1/0/2] speed 1000
[DeviceB-GigabitEthernet1/0/2] dldp enable
[DeviceB-GigabitEthernet1/0/2] quit
```

Set the global port shutdown mode to manual.

```
[DeviceB] dldp unidirectional-shutdown manual
```

Verifying the configuration

Display the DLDP configuration globally and on all the DLDP-enabled ports of Device A.

```
[DeviceA] display dldp
 DLDP global status: Enabled
 DLDP advertisement interval: 5s
 DLDP authentication-mode: None
 DLDP unidirectional-shutdown mode: Manual
 DLDP delaydown-timer value: 1s
 Number of enabled ports: 2

Interface GigabitEthernet1/0/1
 DLDP port state: Bidirectional
 DLDP port unidirectional-shutdown mode: None
 DLDP initial-unidirectional-delay: 0s
 Number of the port’s neighbors: 1
  Neighbor MAC address: 0023-8956-3600
  Neighbor port index: 1
  Neighbor state: Confirmed
  Neighbor aged time: 11s
  Neighbor echo time: -

Interface GigabitEthernet1/0/2
 DLDP port state: Bidirectional
 DLDP port unidirectional-shutdown mode: None
 DLDP initial-unidirectional-delay: 0s
 Number of the port’s neighbors: 1
  Neighbor MAC address: 0023-8956-3600
  Neighbor port index: 2
  Neighbor state: Confirmed
  Neighbor aged time: 12s
  Neighbor echo time: -
```

The output shows that both GigabitEthernet 1/0/1 and GigabitEthernet 1/0/2 are in bidirectional state, which means both links are bidirectional.

Enable the monitoring of logs on the current terminal on Device A. Set the lowest level of the logs that can be output to the current terminal to 6.

```
[DeviceA] quit
<DeviceA> terminal monitor
The current terminal is enabled to display logs.
<DeviceA> terminal logging level 6
```

The following log information is displayed on Device A:

```
<DeviceA>%Jul 12 08:29:17:786 2012 DeviceA IFNET/3/PHY_UPDOWN: Physical state on the interface GigabitEthernet1/0/1 changed to down.
%Jul 12 08:29:17:787 2012 DeviceA IFNET/5/LINK_UPDOWN: Line protocol state on the interface GigabitEthernet1/0/1 changed to down.
%Jul 12 08:29:17:800 2012 DeviceA IFNET/3/PHY_UPDOWN: Physical state on the interface GigabitEthernet1/0/2 changed to down.
%Jul 12 08:29:17:800 2012 DeviceA IFNET/5/LINK_UPDOWN: Line protocol state on the interface GigabitEthernet1/0/2 changed to down.
%Jul 12 08:29:25:004 2012 DeviceA IFNET/3/PHY_UPDOWN: Physical state on the interface GigabitEthernet1/0/1 changed to up.
%Jul 12 08:29:25:005 2012 DeviceA IFNET/5/LINK_UPDOWN: Line protocol state on the interface GigabitEthernet1/0/1 changed to up.
%Jul 12 08:29:25:893 2012 DeviceA IFNET/3/PHY_UPDOWN: Physical state on the interface GigabitEthernet1/0/2 changed to up.
%Jul 12 08:29:25:894 2012 DeviceA IFNET/5/LINK_UPDOWN: Line protocol state on the interface GigabitEthernet1/0/2 changed to up.
```

The output shows that the port status and link status of both GigabitEthernet 1/0/1 and GigabitEthernet 1/0/2 are down and then up.

Display the DLDP configuration globally and of all the DLDP-enabled ports.

```
<DeviceA> display dldp
 DLDP global status: Enabled
 DLDP advertisement interval: 5s
 DLDP authentication-mode: None
 DLDP unidirectional-shutdown mode: Manual
 DLDP delaydown-timer value: 1s
 Number of enabled ports: 2

Interface GigabitEthernet1/0/1
 DLDP port state: Unidirectional
 DLDP port unidirectional-shutdown mode: None
 DLDP initial-unidirectional-delay: 0s
 Number of the port’s neighbors: 0 (Maximum number ever detected: 1)

Interface GigabitEthernet1/0/2
 DLDP port state: Unidirectional
 DLDP port unidirectional-shutdown mode: None
 DLDP initial-unidirectional-delay: 0s
 Number of the port’s neighbors: 0 (Maximum number ever detected: 1)
```

The output shows that the DLDP port status of both GigabitEthernet 1/0/1 and GigabitEthernet 1/0/2 is unidirectional. DLDP detects unidirectional links on the two ports but does not shut them down.

The unidirectional links are caused by cross-connected fibers. Manually shut down the two ports:

Shut down GigabitEthernet 1/0/1.

```
<DeviceA> system-view
[DeviceA] interface gigabitethernet 1/0/1
[DeviceA-GigabitEthernet1/0/1] shutdown
```

The following log information is displayed on Device A:

```
[DeviceA-GigabitEthernet1/0/1]%Jul 12 08:34:23:717 2012 DeviceA IFNET/3/PHY_UPDOWN: Physical state on the interface GigabitEthernet1/0/1 changed to down.
```

```
%Jul 12 08:34:23:718 2012 DeviceA IFNET/5/LINK_UPDOWN: Line protocol state on the interface
GigabitEthernet1/0/1 changed to down.
%Jul 12 08:34:23:778 2012 DeviceA IFNET/3/PHY_UPDOWN: Physical state on the interface
GigabitEthernet1/0/2 changed to down.
%Jul 12 08:34:23:779 2012 DeviceA IFNET/5/LINK_UPDOWN: Line protocol state on the interface
GigabitEthernet1/0/2 changed to down.
```

The output shows that the port status and link status of both GigabitEthernet 1/0/1 and GigabitEthernet 1/0/2 are now down.

Shut down GigabitEthernet 1/0/2.

```
[DeviceA-GigabitEthernet1/0/1] quit
[DeviceA] interface gigabitethernet 1/0/2
[DeviceA-GigabitEthernet1/0/2] shutdown
```

Correct the fiber connections and bring up the two ports:

Bring up GigabitEthernet 1/0/2.

```
[DeviceA-GigabitEthernet1/0/2] undo shutdown
```

The following log information is displayed on Device A:

```
[DeviceA-GigabitEthernet1/0/2]%Jul 12 08:46:17:677 2012 DeviceA IFNET/3/PHY_UPDOWN:
Physical state on the interface GigabitEthernet1/0/2 changed to up.
%Jul 12 08:46:17:678 2012 DeviceA IFNET/5/LINK_UPDOWN: Line protocol state on the interface
GigabitEthernet1/0/2 changed to up.
%Jul 12 08:46:17:959 2012 DeviceA DLDP/6/DLDP_NEIGHBOR_CONFIRMED: A neighbor was confirmed
on interface GigabitEthernet1/0/2. The neighbor's system MAC is 0023-8956-3600, and the
port index is 2.
%Jul 12 08:46:17:959 2012 DeviceA DLDP/6/DLDP_LINK_BIDIRECTIONAL: DLDP detected a
bidirectional link on interface GigabitEthernet1/0/2.
```

The output shows that the port status and link status of GigabitEthernet 1/0/2 are now up and its DLDP neighbors are determined.

Bring up GigabitEthernet 1/0/1.

```
[DeviceA-GigabitEthernet1/0/2] quit
[DeviceA] interface gigabitethernet 1/0/1
[DeviceA-GigabitEthernet1/0/1] undo shutdown
```

The following log information is displayed on Device A:

```
[DeviceA-GigabitEthernet1/0/1]%Jul 12 08:48:25:952 2012 DeviceA IFNET/3/PHY_UPDOWN:
Physical state on the interface GigabitEthernet1/0/1 changed to up.
%Jul 12 08:48:25:952 2012 DeviceA DLDP/6/DLDP_NEIGHBOR_CONFIRMED: A neighbor was confirmed
on interface GigabitEthernet1/0/1. The neighbor's system MAC is 0023-8956-3600, and the
port index is 1.
%Jul 12 08:48:25:953 2012 DeviceA IFNET/5/LINK_UPDOWN: Line protocol state on the interface
GigabitEthernet1/0/1 changed to up.
%Jul 12 08:48:25:953 2012 DeviceA DLDP/6/DLDP_LINK_BIDIRECTIONAL: DLDP detected a
bidirectional link on interface GigabitEthernet1/0/1.
```

The output shows that the port status and link status of GigabitEthernet 1/0/1 are now up and its DLDP neighbors are determined.

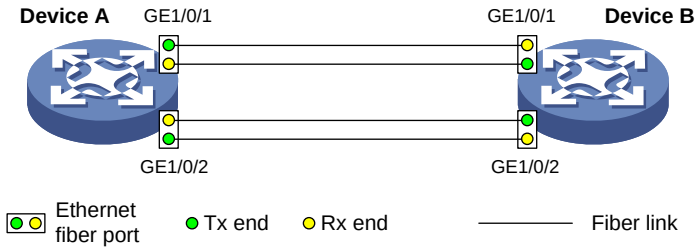
Example: Configuring the hybrid port shutdown mode

Network configuration

As shown in Figure 7Figure 6, Device A and Device B are connected through two fiber pairs.

Configure DLDP to detect unidirectional links. When a unidirectional link is detected, DLDP automatically shuts down the unidirectional port. The administrator needs to bring up the port after clearing the fault.

Figure 7 Network diagram



Procedure

1. Configure Device A:

Enable DLDP globally.

```
<DeviceA> system-view
[DeviceA] dldp enable
```

Configure GigabitEthernet 1/0/1 to operate in full duplex mode and at 1000 Mbps, and enable DLDP on the port.

```
[DeviceA] interface gigabitethernet 1/0/1
[DeviceA-GigabitEthernet1/0/1] duplex full
[DeviceA-GigabitEthernet1/0/1] speed 1000
[DeviceA-GigabitEthernet1/0/1] dldp enable
[DeviceA-GigabitEthernet1/0/1] quit
```

Configure GigabitEthernet 1/0/2 to operate in full duplex mode and at 1000 Mbps, and enable DLDP on the port.

```
[DeviceA] interface gigabitethernet 1/0/2
[DeviceA-GigabitEthernet1/0/2] duplex full
[DeviceA-GigabitEthernet1/0/2] speed 1000
[DeviceA-GigabitEthernet1/0/2] dldp enable
[DeviceA-GigabitEthernet1/0/2] quit
```

Set the global port shutdown mode to hybrid.

```
[DeviceA] dldp unidirectional-shutdown hybrid
```

2. Configure Device B:

Enable DLDP globally.

```
<DeviceB> system-view
[DeviceB] dldp global enable
```

Configure GigabitEthernet 1/0/1 to operate in full duplex mode and at 1000 Mbps, and enable DLDP on it.

```
[DeviceB] interface gigabitethernet 1/0/1
[DeviceB-GigabitEthernet1/0/1] duplex full
[DeviceB-GigabitEthernet1/0/1] speed 1000
[DeviceB-GigabitEthernet1/0/1] dldp enable
[DeviceB-GigabitEthernet1/0/1] quit
```

Configure GigabitEthernet 1/0/2 to operate in full duplex mode and at 1000 Mbps, and enable DLDP on it.

```
[DeviceB] interface gigabitethernet 1/0/2
[DeviceB-GigabitEthernet1/0/2] duplex full
```

```
[DeviceB-GigabitEthernet1/0/2] speed 1000
[DeviceB-GigabitEthernet1/0/2] dldp enable
[DeviceB-GigabitEthernet1/0/2] quit
```

Set the global port shutdown mode to hybrid.

```
[DeviceB] dldp unidirectional-shutdown hybrid
```

Verifying the configuration

Display the DLDP configuration globally and on all the DLDP-enabled ports of Device A.

```
[DeviceA] display dldp
 DLDP global status: Enabled
 DLDP advertisement interval: 5s
 DLDP authentication-mode: None
 DLDP unidirectional-shutdown mode: Hybrid
 DLDP delaydown-timer value: 1s
 Number of enabled ports: 2

Interface GigabitEthernet1/0/1
 DLDP port state: Bidirectional
 DLDP port unidirectional-shutdown mode: None
 DLDP initial-unidirectional-delay: 0s
 Number of the port’s neighbors: 1
  Neighbor MAC address: 0023-8956-3600
  Neighbor port index: 1
  Neighbor state: Confirmed
  Neighbor aged time: 11s
  Neighbor echo time: -

Interface GigabitEthernet1/0/2
 DLDP port state: Bidirectional
 DLDP port unidirectional-shutdown mode: None
 DLDP initial-unidirectional-delay: 0s
 Number of the port’s neighbors: 1
  Neighbor MAC address: 0023-8956-3600
  Neighbor port index: 2
  Neighbor state: Confirmed
  Neighbor aged time: 12s
  Neighbor echo time: -
```

The output shows that both GigabitEthernet 1/0/1 and GigabitEthernet 1/0/2 are in bidirectional state, which means both links are bidirectional.

Enable the monitoring of logs on the current terminal on Device A. Set the lowest level of the logs that can be output to the current terminal to 6.

```
[DeviceA] quit
<DeviceA> terminal monitor
The current terminal is enabled to display logs.
<DeviceA> terminal logging level 6
```

The following log information is displayed on Device A:

```
<DeviceA>%Jan  4 07:16:06:556 2011 DeviceA DLDP/5/DLDP_NEIGHBOR_AGED: A neighbor on
interface
```

```
GigabitEthernet1/0/1 was deleted because the neighbor was aged. The neighbor's system MAC
is 0023-8956-3600, and the port index is 162.
%Jan  4 07:16:06:560 2011 DeviceA DLDP/5/DLDP_NEIGHBOR_AGED: A neighbor on interface
GigabitEthernet1/0/2 was deleted because the neighbor was aged. The neighbor's system MAC
is 0023-8956-3600, and the port index is 165.
%Jan  4 07:16:06:724 2011 DeviceA IFNET/3/PHY_UPDOWN: Physical state on the interface
GigabitEthernet1/0/1 changed to down.
%Jan  4 07:16:06:730 2011 DeviceA IFNET/3/PHY_UPDOWN: Physical state on the interface
GigabitEthernet1/0/2 changed to down.
%Jan 4 07:16:06:736 2011 DeviceA IFNET/5/LINK_UPDOWN: Line protocol state on the interface
GigabitEthernet1/0/1 changed to down.
%Jan 4 07:16:06:738 2011 DeviceA IFNET/5/LINK_UPDOWN: Line protocol state on the interface
GigabitEthernet1/0/2 changed to down.
%Jan  4 07:16:07:152 2011 DeviceA DLDP/3/DLDP_LINK_UNIDIRECTIONAL: DLDP detected a
unidirectional link on interface GigabitEthernet1/0/1. DLDP automatically shut down the
interface. Please manually bring up the interface.
%Jan  4 07:16:07:156 2011 DeviceA DLDP/3/DLDP_LINK_UNIDIRECTIONAL: DLDP detected a
unidirectional link on interface GigabitEthernet1/0/2. DLDP automatically shut down the
interface. Please manually bring up the interface.
```

The output shows that the port status and link status of both GigabitEthernet 1/0/1 and GigabitEthernet 1/0/2 are down.

Display the DLDP configuration globally and of all the DLDP-enabled ports.

```
<DeviceA> display dldp
 DLDP global status: Enabled
 DLDP advertisement interval: 5s
 DLDP authentication-mode: None
 DLDP unidirectional-shutdown mode: Hybrid
 DLDP delaydown-timer value: 1s
 Number of enabled ports: 2

Interface GigabitEthernet1/0/1
 DLDP port state: Inactive
 DLDP port unidirectional-shutdown mode: None
 DLDP initial-unidirectional-delay: 0s
 Number of the port's neighbors: 0 (Maximum number ever detected: 1)
Interface GigabitEthernet1/0/2
 DLDP port state: Inactive
 DLDP port unidirectional-shutdown mode: None
 DLDP initial-unidirectional-delay: 0s
 Number of the port's neighbors: 0 (Maximum number ever detected: 1)
```

The output shows that DLDP detects a unidirectional link and shuts down GigabitEthernet 1/0/1 and GigabitEthernet 1/0/2.

The unidirectional links are caused by cross-connected fibers. Bring up the two ports after correcting the fiber connection:

Bring up GigabitEthernet 1/0/1.

```
<DeviceA> system-view
[DeviceA] interface gigabitethernet 1/0/1
[DeviceA-GigabitEthernet1/0/1] undo shutdown
```

The following log information is displayed on Device A:

```
[DeviceA-GigabitEthernet1/0/1]%Jan  4 07:33:26:574 2011 DeviceA IFNET/3/PHY_UPDOWN:
Physical state on the interface GigabitEthernet1/0/1 changed to up.
%Jan 4 07:33:57:562 2011 DeviceA DLDP/6/DLDP_NEIGHBOR_CONFIRMED: A neighbor was confirmed
on interface GigabitEthernet1/0/1. The neighbor's system MAC is 0023-8956-3600, and the
port index is 162.
%Jan  4 07:33:57:563 2011 DeviceA DLDP/6/DLDP_LINK_BIDIRECTIONAL: DLDP detected a
bidirectional link on interface GigabitEthernet1/0/1.
%Jan 4 07:33:57:590 2011 DeviceA IFNET/5/LINK_UPDOWN: Line protocol state on the interface
GigabitEthernet1/0/1 changed to up.
%Jan  4 07:33:57:609 2011 DeviceA STP/6/STP_DETECTED_TC: Instance 0's port
GigabitEthernet1/0/1 detected a topology change.
```

The output shows that the port status and link status of GigabitEthernet 1/0/1 are now up and its DLDP neighbors are determined.

Bring up GigabitEthernet 1/0/2.

```
[DeviceA-GigabitEthernet1/0/1] quit
[DeviceA] interface gigabitethernet 1/0/2
[DeviceA-GigabitEthernet1/0/2] undo shutdown
```

The following log information is displayed on Device A:

```
[DeviceA-GigabitEthernet1/0/2]%Jan  4 07:35:26:574 2011 DeviceA IFNET/3/PHY_UPDOWN:
Physical state on the interface GigabitEthernet1/0/2 changed to up.
%Jan 4 07:35:57:562 2011 DeviceA DLDP/6/DLDP_NEIGHBOR_CONFIRMED: A neighbor was confirmed
on interface GigabitEthernet1/0/2. The neighbor's system MAC is 0023-8956-3600, and the
port index is 162.
%Jan  4 07:35:57:563 2011 DeviceA DLDP/6/DLDP_LINK_BIDIRECTIONAL: DLDP detected a
bidirectional link on interface GigabitEthernet1/0/2.
%Jan 4 07:35:57:590 2011 DeviceA IFNET/5/LINK_UPDOWN: Line protocol state on the interface
GigabitEthernet1/0/2 changed to up.
%Jan  4 07:35:57:609 2011 DeviceA STP/6/STP_DETECTED_TC: Instance 0's port
GigabitEthernet1/0/2 detected a topology change.
```

The output shows that the port status and link status of GigabitEthernet 1/0/2 are now up and its DLDP neighbors are determined.

Contents

Configuring RRPP

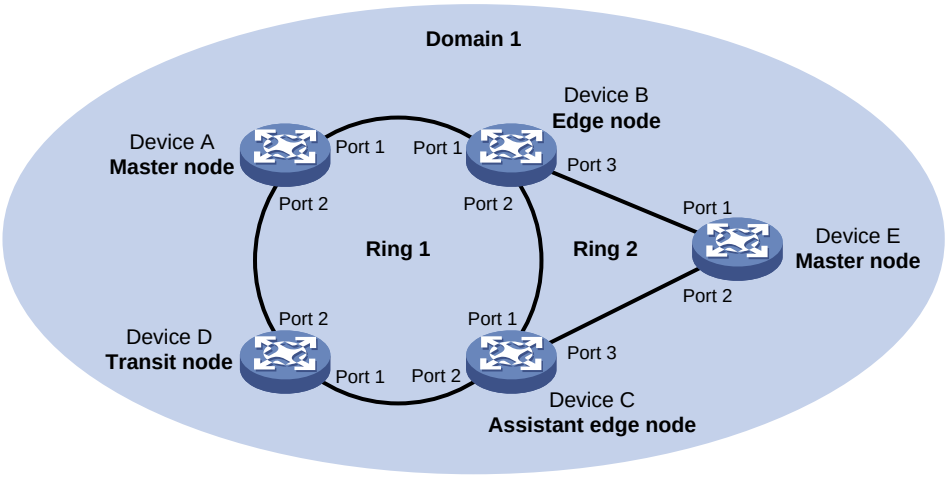
About RRPP

The Rapid Ring Protection Protocol (RRPP) is a link layer protocol designed for Ethernet rings. RRPP can prevent broadcast storms caused by data loops when an Ethernet ring is healthy. RRPP can also rapidly restore the communication paths between the nodes when a link is disconnected on the ring. Compared with the spanning tree protocol, the convergence time of RRPP is fast and independent of the number of nodes in the Ethernet ring. RRPP is applicable to large-diameter networks.

RRPP networking

Figure 1 shows a typical RRPP network with two Ethernet rings and multiple nodes. RRPP detects ring status and sends topology change information by exchanging Rapid Ring Protection Protocol Data Units (RRPPDUs) among the nodes.

Figure 1 RRPP networking diagram



RRPP domain

An RRPP domain is uniquely identified by a domain ID. The interconnected devices with the same domain ID and control VLANs constitute an RRPP domain. An RRPP domain contains the following elements:

- Primary ring and subring.
- Control VLAN.
- Master node, transit node, edge node, and assistant edge node.
- Primary port, secondary port, common port, and edge port.

As shown in Figure 1, Domain 1 is an RRPP domain, containing two RRPP rings: Ring 1 and Ring 2. All the nodes on the two RRPP rings belong to the RRPP domain.

RRPP ring

A ring-shaped Ethernet topology is called an RRPP ring. RRPP rings include primary rings and subrings. You can configure a ring as either the primary ring or a subring by specifying its ring level. The primary ring is of level 0, and a subring is of level 1. An RRPP domain contains one or multiple

RRPP rings, one serving as the primary ring and the others serving as subrings. A ring can be in one of the following states:

- **`Health state`**—All physical links on the Ethernet ring are connected.
- **`Disconnect state`**—Some physical links on the Ethernet ring are not connected.

As shown in Figure 1, Domain 1 contains two RRPP rings: Ring 1 and Ring 2. The level is set to 0 for Ring 1 and 1 for Ring 2. Ring 1 is configured as the primary ring, and Ring 2 is configured as a subring.

Control VLAN and protected VLAN

1. Control VLAN

   In an RRPP domain, a control VLAN is dedicated to transferring RRPPDUs. On a device, the ports accessing an RRPP ring belong to the control VLANs of the ring, and only these ports can join the control VLANs.

   An RRPP domain is configured with the following control VLANs:

   - One primary control VLAN, which is the control VLAN for the primary ring.
   - One secondary control VLAN, which is the control VLAN for subrings.

   After you specify a VLAN as the primary control VLAN, the system automatically configures the secondary control VLAN. The VLAN ID is the primary control VLAN ID plus one. All subrings in the same RRPP domain share the same secondary control VLAN. IP address configuration is prohibited on the control VLAN interfaces.

2. Protected VLAN

   A protected VLAN is dedicated to transferring data packets. Both RRPP ports and non-RRPP ports can be assigned to a protected VLAN.

Node role

Each device on an RRPP ring is a node. The role of a node is configurable. RRPP has the following node roles:

- **Master node**—Each ring has only one master node. The master node initiates the polling mechanism and determines the operations to be performed after a topology change.
- **Transit node**—On the primary ring, transit nodes refer to all nodes except the master node. On the subring, transit nodes refer to all nodes except the master node and the nodes where the primary ring intersects with the subring. A transit node monitors the state of its directly connected RRPP links and notifies the master node of the link state changes, if any. Based on the link state changes, the master node determines the operations to be performed.
- **Edge node**—A special node residing on both the primary ring and a subring at the same time. An edge node acts as a master node or transit node on the primary ring and as an edge node on the subring.
- **Assistant edge node**—A special node residing on both the primary ring and a subring at the same time. An assistant edge node acts as a master node or transit node on the primary ring and as an assistant edge node on the subring. This node works in conjunction with the edge node to detect the integrity of the primary ring and to perform loop guard.

As shown in Figure 1, Ring 1 is the primary ring and Ring 2 is a subring. Device A is the master node of Ring 1. Device B, Device C, and Device D are the transit nodes of Ring 1. Device E is the master node of Ring 2, Device B is the edge node of Ring 2, and Device C is the assistant edge node of Ring 2.

Port role

1. Primary port and secondary port

   Each master node or transit node has two ports connected to an RRPP ring, a primary port and a secondary port. You can determine the role of a port.

   In terms of functionality, the primary port and the secondary port of a master node have the following differences:

- The primary port and the secondary port are designed to play the role of sending and receiving Hello packets, respectively.
- When an RRPP ring is in Health state, the secondary port logically denies protected VLANs and permits only the packets from the control VLANs.
- When an RRPP ring is in Disconnect state, the secondary port forwards packets from protected VLANs.

In terms of functionality, the primary port and the secondary port of a transit node are the same. Both are designed for transferring protocol packets and data packets over an RRPP ring.

As shown in Figure 1, Device A is the master node of Ring 1. Port 1 and Port 2 are the primary port and the secondary port of the master node on Ring 1, respectively. Device B, Device C, and Device D are the transit nodes of Ring 1. Their Port 1 and Port 2 are the primary port and the secondary port on Ring 1, respectively.

2. Common port and edge port

The ports connecting the edge node and assistant edge node to the primary ring are common ports. The ports connecting the edge node and assistant edge node only to the subrings are edge ports. You can determine the role of a port.

As shown in Figure 1, Device B and Device C reside on Ring 1 and Ring 2. Device B's Port 1 and Port 2 and Device C's Port 1 and Port 2 access the primary ring, so they are common ports. Device B's Port 3 and Device C's Port 3 access only the subring, so they are edge ports.

RRPP ring group

To reduce Edge-Hello traffic, you can configure a group of subrings on the edge node or assistant edge node. You must configure a device as the edge node of these subrings, and another device as the assistant edge node of these subrings. Additionally, the subrings of the edge node and assistant edge node must connect to the same subring packet tunnels in major ring (SRPTs). Edge-Hello packets of the edge node of these subrings travel to the assistant edge node of these subrings over the same link.

An RRPP ring group configured on the edge node is an edge node RRPP ring group. An RRPP ring group configured on an assistant edge node is an assistant edge node RRPP ring group. Only one subring in an edge node RRPP ring group is allowed to send Edge-Hello packets.

RRPPDUs

RRPPDUs of subrings are transmitted as data packets in the primary ring, and RRPPDUs of the primary ring can only be transmitted within the primary ring. In the primary ring, Common-Flush-FDB packets and Complete-Flush-FDB packets of subrings are sent to the CPU on each node for processing.

Table 1 RRPPDU types and their functions

Type	Description
Hello	The master node sends Hello packets (also known as Health packets) to detect the integrity of a ring in a network.
Link-Down	When a port on the transit node, edge node, or assistant edge node fails, the node initiates Link-Down packets to notify the master node of the disconnection of the ring.
Common-Flush-FDB	When an RRPP ring transits to Disconnect state, the master node initiates Common-Flush-FDB (FDB stands for Forwarding Database) packets. It uses the packets to instruct the transit nodes, edge nodes, and assistant edge nodes to update their own MAC address entries and ARP/ND entries.
Complete-Flush-FDB	When an RRPP ring transits to Health state, the master node sends Complete-Flush-FDB packets for the following purposes: • Instruct the transit nodes, edge nodes, and assistant edge nodes to update their MAC address entries and ARP/ND entries.

	• Instruct the transit nodes to unblock temporarily blocked ports.
Edge-Hello	The edge node sends Edge-Hello packets to examine the SRPTs between the edge node and the assistant edge node.
Major-Fault	The assistant edge node sends Major-Fault packets to notify the edge node of SRPT failure when an SRPT between assistant edge node and edge node is disconnected.

RRPP timers

When RRPP determines the link state of an Ethernet ring, it uses the following timers:

Hello timer

The Hello timer specifies the interval at which the master node sends Hello packets out of the primary port.

Fail timer

The Fail timer specifies the maximum delay of Hello packets sent from the primary port to the secondary port of the master node. If the secondary port receives the Hello packets sent by the local master node before the Fail timer expires, the ring is in Health state. If the secondary port does not receive the Hello packets before the Fail timer expires, the ring transits to Disconnect state.

In an RRPP domain, a transit node learns the Fail timer value on the master node through the received Hello packets. This ensures that all nodes in the ring network have consistent Fail timer settings.

Link-up delay timer

This feature prevents frequent switchover of RRPP traffic forwarding paths caused by unstable RRPP port states. This feature behaves differently depending on whether you specify the **`distribute`** keyword in the **`linkup-delay-timer`** command.

- If you do not specify the **`distribute`** keyword, the master node starts the link-up delay timer when a faulty port comes up and the master node receives Hello packets from the secondary port.
  - If the master node can still receive Hello packets from the secondary port after the link-up delay timer expires, the master node performs the following operations:
    - Changes the RRPP ring state from Disconnect to Health.
    - Switches the traffic from the secondary port to the primary port.
  - If the master node cannot receive Hello packets from the secondary port after the Fail timer expires and before the link-up delay timer expires, the master node performs the following operations:
    - Stops the link-up delay timer.
    - Keeps the RRPP ring in Disconnect state.
- If you specify the **`distribute`** keyword, all nodes in the RRPP domain can learn the value of the link-up delay timer through Hello packets. When the faulty port comes up, the master node performs the following operations:
  - The hosting RRPP node blocks the faulty port (the faulty port cannot send or receive any packets).
  - Starts the link-up delay timer.

  If the port does not become faulty after the link-up delay timer expires, the hosting RRPP node sets the port state to up. The master node can receive Hello packets from its secondary port again. Then, the master node changes the RRPP ring state from Disconnect to Health and switches the traffic from the secondary port to the primary port.

If the port becomes faulty again before the link-up delay timer expires, the hosting RRPP node blocks the port and stops the link-up delay timer.

How RRPP works

Polling mechanism

The polling mechanism is used by the master node of an RRPP ring to examine the Health state of the ring network.

The master node sends Hello packets out of its primary port at the Hello interval. These Hello packets travel through each transit node on the ring in turn.

- If the ring is complete, the secondary port of the master node receives Hello packets before the Fail timer expires. The master node keeps the secondary port blocked.
- If the ring is disconnected, the secondary port of the master node fails to receive Hello packets before the Fail timer expires. The master node releases the secondary port from blocking protected VLANs. It sends Common-Flush-FDB packets to instruct all transit nodes to update their own MAC address entries and ARP/ND entries.

Link down alarm mechanism

In an RRPP domain, when the transit node, edge node, or assistant edge node finds that any of its ports is down, it immediately sends Link-Down packets to the master node. When the master node receives a Link-Down packet, it takes the following actions:

- Releases the secondary port from blocking protected VLANs.
- Sends Common-Flush-FDB packets to instruct all the transit nodes, edge nodes, and assistant edge nodes to update their MAC address entries and ARP/ND entries.

After each node updates its own entries, traffic is switched to the normal link.

Ring recovery

When the ports in an RRPP domain on the transit nodes, edge nodes, or assistant edge nodes come up again, the ring is recovered. However, the master node might detect the ring recovery after a period of time. A temporary loop might arise in the protected VLAN during this period. As a result, a broadcast storm occurs.

To prevent such cases, non-master nodes block the ports immediately when they find the ports accessing the ring are brought up again. The nodes block only the packets from the protected VLAN, and they permit only the packets from the control VLAN to pass through. The blocked ports are activated only when the nodes determine that no loop will be generated by these ports.

Broadcast storm suppression mechanism in case of SRPT failure in a multi-homed subring

As shown in Figure 5, Ring 1 is the primary ring, and Ring 2 and Ring 3 are subrings. When the two SRPTs between the edge node and the assistant edge node are down, the master nodes of Ring 2 and Ring 3 will open their secondary ports. A loop is generated among Device B, Device C, Device E, and Device F, causing a broadcast storm.

To avoid generating a loop, the edge node will temporarily block the edge port. The blocked edge port is activated only when the edge node determines that no loop will be generated when the edge port is activated.

RRPP ring group

In an edge node RRPP ring group, only the activated subring with the smallest domain ID and ring ID can send Edge-Hello packets. In an assistant edge node RRPP ring group, any activated subring that has received Edge-Hello packets will forward these packets to the other activated subrings. When an edge node RRPP ring group and an assistant edge node RRPP ring group are configured, the CPU workload is reduced because of the following reasons:

- Only one subring sends Edge-Hello packets on the edge node.

- Only one subring receives Edge-Hello packets on the assistant edge node.

As shown in Figure 5, Device B is the edge node of Ring 2 and Ring 3. Device C is the assistant edge node of Ring 2 and Ring 3. Device B and Device C need to send or receive Edge-Hello packets frequently. If more subrings are configured, Device B and Device C will send or receive a large number of Edge-Hello packets.

To reduce Edge-Hello traffic, perform the following tasks:

- Assign Ring 2 and Ring 3 to an RRPP ring group configured on the edge node Device B.
- Assign Ring 2 and Ring 3 to an RRPP ring group configured on the assistant edge node Device C.

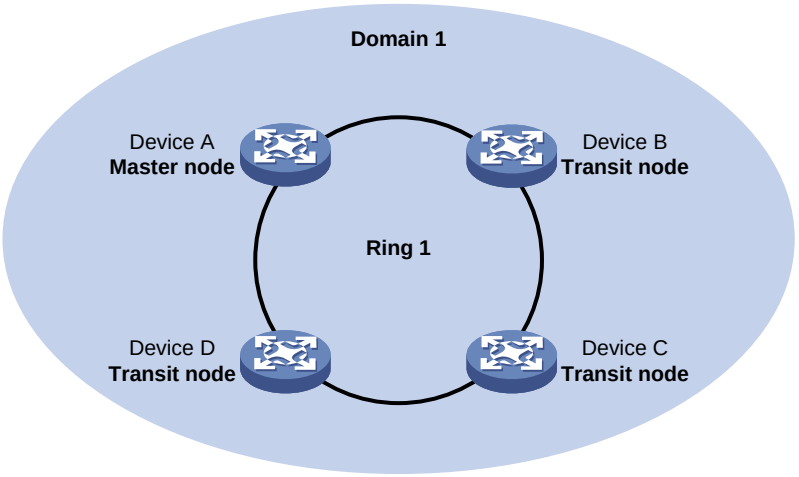
If all rings are activated, only Ring 2 on Device B sends Edge-Hello packets.

Typical RRPP networking

Single ring

As shown in Figure 2, only a single ring exists in the network topology. You need only define an RRPP domain.

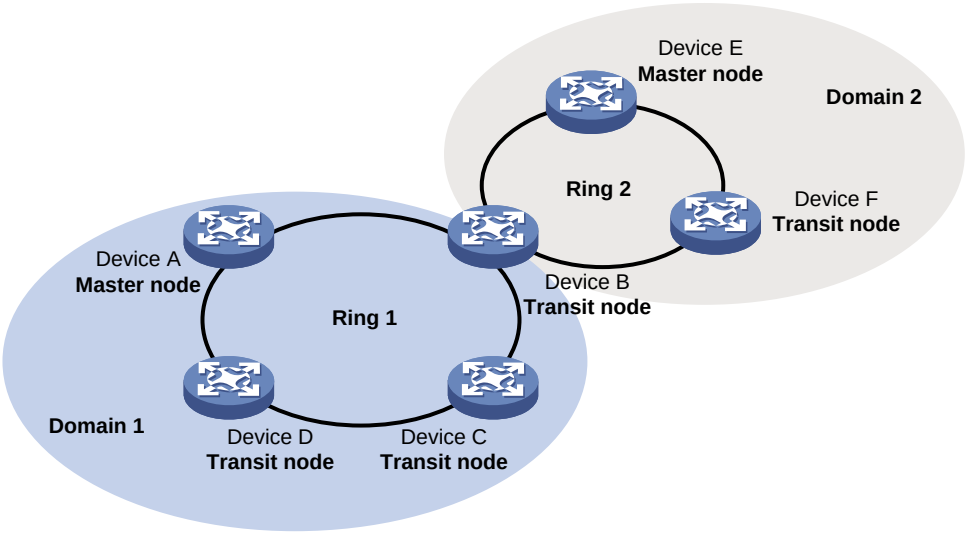
Figure 2 Schematic diagram for a single-ring network



Tangent rings

As shown in Figure 3, two or more rings exist in the network topology and only one common node exists between rings. You must define an RRPP domain for each ring.

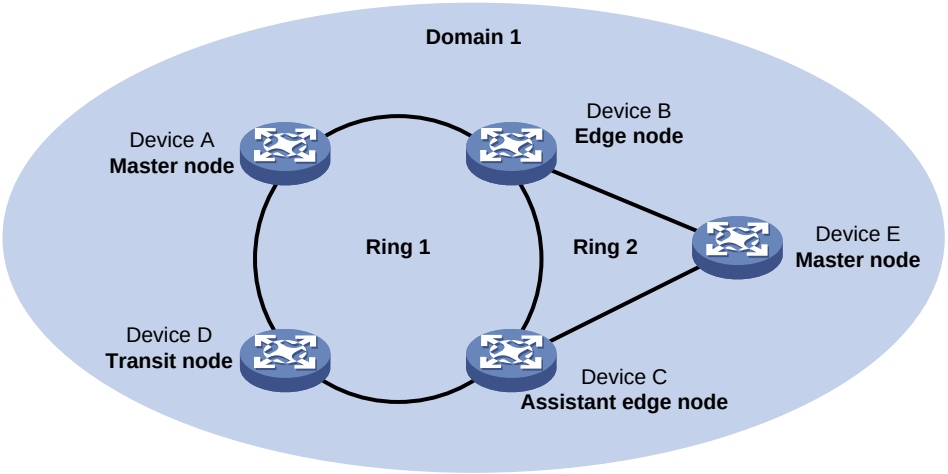
Figure 3 Schematic diagram for a tangent-ring network



Intersecting rings

As shown in Figure 4, two or more rings exist in the network topology and two common nodes exist between rings. You need only define an RRPP domain and configure one ring as the primary ring and the other rings as subrings.

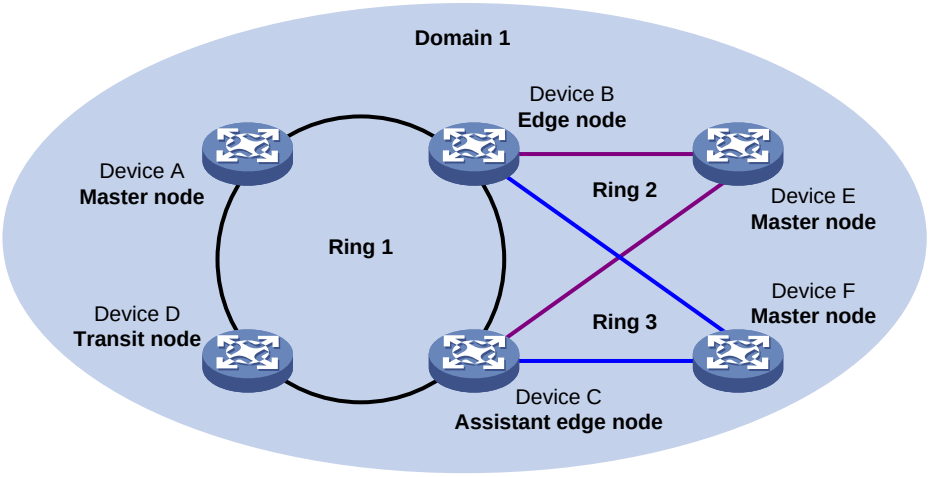
Figure 4 Schematic diagram for an intersecting-ring network



Dual-homed rings

As shown in Figure 5, two or more rings exist in the network topology and two similar common nodes exist between rings. You need only define an RRPP domain and configure one ring as the primary ring and the other rings as subrings.

Figure 5 Schematic diagram for a dual-homed-ring network



Protocols and standards

RFC 3619, *Extreme Networks' Ethernet Automatic Protection Switching (EAPS) Version 1*

Restrictions: Hardware compatibility with RRPP

The following switch series do not support RRPP:

- S5110V2-SI.
- S5000V3-EI.
- S5000V5-EI.
- S5000E-X.
- S5000X-EI.
- WAS6000.

Restrictions and guidelines: RRPP configuration

- RRPP does not have an auto election mechanism. You must configure each node in the ring network correctly for RRPP to monitor and protect the ring network.
- You can configure RRPP in the following order:
  - Create RRPP domains based on service planning.
  - Specify control VLANs and protected VLANs for each RRPP domain.
  - Determine the ring roles and node roles based on the traffic paths in each RRPP domain.

RRPP tasks at a glance

To configure RRPP, perform the following tasks:

1. Creating an RRPP domain

   Perform this task on devices you want to configure as nodes in the RRPP domain.
2. Configuring control VLANs

   Perform this task on all nodes in the RRPP domain.

3. Configuring protected VLANs

   Perform this task on all nodes in the RRPP domain.
4. Configuring RRPP rings
   a. Configuring RRPP ports

      Perform this task on each node's ports intended for accessing RRPP rings.
   b. Configuring RRPP nodes

      Perform this task on all nodes in the RRPP domain.
5. Activating an RRPP domain

   Perform this task on all nodes in the RRPP domain.
6. (Optional.) Configuring RRPP timers

   Perform this task on the master node in the RRPP domain.
   - Configuring the Hello timer and Fail timer
   - Configuring the link-up delay timer
7. (Optional.) Configuring an RRPP ring group

   Perform this task on the edge node and assistant edge node in the RRPP domain.
8. (Optional.) Enabling SNMP notifications for RRPP

Prerequisites for RRPP

Before you configure RRPP, you must physically construct a ring-shaped Ethernet topology.

Creating an RRPP domain

About creating an RRPP domain

When you create an RRPP domain, specify a domain ID to uniquely identify the RRPP domain. All devices in the same RRPP domain must be configured with the same domain ID.

Restrictions and guidelines

Perform this task on devices you want to configure as nodes in the RRPP domain.

Procedure

1. Enter system view.

   `system-view`
2. Create an RRPP domain and enter RRPP domain view.

   `rrpp domain` *`domain-id`*

Configuring control VLANs

Restrictions and guidelines

- Perform this task on all nodes in the RRPP domain.
- Before you configure RRPP rings in an RRPP domain, configure the same control VLANs for all nodes in the RRPP domain first. You need only configure the primary control VLAN for an RRPP domain. The system automatically configures the secondary control VLAN. It uses the primary control VLAN ID plus 1 as the secondary control VLAN ID. For the control VLAN configuration to succeed, make sure the IDs of the two control VLANs are consecutive and have not been previously assigned.

- Do not configure the default VLAN of a port accessing an RRPP ring as the control VLAN.
- For RRPPDUs to be correctly forwarded, do not enable QinQ or VLAN mapping on control VLANs.
- After you configure RRPP rings for an RRPP domain, you cannot delete or modify the primary control VLAN of the domain. You can only use the **undo control-vlan** command to delete a primary control VLAN.
- To transparently transmit RRPPDUs on a device not configured with RRPP, make sure only the two ports accessing the RRPP ring permit packets from the control VLANs. Otherwise, the packets from other VLANs might enter the control VLANs in transparent transmission mode and strike the RRPP ring.

Procedure

1. Enter system view.
   system-view
2. Enter RRPP domain view.
   rrpp domain *domain-id*
3. Configure the primary control VLAN for the RRPP domain.
   control-vlan *vlan-id*

Configuring protected VLANs

Restrictions and guidelines

- Perform this task on all nodes in the RRPP domain.
- Before you configure RRPP rings in an RRPP domain, configure the same protected VLANs for all nodes in the RRPP domain. All VLANs to which the RRPP ports are assigned must be protected by the RRPP domains.

Prerequisites

Before you configure protected VLANs, you must configure an MST region and the VLAN-to-instance mapping table. For more information about MST regions, see spanning tree configuration in *Layer 2—LAN Switching Configuration Guide*.

Procedure

1. Enter system view.
   system-view
2. Enter RRPP domain view.
   rrpp domain *domain-id*
3. Configure protected VLANs for the RRPP domain.
   protected-vlan reference-instance *instance-id-list*

Configuring RRPP rings

When you configure an RRPP ring, you must configure the ports connecting each node to the RRPP ring before configuring the nodes.

Prerequisites

Before you configure an RRPP ring, you must configure control VLANs and protected VLANs.

Configuring RRPP ports

Restrictions and guidelines

- Perform this task on each node's ports intended for accessing RRPP rings.
- Do not enable the OAM remote loopback function on an RRPP port. Otherwise, temporary broadcast storms might occur.
- To accelerate topology convergence, use the **link-delay** command to enable link status rapid report function on an RRPP port. Use this command to set the physical state change suppression interval to 0 seconds. For more information about the **link-delay** command, see *Layer 2—LAN Switching Command Reference*.
- Do not assign a port to both an aggregation group and an RRPP ring. If you do so, the port does not take effect on the RRPP ring.

Procedure

1. Enter system view.
   system-view
2. Enter Layer 2 Ethernet interface view or Layer 2 aggregate interface view.
   interface *interface-type interface-number*
3. Configure the link type of the interface as trunk.
   port link-type trunk
   By default, the link type of an interface is access.
   For more information about the command, see *Layer 2—LAN Switching Command Reference*.
4. Assign the trunk port to the protected VLANs of the RRPP domain.
   port trunk permit vlan { *vlan-id-list* | **all** }
   By default, a trunk port allows only packets from VLAN 1 to pass through.
   RRPP ports always allow packets from the control VLANs to pass through.
   For more information about the command, see *Layer 2—LAN Switching Command Reference*.
5. Disable the spanning tree feature.
   undo stp enable
   By default, the spanning tree feature is enabled.
   For more information about the command, see *Layer 2—LAN Switching Command Reference*.

Configuring RRPP nodes

Restrictions and guidelines

- Perform this task on all nodes in the RRPP domain.
- If a device carries multiple RRPP rings in an RRPP domain, it can only be an edge node or an assistant edge node on a subring.
- When you configure an edge node or an assistant edge node, you must configure the primary ring before configuring the subrings.

Specifying a master node

1. Enter system view.
   system-view
2. Enter RRPP domain view.
   rrpp domain *domain-id*

3. Specify the current device as the master node of the ring, and specify the primary port and the secondary port.

   ring *ring-id* **node-mode master** [**primary-port** *interface-type interface-number*] [**secondary-port** *interface-type interface-number*] **level** *level-value*

Specifying a transit node

1. Enter system view.

   system-view

2. Enter RRPP domain view.

   rrpp domain *domain-id*

3. Specify the current device as a transit node of the ring, and specify the primary port and the secondary port.

   ring *ring-id* **node-mode transit** [**primary-port** *interface-type interface-number*] [**secondary-port** *interface-type interface-number*] **level** *level-value*

Specifying an edge node

1. Enter system view.

   system-view

2. Enter RRPP domain view.

   rrpp domain *domain-id*

3. Specify the current device as a master node or transit node of the primary ring, and specify the primary port and the secondary port.

   ring *ring-id* **node-mode** { **master** | **transit** } [**primary-port** *interface-type interface-number*] [**secondary-port** *interface-type interface-number*] **level** *level-value*

4. Specify the current device as the edge node of a subring, and specify the edge port.

   ring *ring-id* **node-mode edge** [**edge-port** *interface-type interface-number*]

Specifying an assistant edge node

1. Enter system view.

   system-view

2. Enter RRPP domain view.

   rrpp domain *domain-id*

3. Specify the current device as a master node or transit node of the primary ring, and specify the primary port and the secondary port.

   ring *ring-id* **node-mode** { **master** | **transit** } [**primary-port** *interface-type interface-number*] [**secondary-port** *interface-type interface-number*] **level** *level-value*

   By default, a device is not a node of the RRPP ring.

4. Specify the current device as the assistant edge node of the subring, and specify an edge port.

   ring *ring-id* **node-mode assistant-edge** [**edge-port** *interface-type interface-number*]

Activating an RRPP domain

Restrictions and guidelines

- Perform this task on all nodes in the RRPP domain.
- Before you activate an RRPP domain on the current device, enable the RRPP protocol and RRPP rings for the RRPP domain on the current device.
- Before you enable subrings on a device, you must enable the primary ring. Before you disable the primary ring on the device, you must disable all subrings. Otherwise, the system displays error prompts.
- To prevent Hello packets of subrings from being looped on the primary ring, enable the primary ring on its master node first. Then enable the subrings on their respective master nodes.

Procedure

1. Enter system view.
   `system-view`
2. Enable RRPP.
   `rrpp enable`
   By default, RRPP is disabled.
3. Enter RRPP domain view.
   `rrpp domain` *`domain-id`*
4. Enable the specified RRPP ring.
   `ring` *`ring-id`* **`enable`**
   By default, an RRPP ring is disabled.

Configuring RRPP timers

Restrictions and guidelines for RRPP timer configuration

Perform this task on the master node of an RRPP domain.

Configuring the Hello timer and Fail timer

Restrictions and guidelines

- The Fail timer must be greater than or equal to three times the Hello timer.
- In a dual-homed-ring network, to avoid temporary loops when the primary ring fails, make sure the value of *A* is greater than the value of *B*, where:
  - *A* is the difference between the Fail timer values on the master node of the subring and the master node of the primary ring.
  - *B* is twice the Hello timer value on the master node of the subring.

Procedure

1. Enter system view.
   `system-view`
2. Enter RRPP domain view.
   `rrpp domain` *`domain-id`*
3. Set the Hello timer and Fail timer for the RRPP domain.

timer hello-timer *hello-value* **fail-timer** *fail-value*

By default, the Hello timer value is 1 second and the Fail timer value is 3 seconds.

Configuring the link-up delay timer

Restrictions and guidelines

If the **distribute** keyword is not specified, the link-up delay timer value cannot be greater than the Fail timer value minus twice the Hello timer value.

If you specify the **distribute** keyword in an RRPP network implementing load balancing, you must configure the link-up delay timer for each RRPP domain for the timer to take effect. If you set different timer values for different RRPP domains, the smallest timer value takes effect.

Procedure

1. Enter system view.

   system-view
2. Enter RRPP domain view.

   rrpp domain *domain-id*
3. Set the Hello timer and Fail timer for the RRPP domain.

   linkup-delay-timer *delay-time* [**distribute**]

   By default, the link-up delay timer value is 0 seconds, and the **distribute** keyword is not specified.

Configuring an RRPP ring group

About configuring an RRPP ring group

To reduce Edge-Hello traffic, assign subrings with the same edge node and assistant edge node to an RRPP ring group. An RRPP ring group must be configured on both the edge node and the assistant edge node. It can only be configured on these two types of nodes.

Restrictions and guidelines

- Perform this task on the edge node and assistant edge node in the RRPP domain.
- You can assign a subring to only one RRPP ring group. The RRPP ring groups configured on the edge node and the assistant edge node must contain the same subrings. Otherwise, the RRPP ring group cannot operate correctly.
- The subrings in an RRPP ring group must share the same edge node and assistant edge node. The edge node and the assistant edge node must have the same SRPTs.
- Make sure a device is either the edge node or the assistant edge node on the subrings in an RRPP ring group.
- Make sure the RRPP ring groups on the edge node and the assistant edge node have the same configurations and activation status.
- Make sure all subrings in an RRPP ring group have the same SRPTs. If the SRPTs of these subrings are different, the RRPP ring group cannot operate correctly.

Procedure

1. Enter system view.

   system-view
2. Create an RRPP ring group and enter RRPP ring group view.

   rrpp ring-group *ring-group-id*

By default, no RRPP ring groups exist.

3. Assign the specified subrings to the RRPP ring group.

   domain *domain-id* **ring** *ring-id-list*

   By default, no subrings are assigned to an RRPP ring group.

Enabling SNMP notifications for RRPP

About enabling SNMP notifications for RRPP

To report critical RRPP events to an NMS, enable SNMP notifications for RRPP. For RRPP event notifications to be sent correctly, you must also configure SNMP on the device. For more information about SNMP configuration, see the network management and monitoring configuration guide for the device.

Procedure

1. Enter system view.

   system-view

2. Enable SNMP notifications for RRPP.

   snmp-agent trap enable rrpp [**major-fault** | **multi-master** | **ring-fail** | **ring-recover**] *

   By default, SNMP notifications for RRPP are disabled.

Display and maintenance commands for RRPP

Execute **display** commands in any view and **reset** commands in user view.

Task	Command
Display brief RRPP information.	**display rrpp brief**
Display RRPP group configuration information.	**display rrpp ring-group** [*ring-group-id*]
Display RRPPDU statistics.	**display rrpp statistics domain** *domain-id* [**ring** *ring-id*]
Display detailed RRPP information.	**display rrpp verbose domain** *domain-id* [**ring** *ring-id*]
Clear RRPPDU statistics.	**reset rrpp statistics domain** *domain-id* [**ring** *ring-id*]

RRPP configuration examples

Example: Configuring a single ring

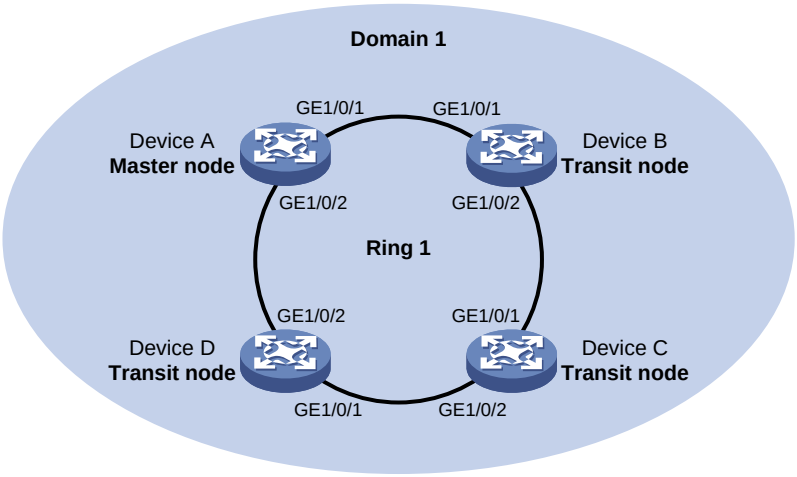
Network configuration

As shown in Figure 6:

- Device A, Device B, Device C, and Device D form RRPP domain 1. Specify the primary control VLAN of RRPP domain 1 as VLAN 4092. Specify the protected VLANs of RRPP domain 1 as VLANs 1 through 30.

- Device A, Device B, Device C, and Device D form primary ring 1.
- Specify Device A as the master node of primary ring 1, GigabitEthernet 1/0/1 as the primary port, and GigabitEthernet 1/0/2 as the secondary port.
- Specify Device B, Device C, and Device D as the transit nodes of primary ring 1. Specify GigabitEthernet 1/0/1 as the primary port and GigabitEthernet 1/0/2 as the secondary port on Device B, Device C, and Device D.

Figure 6 Network diagram



Procedure

1. Configure Device A:

Create VLANs 1 through 30.

```
<DeviceA> system-view
[DeviceA] vlan 1 to 30
```

Map these VLANs to MSTI 1.

```
[DeviceA] stp region-configuration
[DeviceA-mst-region] instance 1 vlan 1 to 30
```

Activate the MST region configuration.

```
[DeviceA-mst-region] active region-configuration
[DeviceA-mst-region] quit
```

Set the physical state change suppression interval to 0 seconds on GigabitEthernet 1/0/1.

```
[DeviceA] interface gigabitethernet 1/0/1
[DeviceA-GigabitEthernet1/0/1] link-delay up 0
[DeviceA-GigabitEthernet1/0/1] link-delay down 0
```

Disable the spanning tree feature on the port.

```
[DeviceA-GigabitEthernet1/0/1] undo stp enable
```

Configure the port as a trunk port.

```
[DeviceA-GigabitEthernet1/0/1] port link-type trunk
```

Assign the port to VLANs 1 through 30.

```
[DeviceA-GigabitEthernet1/0/1] port trunk permit vlan 1 to 30
[DeviceA-GigabitEthernet1/0/1] quit
```

Configure GigabitEthernet 1/0/2 in the same way GigabitEthernet 1/0/1 is configured.

```
[DeviceA] interface gigabitethernet 1/0/2
[DeviceA-GigabitEthernet1/0/2] link-delay up 0
[DeviceA-GigabitEthernet1/0/2] link-delay down 0
```

```
[DeviceA-GigabitEthernet1/0/2] undo stp enable
[DeviceA-GigabitEthernet1/0/2] port link-type trunk
[DeviceA-GigabitEthernet1/0/2] port trunk permit vlan 1 to 30
[DeviceA-GigabitEthernet1/0/2] quit
```

Create RRPP domain 1.

```
[DeviceA] rrpp domain 1
```

Configure VLAN 4092 as the primary control VLAN of RRPP domain 1.

```
[DeviceA-rrpp-domain1] control-vlan 4092
```

Configure the VLANs mapped to MSTI 1 as the protected VLANs of RRPP domain 1.

```
[DeviceA-rrpp-domain1] protected-vlan reference-instance 1
```

Configure Device A as the master node of primary ring 1, with GigabitEthernet 1/0/1 as the primary port and GigabitEthernet 1/0/2 as the secondary port. Enable ring 1.

```
[DeviceA-rrpp-domain1] ring 1 node-mode master primary-port gigabitethernet 1/0/1
secondary-port gigabitethernet 1/0/2 level 0
[DeviceA-rrpp-domain1] ring 1 enable
[DeviceA-rrpp-domain1] quit
```

Enable RRPP.

```
[DeviceA] rrpp enable
```

2. Configure Device B:

Create VLANs 1 through 30.

```
<DeviceB> system-view
[DeviceB] vlan 1 to 30
```

Map these VLANs to MSTI 1.

```
[DeviceB] stp region-configuration
[DeviceB-mst-region] instance 1 vlan 1 to 30
```

Activate the MST region configuration.

```
[DeviceB-mst-region] active region-configuration
[DeviceB-mst-region] quit
```

Set the physical state change suppression interval to 0 seconds on GigabitEthernet 1/0/1.

```
[DeviceB] interface gigabitethernet 1/0/1
[DeviceB-GigabitEthernet1/0/1] link-delay up 0
[DeviceB-GigabitEthernet1/0/1] link-delay down 0
```

Disable the spanning tree feature on the port.

```
[DeviceB-GigabitEthernet1/0/1] undo stp enable
```

Configure the port as a trunk port.

```
[DeviceB-GigabitEthernet1/0/1] port link-type trunk
```

Assign the port to VLANs 1 through 30.

```
[DeviceB-GigabitEthernet1/0/1] port trunk permit vlan 1 to 30
[DeviceB-GigabitEthernet1/0/1] quit
```

Configure GigabitEthernet 1/0/2 in the same way GigabitEthernet 1/0/1 is configured.

```
[DeviceB] interface gigabitethernet 1/0/2
[DeviceB-GigabitEthernet1/0/2] link-delay up 0
[DeviceB-GigabitEthernet1/0/2] link-delay down 0
[DeviceB-GigabitEthernet1/0/2] undo stp enable
[DeviceB-GigabitEthernet1/0/2] port link-type trunk
[DeviceB-GigabitEthernet1/0/2] port trunk permit vlan 1 to 30
[DeviceB-GigabitEthernet1/0/2] quit
```

Create RRPP domain 1.

```
[DeviceB] rrpp domain 1
```

Configure VLAN 4092 as the primary control VLAN of RRPP domain 1.

```
[DeviceB-rrpp-domain1] control-vlan 4092
```

Configure the VLANs mapped to MSTI 1 as the protected VLANs of RRPP domain 1.

```
[DeviceB-rrpp-domain1] protected-vlan reference-instance 1
```

Configure Device B as the transit node of primary ring 1, with GigabitEthernet 1/0/1 as the primary port and GigabitEthernet 1/0/2 as the secondary port. Enable ring 1.

```
[DeviceB-rrpp-domain1] ring 1 node-mode transit primary-port gigabitethernet 1/0/1
secondary-port gigabitethernet 1/0/2 level 0
[DeviceB-rrpp-domain1] ring 1 enable
[DeviceB-rrpp-domain1] quit
```

Enable RRPP.

```
[DeviceB] rrpp enable
```

3. Configure Device C:

   Configure Device C in the same way Device B is configured.

4. Configure Device D:

   Configure Device D in the same way Device B is configured.

Verifying the configuration

Use the **display** commands to view RRPP configuration and operational information on each device.

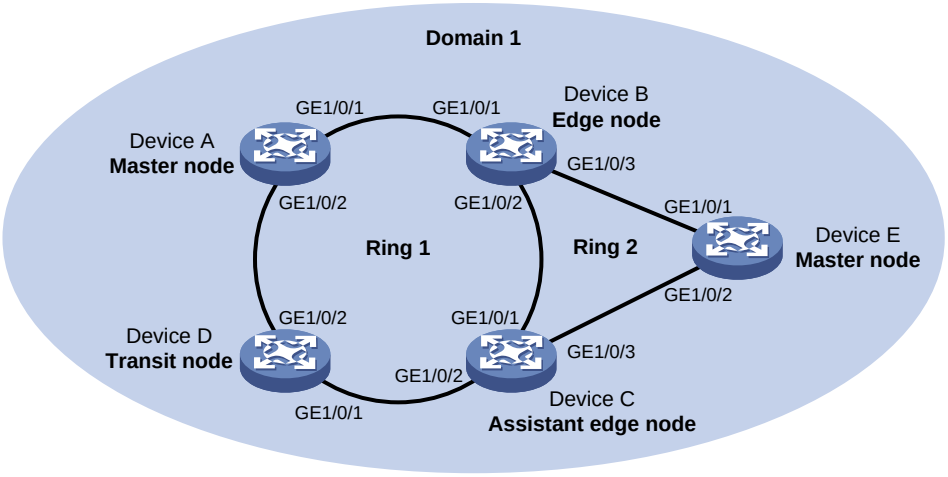
Example: Configuring intersecting rings

Network configuration

As shown in Figure 7:

- Device A, Device B, Device C, Device D, and Device E form RRPP domain 1. VLAN 4092 is the primary control VLAN of RRPP domain 1. RRPP domain 1 protects VLANs 1 through 30.
- Device A, Device B, Device C, and Device D form primary ring 1. Device B, Device C, and Device E form subring 2.
- Device A is the master node of primary ring 1, with GigabitEthernet 1/0/1 as the primary port and GigabitEthernet 1/0/2 the secondary port.
- Device E is the master node of subring 2, with GigabitEthernet 1/0/1 as the primary port and GigabitEthernet 1/0/2 the secondary port.
- Device B is the transit node of primary ring 1 and the edge node of subring 2, with GigabitEthernet 1/0/3 as the edge port.
- Device C is the transit node of primary ring 1 and the assistant edge node of subring 1, with GigabitEthernet 1/0/3 as the edge port.
- Device D is the transit node of primary ring 1, with GigabitEthernet 1/0/1 as the primary port and GigabitEthernet 1/0/2 the secondary port.

Figure 7 Network diagram



Procedure

1. Configure Device A:

Create VLANs 1 through 30.

```
<DeviceA> system-view
[DeviceA] vlan 1 to 30
```

Map these VLANs to MSTI 1.

```
[DeviceA] stp region-configuration
[DeviceA-mst-region] instance 1 vlan 1 to 30
```

Activate the MST region configuration.

```
[DeviceA-mst-region] active region-configuration
[DeviceA-mst-region] quit
```

Set the physical state change suppression interval to 0 seconds on GigabitEthernet 1/0/1.

```
[DeviceA] interface gigabitethernet 1/0/1
[DeviceA-GigabitEthernet1/0/1] link-delay up 0
[DeviceA-GigabitEthernet1/0/1] link-delay down 0
```

Disable the spanning tree feature on the port.

```
[DeviceA-GigabitEthernet1/0/1] undo stp enable
```

Configure the port as a trunk port.

```
[DeviceA-GigabitEthernet1/0/1] port link-type trunk
```

Assign the port to VLANs 1 through 30.

```
[DeviceA-GigabitEthernet1/0/1] port trunk permit vlan 1 to 30
[DeviceA-GigabitEthernet1/0/1] quit
```

Configure GigabitEthernet 1/0/2 in the same way GigabitEthernet 1/0/1 is configured.

```
[DeviceA] interface gigabitethernet 1/0/2
[DeviceA-GigabitEthernet1/0/2] link-delay up 0
[DeviceA-GigabitEthernet1/0/2] link-delay down 0
[DeviceA-GigabitEthernet1/0/2] undo stp enable
[DeviceA-GigabitEthernet1/0/2] port link-type trunk
[DeviceA-GigabitEthernet1/0/2] port trunk permit vlan 1 to 30
[DeviceA-GigabitEthernet1/0/2] quit
```

Create RRPP domain 1.

```
[DeviceA] rrpp domain 1
```

Configure VLAN 4092 as the primary control VLAN of RRPP domain 1.

```
[DeviceA-rrpp-domain1] control-vlan 4092
```

Configure the VLANs mapped to MSTI 1 as the protected VLANs of RRPP domain 1.

```
[DeviceA-rrpp-domain1] protected-vlan reference-instance 1
```

Configure Device A as the master node of primary ring 1, with GigabitEthernet 1/0/1 as the primary port and GigabitEthernet 1/0/2 as the secondary port. Enable ring 1.

```
[DeviceA-rrpp-domain1] ring 1 node-mode master primary-port gigabitethernet 1/0/1
secondary-port gigabitethernet 1/0/2 level 0
[DeviceA-rrpp-domain1] ring 1 enable
[DeviceA-rrpp-domain1] quit
```

Enable RRPP.

```
[DeviceA] rrpp enable
```

2. Configure Device B:

Create VLANs 1 through 30.

```
<DeviceB> system-view
[DeviceB] vlan 1 to 30
```

Map these VLANs to MSTI 1.

```
[DeviceB] stp region-configuration
[DeviceB-mst-region] instance 1 vlan 1 to 30
```

Activate the MST region configuration.

```
[DeviceB-mst-region] active region-configuration
[DeviceB-mst-region] quit
```

Set the physical state change suppression interval to 0 seconds on GigabitEthernet 1/0/1.

```
[DeviceB] interface gigabitethernet 1/0/1
[DeviceB-GigabitEthernet1/0/1] link-delay up 0
[DeviceB-GigabitEthernet1/0/1] link-delay down 0
```

Disable the spanning tree feature on the port.

```
[DeviceB-GigabitEthernet1/0/1] undo stp enable
```

Configure the port as a trunk port.

```
[DeviceB-GigabitEthernet1/0/1] port link-type trunk
```

Assign the port to VLANs 1 through 30.

```
[DeviceB-GigabitEthernet1/0/1] port trunk permit vlan 1 to 30
[DeviceB-GigabitEthernet1/0/1] quit
```

Configure GigabitEthernet 1/0/2 in the same way GigabitEthernet 1/0/1 is configured.

```
[DeviceB] interface gigabitethernet 1/0/2
[DeviceB-GigabitEthernet1/0/2] link-delay up 0
[DeviceB-GigabitEthernet1/0/2] link-delay down 0
[DeviceB-GigabitEthernet1/0/2] undo stp enable
[DeviceB-GigabitEthernet1/0/2] port link-type trunk
[DeviceB-GigabitEthernet1/0/2] port trunk permit vlan 1 to 30
[DeviceB-GigabitEthernet1/0/2] quit
```

Configure GigabitEthernet 1/0/3 in the same way GigabitEthernet 1/0/1 is configured.

```
[DeviceB] interface gigabitethernet 1/0/3
[DeviceB-GigabitEthernet1/0/3] link-delay up 0
[DeviceB-GigabitEthernet1/0/3] undo stp enable
[DeviceB-GigabitEthernet1/0/3] port link-type trunk
[DeviceB-GigabitEthernet1/0/3] port trunk permit vlan 1 to 30
```

```
[DeviceB-GigabitEthernet1/0/3] quit
```

Create RRPP domain 1.

```
[DeviceB] rrpp domain 1
```

Configure VLAN 4092 as the primary control VLAN of RRPP domain 1.

```
[DeviceB-rrpp-domain1] control-vlan 4092
```

Configure the VLANs mapped to MSTI 1 as the protected VLANs of RRPP domain 1.

```
[DeviceB-rrpp-domain1] protected-vlan reference-instance 1
```

Configure Device B as a transit node of primary ring 1, with GigabitEthernet 1/0/1 as the primary port and GigabitEthernet 1/0/2 as the secondary port. Enable ring 1.

```
[DeviceB-rrpp-domain1] ring 1 node-mode transit primary-port gigabitethernet 1/0/1
secondary-port gigabitethernet 1/0/2 level 0
[DeviceB-rrpp-domain1] ring 1 enable
```

Configure Device B as the edge node of subring 2, with GigabitEthernet 1/0/3 as the edge port. Enable ring 2.

```
[DeviceB-rrpp-domain1] ring 2 node-mode edge edge-port gigabitethernet 1/0/3
[DeviceB-rrpp-domain1] ring 2 enable
[DeviceB-rrpp-domain1] quit
```

Enable RRPP.

```
[DeviceB] rrpp enable
```

3. Configure Device C:

Create VLANs 1 through 30.

```
<DeviceC> system-view
[DeviceC] vlan 1 to 30
```

Map these VLANs to MSTI 1.

```
[DeviceC] stp region-configuration
[DeviceC-mst-region] instance 1 vlan 1 to 30
```

Activate the MST region configuration.

```
[DeviceC-mst-region] active region-configuration
[DeviceC-mst-region] quit
```

Set the physical state change suppression interval to 0 seconds on GigabitEthernet 1/0/1.

```
[DeviceC] interface gigabitethernet 1/0/1
[DeviceC-GigabitEthernet1/0/1] link-delay up 0
[DeviceC-GigabitEthernet1/0/1] link-delay down 0
```

Disable the spanning tree feature on the port.

```
[DeviceC-GigabitEthernet1/0/1] undo stp enable
```

Configure the port as a trunk port.

```
[DeviceC-GigabitEthernet1/0/1] port link-type trunk
```

Assign the port to VLANs 1 through 30.

```
[DeviceC-GigabitEthernet1/0/1] port trunk permit vlan 1 to 30
[DeviceC-GigabitEthernet1/0/1] quit
```

Configure GigabitEthernet 1/0/2 in the same way GigabitEthernet 1/0/1 is configured.

```
[DeviceC] interface gigabitethernet 1/0/2
[DeviceC-GigabitEthernet1/0/2] link-delay up 0
[DeviceC-GigabitEthernet1/0/2] link-delay down 0
[DeviceC-GigabitEthernet1/0/2] undo stp enable
[DeviceC-GigabitEthernet1/0/2] port link-type trunk
[DeviceC-GigabitEthernet1/0/2] port trunk permit vlan 1 to 30
```

```
[DeviceC-GigabitEthernet1/0/2] quit
```

Configure GigabitEthernet 1/0/3 in the same way GigabitEthernet 1/0/1 is configured.

```
[DeviceC] interface gigabitethernet 1/0/3
[DeviceC-GigabitEthernet1/0/3] link-delay up 0
[DeviceC-GigabitEthernet1/0/3] link-delay down 0
[DeviceC-GigabitEthernet1/0/3] undo stp enable
[DeviceC-GigabitEthernet1/0/3] port link-type trunk
[DeviceC-GigabitEthernet1/0/3] port trunk permit vlan 1 to 30
[DeviceC-GigabitEthernet1/0/3] quit
```

Create RRPP domain 1.

```
[DeviceC] rrpp domain 1
```

Configure VLAN 4092 as the primary control VLAN of RRPP domain 1.

```
[DeviceC-rrpp-domain1] control-vlan 4092
```

Configure the VLANs mapped to MSTI 1 as the protected VLANs of RRPP domain 1.

```
[DeviceC-rrpp-domain1] protected-vlan reference-instance 1
```

Configure Device C as a transit node of primary ring 1, with GigabitEthernet 1/0/1 as the primary port and GigabitEthernet 1/0/2 as the secondary port. Enable ring 1.

```
[DeviceC-rrpp-domain1] ring 1 node-mode transit primary-port gigabitethernet 1/0/1
secondary-port gigabitethernet 1/0/2 level 0
[DeviceC-rrpp-domain1] ring 1 enable
```

Configure Device C as the assistant edge node of subring 2, with GigabitEthernet 1/0/3 as the edge port. Enable ring 2.

```
[DeviceC-rrpp-domain1] ring 2 node-mode assistant-edge edge-port gigabitethernet
1/0/3
[DeviceC-rrpp-domain1] ring 2 enable
[DeviceC-rrpp-domain1] quit
```

Enable RRPP.

```
[DeviceC] rrpp enable
```

4. Configure Device D:

Create VLANs 1 through 30.

```
<DeviceD> system-view
[DeviceD] vlan 1 to 30
```

Map these VLANs to MSTI 1.

```
[DeviceD] stp region-configuration
[DeviceD-mst-region] instance 1 vlan 1 to 30
```

Activate the MST region configuration.

```
[DeviceD-mst-region] active region-configuration
[DeviceD-mst-region] quit
```

Set the physical state change suppression interval to 0 seconds on GigabitEthernet 1/0/1.

```
[DeviceD] interface gigabitethernet 1/0/1
[DeviceD-GigabitEthernet1/0/1] link-delay up 0
[DeviceD-GigabitEthernet1/0/1] link-delay down 0
```

Disable the spanning tree feature on the port.

```
[DeviceD-GigabitEthernet1/0/1] undo stp enable
```

Configure the port as a trunk port.

```
[DeviceD-GigabitEthernet1/0/1] port link-type trunk
```

Assign the port to VLANs 1 through 30.

```
[DeviceD-GigabitEthernet1/0/1] port trunk permit vlan 1 to 30
[DeviceD-GigabitEthernet1/0/1] quit
```

Configure GigabitEthernet 1/0/2 in the same way GigabitEthernet 1/0/1 is configured.

```
[DeviceD] interface gigabitethernet 1/0/2
[DeviceD-GigabitEthernet1/0/2] link-delay up 0
[DeviceD-GigabitEthernet1/0/2] link-delay down 0
[DeviceD-GigabitEthernet1/0/2] undo stp enable
[DeviceD-GigabitEthernet1/0/2] port link-type trunk
[DeviceD-GigabitEthernet1/0/2] port trunk permit vlan 1 to 30
[DeviceD-GigabitEthernet1/0/2] quit
```

Create RRPP domain 1.

```
[DeviceD] rrpp domain 1
```

Configure VLAN 4092 as the primary control VLAN of RRPP domain 1.

```
[DeviceD-rrpp-domain1] control-vlan 4092
```

Configure the VLANs mapped to MSTI 1 as the protected VLANs of RRPP domain 1.

```
[DeviceD-rrpp-domain1] protected-vlan reference-instance 1
```

Configure Device D as the transit node of primary ring 1, with GigabitEthernet 1/0/1 as the primary port and GigabitEthernet 1/0/2 as the secondary port. Enable ring 1.

```
[DeviceD-rrpp-domain1] ring 1 node-mode transit primary-port gigabitethernet 1/0/1
secondary-port gigabitethernet 1/0/2 level 0
[DeviceD-rrpp-domain1] ring 1 enable
[DeviceD-rrpp-domain1] quit
```

Enable RRPP.

```
[DeviceD] rrpp enable
```

5. Configure Device E:

Create VLANs 1 through 30.

```
<DeviceE> system-view
[DeviceE] vlan 1 to 30
```

Map these VLANs to MSTI 1.

```
[DeviceE] stp region-configuration
[DeviceE-mst-region] instance 1 vlan 1 to 30
```

Activate the MST region configuration.

```
[DeviceE-mst-region] active region-configuration
[DeviceE-mst-region] quit
```

Set the physical state change suppression interval to 0 seconds on GigabitEthernet 1/0/1.

```
[DeviceE] interface gigabitethernet 1/0/1
[DeviceE-GigabitEthernet1/0/1] link-delay up 0
[DeviceE-GigabitEthernet1/0/1] link-delay down 0
```

Disable the spanning tree feature on the port.

```
[DeviceE-GigabitEthernet1/0/1] undo stp enable
```

Configure the port as a trunk port.

```
[DeviceE-GigabitEthernet1/0/1] port link-type trunk
```

Assign the port to VLANs 1 through 30.

```
[DeviceE-GigabitEthernet1/0/1] port trunk permit vlan 1 to 30
[DeviceE-GigabitEthernet1/0/1] quit
```

Configure GigabitEthernet 1/0/2 in the same way GigabitEthernet 1/0/1 is configured.

```
[DeviceE] interface gigabitethernet 1/0/2
```

```
[DeviceE-GigabitEthernet1/0/2] link-delay up 0
[DeviceE-GigabitEthernet1/0/2] link-delay down 0
[DeviceE-GigabitEthernet1/0/2] undo stp enable
[DeviceE-GigabitEthernet1/0/2] port link-type trunk
[DeviceE-GigabitEthernet1/0/2] port trunk permit vlan 1 to 30
[DeviceE-GigabitEthernet1/0/2] quit
```

Create RRPP domain 1.

```
[DeviceE] rrpp domain 1
```

Configure VLAN 4092 as the primary control VLAN of RRPP domain 1.

```
[DeviceE-rrpp-domain1] control-vlan 4092
```

Configure the VLANs mapped to MSTI 1 as the protected VLANs of RRPP domain 1.

```
[DeviceE-rrpp-domain1] protected-vlan reference-instance 1
```

Configure Device E as the master node of subring 2, with GigabitEthernet 1/0/1 as the primary port and GigabitEthernet 1/0/2 as the secondary port. Enable ring 2.

```
[DeviceE-rrpp-domain1] ring 2 node-mode master primary-port gigabitethernet 1/0/1
secondary-port gigabitethernet 1/0/2 level 1
[DeviceE-rrpp-domain1] ring 2 enable
[DeviceE-rrpp-domain1] quit
```

Enable RRPP.

```
[DeviceE] rrpp enable
```

Verifying the configuration

Use the **display** commands to view RRPP configuration and operational information on each device.

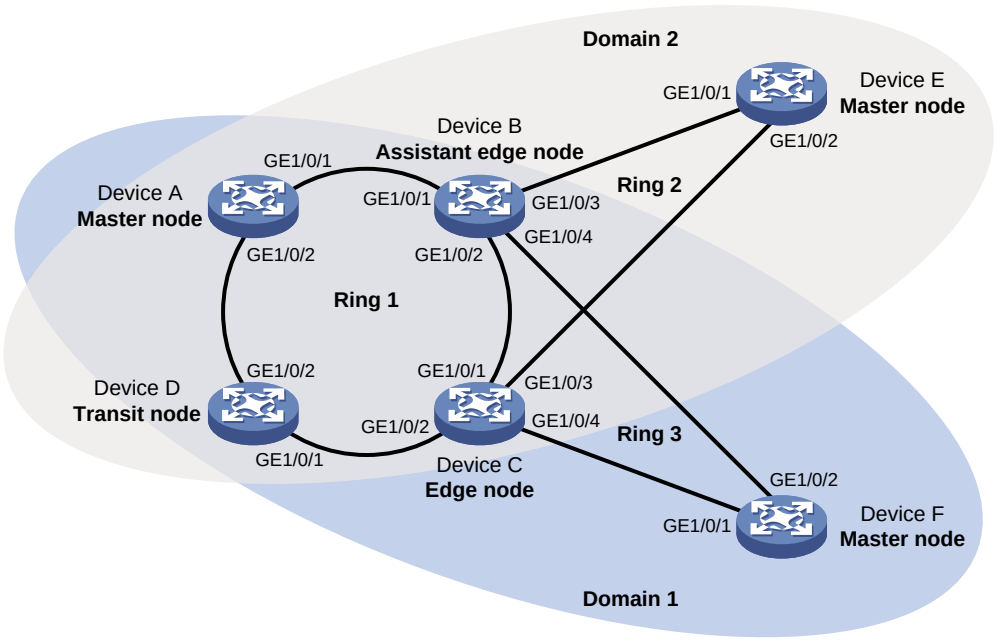
Example: Configuring load-balanced intersecting rings

Network configuration

As shown in Figure 8:

- Device A, Device B, Device C, Device D, and Device F form RRPP domain 1. VLAN 100 is the primary control VLAN of the RRPP domain. Device A is the master node of the primary ring, Ring 1. Device D is the transit node of Ring 1. Device F is the master node of the subring Ring 3. Device C is the edge node of the subring Ring 3. Device B is the assistant edge node of the subring Ring 3.
- Device A, Device B, Device C, Device D, and Device E form RRPP domain 2. VLAN 105 is the primary control VLAN of the RRPP domain. Device A is the master node of the primary ring, Ring 1. Device D is the transit node of Ring 1. Device E is the master node of the subring Ring 2. Device C is the edge node of the subring Ring 2. Device B is the assistant edge node of the subring Ring 2.
- Specify VLAN 11 as the protected VLAN of domain 1, and VLAN 12 the protected VLAN of domain 2. You can implement VLAN-based load balancing on Ring 1.
- Ring 2 and Ring 3 have the same edge node and assistant edge node, and the two subrings have the same SRPTs. You can add Ring 2 and Ring 3 to an RRPP ring group to reduce Edge-Hello traffic.

Figure 8 Network diagram



Procedure

1. Configure Device A:

   # Create VLANs 11 and 12.

   ```
   <DeviceA> system-view
   [DeviceA] vlan 11 to 12
   ```

   # Map VLAN 11 to MSTI 1 and VLAN 12 to MSTI 2.

   ```
   [DeviceA] stp region-configuration
   [DeviceA-mst-region] instance 1 vlan 11
   [DeviceA-mst-region] instance 2 vlan 12
   ```

   # Activate the MST region configuration.

   ```
   [DeviceA-mst-region] active region-configuration
   [DeviceA-mst-region] quit
   ```

   # Set the physical state change suppression interval to 0 seconds on GigabitEthernet 1/0/1.

   ```
   [DeviceA] interface gigabitethernet 1/0/1
   [DeviceA-GigabitEthernet1/0/1] link-delay up 0
   [DeviceA-GigabitEthernet1/0/1] link-delay down 0
   ```

   # Disable the spanning tree feature on the port.

   ```
   [DeviceA-GigabitEthernet1/0/1] undo stp enable
   ```

   # Configure the port as a trunk port.

   ```
   [DeviceA-GigabitEthernet1/0/1] port link-type trunk
   ```

   # Remove the port from VLAN 1, and assign it to VLANs 11 and 12.

   ```
   [DeviceA-GigabitEthernet1/0/1] undo port trunk permit vlan 1
   [DeviceA-GigabitEthernet1/0/1] port trunk permit vlan 11 12
   ```

   # Configure VLAN 11 as the default VLAN.

   ```
   [DeviceA-GigabitEthernet1/0/1] port trunk pvid vlan 11
   [DeviceA-GigabitEthernet1/0/1] quit
   ```

   # Configure GigabitEthernet 1/0/2 in the same way GigabitEthernet 1/0/1 is configured.

   ```
   [DeviceA] interface gigabitethernet 1/0/2
   ```

```
[DeviceA-GigabitEthernet1/0/2] link-delay up 0
[DeviceA-GigabitEthernet1/0/2] link-delay down 0
[DeviceA-GigabitEthernet1/0/2] undo stp enable
[DeviceA-GigabitEthernet1/0/2] port link-type trunk
[DeviceA-GigabitEthernet1/0/2] undo port trunk permit vlan 1
[DeviceA-GigabitEthernet1/0/2] port trunk permit vlan 11 12
[DeviceA-GigabitEthernet1/0/2] port trunk pvid vlan 11
[DeviceA-GigabitEthernet1/0/2] quit
```

Create RRPP domain 1.

```
[DeviceA] rrpp domain 1
```

Configure VLAN 100 as the primary control VLAN of RRPP domain 1.

```
[DeviceA-rrpp-domain1] control-vlan 100
```

Configure the VLAN mapped to MSTI 1 as the protected VLAN of RRPP domain 1.

```
[DeviceA-rrpp-domain1] protected-vlan reference-instance 1
```

Configure Device A as the master node of primary ring 1, with GigabitEthernet 1/0/1 as the primary port and GigabitEthernet 1/0/2 as the secondary port. Enable ring 1.

```
[DeviceA-rrpp-domain1] ring 1 node-mode master primary-port gigabitethernet 1/0/1
secondary-port gigabitethernet 1/0/2 level 0
[DeviceA-rrpp-domain1] ring 1 enable
[DeviceA-rrpp-domain1] quit
```

Create RRPP domain 2.

```
[DeviceA] rrpp domain 2
```

Configure VLAN 105 as the primary control VLAN of RRPP domain 2.

```
[DeviceA-rrpp-domain2] control-vlan 105
```

Configure the VLAN mapped to MSTI 2 as the protected VLAN of RRPP domain 2.

```
[DeviceA-rrpp-domain2] protected-vlan reference-instance 2
```

Configure Device A as the master node of primary ring 1, with GigabitEthernet 1/0/2 as the master port and GigabitEthernet 1/0/1 as the secondary port. Enable ring 1.

```
[DeviceA-rrpp-domain2] ring 1 node-mode master primary-port gigabitethernet 1/0/2
secondary-port gigabitethernet 1/0/1 level 0
[DeviceA-rrpp-domain2] ring 1 enable
[DeviceA-rrpp-domain2] quit
```

Enable RRPP.

```
[DeviceA] rrpp enable
```

2. Configure Device B:

Create VLANs 11 and 12.

```
<DeviceB> system-view
[DeviceB] vlan 11 to 12
```

Map VLAN 11 to MSTI 1 and VLAN 12 to MSTI 2.

```
[DeviceB] stp region-configuration
[DeviceB-mst-region] instance 1 vlan 11
[DeviceB-mst-region] instance 2 vlan 12
```

Activate the MST region configuration.

```
[DeviceB-mst-region] active region-configuration
[DeviceB-mst-region] quit
```

Set the physical state change suppression interval to 0 seconds on GigabitEthernet 1/0/1.

```
[DeviceB] interface gigabitethernet 1/0/1
[DeviceB-GigabitEthernet1/0/1] link-delay up 0
```

```
[DeviceB-GigabitEthernet1/0/1] link-delay down 0
```
Disable the spanning tree feature on the port.
```
[DeviceB-GigabitEthernet1/0/1] undo stp enable
```
Configure the port as a trunk port.
```
[DeviceB-GigabitEthernet1/0/1] port link-type trunk
```
Remove the port from VLAN 1, and assign it to VLANs 11 and 12.
```
[DeviceB-GigabitEthernet1/0/1] undo port trunk permit vlan 1
[DeviceB-GigabitEthernet1/0/1] port trunk permit vlan 11 12
```
Configure VLAN 11 as the default VLAN.
```
[DeviceB-GigabitEthernet1/0/1] port trunk pvid vlan 11
[DeviceB-GigabitEthernet1/0/1] quit
```
Configure GigabitEthernet 1/0/2 in the same way GigabitEthernet 1/0/1 is configured.
```
[DeviceB] interface gigabitethernet 1/0/2
[DeviceB-GigabitEthernet1/0/2] link-delay up 0
[DeviceB-GigabitEthernet1/0/2] link-delay down 0
[DeviceB-GigabitEthernet1/0/2] undo stp enable
[DeviceB-GigabitEthernet1/0/2] port link-type trunk
[DeviceB-GigabitEthernet1/0/2] undo port trunk permit vlan 1
[DeviceB-GigabitEthernet1/0/2] port trunk permit vlan 11 12
[DeviceB-GigabitEthernet1/0/2] port trunk pvid vlan 11
[DeviceB-GigabitEthernet1/0/2] quit
```
Set the physical state change suppression interval to 0 seconds on GigabitEthernet 1/0/3.
```
[DeviceB] interface gigabitethernet 1/0/3
[DeviceB-GigabitEthernet1/0/3] link-delay up 0
[DeviceB-GigabitEthernet1/0/3] link-delay down 0
```
Disable the spanning tree feature on the port.
```
[DeviceB-GigabitEthernet1/0/3] undo stp enable
```
Configure the port as a trunk port.
```
[DeviceB-GigabitEthernet1/0/3] port link-type trunk
```
Remove the port from VLAN 1, and assign it to VLAN 12.
```
[DeviceB-GigabitEthernet1/0/3] undo port trunk permit vlan 1
[DeviceB-GigabitEthernet1/0/3] port trunk permit vlan 12
```
Configure VLAN 12 as the default VLAN.
```
[DeviceB-GigabitEthernet1/0/3] port trunk pvid vlan 12
[DeviceB-GigabitEthernet1/0/3] quit
```
Set the physical state change suppression interval to 0 seconds on GigabitEthernet 1/0/4.
```
[DeviceB] interface gigabitethernet 1/0/4
[DeviceB-GigabitEthernet1/0/4] link-delay up 0
[DeviceB-GigabitEthernet1/0/4] link-delay down 0
```
Disable the spanning tree feature on the port.
```
[DeviceB-GigabitEthernet1/0/4] undo stp enable
```
Configure the port as a trunk port.
```
[DeviceB-GigabitEthernet1/0/4] port link-type trunk
```
Remove the port from VLAN 1, and assign it to VLAN 11.
```
[DeviceB-GigabitEthernet1/0/4] undo port trunk permit vlan 1
[DeviceB-GigabitEthernet1/0/4] port trunk permit vlan 11
```
Configure VLAN 11 as the default VLAN.

```
[DeviceB-GigabitEthernet1/0/4] port trunk pvid vlan 11
[DeviceB-GigabitEthernet1/0/4] quit
```

Create RRPP domain 1.

```
[DeviceB] rrpp domain 1
```

Configure VLAN 100 as the primary control VLAN of RRPP domain 1.

```
[DeviceB-rrpp-domain1] control-vlan 100
```

Configure the VLAN mapped to MSTI 1 as the protected VLAN of RRPP domain 1.

```
[DeviceB-rrpp-domain1] protected-vlan reference-instance 1
```

Configure Device B as a transit node of primary ring 1 in RRPP domain 1, with GigabitEthernet 1/0/1 as the primary port and GigabitEthernet 1/0/2 as the secondary port. Enable ring 1.

```
[DeviceB-rrpp-domain1] ring 1 node-mode transit primary-port gigabitethernet 1/0/1
secondary-port gigabitethernet 1/0/2 level 0
[DeviceB-rrpp-domain1] ring 1 enable
```

Configure Device B as the assistant edge node of subring 3 in RRPP domain 1, with GigabitEthernet 1/0/4 as the edge port. Enable subring 3.

```
[DeviceB-rrpp-domain1] ring 3 node-mode assistant-edge edge-port gigabitethernet
1/0/4
[DeviceB-rrpp-domain1] ring 3 enable
[DeviceB-rrpp-domain1] quit
```

Create RRPP domain 2.

```
[DeviceB] rrpp domain 2
```

Configure VLAN 105 as the primary control VLAN of RRPP domain 2.

```
[DeviceB-rrpp-domain2] control-vlan 105
```

Configure the VLAN mapped to MSTI 2 as the protected VLAN of RRPP domain 2.

```
[DeviceB-rrpp-domain2] protected-vlan reference-instance 2
```

Configure Device B as the transit node of primary ring 1, with GigabitEthernet 1/0/1 as the primary port and GigabitEthernet 1/0/2 as the secondary port. Enable ring 1.

```
[DeviceB-rrpp-domain2] ring 1 node-mode transit primary-port gigabitethernet 1/0/1
secondary-port gigabitethernet 1/0/2 level 0
[DeviceB-rrpp-domain2] ring 1 enable
```

Configure Device B as the assistant edge node of subring 2 in RRPP domain 2, with GigabitEthernet 1/0/3 as the edge port. Enable subring 2.

```
[DeviceB-rrpp-domain2] ring 2 node-mode assistant-edge edge-port gigabitethernet
1/0/3
[DeviceB-rrpp-domain2] ring 2 enable
[DeviceC-rrpp-domain2] quit
```

Enable RRPP.

```
[DeviceB] rrpp enable
```

3. Configure Device C:

Create VLANs 11 and 12.

```
<DeviceC> system-view
[DeviceC] vlan 11 to 12
```

Map VLAN 11 to MSTI 1 and VLAN 12 to MSTI 2.

```
[DeviceC] stp region-configuration
[DeviceC-mst-region] instance 1 vlan 11
[DeviceC-mst-region] instance 2 vlan 12
```

Activate the MST region configuration.

```
[DeviceC-mst-region] active region-configuration
[DeviceC-mst-region] quit
```
Set the physical state change suppression interval to 0 seconds on GigabitEthernet 1/0/1.
```
[DeviceC] interface gigabitethernet 1/0/1
[DeviceC-GigabitEthernet1/0/1] link-delay up 0
[DeviceC-GigabitEthernet1/0/1] link-delay down 0
```
Disable the spanning tree feature on the port.
```
[DeviceC-GigabitEthernet1/0/1] undo stp enable
```
Configure the port as a trunk port.
```
[DeviceC-GigabitEthernet1/0/1] port link-type trunk
```
Remove the port from VLAN 1, and assign it to VLANs 11 and 12.
```
[DeviceC-GigabitEthernet1/0/1] undo port trunk permit vlan 1
[DeviceC-GigabitEthernet1/0/1] port trunk permit vlan 11 12
```
Configure VLAN 11 as the default VLAN.
```
[DeviceC-GigabitEthernet1/0/1] port trunk pvid vlan 11
[DeviceC-GigabitEthernet1/0/1] quit
```
Configure GigabitEthernet 1/0/2 in the same way GigabitEthernet 1/0/1 is configured.
```
[DeviceC] interface gigabitethernet 1/0/2
[DeviceC-GigabitEthernet1/0/2] link-delay up 0
[DeviceC-GigabitEthernet1/0/2] link-delay down 0
[DeviceC-GigabitEthernet1/0/2] undo stp enable
[DeviceC-GigabitEthernet1/0/2] port link-type trunk
[DeviceC-GigabitEthernet1/0/2] undo port trunk permit vlan 1
[DeviceC-GigabitEthernet1/0/2] port trunk permit vlan 11 12
[DeviceC-GigabitEthernet1/0/2] port trunk pvid vlan 11
[DeviceC-GigabitEthernet1/0/2] quit
```
Set the physical state change suppression interval to 0 seconds on GigabitEthernet 1/0/3.
```
[DeviceC] interface gigabitethernet 1/0/3
[DeviceC-GigabitEthernet1/0/3] link-delay up 0
[DeviceC-GigabitEthernet1/0/3] link-delay down 0
```
Disable the spanning tree feature on the port.
```
[DeviceC-GigabitEthernet1/0/3] undo stp enable
```
Configure the port as a trunk port.
```
[DeviceC-GigabitEthernet1/0/3] port link-type trunk
```
Remove the port from VLAN 1, and assign it to VLAN 12.
```
[DeviceC-GigabitEthernet1/0/3] undo port trunk permit vlan 1
[DeviceC-GigabitEthernet1/0/3] port trunk permit vlan 12
```
Configure VLAN 12 as the default VLAN.
```
[DeviceC-GigabitEthernet1/0/3] port trunk pvid vlan 12
[DeviceC-GigabitEthernet1/0/3] quit
```
Set the physical state change suppression interval to 0 seconds on GigabitEthernet 1/0/4.
```
[DeviceC] interface gigabitethernet 1/0/4
[DeviceC-GigabitEthernet1/0/4] link-delay up 0
[DeviceC-GigabitEthernet1/0/4] link-delay down 0
```
Disable the spanning tree feature on the port.
```
[DeviceC-GigabitEthernet1/0/4] undo stp enable
```
Configure the port as a trunk port.

```
[DeviceC-GigabitEthernet1/0/4] port link-type trunk
```

Remove the port from VLAN 1, and assign it to VLAN 11.

```
[DeviceC-GigabitEthernet1/0/4] undo port trunk permit vlan 1
[DeviceC-GigabitEthernet1/0/4] port trunk permit vlan 11
```

Configure VLAN 11 as the default VLAN.

```
[DeviceC-GigabitEthernet1/0/4] port trunk pvid vlan 11
[DeviceC-GigabitEthernet1/0/4] quit
```

Create RRPP domain 1.

```
[DeviceC] rrpp domain 1
```

Configure VLAN 100 as the primary control VLAN of RRPP domain 1.

```
[DeviceC-rrpp-domain1] control-vlan 100
```

Configure the VLAN mapped to MSTI 1 as the protected VLAN of RRPP domain 1.

```
[DeviceC-rrpp-domain1] protected-vlan reference-instance 1
```

Configure Device C as the transit node of primary ring 1 in RRPP domain 1, with GigabitEthernet 1/0/1 as the primary port and GigabitEthernet 1/0/2 as the secondary port. Enable ring 1.

```
[DeviceC-rrpp-domain1] ring 1 node-mode transit primary-port gigabitethernet 1/0/1
secondary-port gigabitethernet 1/0/2 level 0
[DeviceC-rrpp-domain1] ring 1 enable
```

Configure Device C as the edge node of subring 3 in RRPP domain 1, with GigabitEthernet 1/0/4 as the edge port. Enable subring 3.

```
[DeviceC-rrpp-domain1] ring 3 node-mode edge edge-port gigabitethernet 1/0/4
[DeviceC-rrpp-domain1] ring 3 enable
[DeviceC-rrpp-domain1] quit
```

Create RRPP domain 2.

```
[DeviceC] rrpp domain 2
```

Configure VLAN 105 as the primary control VLAN of RRPP domain 2.

```
[DeviceC-rrpp-domain2] control-vlan 105
```

Configure the VLAN mapped to MSTI 2 as the protected VLAN of RRPP domain 2.

```
[DeviceC-rrpp-domain2] protected-vlan reference-instance 2
```

Configure Device C as the transit node of primary ring 1 in RRPP domain 2, with GigabitEthernet 1/0/1 as the primary port and GigabitEthernet 1/0/2 as the secondary port. Enable ring 1.

```
[DeviceC-rrpp-domain2] ring 1 node-mode transit primary-port gigabitethernet 1/0/1
secondary-port gigabitethernet 1/0/2 level 0
[DeviceC-rrpp-domain2] ring 1 enable
```

Configure Device C as the edge node of subring 2 in RRPP domain 2, with GigabitEthernet 1/0/3 as the edge port. Enable subring 2.

```
[DeviceC-rrpp-domain2] ring 2 node-mode edge edge-port gigabitethernet 1/0/3
[DeviceC-rrpp-domain2] ring 2 enable
[DeviceC-rrpp-domain2] quit
```

Enable RRPP.

```
[DeviceC] rrpp enable
```

4. Configure Device D:

Create VLANs 11 and 12.

```
<DeviceD> system-view
[DeviceD] vlan 11 to 12
```

Map VLAN 11 to MSTI 1 and VLAN 12 to MSTI 2.

```
[DeviceD] stp region-configuration
[DeviceD-mst-region] instance 1 vlan 11
[DeviceD-mst-region] instance 2 vlan 12
```

Activate the MST region configuration.

```
[DeviceD-mst-region] active region-configuration
[DeviceD-mst-region] quit
```

Set the physical state change suppression interval to 0 seconds on GigabitEthernet 1/0/1.

```
[DeviceD] interface gigabitethernet 1/0/1
[DeviceD-GigabitEthernet1/0/1] link-delay up 0
[DeviceD-GigabitEthernet1/0/1] link-delay down 0
```

Disable the spanning tree feature on the port.

```
[DeviceD-GigabitEthernet1/0/1] undo stp enable
```

Configure the port as a trunk port.

```
[DeviceD-GigabitEthernet1/0/1] port link-type trunk
```

Remove the port from VLAN 1, and assign it to VLANs 11 and 12.

```
[DeviceD-GigabitEthernet1/0/1] undo port trunk permit vlan 1
[DeviceD-GigabitEthernet1/0/1] port trunk permit vlan 11 12
```

Configure VLAN 11 as the default VLAN.

```
[DeviceD-GigabitEthernet1/0/1] port trunk pvid vlan 11
[DeviceD-GigabitEthernet1/0/1] quit
```

Configure GigabitEthernet 1/0/2 in the same way GigabitEthernet 1/0/1 is configured.

```
[DeviceD] interface gigabitethernet 1/0/2
[DeviceD-GigabitEthernet1/0/2] link-delay up 0
[DeviceD-GigabitEthernet1/0/2] link-delay down 0
[DeviceD-GigabitEthernet1/0/2] undo stp enable
[DeviceD-GigabitEthernet1/0/2] port link-type trunk
[DeviceD-GigabitEthernet1/0/2] undo port trunk permit vlan 1
[DeviceD-GigabitEthernet1/0/2] port trunk permit vlan 11 12
[DeviceD-GigabitEthernet1/0/2] port trunk pvid vlan 11
[DeviceD-GigabitEthernet1/0/2] quit
```

Create RRPP domain 1.

```
[DeviceD] rrpp domain 1
```

Configure VLAN 100 as the primary control VLAN of RRPP domain 1.

```
[DeviceD-rrpp-domain1] control-vlan 100
```

Configure the VLAN mapped to MSTI 1 as the protected VLAN of RRPP domain 1.

```
[DeviceD-rrpp-domain1] protected-vlan reference-instance 1
```

Configure Device D as the transit node of primary ring 1 in RRPP domain 1, with GigabitEthernet 1/0/1 as the primary port and GigabitEthernet 1/0/2 as the secondary port. Enable ring 1.

```
[DeviceD-rrpp-domain1] ring 1 node-mode transit primary-port gigabitethernet 1/0/1
secondary-port gigabitethernet 1/0/2 level 0
[DeviceD-rrpp-domain1] ring 1 enable
[DeviceD-rrpp-domain1] quit
```

Create RRPP domain 2.

```
[DeviceD] rrpp domain 2
```

Configure VLAN 105 as the primary control VLAN of RRPP domain 2.

```
[DeviceD-rrpp-domain2] control-vlan 105
```

Configure the VLAN mapped to MSTI 2 as the protected VLAN of RRPP domain 2.

```
[DeviceD-rrpp-domain2] protected-vlan reference-instance 2
```

Configure Device D as the transit node of primary ring 1 in RRPP domain 2, with GigabitEthernet 1/0/1 as the primary port and GigabitEthernet 1/0/2 as the secondary port. Enable ring 1.

```
[DeviceD-rrpp-domain2] ring 1 node-mode transit primary-port gigabitethernet 1/0/1
secondary-port gigabitethernet 1/0/2 level 0
[DeviceD-rrpp-domain2] ring 1 enable
[DeviceD-rrpp-domain2] quit
```

Enable RRPP.

```
[DeviceD] rrpp enable
```

5. Configure Device E:

Create VLAN 12.

```
<DeviceE> system-view
[DeviceE] vlan 12
```

Map VLAN 12 to MSTI 2.

```
[DeviceE-vlan12] quit
[DeviceE] stp region-configuration
[DeviceE-mst-region] instance 2 vlan 12
```

Activate the MST region configuration.

```
[DeviceE-mst-region] active region-configuration
[DeviceE-mst-region] quit
```

Set the physical state change suppression interval to 0 seconds on GigabitEthernet 1/0/1.

```
[DeviceE] interface gigabitethernet 1/0/1
[DeviceE-GigabitEthernet1/0/1] link-delay up 0
[DeviceE-GigabitEthernet1/0/1] link-delay down 0
```

Disable the spanning tree feature on the port.

```
[DeviceE-GigabitEthernet1/0/1] undo stp enable
```

Configure the port as a trunk port.

```
[DeviceE-GigabitEthernet1/0/1] port link-type trunk
```

Remove the port from VLAN 1, and assign it to VLAN 12.

```
[DeviceE-GigabitEthernet1/0/1] undo port trunk permit vlan 1
[DeviceE-GigabitEthernet1/0/1] port trunk permit vlan 12
```

Configure VLAN 12 as the default VLAN.

```
[DeviceE-GigabitEthernet1/0/1] port trunk pvid vlan 12
[DeviceE-GigabitEthernet1/0/1] quit
```

Configure GigabitEthernet 1/0/2 in the same way GigabitEthernet 1/0/1 is configured.

```
[DeviceE] interface gigabitethernet 1/0/2
[DeviceE-GigabitEthernet1/0/2] link-delay up 0
[DeviceE-GigabitEthernet1/0/2] link-delay down 0
[DeviceE-GigabitEthernet1/0/2] undo stp enable
[DeviceE-GigabitEthernet1/0/2] port link-type trunk
[DeviceE-GigabitEthernet1/0/2] undo port trunk permit vlan 1
[DeviceE-GigabitEthernet1/0/2] port trunk permit vlan 12
[DeviceE-GigabitEthernet1/0/2] port trunk pvid vlan 12
[DeviceE-GigabitEthernet1/0/2] quit
```

Create RRPP domain 2.

```
[DeviceE] rrpp domain 2
```

Configure VLAN 105 as the primary control VLAN of RRPP domain 2.

```
[DeviceE-rrpp-domain2] control-vlan 105
```

Configure the VLAN mapped to MSTI 2 as the protected VLAN of RRPP domain 2.

```
[DeviceE-rrpp-domain2] protected-vlan reference-instance 2
```

Configure Device E as the master mode of subring 2 in RRPP domain 2, with GigabitEthernet 1/0/2 as the primary port and GigabitEthernet 1/0/1 as the secondary port. Enable ring 2.

```
[DeviceE-rrpp-domain2] ring 2 node-mode master primary-port gigabitethernet 1/0/2
secondary-port gigabitethernet 1/0/1 level 1
[DeviceE-rrpp-domain2] ring 2 enable
[DeviceE-rrpp-domain2] quit
```

Enable RRPP.

```
[DeviceE] rrpp enable
```

6. Configure Device F:

Create VLAN 11.

```
<DeviceF> system-view
[DeviceF] vlan 11
[DeviceF-vlan11] quit
```

Map VLAN 11 to MSTI 1.

```
[DeviceF] stp region-configuration
[DeviceF-mst-region] instance 1 vlan 11
```

Activate the MST region configuration.

```
[DeviceF-mst-region] active region-configuration
[DeviceF-mst-region] quit
```

Set the physical state change suppression interval to 0 seconds on GigabitEthernet 1/0/1.

```
[DeviceF] interface gigabitethernet 1/0/1
[DeviceF-GigabitEthernet1/0/1] link-delay up 0
[DeviceF-GigabitEthernet1/0/1] link-delay down 0
```

Disable the spanning tree feature on the port.

```
[DeviceF-GigabitEthernet1/0/1] undo stp enable
```

Configure the port as a trunk port.

```
[DeviceF-GigabitEthernet1/0/1] port link-type trunk
```

Remove the port from VLAN 1, and assign it to VLAN 11.

```
[DeviceF-GigabitEthernet1/0/1] undo port trunk permit vlan 1
[DeviceF-GigabitEthernet1/0/1] port trunk permit vlan 11
```

Configure VLAN 11 as the default VLAN.

```
[DeviceF-GigabitEthernet1/0/1] port trunk pvid vlan 11
[DeviceF-GigabitEthernet1/0/1] quit
```

Configure GigabitEthernet 1/0/2 in the same way GigabitEthernet 1/0/1 is configured.

```
[DeviceF] interface gigabitethernet 1/0/2
[DeviceF-GigabitEthernet1/0/2] link-delay up 0
[DeviceF-GigabitEthernet1/0/2] link-delay down 0
[DeviceF-GigabitEthernet1/0/2] undo stp enable
[DeviceF-GigabitEthernet1/0/2] port link-type trunk
[DeviceF-GigabitEthernet1/0/2] undo port trunk permit vlan 1
[DeviceF-GigabitEthernet1/0/2] port trunk permit vlan 11
[DeviceF-GigabitEthernet1/0/2] port trunk pvid vlan 11
[DeviceF-GigabitEthernet1/0/2] quit
```

Create RRPP domain 1.

```
[DeviceF] rrpp domain 1
```

Configure VLAN 100 as the primary control VLAN of RRPP domain 1.

```
[DeviceF-rrpp-domain1] control-vlan 100
```

Configure the VLAN mapped to MSTI 1 as the protected VLAN of RRPP domain 1.

```
[DeviceF-rrpp-domain1] protected-vlan reference-instance 1
```

Configure Device F as the master node of subring 3 in RRPP domain 1, with GigabitEthernet 1/0/1 as the primary port and GigabitEthernet 1/0/2 as the secondary port. Enable subring 3.

```
[DeviceF-rrpp-domain1] ring 3 node-mode master primary-port gigabitethernet 1/0/1
secondary-port gigabitethernet 1/0/2 level 1
[DeviceF-rrpp-domain1] ring 3 enable
[DeviceF-rrpp-domain1] quit
```

Enable RRPP.

```
[DeviceF] rrpp enable
```

7. Configure RRPP ring group settings on Device B and Device C:

Create RRPP ring group 1 on Device B, and add subrings 2 and 3 to the RRPP ring group.

```
[DeviceB] rrpp ring-group 1
[DeviceB-rrpp-ring-group1] domain 2 ring 2
[DeviceB-rrpp-ring-group1] domain 1 ring 3
```

Create RRPP ring group 1 on Device C, and add subrings 2 and 3 to the RRPP ring group.

```
[DeviceC] rrpp ring-group 1
[DeviceC-rrpp-ring-group1] domain 2 ring 2
[DeviceC-rrpp-ring-group1] domain 1 ring 3
```

Verifying the configuration

Use the **`display`** commands to view RRPP configuration and operational information on each device.

Troubleshooting RRPP

The primary node cannot receive Hello packets when the link state is normal

Symptom

When the link state is normal, the master node cannot receive Hello packets, and it unblocks the secondary port.

Analysis

The following are possible causes:

- One or more nodes on the RRPP ring are not enabled with RRPP.
- The domain IDs or control VLANs are not the same for all nodes on the RRPP ring.
- The port on the RRPP ring does not work correctly.

Solution

To resolve the problem:

1. Use the **`display rrpp brief`** command to determine whether RRPP is enabled for all nodes. If it is not, use the **`rrpp enable`** command and the **`ring enable`** command to enable RRPP and RRPP rings for all nodes.

2. Use the **display rrpp brief** command to determine whether the domain ID and primary control VLAN ID are the same for all nodes. If they are not, set the same domain ID and primary control VLAN ID for the nodes.
3. Use the **display rrpp verbose** command to examine the link state of each port in each ring.
4. Use the **debugging rrpp** command on each node to determine whether a port receives or transmits Hello packets. If it does not, Hello packets are lost.
5. If the problem persists, contact H3C Support.

Contents

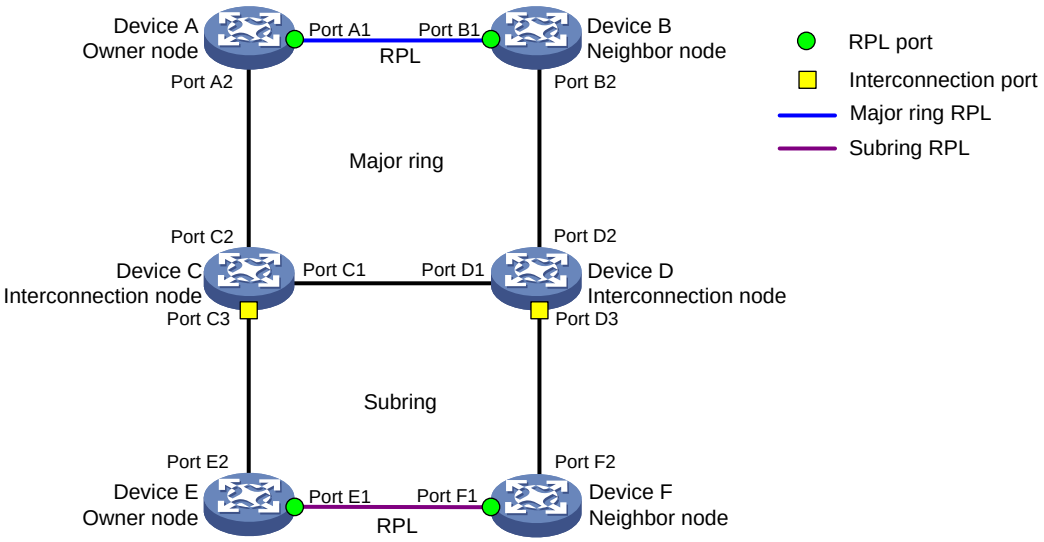
Configuring ERPS

About ERPS

Ethernet Ring Protection Switching (ERPS) is a robust link layer protocol that ensures a loop-free topology and implements quick link recovery.

ERPS structure

Figure 1 ERPS ring structure



Rings

ERPS rings can be divided into major rings and subrings. An ERPS network consists of one major ring or multiple major rings, and multiple subrings. By default, a ring is a major ring. You can configure a ring as a subring manually.

As shown in Figure 1, a major ring is a closed ring formed by Device A, Device B, Device C, and Device D. A subring is an open ring formed by the link Device C<—>Device E<—>Device F<—>Device D.

RPL

An ERPS ring is composed of many nodes. Some nodes use ring protection links (RPLs) to prevent loops on the ERPS ring. As shown in Figure 1, the link between Device A and Device B and the link between Device E and Device F are RPLs.

Nodes

ERPS nodes include owner nodes, neighbor nodes, interconnection nodes, and normal nodes.

- The owner node and neighbor node block and unblock ports on the RPL to prevent loops and switch traffic. An RPL connects an owner node and a neighbor node.
- Interconnection nodes connect different rings. Interconnection nodes reside on subrings and forward service packets but not protocol packets.
- Normal nodes forward both service packets and protocol packets.

As shown in Figure 1, on the major ring, Device A is the owner node and Device B is the neighbor node. On the subring, Device E is the owner node and Device F is the neighbor node. Devices C and D are interconnection nodes.

Ports

Each node consists of two ERPS ring member ports: Port 0 and port 1. ERPS ring member ports have the following types:

- **RPL port**—Port on an RPL link.
- **Interconnection port**—Port that connects a subring to a major ring.
- **Normal port**—Default type of a port that forwards both service packets and protocol packets.

As shown in Figure 1, ports A1, B1, E1, and F1 are RPL ports. Ports C3 and D3 are interconnection ports. Other ports are normal ports.

Instances

An ERPS ring supports multiple ERPS instances. An ERPS instance is a logical ring to process service and protocol packets. Each ERPS instance has its own owner node and maintains its own state and data. An ERPS instance is uniquely identified by the ring ID and VLAN ID of ERPS packets. The ring ID indicates the ring of ERPS packets. It can be represented by the last byte in the destination MAC address of the packets. The VLAN ID indicates the ERPS instance of the packets.

ERPS protocol packets

ERPS protocol packets are Ring Automatic Protection Switching (R-APS) packets. You can configure the R-APS packet level. A node does not process R-APS packets whose levels are greater than the level of the packets sent by the node. On a ring, the levels of R-APS packets must be the same for all nodes in an ERPS instance.

Table 1 R-APS packet types and functions

Packet type	Function
No request, RPL block (NR-RB)	When the link is stable, an owner node in idle state periodically sends NR-RB packets to inform other nodes that the RPL ports are blocked. The nodes that receive the NR-RB packets unblock available ports and update MAC address entries.
No request (NR)	After the link fault is cleared, the node that detects the recovery periodically sends NR packets. When the owner node receives the NR packets, it starts the WTR timer. The node stops sending NR packets after receiving NR-RB packets from the owner node.
Signal fail (SF)	When a link fails to send or receive signals, the node that detects the fault periodically sends SF packets. When the owner node and neighbor node receive the FS packets, they unblock the RPL ports. The node stops sending SF packets after the fault is cleared.
Manual switch (MS)	A port configured with the MS mode is blocked and periodically sends MS packets. When other nodes receive the MS packets, they unblock available ports and update MAC address entries.
Forced switch (FS)	A port configured with the FS mode is blocked and periodically sends FS packets. When other nodes receive the FS packets, they unblock all ports and update MAC address entries.
Flush	If the topology of a subring changes, the interconnection ports on the subring broadcasts flush packets. All nodes that receive the flush packets update MAC address entries.

NOTE:

- Typically R-APS packets are transmitted within a ring. The flush packets sourced from the subring can be forwarded to the major ring.
- Service packets can be transmitted between different rings.

ERPS node states

Table 2 ERPS states

State	Description
Init	State for a non-interconnection node that has less than two ERPS ring member ports or for an interconnection node that does not have ERPS ring member ports.
Idle	Stable state when all non-RPL links are available. In this state, the owner node blocks the RPL port and periodically sends NR-RB packets. The neighbor node blocks the RPL port. All nodes enter the idle state after the owner node enters the idle state.
Protection	State when a non-RPL link is faulty. In this state, the RPL link is unblocked to forward traffic. All nodes enter the protection state after a node enters the protection state.
MS	State when traffic paths are manually switched. All nodes enter the MS state after a node is configured with the MS mode.
FS	State when traffic paths are forcibly switched. All nodes enter the FS state after a node is configured with the FS mode.
Pending	Transient state between the previous states.

ERPS timers

Hold-off timer

The hold-off timer starts when the port detects a link fault. The port reports the link fault if the fault persists when the timer expires.

This timer delays the fault report time and affects the link switching performance.

Guard timer

The guard timer starts when the port detects a link recovery. The port does not process R-APS packets before the timer expires.

This timer prevents R-APS packets from impacting the network and affects the link switching performance when multiple points of failures exist.

WTR timer

In revertive mode, the WTR timer starts when the owner node in protection state receives NR packets. The RPL is unblocked and the recovered node is blocked before the timer expires. The owner node blocks the RPL and sends NR-RB packets when the timer expires. If the port receives SF packets before the timer expires, the timer stops and the RPL remains unblocked.

This timer prevents intermittent link failures from impacting the network.

WTB timer

In revertive mode, the WTB timer starts when the owner node in MS or FS state receives NR packets. The RPL is unblocked and the recovered node sends NR packets before the timer expires. The owner node blocks the RPL and sends NR-RB packets when the timer expires. If the port receives SF packets before the timer expires, the timer stops and the RPL remains unblocked.

This timer prevents the RPL ports from being blocked and unblocked frequently.

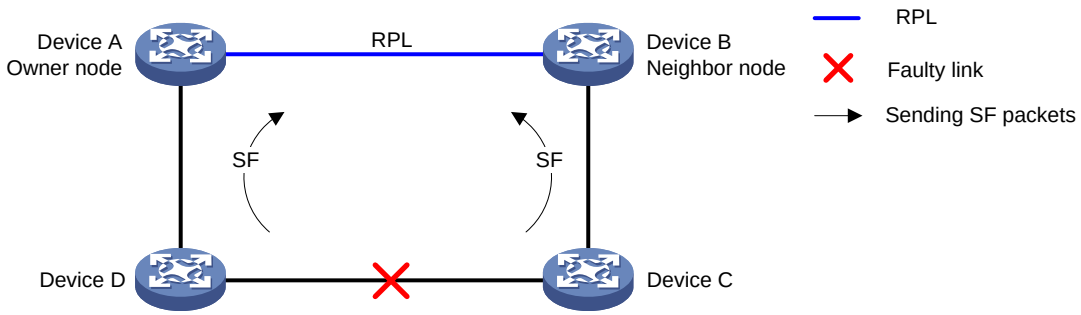
ERPS operation mechanism

ERPS uses the detection mechanism defined in ITU-T G.8032/Y.1344 to locate the point of failure and identify unidirectional or bidirectional faults.

ERPS uses the SF packets to report signal failures on a link and the NR packets to report link recovery. When a node detects a link status change, the node sends three packets first and then sends subsequent packets every five seconds.

Link-down report mechanism

Figure 2 Link-down report mechanism



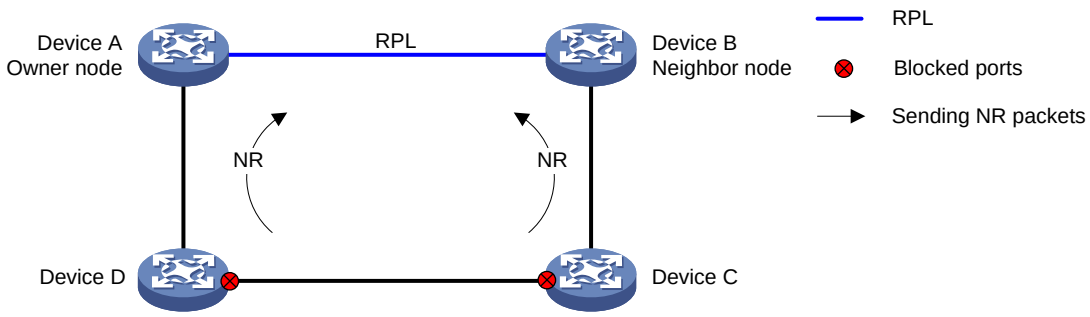
As shown in Figure 2, the link-down report mechanism uses the following process:

1. Device C and Device D detect the link failure and perform the following operations:
   a. Block the ports on both side of the faulty link.
   b. Periodically send SF packets to other nodes.
2. Device A and Device B receive the SF packets and perform the following operations:
   a. Unblock RPL ports.
   b. Update the MAC address entries.

Service packets are switched to the RPL link.

Link recovery mechanism

Figure 3 Link recovery mechanism



As shown in Figure 3, the link recovery mechanism uses the following process:

1. Device C and Device D detect the link recovery and perform the following operations:
   a. Block the recovered ports.
   b. Start the guard timer.
   c. Send NR packets.
2. When Device A (owner node) receives the NR packets, it does not perform any operations if it is in non-revertive mode. If Device A is in revertive mode, it performs the following operations:

a. Starts the WTR timer.

b. Blocks the RPL port and periodically sends NR-RB packets when the WTR timer expires.

3. When other nodes receive the NR-RB packets, they perform the following operations:

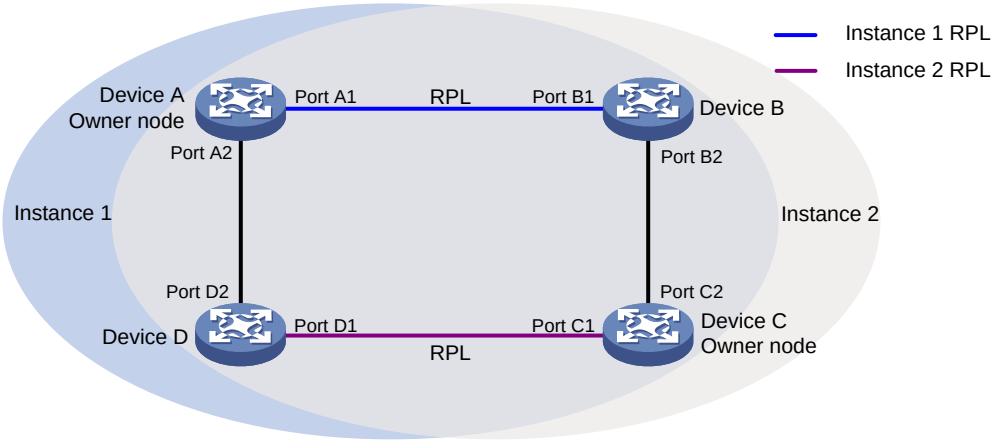
a. Device B (neighbor port) blocks the RPL port.

b. Device C and Device D unblock the recovered ports.

Service packets are switched to the recovered link.

Multi-instance load balancing mechanism

Figure 4 Multi-instance load balancing mechanism



An ERPS ring topology might carry traffic from multiple VLANs. Traffic from different VLANs can be load balanced among different ERPS instances.

ERPS uses the following types of VLANs:

- **Control VLAN**—Carries ERPS protocol packets. Each ERPS instance has its own control VLAN.
- **Protected VLAN**—Carries data packets. Each ERPS instance has its own protected VLAN. Protected VLANs are configured by using the mappings between VLANs and MSTIs.

As shown in Figure 4, the ERPS ring is configured with instance 1 and instance 2. For instance 1, the owner node is Device A, and the RPL is the link between Device A and Device B. For instance 2, the owner node is Device C, and the RPL is the link between Device C and Device D. Traffic from different VLANs can be load balanced among different links.

Manual configuration mechanism

ERPS supports the following manual configuration modes:

- **MS**—Use the **`erps switch manual`** command to block an ERPS ring member port. A port in MS mode is blocked and sends MS packets. The nodes that receive the MS packets unblock available ports. If the nodes in MS mode receive an SF packet, they unblock the blocked ports.
- **FS**—Use the **`erps switch force ring`** command to block an ERPS ring member port. A port in FS mode is blocked and sends FS packets. The nodes that receive the FS packets unblock available ports. If the nodes in FS mode receive an SF packet, they do not unblock the blocked ports.

Collaboration mechanism

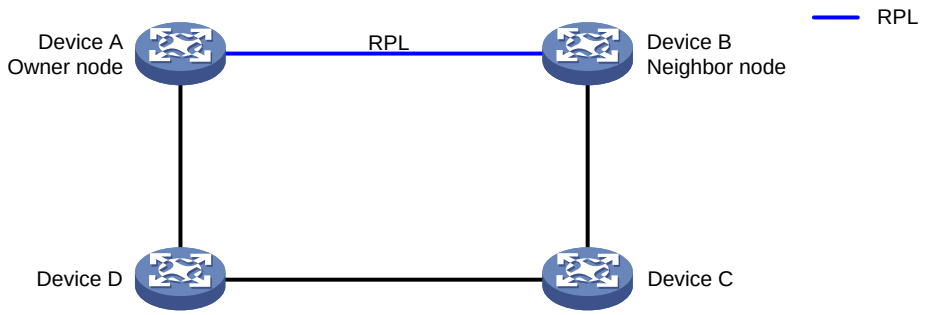
To detect and clear link faults typically for a fiber link, use ERPS with CFD and Track. You can associate ERPS ring member ports with the continuity check function of CFD through track entries. For more information about CFD and Track, see "Configuring CFD" and "Configuring Track."

ERPS network diagrams

One major ring

The network has one major ring.

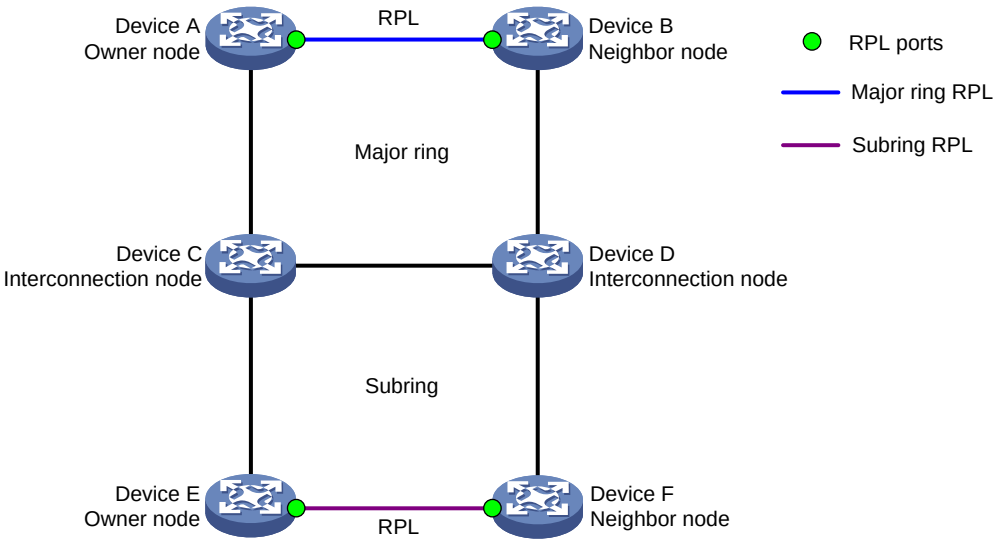
Figure 5 Network diagram



One major ring connecting one subring

The network has one major ring and one subring.

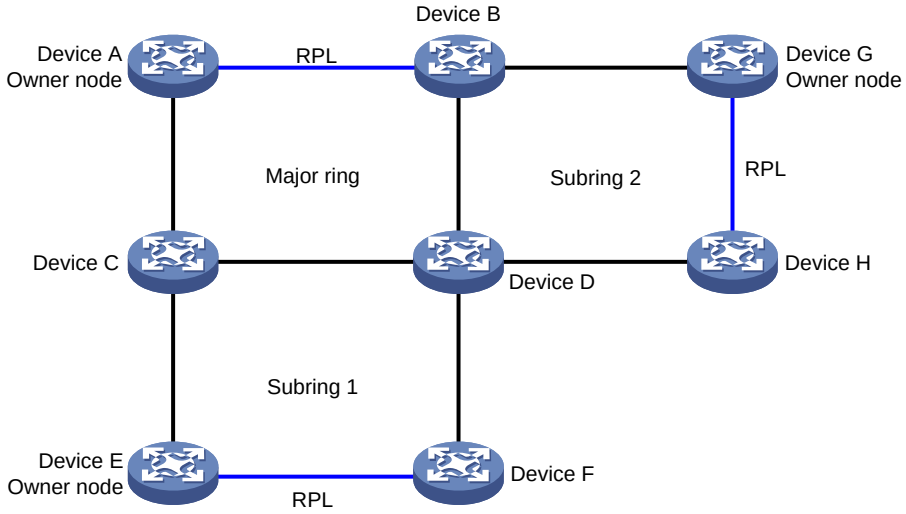
Figure 6 Network diagram



One major ring connecting multiple subrings

The network has three or more rings. Each subring is connected to the major ring by two interconnection nodes.

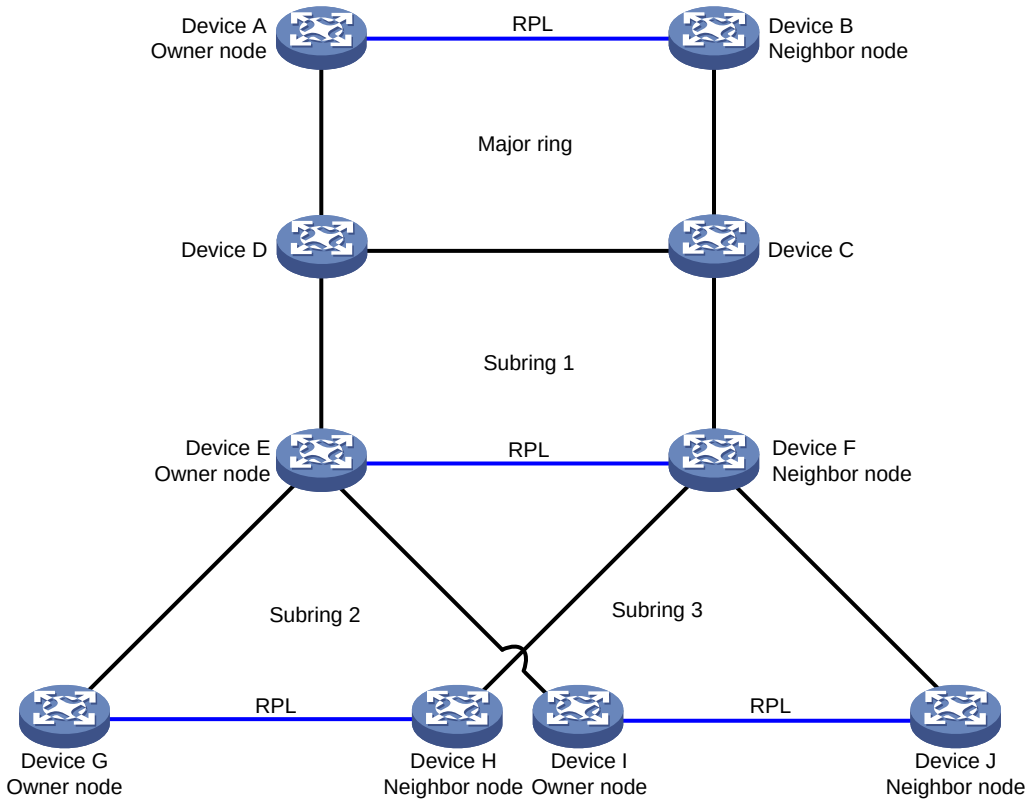
Figure 7 Network diagram



One subring connecting multiple subrings

The network has three or more rings. As shown in Figure 8, subring 1 is connected to the major ring. Other subrings are connected to subring 1 by two interconnection nodes.

Figure 8 Network diagram



One subring connecting multiple rings

The network has three or more rings. A minimum of one subring is connected to two rings. As shown in Figure 9, one interconnection node on subring 2 is connected to the major ring; and another interconnection node is connected to subring 1. As shown in Figure 10, subring 3 is connected to subring 1 and subring 2.

Figure 9 Network diagram 1

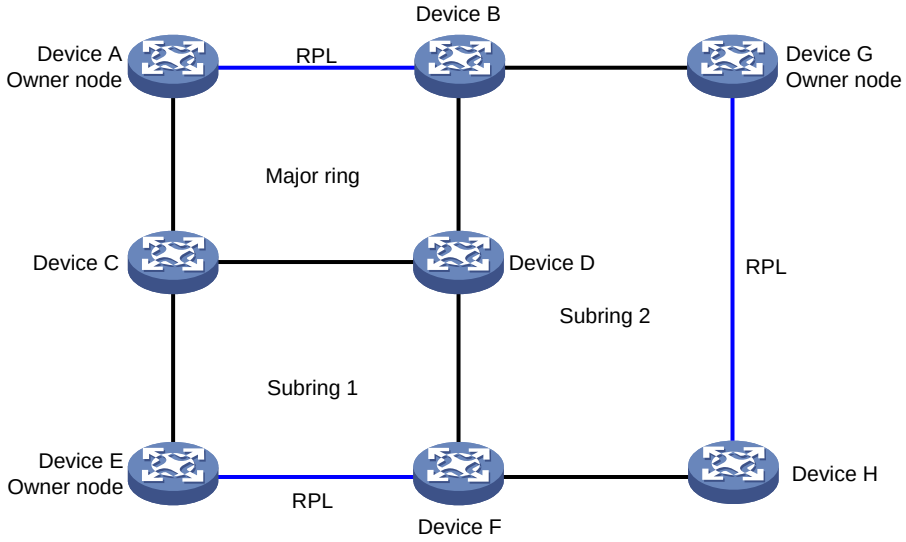
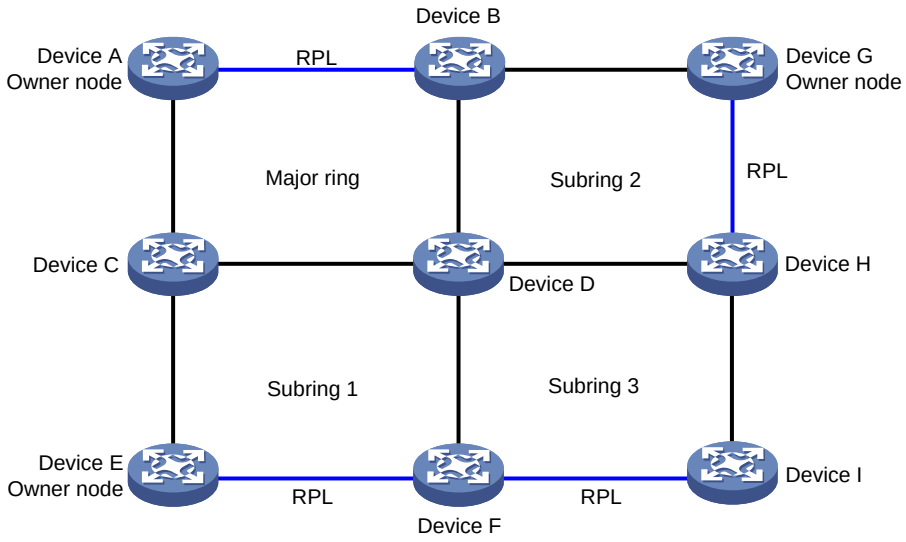


Figure 10 Network diagram 2



Protocols and standards

- ITU-T G.8032, *Recommendation ITU-T G.8032/Y.1344, Ethernet ring protection switching*
- IEEE 802.1D, *IEEE Std 802.1D™-2004, IEEE Standard for Local and Metropolitan Area Networks—Media Access Control (MAC) Bridges*
- IEEE 802.3, *IEEE Std 802.3-2008, IEEE Standard for Information technology*

Restrictions and guidelines: ERPS configuration

ERPS does not provide an election mechanism. To implement ring detection and protection, configure all nodes correctly.

ERPS tasks at a glance

To configure ERPS, perform the following tasks:

1. Enabling ERPS globally
   Perform this task on devices you want to configure as ERPS nodes.
2. Configuring an ERPS ring
   Perform this task on all nodes on an ERPS ring.
   a. Creating an ERPS ring
   b. Configuring ERPS ring member ports
   c. Configuring control VLANs
   d. Configuring protected VLANs
   e. Configuring the node role
3. Enabling ERPS for an instance
   Perform this task on all nodes on an ERPS ring.
4. (Optional.) Enabling R-APS packets to carry the ring ID in the destination MAC address
   Perform this task on all nodes on an ERPS ring.
5. (Optional.) Configuring R-APS packet levels
6. (Optional.) Setting ERPS timers
   Perform this task on the owner node on an ERPS ring.
7. (Optional.) Setting the non-revertive mode
   Perform this task on the owner node on an ERPS ring.
8. (Optional.) Setting a switchover mode
   Perform this task on the nodes that you want to block their ports.
9. (Optional.) Associating a ring with a subring
   Perform this task on the interconnection node on an ERPS ring.
10. (Optional.) Enabling flush packet transparent transmission
    Perform this task on the interconnection node on an ERPS ring.
11. (Optional.) Associating an ERPS ring member port with a track entry
12. (Optional.) Removing the MS mode and FS mode settings for an ERPS ring

Prerequisites

Before you configure ERPS, complete the following tasks:

- Establish the Ethernet ring topology.
- Determine the ERPS rings, ERPS instances, control VLANs, protected VLANs, and node roles.

Enabling ERPS globally

Restrictions and guidelines

- Perform this task on devices you want to configure as ERPS nodes.
- For ERPS to take effect for an instance, enable it globally first.

Procedure

1. Enter system view.

system-view

2. Enable ERPS globally.

   erps enable

   By default, ERPS is disabled globally.

Configuring an ERPS ring

Creating an ERPS ring

Restrictions and guidelines

- Perform this task on all nodes on an ERPS ring.
- A ring ID uniquely identifies an ERPS ring. All nodes on an ERPS ring must be configured with the same ring ID.

Procedure

1. Enter system view.

   system-view

2. Create an ERPS ring.

   erps ring *ring-id*

3. (Optional.) Configure the ring type.

   ring-type sub-ring

   By default, an ERPS ring is a major ring.

Configuring ERPS ring member ports

Restrictions and guidelines

- Perform this task on each node's ports intended for accessing ERPS rings.
- ERPS ring member ports automatically allow packets from the control VLAN to pass through.
- Do not enable Ethernet OAM remote loopback for ERPS ring member ports. This feature might cause a broadcast storm. For more information about Ethernet OAM, see "Configuring Ethernet OAM."
- For faster topology convergence, use the **link-delay** command on ERPS ring member ports to set the physical state change suppression interval to 0 seconds. For more information about the **link-delay** command, see *Layer 2—LAN Switching Command Reference*.
- You must configure ERPS ring member ports as trunk ports.
- Do not assign an interface to both an aggregation group and an ERPS ring. If you do so, the interface does not take effect on the ERPS ring and cannot be displayed by using the **display erps detail** command.

Configuring ERPS ring member port attributes

1. Enter system view.

   system-view

2. Enter Layer 2 Ethernet interface view or Layer 2 aggregate interface view.

   interface *interface-type interface-number*

3. Configure the port as a trunk port.

   port link-type trunk

By default, a port is an access port.

For more information about this command, see *Layer 2—LAN Switching Command Reference*.

4. Assign the trunk port to protected VLANs.

   port trunk permit vlan { *vlan-id-list* | **all** }

   By default, a trunk port is assigned only to VLAN 1.

   For more information about this command, see *Layer 2—LAN Switching Command Reference*.

5. Disable the spanning tree feature.

   undo stp enable

   By default, the spanning tree feature is enabled.

   For more information about this command, see *Layer 2—LAN Switching Command Reference*.

Configuring an ERPS ring member port

1. Enter system view.

   system-view

2. Enter ERPS ring view.

   erps ring *ring-id*

3. Configure an ERPS ring member port.

   { **port0** | **port1** } **interface** *interface-type interface-number*

   By default, an ERPS ring does not have ERPS ring member ports.

Configuring control VLANs

Restrictions and guidelines

- Perform this task on all nodes on an ERPS ring.
- The control VLAN must be a VLAN that has not been created on the device.
- Configure the same control VLAN for all nodes in an ERPS instance.
- Do not configure the default VLAN of an ERPS ring member port as the control VLAN.
- Do not enable QinQ or VLAN mapping on control VLANs. If you do, ERPS packets cannot be correctly forwarded and received.
- Make sure the ERPS instance has been configured. After the ERPS instance is enabled, the control VLAN cannot be changed.
- For a device not configured with ERPS to transparently transmit ERPS packets, make sure only the two ports accessing the ERPS ring permit packets from the control VLAN. If other ports on the device permit packets from the control VLAN, the packets from other VLANs might enter the control VLAN and strike the ERPS ring.

Procedure

1. Enter system view.

   system-view

2. Enter ERPS ring view.

   erps ring *ring-id*

3. Enable ERPS instance view.

   instance *instance-id*

4. Configure a control VLAN.

   control-vlan *vlan-id*

Configuring protected VLANs

Restrictions and guidelines

- Perform this task on all nodes on an ERPS ring.
- Configure the same protected VLAN for all nodes of an ERPS instance. To implement load balancing, configure different protected VLANs for different ERPS instances.

Prerequisites

Before you configure protected VLANs, you must configure an MST region and the VLAN-to-instance mapping table. For more information about MST regions, see spanning tree configuration in *Layer 2—LAN Switching Configuration Guide*.

Procedure

1. Enter system view.
   system-view
2. Enter ERPS ring view.
   erps ring *ring-id*
3. Enable ERPS instance view.
   instance *instance-id*
4. Configure the protected VLANs.
   protected-vlan reference-instance *instance-id-list*

Configuring the node role

Restrictions and guidelines

- Perform this task on all nodes on an ERPS ring.
- For the owner node to work correctly, you must configure only one owner node for an ERPS ring.
- You can only configure the interconnection node for subrings.

Procedure

1. Enter system view.
   system-view
2. Enter ERPS ring view.
   erps ring *ring-id*
3. Enter ERPS instance view.
   instance *instance-id*
4. Configure the node role.
   node-role { { **owner** | **neighbor** } **rpl** | **interconnection** } { **port0** | **port1** }
   By default, a node is a normal node.

Enabling ERPS for an instance

Restrictions and guidelines

- Perform this task on all nodes on an ERPS ring.

- You can enable ERPS for an instance only when it is configured with a control VLAN and a protected VLAN.

Procedure

1. Enter system view.
   system-view
2. Enter ERPS ring view.
   erps ring *ring-id*
3. Enter ERPS instance view.
   instance *instance-id*
4. Enable ERPS for the instance.
   instance enable
   By default, ERPS is disabled for an instance.

Enabling R-APS packets to carry the ring ID in the destination MAC address

About this feature

Perform this task to configure the ring ID as the last byte of the destination MAC address for R-APS packets. The ring of R-APS packets can be identified by their destination MAC addresses.

Restrictions and guidelines

Perform this task on all nodes on an ERPS ring.

Procedure

1. Enter system view.
   system-view
2. Enter ERPS ring view.
   erps ring *ring-id*
3. Enable R-APS packets to carry the ring ID in the destination MAC address.
   r-aps ring-mac
   By default, R-APS packets do not carry ring IDs in their destination MAC addresses. The last byte of the destination MAC address is 1.

Configuring R-APS packet levels

Restrictions and guidelines

Perform this task on all nodes on an ERPS ring.

On a ring, the levels of R-APS packets must be the same for all nodes in an ERPS instance.

A node does not process R-APS packets whose levels are greater than the level of R-APS packets sent by the node.

Procedure

1. Enter system view.
   system-view
2. Enter ERPS ring view.

erps ring *ring-id*

3. Enter ERPS instance view.
   instance *instance-id*
4. Configure the R-APS packet level.
   r-aps level *level-value*
   By default, the level for R-APS packets is 7.

Setting ERPS timers

Restrictions and guidelines

Perform this task on the owner node on an ERPS ring.

Procedure

1. Enter system view.
   system-view
2. Enter ERPS ring view.
   erps ring *ring-id*
3. Enter ERPS instance view.
   instance *instance-id*
4. Set the guard timer.
   timer guard *guard-value*
   By default, the guard timer is 500 milliseconds.
5. Set the hold-off timer.
   timer hold-off *hold-off-value*
   By default, the hold-off timer is 0 milliseconds.
6. Set the WTR timer.
   timer wtr *wtr-value*
   By default, the WTR timer is 5 minutes.

Setting the non-revertive mode

About setting the non-revertive mode

Perform this task if you do not want to switch back to the recovered link after the link fault is cleared.

Restrictions and guidelines

Perform this task on the owner node on an ERPS ring.

Procedure

1. Enter system view.
   system-view
2. Enter ERPS ring view.
   erps ring *ring-id*
3. Enter ERPS instance view.
   instance *instance-id*
4. Set the non-revertive mode.

revertive-operation non-revertive

By default, revertive mode is used.

Setting a switchover mode

Restrictions and guidelines

Perform this task on the nodes that you want to block their ports.

Procedure

1. Enter system view.

   system-view

2. Set a switchover mode.

   erps switch { **force** | **manual** } **ring** *ring-id* **instance** *instance-id* { **port0** | **port1** }

   By default, no switchover mode is not set.

Associating a ring with a subring

About associating a ring with a subring

On a multi-ring network, perform this task if you want to advertise topology changes in a subring to a ring.

Restrictions and guidelines

Perform this task on the interconnection node on an ERPS ring.

Procedure

1. Enter system view.

   system-view

2. Enter ERPS ring view.

   erps ring *ring-id*

3. Configure the ERPS ring as a subring.

   ring-type sub-ring

   By default, an ERPS ring is a major ring.

4. Enter ERPS instance view.

   instance *instance-id*

5. Associate a ring with the subring.

   sub-ring connect ring *ring-id* **instance** *instance-id*

   By default, a subring is not associated with any rings.

Enabling flush packet transparent transmission

About enabling flush packet transparent transmission

This feature enables the interconnection nodes to forward flush packets for topology changes in the subring to the ring associated with the subring. The associated ring can flush the MAC address table quickly to speed up convergence.

Restrictions and guidelines

Perform this task on the interconnection node on an ERPS ring.

To use this feature, you must also associate a subring on the interconnection node with the ring.

Procedure

1. Enter system view.
   system-view
2. Enable flush packet transparent transmission.
   erps tcn-propagation
   By default, flush packet transparent transmission is disabled.

Associating an ERPS ring member port with a track entry

Restrictions and guidelines

Before you associate a port with a track entry, make sure the port has joined an ERPS instance.

Procedure

1. Enter system view.
   system-view
2. Enter Layer 2 Ethernet interface view or Layer 2 aggregate interface view.
   interface *interface-type interface-number*
3. Associate an ERPS ring member port with a track entry.
   port erps ring *ring-id* **instance** *instance-id* **track** *track-entry-index*
   By default, an ERPS ring member port is not associated with any track entries.

Removing the MS mode and FS mode settings for an ERPS ring

About removing the MS mode and FS mode settings

After you configure this task, the owner node can ignore the WTR timer and immediately switch traffic to the recovered link upon link recovery.

This task also switches an ERPS ring in non-revertive mode to revertive mode.

Procedure

1. Enter system view.
   system-view
2. Enter Layer 2 Ethernet interface view or Layer 2 aggregate interface view.
   erps clear ring *ring-id* **instance** *instance-id*

Displaying and maintaining ERPS

Execute **display** commands in any view and **reset** commands in user view.

Task	Command
Display brief ERPS information.	**display erps**
Display detailed ERPS information.	**display erps detail ring** *ring-id* [**instance** *instance-id*]
Display ERPS packet statistics.	**display erps statistics** [**ring** *ring-id* [**instance** *instance-id*]]
Clear ERPS packet statistics.	**reset erps statistics ring** *ring-id* [**instance** *instance-id*]

ERPS configuration examples

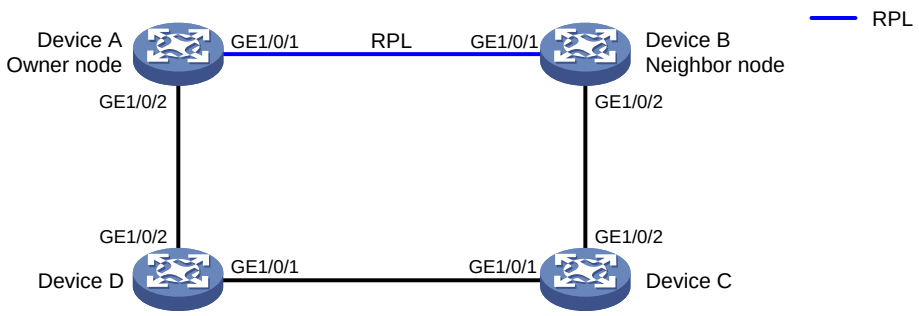
Example: Configuring one ring

Network configuration

As shown in Figure 11, perform the following tasks to eliminate loops on the network:

- Configure the ring as ERPS ring 1.
- Configure VLAN 100 as the control VLAN for ERPS ring 1.
- Configure VLANs 1 to 30 as the protected VLANs for ERPS ring 1.
- Configure Device A as the owner node, GigabitEthernet 1/0/1 as ERPS ring member port 0 and the RPL port, and GigabitEthernet 1/0/2 as ERPS ring member port 1.
- Configure Device B as the neighbor node, GigabitEthernet 1/0/1 as ERPS ring member port 0 and the RPL port, and GigabitEthernet 1/0/2 as ERPS ring member port 1.
- Configure Device C and Device D as normal nodes, GigabitEthernet 1/0/1 as ERPS ring member port 0, and GigabitEthernet 1/0/2 as ERPS ring member port 1.

Figure 11 Network diagram



Procedure

1. Configure Device A.

   # Create VLANs 1 to 30, map these VLANs to MSTI 1, and activate the MST region configuration.

   ```
   <DeviceA> system-view
   [DeviceA] vlan 1 to 30
   [DeviceA] stp region-configuration
   [DeviceA-mst-region] instance 1 vlan 1 to 30
   [DeviceA-mst-region] active region-configuration
   ```

```
[DeviceA-mst-region] quit
```

Set the link state change suppression interval to 0 seconds on GigabitEthernet 1/0/1.

```
[DeviceA] interface gigabitethernet 1/0/1
[DeviceA-GigabitEthernet1/0/1] link-delay up 0
[DeviceA-GigabitEthernet1/0/1] link-delay down 0
```

Disable the spanning tree feature on the port.

```
[DeviceA-GigabitEthernet1/0/1] undo stp enable
```

Configure the port as a trunk port and assign it to VLANs 1 to 30.

```
[DeviceA-GigabitEthernet1/0/1] port link-type trunk
[DeviceA-GigabitEthernet1/0/1] port trunk permit vlan 1 to 30
[DeviceA-GigabitEthernet1/0/1] quit
```

Configure GigabitEthernet 1/0/2 in the same way GigabitEthernet 1/0/1 is configured.

```
[DeviceA] interface gigabitethernet 1/0/2
[DeviceA-GigabitEthernet1/0/2] link-delay up 0
[DeviceA-GigabitEthernet1/0/2] link-delay down 0
[DeviceA-GigabitEthernet1/0/2] undo stp enable
[DeviceA-GigabitEthernet1/0/2] port link-type trunk
[DeviceA-GigabitEthernet1/0/2] port trunk permit vlan 1 to 30
[DeviceA-GigabitEthernet1/0/2] quit
```

Create ERPS ring 1.

```
[DeviceA] erps ring 1
```

Configure ERPS ring member ports.

```
[DeviceA-erps-ring1] port0 interface gigabitethernet 1/0/1
[DeviceA-erps-ring1] port1 interface gigabitethernet 1/0/2
```

Enable R-APS packets to carry ring ID in the destination MAC address.

```
[DeviceA-erps-ring1] r-aps ring-mac
```

Create ERPS instance 1.

```
[DeviceA-erps-ring1] instance 1
```

Configure the node role.

```
[DeviceA-erps-ring1-inst1] node-role owner rpl port0
```

Configure the control VLAN.

```
[DeviceA-erps-ring1-inst1] control-vlan 100
```

Configure the protected VLANs.

```
[DeviceA-erps-ring1-inst1] protected-vlan reference-instance 1
```

Enable ERPS for instance 1.

```
[DeviceA-erps-ring1-inst1] instance enable
[DeviceA-erps-ring1-inst1] quit
[DeviceA-erps-ring1] quit
```

Enable CFD, and create a level-5 MD named **MD_A**.

```
[DeviceA] cfd enable
[DeviceA] cfd md MD_A level 5
```

Create service instance 1, in which the MA is identified by a VLAN and serves VLAN 1.

```
[DeviceA] cfd service-instance 1 ma-id vlan-based md MD_A vlan 1
```

Configure a MEP list in service instance 1, create outward-facing MEP 1001 in service instance 1, and enable CCM sending on GigabitEthernet 1/0/1.

```
[DeviceA] cfd meplist 1001 1002 service-instance 1
[DeviceA] interface gigabitethernet 1/0/1
```

```
[DeviceA-GigabitEthernet1/0/1] cfd mep 1001 service-instance 1 outbound
[DeviceA-GigabitEthernet1/0/1] cfd cc service-instance 1 mep 1001 enable
[DeviceA-GigabitEthernet1/0/1] quit
```

Create service instance 2, in which the MA is identified by a VLAN and serves VLAN 2.

```
[DeviceA] cfd service-instance 2 ma-id vlan-based md MD_A vlan 2
```

Configure a MEP list in service instance 2, create outward-facing MEP 2001 in service instance 1, and enable CCM sending on GigabitEthernet 1/0/2.

```
[DeviceA] cfd meplist 2001 2002 service-instance 2
[DeviceA] interface gigabitethernet 1/0/2
[DeviceA-GigabitEthernet1/0/2] cfd mep 2001 service-instance 2 outbound
[DeviceA-GigabitEthernet1/0/2] cfd cc service-instance 2 mep 2001 enable
[DeviceA-GigabitEthernet1/0/2] quit
```

Create track entry 1 and associate it with the CC function of CFD for MEP 1001 in service instance 1.

```
[DeviceA] track 1 cfd cc service-instance 1 mep 1001
```

Associate GigabitEthernet 1/0/1 with track entry 1 and bring up the port.

```
[DeviceA] interface gigabitethernet 1/0/1
[DeviceA-GigabitEthernet1/0/1] port erps ring 1 instance 1 track 1
[DeviceA-GigabitEthernet1/0/1] undo shutdown
[DeviceA-GigabitEthernet1/0/1] quit
```

Create track entry 2 and associate it with the CC function of CFD for MEP 2001 in service instance 2.

```
[DeviceA] track 2 cfd cc service-instance 2 mep 2001
```

Associate GigabitEthernet 1/0/2 with track entry 2 and bring up the port.

```
[DeviceA] interface gigabitethernet 1/0/2
[DeviceA-GigabitEthernet1/0/2] port erps ring 1 instance 1 track 2
[DeviceA-GigabitEthernet1/0/2] undo shutdown
[DeviceA-GigabitEthernet1/0/2] quit
```

Enable ERPS.

```
[DeviceA] erps enable
```

2. Configure Device B.

Create VLANs 1 to 30, map these VLANs to MSTI 1, and activate the MST region configuration.

```
<DeviceB> system-view
[DeviceB] vlan 1 to 30
[DeviceB] stp region-configuration
[DeviceB-mst-region] instance 1 vlan 1 to 30
[DeviceB-mst-region] active region-configuration
[DeviceB-mst-region] quit
```

Set the link state change suppression interval to 0 seconds on GigabitEthernet 1/0/1.

```
[DeviceB] interface gigabitethernet 1/0/1
[DeviceB-GigabitEthernet1/0/1] link-delay up 0
[DeviceB-GigabitEthernet1/0/1] link-delay down 0
```

Disable the spanning tree feature on the port.

```
[DeviceB-GigabitEthernet1/0/1] undo stp enable
[DeviceB-GigabitEthernet1/0/1] port link-type trunk
```

Configure the port as a trunk port and assign it to VLANs 1 to 30.

```
[DeviceB-GigabitEthernet1/0/1] port trunk permit vlan 1 to 30
```

```
[DeviceB-GigabitEthernet1/0/1] quit
```

Configure GigabitEthernet 1/0/2 in the same way GigabitEthernet 1/0/1 is configured.

```
[DeviceB] interface gigabitethernet 1/0/2
[DeviceB-GigabitEthernet1/0/2] link-delay up 0
[DeviceB-GigabitEthernet1/0/2] link-delay down 0
[DeviceB-GigabitEthernet1/0/2] undo stp enable
[DeviceB-GigabitEthernet1/0/2] port link-type trunk
[DeviceB-GigabitEthernet1/0/2] port trunk permit vlan 1 to 30
[DeviceB-GigabitEthernet1/0/2] quit
```

Create ERPS ring 1.

```
[DeviceB] erps ring 1
```

Configure ERPS ring member ports.

```
[DeviceB-erps-ring1] port0 interface gigabitethernet 1/0/1
[DeviceB-erps-ring1] port1 interface gigabitethernet 1/0/2
```

Enable R-APS packets to carry ring ID in the destination MAC address.

```
[DeviceB-erps-ring1] r-aps ring-mac
```

Create ERPS instance 1.

```
[DeviceB-erps-ring1] instance 1
```

Configure the node role.

```
[DeviceB-erps-ring1-inst1] node-role neighbor rpl port0
```

Configure the control VLAN.

```
[DeviceB-erps-ring1-inst1] control-vlan 100
```

Configure the protected VLANs.

```
[DeviceB-erps-ring1-inst1] protected-vlan reference-instance 1
```

Enable ERPS for instance 1.

```
[DeviceB-erps-ring1-inst1] instance enable
[DeviceB-erps-ring1-inst1] quit
[DeviceB-erps-ring1] quit
```

Enable CFD, and create a level-5 MD named **MD_A**.

```
[DeviceB] cfd enable
[DeviceB] cfd md MD_A level 5
```

Create service instance 1, in which the MA is identified by a VLAN and serves VLAN 1.

```
[DeviceB] cfd service-instance 1 ma-id vlan-based md MD_A vlan 1
```

Configure a MEP list in service instance 1, create outward-facing MEP 1002 in service instance 1, and enable CCM sending on GigabitEthernet 1/0/1.

```
[DeviceB] cfd meplist 1001 1002 service-instance 1
[DeviceB] interface gigabitethernet 1/0/1
[DeviceB-GigabitEthernet1/0/1] cfd mep 1002 service-instance 1 outbound
[DeviceB-GigabitEthernet1/0/1] cfd cc service-instance 1 mep 1002 enable
[DeviceB-GigabitEthernet1/0/1] quit
```

Create service instance 3, in which the MA is identified by a VLAN and serves VLAN 3.

```
[DeviceB] cfd service-instance 3 ma-id vlan-based md MD_A vlan 3
```

Configure a MEP list in service instance 3, create outward-facing MEP 3002 in service instance 1, and enable CCM sending on GigabitEthernet 1/0/2.

```
[DeviceB] cfd meplist 3001 3002 service-instance 3
[DeviceB] interface gigabitethernet 1/0/2
[DeviceB-GigabitEthernet1/0/2] cfd mep 3002 service-instance 3 outbound
```

```
[DeviceB-GigabitEthernet1/0/2] cfd cc service-instance 3 mep 3002 enable
[DeviceB-GigabitEthernet1/0/2] quit
```

Create track entry 1 and associate it with the CC function of CFD for MEP 1002 in service instance 1.

```
[DeviceB] track 1 cfd cc service-instance 1 mep 1002
```

Associate GigabitEthernet 1/0/1 with track entry 1 and bring up the port.

```
[DeviceB] interface gigabitethernet 1/0/1
[DeviceB-GigabitEthernet1/0/1] port erps ring 1 instance 1 track 1
[DeviceB-GigabitEthernet1/0/1] undo shutdown
[DeviceB-GigabitEthernet1/0/1] quit
```

Create track entry 3 and associate it with the CC function of CFD for MEP 3002 in service instance 3.

```
[DeviceB] track 3 cfd cc service-instance 3 mep 3002
```

Associate GigabitEthernet 1/0/2 with track entry 3 and bring up the port.

```
[DeviceB] interface gigabitethernet 1/0/2
[DeviceB-GigabitEthernet1/0/2] port erps ring 1 instance 1 track 2
[DeviceB-GigabitEthernet1/0/2] undo shutdown
[DeviceB-GigabitEthernet1/0/2] quit
```

Enable ERPS.

```
[DeviceB] erps enable
```

3. Configure Device C.

Create VLANs 1 to 30, map these VLANs to MSTI 1, and activate the MST region configuration.

```
<DeviceC> system-view
[DeviceC] vlan 1 to 30
[DeviceC] stp region-configuration
[DeviceC-mst-region] instance 1 vlan 1 to 30
[DeviceC-mst-region] active region-configuration
[DeviceC-mst-region] quit
```

Set the link state change suppression interval to 0 seconds on GigabitEthernet 1/0/1.

```
[DeviceC] interface gigabitethernet 1/0/1
[DeviceC-GigabitEthernet1/0/1] link-delay up 0
[DeviceC-GigabitEthernet1/0/1] link-delay down 0
```

Disable the spanning tree feature on the port.

```
[DeviceC-GigabitEthernet1/0/1] undo stp enable
```

Configure the port as a trunk port and assign it to VLANs 1 to 30.

```
[DeviceC-GigabitEthernet1/0/1] port link-type trunk
[DeviceC-GigabitEthernet1/0/1] port trunk permit vlan 1 to 30
[DeviceC-GigabitEthernet1/0/1] quit
```

Configure GigabitEthernet 1/0/2 in the same way GigabitEthernet 1/0/1 is configured.

```
[DeviceC] interface gigabitethernet 1/0/2
[DeviceC-GigabitEthernet1/0/2] link-delay up 0
[DeviceC-GigabitEthernet1/0/2] link-delay down 0
[DeviceC-GigabitEthernet1/0/2] undo stp enable
[DeviceC-GigabitEthernet1/0/2] port link-type trunk
[DeviceC-GigabitEthernet1/0/2] port trunk permit vlan 1 to 30
[DeviceC-GigabitEthernet1/0/2] quit
```

Create ERPS ring 1.

```
[DeviceC] erps ring 1
```

Configure ERPS ring member ports.

```
[DeviceC-erps-ring1] port0 interface gigabitethernet 1/0/1
[DeviceC-erps-ring1] port1 interface gigabitethernet 1/0/2
```

Enable R-APS packets to carry ring ID in the destination MAC address.

```
[DeviceC-erps-ring1] r-aps ring-mac
```

Create ERPS instance 1.

```
[DeviceC-erps-ring1] instance 1
```

Configure the control VLAN.

```
[DeviceC-erps-ring1-inst1] control-vlan 100
```

Configure the protected VLANs.

```
[DeviceC-erps-ring1-inst1] protected-vlan reference-instance 1
```

Enable ERPS for instance 1.

```
[DeviceC-erps-ring1-inst1] instance enable
[DeviceC-erps-ring1-inst1] quit
[DeviceC-erps-ring1] quit
```

Enable CFD, and create a level-5 MD named **MD_A**.

```
[DeviceC] cfd enable
[DeviceC] cfd md MD_A level 5
```

Create service instance 3, in which the MA is identified by a VLAN and serves VLAN 3.

```
[DeviceC] cfd service-instance 3 ma-id vlan-based md MD_A vlan 3
```

Configure a MEP list in service instance 3, create outward-facing MEP 3001 in service instance 3, and enable CCM sending on GigabitEthernet 1/0/2.

```
[DeviceC] cfd meplist 3001 3002 service-instance 3
[DeviceC] interface gigabitethernet 1/0/2
[DeviceC-GigabitEthernet1/0/2] cfd mep 3001 service-instance 3 outbound
[DeviceC-GigabitEthernet1/0/2] cfd cc service-instance 3 mep 3001 enable
[DeviceC-GigabitEthernet1/0/2] quit
```

Create service instance 4, in which the MA is identified by a VLAN and serves VLAN 4.

```
[DeviceC] cfd service-instance 4 ma-id vlan-based md MD_A vlan 4
```

Configure a MEP list in service instance 4, create outward-facing MEP 4001 in service instance 4, and enable CCM sending on GigabitEthernet 1/0/1.

```
[DeviceC] cfd meplist 4001 4002 service-instance 4
[DeviceC] interface gigabitethernet 1/0/1
[DeviceC-GigabitEthernet1/0/1] cfd mep 4001 service-instance 4 outbound
[DeviceC-GigabitEthernet1/0/1] cfd cc service-instance 4 mep 4001 enable
[DeviceC-GigabitEthernet1/0/1] quit
```

Create track entry 1 and associate it with the CC function of CFD for MEP 3001 in service instance 3.

```
[DeviceC] track 1 cfd cc service-instance 3 mep 3001
```

Associate GigabitEthernet 1/0/2 with track entry 1 and bring up the port.

```
[DeviceC] interface gigabitethernet 1/0/2
[DeviceC-GigabitEthernet1/0/2] port erps ring 1 instance 1 track 1
[DeviceC-GigabitEthernet1/0/2] undo shutdown
[DeviceC-GigabitEthernet1/0/2] quit
```

Create track entry 2 and associate it with the CC function of CFD for MEP 4001 in service instance 4.

```
[DeviceC] track 2 cfd cc service-instance 4 mep 4001
```

Associate GigabitEthernet 1/0/1 with track entry 3 and bring up the port.

```
[DeviceC] interface gigabitethernet 1/0/1
[DeviceC-GigabitEthernet1/0/1] port erps ring 1 instance 1 track 2
[DeviceC-GigabitEthernet1/0/1] undo shutdown
[DeviceC-GigabitEthernet1/0/1] quit
```

Enable ERPS.

```
[DeviceC] erps enable
```

4. Configure Device D.

Create VLANs 1 to 30, map these VLANs to MSTI 1, and activate the MST region configuration.

```
<DeviceD> system-view
[DeviceD] vlan 1 to 30
[DeviceD] stp region-configuration
[DeviceD-mst-region] instance 1 vlan 1 to 30
[DeviceD-mst-region] active region-configuration
[DeviceD-mst-region] quit
```

Set the link state change suppression interval to 0 seconds on GigabitEthernet 1/0/1.

```
[DeviceD] interface gigabitethernet 1/0/1
[DeviceD-GigabitEthernet1/0/1] link-delay up 0
[DeviceD-GigabitEthernet1/0/1] link-delay down 0
```

Disable the spanning tree feature on the port.

```
[DeviceD-GigabitEthernet1/0/1] undo stp enable
```

Configure the port as a trunk port and assign it to VLANs 1 to 30.

```
[DeviceD-GigabitEthernet1/0/1] port link-type trunk
[DeviceD-GigabitEthernet1/0/1] port trunk permit vlan 1 to 30
[DeviceD-GigabitEthernet1/0/1] quit
```

Configure GigabitEthernet 1/0/2 in the same way GigabitEthernet 1/0/1 is configured.

```
[DeviceD] interface gigabitethernet 1/0/2
[DeviceD-GigabitEthernet1/0/2] link-delay up 0
[DeviceD-GigabitEthernet1/0/2] link-delay down 0
[DeviceD-GigabitEthernet1/0/2] undo stp enable
[DeviceD-GigabitEthernet1/0/2] port link-type trunk
[DeviceD-GigabitEthernet1/0/2] port trunk permit vlan 1 to 30
[DeviceD-GigabitEthernet1/0/2] quit
```

Create ERPS ring 1.

```
[DeviceD] erps ring 1
```

Configure ERPS ring member ports.

```
[DeviceD-erps-ring1] port0 interface gigabitethernet 1/0/1
[DeviceD-erps-ring1] port1 interface gigabitethernet 1/0/2
```

Enable R-APS packets to carry ring ID in the destination MAC address.

```
[DeviceD-erps-ring1] r-aps ring-mac
```

Create ERPS instance 1.

```
[DeviceD-erps-ring1] instance 1
```

Configure the control VLAN.

```
[DeviceD-erps-ring1-inst1] control-vlan 100
```

Configure the protected VLANs.

```
[DeviceD-erps-ring1-inst1] protected-vlan reference-instance 1
```

Enable ERPS for instance 1.

```
[DeviceD-erps-ring1-inst1] instance enable
[DeviceD-erps-ring1-inst1] quit
[DeviceD-erps-ring1] quit
```

Enable CFD, and create a level-5 MD named **MD_A**.

```
[DeviceD] cfd enable
[DeviceD] cfd md MD_A level 5
```

Create service instance 2, in which the MA is identified by a VLAN and serves VLAN 2.

```
[DeviceD] cfd service-instance 2 ma-id vlan-based md MD_A vlan 2
```

Configure a MEP list in service instance 2, create outward-facing MEP 2002 in service instance 2, and enable CCM sending on GigabitEthernet 1/0/2.

```
[DeviceD] cfd meplist 2001 2002 service-instance 2
[DeviceD] interface gigabitethernet 1/0/2
[DeviceD-GigabitEthernet1/0/2] cfd mep 2002 service-instance 2 outbound
[DeviceD-GigabitEthernet1/0/2] cfd cc service-instance 2 mep 2002 enable
[DeviceD-GigabitEthernet1/0/2] quit
```

Create service instance 4, in which the MA is identified by a VLAN and serves VLAN 4.

```
[DeviceD] cfd service-instance 4 ma-id vlan-based md MD_A vlan 4
```

Configure a MEP list in service instance 4, create outward-facing MEP 4002 in service instance 4, and enable CCM sending on GigabitEthernet 1/0/1.

```
[DeviceD] cfd meplist 4001 4002 service-instance 4
[DeviceD] interface gigabitethernet 1/0/1
[DeviceD-GigabitEthernet1/0/1] cfd mep 4002 service-instance 4 outbound
[DeviceD-GigabitEthernet1/0/1] cfd cc service-instance 4 mep 4002 enable
[DeviceD-GigabitEthernet1/0/1] quit
```

Create track entry 1 and associate it with the CC function of CFD for MEP 2002 in service instance 2.

```
[DeviceD] track 1 cfd cc service-instance 2 mep 2002
```

Associate GigabitEthernet 1/0/2 with track entry 1 and bring up the port.

```
[DeviceD] interface gigabitethernet 1/0/2
[DeviceD-GigabitEthernet1/0/2] port erps ring 1 instance 1 track 1
[DeviceD-GigabitEthernet1/0/2] undo shutdown
[DeviceD-GigabitEthernet1/0/2] quit
```

Create track entry 2 and associate it with the CC function of CFD for MEP 4002 in service instance 4.

```
[DeviceD] track 2 cfd cc service-instance 4 mep 4002
```

Associate GigabitEthernet 1/0/1 with track entry 2 and bring up the port.

```
[DeviceD] interface gigabitethernet 1/0/1
[DeviceD-GigabitEthernet1/0/1] port erps ring 1 instance 1 track 2
[DeviceD-GigabitEthernet1/0/1] undo shutdown
[DeviceD-GigabitEthernet1/0/1] quit
```

Enable ERPS.

```
[DeviceD] erps enable
```

Verifying the configuration

Display information about ERPS instance 1 for Device A.

```
[DeviceA] display erps detail ring 1
 Ring ID              : 1
 Port0                : GigabitEthernet1/0/1
```

```
Port1                 : GigabitEthernet1/0/2
Subring               : No
Default MAC           : No
Instance ID           : 1
Node role             : Owner
Node state            : Idle
Connect(ring/instance): -
Control VLAN          : 100
Protected VLAN        : Reference-instance 1
Guard timer           : 500 ms
Hold-off timer        : 0 ms
WTR timer             : 5 min
Revertive operation   : Revertive
Enable status         : Yes, Active status : Yes
R-APS level           : 7
Port                  PortRole                PortStatus
--------------------------------------------------------------------------------
Port0                 RPL                     Block
Port1                 Non-RPL                 Up
```

The output shows the following information:

- Device A is the owner node.
- The ERPS ring is in idle state.
- The RPL port is blocked.
- The non-RPL port is unblocked.

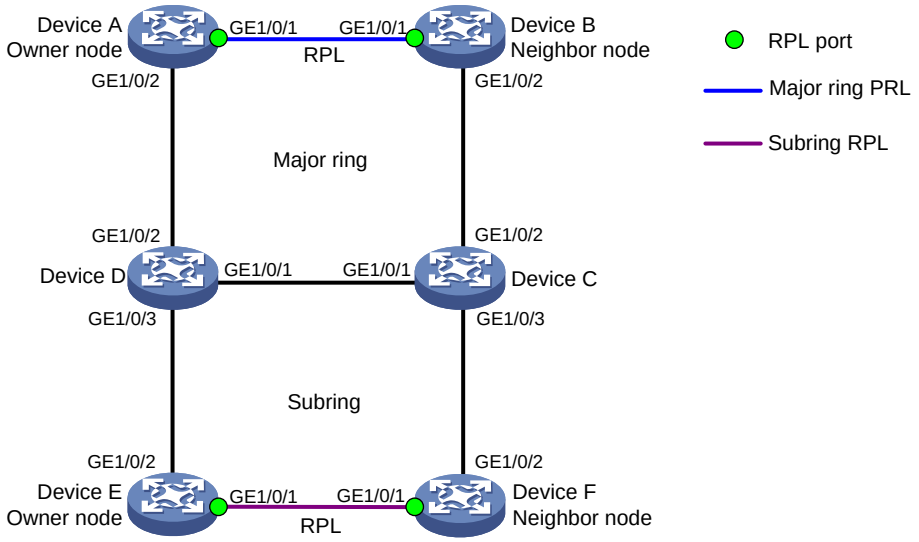
Example: Configuring one subring

Network configuration

As shown in Figure 12, perform the following tasks to eliminate loops on the network:

- Configure VLAN 100 and VLAN 200 as the control VLANs for the major ring and the subring, respectively.
- Configure VLANs 1 to 30 as the protected VLANs for the major ring and subring.
- Configure Device A as the owner node for the major ring, GigabitEthernet 1/0/1 as ERPS ring member port 0 and the RPL port, and GigabitEthernet 1/0/2 as ERPS ring member port 1.
- Configure Device B as the neighbor node for the major ring, GigabitEthernet 1/0/1 as ERPS ring member port 0 and the RPL port, and GigabitEthernet 1/0/2 as ERPS ring member port 1.
- Configure Devices C and D as interconnection nodes, GigabitEthernet 1/0/1 as ERPS ring member port 0, GigabitEthernet 1/0/2 as ERPS ring member port 1, and GigabitEthernet 1/0/3 as the interconnection port.
- Configure Device E as the owner node for the subring, GigabitEthernet 1/0/1 as ERPS ring member port 0 and the RPL port, and GigabitEthernet 1/0/2 as ERPS ring member port 1.
- Configure Device F as the neighbor node for the subring, GigabitEthernet 1/0/1 as ERPS ring member port 0 and the RPL port, and GigabitEthernet 1/0/2 as ERPS ring member port 1.

Figure 12 Network diagram



Procedure

1. Configure Device A.

   # Create VLANs 1 to 30, map these VLANs to MSTI 1, and activate the MST region configuration.

   ```
   <DeviceA> system-view
   [DeviceA] vlan 1 to 30
   [DeviceA] stp region-configuration
   [DeviceA-mst-region] instance 1 vlan 1 to 30
   [DeviceA-mst-region] active region-configuration
   [DeviceA-mst-region] quit
   ```

   # Set the link state change suppression interval to 0 seconds on GigabitEthernet 1/0/1.

   ```
   [DeviceA] interface gigabitethernet 1/0/1
   [DeviceA-GigabitEthernet1/0/1] link-delay up 0
   [DeviceA-GigabitEthernet1/0/1] link-delay down 0
   ```

   # Disable the spanning tree feature on the port.

   ```
   [DeviceA-GigabitEthernet1/0/1] undo stp enable
   ```

   # Configure the port as a trunk port and assign it to VLANs 1 to 30.

   ```
   [DeviceA-GigabitEthernet1/0/1] port link-type trunk
   [DeviceA-GigabitEthernet1/0/1] port trunk permit vlan 1 to 30
   [DeviceA-GigabitEthernet1/0/1] quit
   ```

   # Configure GigabitEthernet 1/0/2 in the same way GigabitEthernet 1/0/1 is configured.

   ```
   [DeviceA] interface gigabitethernet 1/0/2
   [DeviceA-GigabitEthernet1/0/2] link-delay up 0
   [DeviceA-GigabitEthernet1/0/2] link-delay down 0
   [DeviceA-GigabitEthernet1/0/2] undo stp enable
   [DeviceA-GigabitEthernet1/0/2] port link-type trunk
   [DeviceA-GigabitEthernet1/0/2] port trunk permit vlan 1 to 30
   [DeviceA-GigabitEthernet1/0/2] quit
   ```

   # Create ERPS ring 1.

   ```
   [DeviceA] erps ring 1
   ```

   # Configure ERPS ring member ports.

```
[DeviceA-erps-ring1] port0 interface gigabitethernet 1/0/1
[DeviceA-erps-ring1] port1 interface gigabitethernet 1/0/2
```

Create ERPS instance 1.

```
[DeviceA-erps-ring1] instance 1
```

Configure the node role.

```
[DeviceA-erps-ring1-inst1] node-role owner rpl port0
```

Configure the control VLAN.

```
[DeviceA-erps-ring1-inst1] control-vlan 100
```

Configure the protected VLANs.

```
[DeviceA-erps-ring1-inst1] protected-vlan reference-instance 1
```

Enable ERPS for instance 1.

```
[DeviceA-erps-ring1-inst1] instance enable
[DeviceA-erps-ring1-inst1] quit
[DeviceA-erps-ring1] quit
```

Enable CFD, and create a level-5 MD named **MD_A**.

```
[DeviceA] cfd enable
[DeviceA] cfd md MD_A level 5
```

Create service instance 1, in which the MA is identified by a VLAN and serves VLAN 1.

```
[DeviceA] cfd service-instance 1 ma-id vlan-based md MD_A vlan 1
```

Configure a MEP list in service instance 1, create outward-facing MEP 1001 in service instance 1, and enable CCM sending on GigabitEthernet 1/0/1.

```
[DeviceA] cfd meplist 1001 1002 service-instance 1
[DeviceA] interface gigabitethernet 1/0/1
[DeviceA-GigabitEthernet1/0/1] cfd mep 1001 service-instance 1 outbound
[DeviceA-GigabitEthernet1/0/1] cfd cc service-instance 1 mep 1001 enable
[DeviceA-GigabitEthernet1/0/1] quit
```

Create service instance 2, in which the MA is identified by a VLAN and serves VLAN 2.

```
[DeviceA] cfd service-instance 2 ma-id vlan-based md MD_A vlan 2
```

Configure a MEP list in service instance 2, create outward-facing MEP 2001 in service instance 1, and enable CCM sending on GigabitEthernet 1/0/2.

```
[DeviceA] cfd meplist 2001 2002 service-instance 2
[DeviceA] interface gigabitethernet 1/0/2
[DeviceA-GigabitEthernet1/0/2] cfd mep 2001 service-instance 2 outbound
[DeviceA-GigabitEthernet1/0/2] cfd cc service-instance 2 mep 2001 enable
[DeviceA-GigabitEthernet1/0/2] quit
```

Create track entry 1 and associate it with the CC function of CFD for MEP 1001 in service instance 1.

```
[DeviceA] track 1 cfd cc service-instance 1 mep 1001
```

Associate GigabitEthernet 1/0/1 with track entry 1 and bring up the port.

```
[DeviceA] interface gigabitethernet 1/0/1
[DeviceA-GigabitEthernet1/0/1] port erps ring 1 instance 1 track 1
[DeviceA-GigabitEthernet1/0/1] undo shutdown
[DeviceA-GigabitEthernet1/0/1] quit
```

Create track entry 2 and associate it with the CC function of CFD for MEP 2001 in service instance 2.

```
[DeviceA] track 2 cfd cc service-instance 2 mep 2001
```

Associate GigabitEthernet 1/0/2 with track entry 2 and bring up the port.

```
[DeviceA] interface gigabitethernet 1/0/2
```

```
[DeviceA-GigabitEthernet1/0/2] port erps ring 1 instance 1 track 2
[DeviceA-GigabitEthernet1/0/2] undo shutdown
[DeviceA-GigabitEthernet1/0/2] quit
```

Enable ERPS.

```
[DeviceA] erps enable
```

2. Configure Device B.

Create VLANs 1 to 30, map these VLANs to MSTI 1, and activate the MST region configuration.

```
<DeviceB> system-view
[DeviceB] vlan 1 to 30
[DeviceB] stp region-configuration
[DeviceB-mst-region] instance 1 vlan 1 to 30
[DeviceB-mst-region] active region-configuration
[DeviceB-mst-region] quit
```

Set the link state change suppression interval to 0 seconds on GigabitEthernet 1/0/1.

```
[DeviceB] interface gigabitethernet 1/0/1
[DeviceB-GigabitEthernet1/0/1] link-delay up 0
[DeviceB-GigabitEthernet1/0/1] link-delay down 0
```

Disable the spanning tree feature on the port.

```
[DeviceB-GigabitEthernet1/0/1] undo stp enable
```

Configure the port as a trunk port and assign it to VLANs 1 to 30.

```
[DeviceB-GigabitEthernet1/0/1] port link-type trunk
[DeviceB-GigabitEthernet1/0/1] port trunk permit vlan 1 to 30
[DeviceB-GigabitEthernet1/0/1] quit
```

Configure GigabitEthernet 1/0/2 in the same way GigabitEthernet 1/0/1 is configured.

```
[DeviceB] interface gigabitethernet 1/0/2
[DeviceB-GigabitEthernet1/0/2] link-delay up 0
[DeviceB-GigabitEthernet1/0/2] link-delay down 0
[DeviceB-GigabitEthernet1/0/2] undo stp enable
[DeviceB-GigabitEthernet1/0/2] port link-type trunk
[DeviceB-GigabitEthernet1/0/2] port trunk permit vlan 1 to 30
[DeviceB-GigabitEthernet1/0/2] quit
```

Create ERPS ring 1.

```
[DeviceB] erps ring 1
```

Configure ERPS ring member ports.

```
[DeviceB-erps-ring1] port0 interface gigabitethernet 1/0/1
[DeviceB-erps-ring1] port1 interface gigabitethernet 1/0/2
```

Create ERPS instance 1.

```
[DeviceB-erps-ring1] instance 1
```

Configure the node role.

```
[DeviceB-erps-ring1-inst1] node-role neighbor rpl port0
```

Configure the control VLAN.

```
[DeviceB-erps-ring1-inst1] control-vlan 100
```

Configure the protected VLANs.

```
[DeviceB-erps-ring1-inst1] protected-vlan reference-instance 1
```

Enable ERPS for instance 1.

```
[DeviceB-erps-ring1-inst1] instance enable
```

```
[DeviceB-erps-ring1-inst1] quit
[DeviceB-erps-ring1] quit
```

Enable CFD, and create a level-5 MD named **MD_A**.

```
[DeviceB] cfd enable
[DeviceB] cfd md MD_A level 5
```

Create service instance 1, in which the MA is identified by a VLAN and serves VLAN 1.

```
[DeviceB] cfd service-instance 1 ma-id vlan-based md MD_A vlan 1
```

Configure a MEP list in service instance 1, create outward-facing MEP 1002 in service instance 1, and enable CCM sending on GigabitEthernet 1/0/1.

```
[DeviceB] cfd meplist 1001 1002 service-instance 1
[DeviceB] interface gigabitethernet 1/0/1
[DeviceB-GigabitEthernet1/0/1] cfd mep 1002 service-instance 1 outbound
[DeviceB-GigabitEthernet1/0/1] cfd cc service-instance 1 mep 1002 enable
[DeviceB-GigabitEthernet1/0/1] quit
```

Create service instance 3, in which the MA is identified by a VLAN and serves VLAN 3.

```
[DeviceB] cfd service-instance 3 ma-id vlan-based md MD_A vlan 3
```

Configure a MEP list in service instance 3, create outward-facing MEP 3002 in service instance 2, and enable CCM sending on GigabitEthernet 1/0/2.

```
[DeviceB] cfd meplist 3001 3002 service-instance 3
[DeviceB] interface gigabitethernet 1/0/2
[DeviceB-GigabitEthernet1/0/2] cfd mep 3002 service-instance 3 outbound
[DeviceB-GigabitEthernet1/0/2] cfd cc service-instance 3 mep 3002 enable
[DeviceB-GigabitEthernet1/0/2] quit
```

Create track entry 1 and associate it with the CC function of CFD for MEP 1002 in service instance 1.

```
[DeviceB] track 1 cfd cc service-instance 1 mep 1002
```

Associate GigabitEthernet 1/0/1 with track entry 1 and bring up the port.

```
[DeviceB] interface gigabitethernet 1/0/1
[DeviceB-GigabitEthernet1/0/1] port erps ring 1 instance 1 track 1
[DeviceB-GigabitEthernet1/0/1] undo shutdown
[DeviceB-GigabitEthernet1/0/1] quit
```

Create track entry 3 and associate it with the CC function of CFD for MEP 3002 in service instance 3.

```
[DeviceB] track 3 cfd cc service-instance 3 mep 3002
```

Associate GigabitEthernet 1/0/2 with track entry 3 and bring up the port.

```
[DeviceB] interface gigabitethernet 1/0/2
[DeviceB-GigabitEthernet1/0/2] port erps ring 1 instance 1 track 2
[DeviceB-GigabitEthernet1/0/2] undo shutdown
[DeviceB-GigabitEthernet1/0/2] quit
```

Enable ERPS.

```
[DeviceB] erps enable
```

3. Configure Device C.

Create VLANs 1 to 30, map these VLANs to MSTI 1, and activate the MST region configuration.

```
<DeviceC> system-view
[DeviceC] vlan 1 to 30
[DeviceC] stp region-configuration
[DeviceC-mst-region] instance 1 vlan 1 to 30
```

```
[DeviceC-mst-region] active region-configuration
[DeviceC-mst-region] quit
```

Set the link state change suppression interval to 0 seconds on GigabitEthernet 1/0/1.

```
[DeviceC] interface gigabitethernet 1/0/1
[DeviceC-GigabitEthernet1/0/1] link-delay up 0
[DeviceC-GigabitEthernet1/0/1] link-delay down 0
```

Disable the spanning tree feature on the port.

```
[DeviceC-GigabitEthernet1/0/1] undo stp enable
```

Configure the port as a trunk port and assign it to VLANs 1 to 30.

```
[DeviceC-GigabitEthernet1/0/1] port link-type trunk
[DeviceC-GigabitEthernet1/0/1] port trunk permit vlan 1 to 30
[DeviceC-GigabitEthernet1/0/1] quit
```

Configure GigabitEthernet 1/0/2 in the same way GigabitEthernet 1/0/1 is configured.

```
[DeviceC] interface gigabitethernet 1/0/2
[DeviceC-GigabitEthernet1/0/2] link-delay up 0
[DeviceC-GigabitEthernet1/0/2] link-delay down 0
[DeviceC-GigabitEthernet1/0/2] undo stp enable
[DeviceC-GigabitEthernet1/0/2] port link-type trunk
[DeviceC-GigabitEthernet1/0/2] port trunk permit vlan 1 to 30
[DeviceC-GigabitEthernet1/0/2] quit
```

Configure GigabitEthernet 1/0/3 in the same way GigabitEthernet 1/0/1 is configured.

```
[DeviceC] interface gigabitethernet 1/0/3
[DeviceC-GigabitEthernet1/0/3] link-delay up 0
[DeviceC-GigabitEthernet1/0/3] link-delay down 0
[DeviceC-GigabitEthernet1/0/3] undo stp enable
[DeviceC-GigabitEthernet1/0/3] port link-type trunk
[DeviceC-GigabitEthernet1/0/3] port trunk permit vlan 1 to 30
[DeviceC-GigabitEthernet1/0/3] quit
```

Create ERPS ring 1.

```
[DeviceC] erps ring 1
```

Configure ERPS ring member ports.

```
[DeviceC-erps-ring1] port0 interface gigabitethernet 1/0/1
[DeviceC-erps-ring1] port1 interface gigabitethernet 1/0/2
```

Create ERPS instance 1.

```
[DeviceC-erps-ring1] instance 1
```

Configure the control VLAN.

```
[DeviceC-erps-ring1-inst1] control-vlan 100
```

Configure the protected VLANs.

```
[DeviceC-erps-ring1-inst1] protected-vlan reference-instance 1
```

Enable ERPS for instance 1.

```
[DeviceC-erps-ring1-inst1] instance enable
[DeviceC-erps-ring1-inst1] quit
[DeviceC-erps-ring1] quit
```

Enable CFD, and create a level-5 MD named **MD_A**.

```
[DeviceC] cfd enable
[DeviceC] cfd md MD_A level 5
```

Create service instance 3, in which the MA is identified by a VLAN and serves VLAN 3.

```
[DeviceC] cfd service-instance 3 ma-id vlan-based md MD_A vlan 3
```

Configure a MEP list in service instance 3, create outward-facing MEP 3001 in service instance 3, and enable CCM sending on GigabitEthernet 1/0/2.

```
[DeviceC] cfd meplist 3001 3002 service-instance 3
[DeviceC] interface gigabitethernet 1/0/2
[DeviceC-GigabitEthernet1/0/2] cfd mep 3001 service-instance 3 outbound
[DeviceC-GigabitEthernet1/0/2] cfd cc service-instance 3 mep 3001 enable
[DeviceC-GigabitEthernet1/0/2] quit
```

Create service instance 4, in which the MA is identified by a VLAN and serves VLAN 4.

```
[DeviceC] cfd service-instance 4 ma-id vlan-based md MD_A vlan 4
```

Configure a MEP list in service instance 4, create outward-facing MEP 4001 in service instance 4, and enable CCM sending on GigabitEthernet 1/0/1.

```
[DeviceC] cfd meplist 4001 4002 service-instance 4
[DeviceC] interface gigabitethernet 1/0/1
[DeviceC-GigabitEthernet1/0/1] cfd mep 4001 service-instance 4 outbound
[DeviceC-GigabitEthernet1/0/1] cfd cc service-instance 4 mep 4001 enable
[DeviceC-GigabitEthernet1/0/1] quit
```

Create track entry 1 and associate it with the CC function of CFD for MEP 3001 in service instance 3.

```
[DeviceC] track 1 cfd cc service-instance 3 mep 3001
```

Associate GigabitEthernet 1/0/2 with track entry 1 and bring up the port.

```
[DeviceC] interface gigabitethernet 1/0/2
[DeviceC-GigabitEthernet1/0/2] port erps ring 1 instance 1 track 1
[DeviceC-GigabitEthernet1/0/2] undo shutdown
[DeviceC-GigabitEthernet1/0/2] quit
```

Create track entry 2 and associate it with the CC function of CFD for MEP 4001 in service instance 4.

```
[DeviceC] track 2 cfd cc service-instance 4 mep 4001
```

Associate GigabitEthernet 1/0/1 with track entry 2 and bring up the port.

```
[DeviceC] interface gigabitethernet 1/0/1
[DeviceC-GigabitEthernet1/0/1] port erps ring 1 instance 1 track 2
[DeviceC-GigabitEthernet1/0/1] undo shutdown
[DeviceC-GigabitEthernet1/0/1] quit
```

Create ERPS ring 2.

```
[DeviceC] erps ring 2
```

Configure ERPS ring member ports.

```
[DeviceC-erps-ring2] port0 interface gigabitethernet 1/0/3
```

Configure ERPS ring 2 as the subring.

```
[DeviceC-erps-ring2] ring-type sub-ring
```

Create ERPS instance 1.

```
[DeviceC-erps-ring2] instance 1
```

Configure the node role.

```
[DeviceC-erps-ring2-inst1] node-role interconnection port0
```

Configure the control VLAN.

```
[DeviceC-erps-ring2-inst1] control-vlan 110
```

Configure the protected VLANs.

```
[DeviceC-erps-ring2-inst1] protected-vlan reference-instance 1
```

Enable ERPS for instance 1.

```
[DeviceC-erps-ring2-inst1] instance enable
[DeviceC-erps-ring2-inst1] quit
[DeviceC-erps-ring2] quit
```

Create service instance 5, in which the MA is identified by a VLAN and serves VLAN 5.

```
[DeviceC] cfd service-instance 5 ma-id vlan-based md MD_A vlan 5
```

Configure a MEP list in service instance 5, create outward-facing MEP 5001 in service instance 3, and enable CCM sending on GigabitEthernet 1/0/3.

```
[DeviceC] cfd meplist 5001 5002 service-instance 5
[DeviceC] interface gigabitethernet 1/0/3
[DeviceC-GigabitEthernet1/0/3] cfd mep 5001 service-instance 5 outbound
[DeviceC-GigabitEthernet1/0/3] cfd cc service-instance 5 mep 5001 enable
[DeviceC-GigabitEthernet1/0/3] quit
```

Create track entry 1 and associate it with the CC function of CFD for MEP 5001 in service instance 3.

```
[DeviceC] track 1 cfd cc service-instance 5 mep 5001
```

Associate GigabitEthernet 1/0/3 with track entry 1 and bring up the port.

```
[DeviceC] interface gigabitethernet 1/0/3
[DeviceC-GigabitEthernet1/0/3] port erps ring 2 instance 1 track 1
[DeviceC-GigabitEthernet1/0/3] undo shutdown
[DeviceC-GigabitEthernet1/0/3] quit
```

Enable ERPS.

```
[DeviceC] erps enable
```

4. Configure Device D.

Create VLANs 1 to 30, map these VLANs to MSTI 1, and activate the MST region configuration.

```
<DeviceD> system-view
[DeviceD] vlan 1 to 30
[DeviceD] stp region-configuration
[DeviceD-mst-region] instance 1 vlan 1 to 30
[DeviceD-mst-region] active region-configuration
[DeviceD-mst-region] quit
```

Set the link state change suppression interval to 0 seconds on GigabitEthernet 1/0/1.

```
[DeviceD] interface gigabitethernet 1/0/1
[DeviceD-GigabitEthernet1/0/1] link-delay up 0
[DeviceD-GigabitEthernet1/0/1] link-delay down 0
```

Disable the spanning tree feature on the port.

```
[DeviceD-GigabitEthernet1/0/1] undo stp enable
```

Configure the port as a trunk port and assign it to VLANs 1 to 30.

```
[DeviceD-GigabitEthernet1/0/1] port link-type trunk
[DeviceD-GigabitEthernet1/0/1] port trunk permit vlan 1 to 30
[DeviceD-GigabitEthernet1/0/1] quit
```

Configure GigabitEthernet 1/0/2 in the same way GigabitEthernet 1/0/1 is configured.

```
[DeviceD] interface gigabitethernet 1/0/2
[DeviceD-GigabitEthernet1/0/2] link-delay up 0
[DeviceD-GigabitEthernet1/0/2] link-delay down 0
[DeviceD-GigabitEthernet1/0/2] undo stp enable
[DeviceD-GigabitEthernet1/0/2] port link-type trunk
[DeviceD-GigabitEthernet1/0/2] port trunk permit vlan 1 to 30
```

```
[DeviceD-GigabitEthernet1/0/2] quit
```

Configure GigabitEthernet 1/0/3 in the same way GigabitEthernet 1/0/1 is configured.

```
[DeviceD] interface gigabitethernet 1/0/3
[DeviceD-GigabitEthernet1/0/3] link-delay up 0
[DeviceD-GigabitEthernet1/0/3] link-delay down 0
[DeviceD-GigabitEthernet1/0/3] undo stp enable
[DeviceD-GigabitEthernet1/0/3] port link-type trunk
[DeviceD-GigabitEthernet1/0/3] port trunk permit vlan 1 to 30
[DeviceD-GigabitEthernet1/0/3] quit
```

Create ERPS ring 1.

```
[DeviceD] erps ring 1
```

Configure ERPS ring member ports.

```
[DeviceD-erps-ring1] port0 interface gigabitethernet 1/0/1
[DeviceD-erps-ring1] port1 interface gigabitethernet 1/0/2
```

Create ERPS instance 1.

```
[DeviceD-erps-ring1] instance 1
```

Configure the control VLAN.

```
[DeviceD-erps-ring1-inst1] control-vlan 100
```

Configure the protected VLANs.

```
[DeviceD-erps-ring1-inst1] protected-vlan reference-instance 1
```

Enable ERPS for instance 1.

```
[DeviceD-erps-ring1-inst1] instance enable
[DeviceD-erps-ring1-inst1] quit
[DeviceD-erps-ring1] quit
```

Enable CFD, and create a level-5 MD named **MD_A**.

```
[DeviceD] cfd enable
[DeviceD] cfd md MD_A level 5
```

Create service instance 2, in which the MA is identified by a VLAN and serves VLAN 2.

```
[DeviceD] cfd service-instance 2 ma-id vlan-based md MD_A vlan 2
```

Configure a MEP list in service instance 2, create outward-facing MEP 2002 in service instance 2, and enable CCM sending on GigabitEthernet 1/0/2.

```
[DeviceD] cfd meplist 2001 2002 service-instance 2
[DeviceD] interface gigabitethernet 1/0/2
[DeviceD-GigabitEthernet1/0/2] cfd mep 2002 service-instance 2 outbound
[DeviceD-GigabitEthernet1/0/2] cfd cc service-instance 2 mep 2002 enable
[DeviceD-GigabitEthernet1/0/2] quit
```

Create service instance 4, in which the MA is identified by a VLAN and serves VLAN 4.

```
[DeviceD] cfd service-instance 4 ma-id vlan-based md MD_A vlan 4
```

Configure a MEP list in service instance 4, create outward-facing MEP 4002 in service instance 4, and enable CCM sending on GigabitEthernet 1/0/1.

```
[DeviceD] cfd meplist 4001 4002 service-instance 4
[DeviceD] interface gigabitethernet 1/0/1
[DeviceD-GigabitEthernet1/0/1] cfd mep 4002 service-instance 4 outbound
[DeviceD-GigabitEthernet1/0/1] cfd cc service-instance 4 mep 4002 enable
[DeviceD-GigabitEthernet1/0/1] quit
```

Create track entry 1 and associate it with the CC function of CFD for MEP 2002 in service instance 2.

```
[DeviceD] track 1 cfd cc service-instance 2 mep 2002
```

Associate GigabitEthernet 1/0/2 with track entry 1 and bring up the port.

```
[DeviceD] interface gigabitethernet 1/0/2
[DeviceD-GigabitEthernet1/0/2] port erps ring 1 instance 1 track 1
[DeviceD-GigabitEthernet1/0/2] undo shutdown
[DeviceD-GigabitEthernet1/0/2] quit
```

Create track entry 2 and associate it with the CC function of CFD for MEP 4002 in service instance 4.

```
[DeviceD] track 2 cfd cc service-instance 4 mep 4002
```

Associate GigabitEthernet 1/0/1 with track entry 2 and bring up the port.

```
[DeviceD] interface gigabitethernet 1/0/1
[DeviceD-GigabitEthernet1/0/1] port erps ring 1 instance 1 track 2
[DeviceD-GigabitEthernet1/0/1] undo shutdown
[DeviceD-GigabitEthernet1/0/1] quit
```

Create ERPS ring 2.

```
[DeviceD] erps ring 2
```

Configure ERPS ring member ports.

```
[DeviceD-erps-ring2] port0 interface gigabitethernet 1/0/3
```

Configure ERPS ring 2 as the subring.

```
[DeviceD-erps-ring2] ring-type sub-ring
```

Create ERPS instance 1.

```
[DeviceD-erps-ring2] instance 1
```

Configure the node role.

```
[DeviceD-erps-ring2-inst1] node-role interconnection port0
```

Configure the control VLAN.

```
[DeviceD-erps-ring2-inst1] control-vlan 110
```

Configure the protected VLANs.

```
[DeviceD-erps-ring2-inst1] protected-vlan reference-instance 1
```

Enable ERPS for instance 1.

```
[DeviceD-erps-ring2-inst1] instance enable
[DeviceD-erps-ring2-inst1] quit
[DeviceD-erps-ring2] quit
```

Create service instance 6, in which the MA is identified by a VLAN and serves VLAN 6.

```
[DeviceD] cfd service-instance 6 ma-id vlan-based md MD_A vlan 6
```

Configure a MEP list in service instance 6, create outward-facing MEP 6002 in service instance 3, and enable CCM sending on GigabitEthernet 1/0/3.

```
[DeviceD] cfd meplist 6001 6002 service-instance 6
[DeviceD] interface gigabitethernet 1/0/3
[DeviceD-GigabitEthernet1/0/3] cfd mep 6002 service-instance 6 outbound
[DeviceD-GigabitEthernet1/0/3] cfd cc service-instance 6 mep 6002 enable
[DeviceD-GigabitEthernet1/0/3] quit
```

Create track entry 3 and associate it with the CC function of CFD for MEP 6002 in service instance 6.

```
[DeviceD] track 3 cfd cc service-instance 6 mep 6002
```

Associate GigabitEthernet 1/0/3 with track entry 3 and bring up the port.

```
[DeviceD] interface gigabitethernet 1/0/3
[DeviceD-GigabitEthernet1/0/3] port erps ring 2 instance 1 track 3
[DeviceD-GigabitEthernet1/0/3] undo shutdown
[DeviceD-GigabitEthernet1/0/3] quit
```

Enable ERPS.

```
[DeviceD] erps enable
```

5. Configure Device E.

Create VLANs 1 to 30, map these VLANs to MSTI 1, and activate the MST region configuration.

```
<DeviceE> system-view
[DeviceE] vlan 1 to 30
[DeviceE] stp region-configuration
[DeviceE-mst-region] instance 1 vlan 1 to 30
[DeviceE-mst-region] active region-configuration
[DeviceE-mst-region] quit
```

Set the link state change suppression interval to 0 seconds on GigabitEthernet 1/0/1.

```
[DeviceE] interface gigabitethernet 1/0/1
[DeviceE-GigabitEthernet1/0/1] link-delay up 0
[DeviceE-GigabitEthernet1/0/1] link-delay down 0
```

Disable the spanning tree feature on the port.

```
[DeviceE-GigabitEthernet1/0/1] undo stp enable
```

Configure the port as a trunk port and assign it to VLANs 1 to 30.

```
[DeviceE-GigabitEthernet1/0/1] port link-type trunk
[DeviceE-GigabitEthernet1/0/1] port trunk permit vlan 1 to 30
[DeviceE-GigabitEthernet1/0/1] quit
```

Configure GigabitEthernet 1/0/2 in the same way GigabitEthernet 1/0/1 is configured.

```
[DeviceE] interface gigabitethernet 1/0/2
[DeviceE-GigabitEthernet1/0/2] link-delay up 0
[DeviceE-GigabitEthernet1/0/2] link-delay down 0
[DeviceE-GigabitEthernet1/0/2] undo stp enable
[DeviceE-GigabitEthernet1/0/2] port link-type trunk
[DeviceE-GigabitEthernet1/0/2] port trunk permit vlan 1 to 30
[DeviceE-GigabitEthernet1/0/2] quit
```

Create ERPS ring 2.

```
[DeviceE] erps ring 2
```

Configure ERPS ring member ports.

```
[DeviceE-erps-ring2] port0 interface gigabitethernet 1/0/1
[DeviceE-erps-ring2] port1 interface gigabitethernet 1/0/2
```

Configure ERPS ring 2 as the subring.

```
[DeviceE-erps-ring2] ring-type sub-ring
```

Create ERPS instance 1.

```
[DeviceE-erps-ring2] instance 1
```

Configure the node role.

```
[DeviceE-erps-ring2] node-role owner rpl port0
```

Configure the control VLAN.

```
[DeviceE-erps-ring2-inst1] control-vlan 110
```

Configure the protected VLANs.

```
[DeviceE-erps-ring2-inst1] protected-vlan reference-instance 1
```

Enable ERPS for instance 1.

```
[DeviceE-erps-ring2-inst1] instance enable
[DeviceE-erps-ring2-inst1] quit
```

```
[DeviceE-erps-ring2] quit
```

Enable CFD, and create a level-5 MD named **MD_A**.

```
[DeviceE] cfd enable
[DeviceE] cfd md MD_A level 5
```

Create service instance 6, in which the MA is identified by a VLAN and serves VLAN 6.

```
[DeviceE] cfd service-instance 6 ma-id vlan-based md MD_A vlan 6
```

Configure a MEP list in service instance 6, create outward-facing MEP 6001 in service instance 6, and enable CCM sending on GigabitEthernet 1/0/2.

```
[DeviceE] cfd meplist 6001 6002 service-instance 6
[DeviceE] interface gigabitethernet 1/0/2
[DeviceE-GigabitEthernet1/0/2] cfd mep 6001 service-instance 6 outbound
[DeviceE-GigabitEthernet1/0/2] cfd cc service-instance 6 mep 6001 enable
[DeviceE-GigabitEthernet1/0/2] quit
```

Create service instance 7, in which the MA is identified by a VLAN and serves VLAN 7.

```
[DeviceE] cfd service-instance 7 ma-id vlan-based md MD_A vlan 7
```

Configure a MEP list in service instance 7, create outward-facing MEP 7001 in service instance 7, and enable CCM sending on GigabitEthernet 1/0/1.

```
[DeviceE] cfd meplist 7001 7002 service-instance 7
[DeviceE] interface gigabitethernet 1/0/1
[DeviceE-GigabitEthernet1/0/1] cfd mep 7001 service-instance 7 outbound
[DeviceE-GigabitEthernet1/0/1] cfd cc service-instance 7 mep 7001 enable
[DeviceE-GigabitEthernet1/0/1] quit
```

Create track entry 1 and associate it with the CC function of CFD for MEP 6001 in service instance 6.

```
[DeviceE] track 1 cfd cc service-instance 6 mep 6001
```

Associate GigabitEthernet 1/0/2 with track entry 1 and bring up the port.

```
[DeviceE] interface gigabitethernet 1/0/2
[DeviceE-GigabitEthernet1/0/2] port erps ring 2 instance 1 track 1
[DeviceE-GigabitEthernet1/0/2] undo shutdown
[DeviceE-GigabitEthernet1/0/2] quit
```

Create track entry 2 and associate it with the CC function of CFD for MEP 7001 in service instance 7.

```
[DeviceE] track 2 cfd cc service-instance 7 mep 7001
```

Associate GigabitEthernet 1/0/1 with track entry 2 and bring up the port.

```
[DeviceE] interface gigabitethernet 1/0/1
[DeviceE-GigabitEthernet1/0/1] port erps ring 2 instance 1 track 2
[DeviceE-GigabitEthernet1/0/1] undo shutdown
[DeviceE-GigabitEthernet1/0/1] quit
```

Enable ERPS.

```
[DeviceE] erps enable
```

6. Configure Device F.

Create VLANs 1 to 30, map these VLANs to MSTI 1, and activate the MST region configuration.

```
<DeviceF> system-view
[DeviceF] vlan 1 to 30
[DeviceF] stp region-configuration
[DeviceF-mst-region] instance 1 vlan 1 to 30
[DeviceF-mst-region] active region-configuration
```

```
[DeviceF-mst-region] quit
```

Set the link state change suppression interval to 0 seconds on GigabitEthernet 1/0/1.

```
[DeviceF] interface gigabitethernet 1/0/1
[DeviceF-GigabitEthernet1/0/1] link-delay up 0
[DeviceF-GigabitEthernet1/0/1] link-delay down 0
```

Disable the spanning tree feature on the port.

```
[DeviceF-GigabitEthernet1/0/1] undo stp enable
[DeviceF-GigabitEthernet1/0/1] port link-type trunk
```

Configure the port as a trunk port and assign it to VLANs 1 to 30.

```
[DeviceF-GigabitEthernet1/0/1] port trunk permit vlan 1 to 30
[DeviceF-GigabitEthernet1/0/1] quit
```

Configure GigabitEthernet 1/0/2 in the same way GigabitEthernet 1/0/1 is configured.

```
[DeviceF] interface gigabitethernet 1/0/2
[DeviceF-GigabitEthernet1/0/2] link-delay up 0
[DeviceF-GigabitEthernet1/0/2] link-delay down 0
[DeviceF-GigabitEthernet1/0/2] undo stp enable
[DeviceF-GigabitEthernet1/0/2] port link-type trunk
[DeviceF-GigabitEthernet1/0/2] port trunk permit vlan 1 to 30
[DeviceF-GigabitEthernet1/0/2] quit
```

Create ERPS ring 2.

```
[DeviceF] erps ring 2
```

Configure ERPS ring member ports.

```
[DeviceF-erps-ring2] port0 interface gigabitethernet 1/0/1
[DeviceF-erps-ring2] port1 interface gigabitethernet 1/0/2
```

Configure ERPS ring 2 as the subring.

```
[DeviceF-erps-ring2] ring-type sub-ring
```

Create ERPS instance 1.

```
[DeviceF-erps-ring2] instance 1
```

Configure the node role.

```
[DeviceF-erps-ring2] node-role neighbor rpl port0
```

Configure the control VLAN.

```
[DeviceF-erps-ring2-inst1] control-vlan 110
```

Configure the protected VLANs.

```
[DeviceF-erps-ring2-inst1] protected-vlan reference-instance 1
```

Enable ERPS for instance 1.

```
[DeviceF-erps-ring2-inst1] instance enable
[DeviceF-erps-ring2-inst1] quit
[DeviceF-erps-ring2] quit
```

Enable CFD, and create a level-5 MD named **MD_A**.

```
[DeviceF] cfd enable
[DeviceF] cfd md MD_A level 5
```

Create service instance 5, in which the MA is identified by a VLAN and serves VLAN 5.

```
[DeviceF] cfd service-instance 5 ma-id vlan-based md MD_A vlan 5
```

Configure a MEP list in service instance 5, create outward-facing MEP 5002 in service instance 5, and enable CCM sending on GigabitEthernet 1/0/2.

```
[DeviceF] cfd meplist 5001 5002 service-instance 5
[DeviceF] interface gigabitethernet 1/0/2
```

```
[DeviceF-GigabitEthernet1/0/2] cfd mep 5002 service-instance 5 outbound
[DeviceF-GigabitEthernet1/0/2] cfd cc service-instance 5 mep 5002 enable
[DeviceF-GigabitEthernet1/0/2] quit
```

Create service instance 7, in which the MA is identified by a VLAN and serves VLAN 7.

```
[DeviceF] cfd service-instance 7 ma-id vlan-based md MD_A vlan 7
```

Configure a MEP list in service instance 7, create outward-facing MEP 7002 in service instance 7, and enable CCM sending on GigabitEthernet 1/0/1.

```
[DeviceF] cfd meplist 7001 7002 service-instance 7
[DeviceF] interface gigabitethernet 1/0/1
[DeviceF-GigabitEthernet1/0/1] cfd mep 7002 service-instance 7 outbound
[DeviceF-GigabitEthernet1/0/1] cfd cc service-instance 7 mep 7002 enable
[DeviceF-GigabitEthernet1/0/1] quit
```

Create track entry 1 and associate it with the CC function of CFD for MEP 5001 in service instance 5.

```
[DeviceF] track 1 cfd cc service-instance 5 mep 5002
```

Associate GigabitEthernet 1/0/2 with track entry 1 and bring up the port.

```
[DeviceF] interface gigabitethernet 1/0/2
[DeviceF-GigabitEthernet1/0/2] port erps ring 2 instance 1 track 1
[DeviceF-GigabitEthernet1/0/2] undo shutdown
[DeviceF-GigabitEthernet1/0/2] quit
```

Create track entry 2 and associate it with the CC function of CFD for MEP 7002 in service instance 7.

```
[DeviceF] track 2 cfd cc service-instance 7 mep 7002
```

Associate GigabitEthernet 1/0/1 with track entry 2 and bring up the port.

```
[DeviceF] interface gigabitethernet 1/0/1
[DeviceF-GigabitEthernet1/0/1] port erps ring 2 instance 1 track 2
[DeviceF-GigabitEthernet1/0/1] undo shutdown
[DeviceF-GigabitEthernet1/0/1] quit
```

Enable ERPS.

```
[DeviceF] erps enable
```

Verifying the configuration

Display information about ERPS instance 1 for Device A.

```
[Device A] display erps detail ring 1
 Ring ID               : 1
 Port0                 : GigabitEthernet1/0/1
 Port1                 : GigabitEthernet1/0/2
 Subring               : Yes
 Default MAC           : No
 Instance ID           : 1
 Node role             : Owner
 Node state            : Idle
 Connect(ring/instance): -
 Control VLAN          : 100
 Protected VLAN        : Reference-instance 1
 Guard timer           : 500 ms
 Hold-off timer        : 0 ms
 WTR timer             : 5 min
 Revertive operation   : Revertive
```

```
Enable status          : Yes, Active status : Yes
R-APS level            : 7
Port                   PortRole                PortStatus
--------------------------------------------------------------------------------
Port0                  RPL                     Block
Port1                  Non-RPL                 Up
```

The output shows the following information:

- Device A is the owner node.
- The ERPS ring is in idle state.
- The RPL port is blocked.
- The non-RPL port is unblocked.

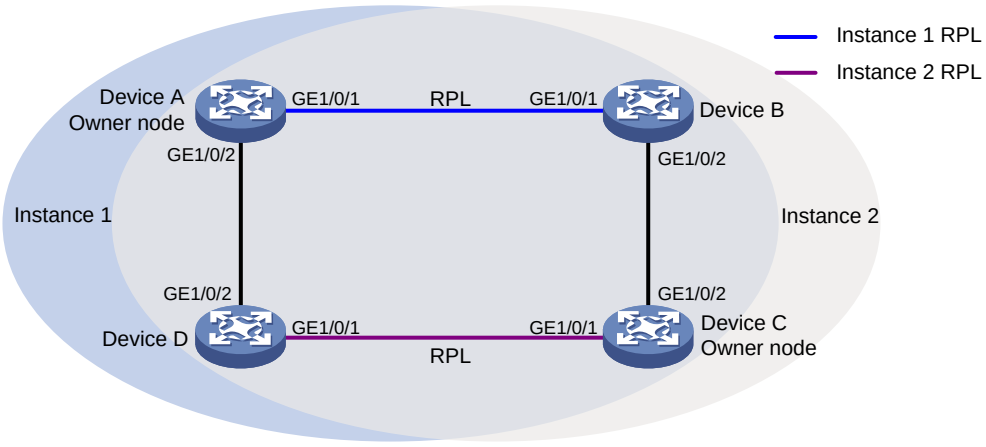
Example: Configuring one-ring multi-instance load balancing

Network configuration

As shown in Figure 13, perform the following tasks to improve network resource utilization and implement load balancing among links:

- Configure ERPS instances 1 and 2 on the ERPS ring.
- For ERPS instance 1, configure the following items:
  - Configure Device A as the owner node.
  - Configure the link between Devices A and Device B as the RPL.
  - Configure VLAN 100 as the control VLAN.
  - Configure VLANs 1 to 30 as the protected VLANs.
- For ERPS instance 2, configure the following items:
  - Configure Device A as the owner node.
  - Configure the link between Devices C and Device D as the RPL.
  - Configure VLAN 100 as the control VLAN.
  - Configure VLANs 31 to 60 as the protected VLANs.

Figure 13 Network diagram



Procedure

1. Configure Device A.

Create VLANs 1 to 60, map VLANs 1 to 30 to MSTI 1, map VLANs 31 to 60 to MSTI 2, and activate the MST region configuration.

```
<DeviceA> system-view
[DeviceA] vlan 1 to 60
[DeviceA] stp region-configuration
[DeviceA-mst-region] instance 1 vlan 1 to 30
[DeviceA-mst-region] instance 2 vlan 31 to 60
[DeviceA-mst-region] active region-configuration
[DeviceA-mst-region] quit
```

Set the link state change suppression interval to 0 seconds on GigabitEthernet 1/0/1.

```
[DeviceA] interface gigabitethernet 1/0/1
[DeviceA-GigabitEthernet1/0/1] link-delay up 0
[DeviceA-GigabitEthernet1/0/1] link-delay down 0
```

Disable the spanning tree feature on the port.

```
[DeviceA-GigabitEthernet1/0/1] undo stp enable
```

Configure the port as a trunk port and assign it to VLANs 1 to 60.

```
[DeviceA-GigabitEthernet1/0/1] port link-type trunk
[DeviceA-GigabitEthernet1/0/1] port trunk permit vlan 1 to 60
[DeviceA-GigabitEthernet1/0/1] quit
```

Configure GigabitEthernet 1/0/2 in the same way GigabitEthernet 1/0/1 is configured.

```
[DeviceA] interface gigabitethernet 1/0/2
[DeviceA-GigabitEthernet1/0/2] link-delay up 0
[DeviceA-GigabitEthernet1/0/2] link-delay down 0
[DeviceA-GigabitEthernet1/0/2] undo stp enable
[DeviceA-GigabitEthernet1/0/2] port link-type trunk
[DeviceA-GigabitEthernet1/0/2] port trunk permit vlan 1 to 60
[DeviceA-GigabitEthernet1/0/2] quit
```

Create ERPS ring 1.

```
[DeviceA] erps ring 1
```

Configure ERPS ring member ports.

```
[DeviceA-erps-ring1] port0 interface gigabitethernet 1/0/1
[DeviceA-erps-ring1] port1 interface gigabitethernet 1/0/2
```

Create ERPS instance 1.

```
[DeviceA-erps-ring1] instance 1
```

Configure the node role.

```
[DeviceA-erps-ring1-inst1] node-role owner rpl port0
```

Configure the control VLAN.

```
[DeviceA-erps-ring1-inst1] control-vlan 100
```

Configure the protected VLANs.

```
[DeviceA-erps-ring1-inst1] protected-vlan reference-instance 1
```

Enable ERPS for instance 1.

```
[DeviceA-erps-ring1-inst1] instance enable
[DeviceA-erps-ring1-inst1] quit
[DeviceA-erps-ring1] quit
```

Create ERPS instance 2.

```
[DeviceA-erps-ring1] instance 2
```

Configure the control VLAN.

```
[DeviceA-erps-ring1-inst2] control-vlan 110
```

Configure the protected VLANs.

```
[DeviceA-erps-ring1-inst2] protected-vlan reference-instance 2
```

Enable ERPS for instance 2.

```
[DeviceA-erps-ring1-inst2] instance enable
[DeviceA-erps-ring1-inst2] quit
[DeviceA-erps-ring1] quit
```

Enable CFD, and create a level-5 MD named **MD_A**.

```
[DeviceA] cfd enable
[DeviceA] cfd md MD_A level 5
```

Create service instance 1, in which the MA is identified by a VLAN and serves VLAN 1.

```
[DeviceA] cfd service-instance 1 ma-id vlan-based md MD_A vlan 1
```

Configure a MEP list in service instance 1, create outward-facing MEP 1001 in service instance 1, and enable CCM sending on GigabitEthernet 1/0/1.

```
[DeviceA] cfd meplist 1001 1002 service-instance 1
[DeviceA] interface gigabitethernet 1/0/1
[DeviceA-GigabitEthernet1/0/1] cfd mep 1001 service-instance 1 outbound
[DeviceA-GigabitEthernet1/0/1] cfd cc service-instance 1 mep 1001 enable
[DeviceA-GigabitEthernet1/0/1] quit
```

Create service instance 2, in which the MA is identified by a VLAN and serves VLAN 2.

```
[DeviceA] cfd service-instance 2 ma-id vlan-based md MD_A vlan 2
```

Configure a MEP list in service instance 2, create outward-facing MEP 2001 in service instance 1, and enable CCM sending on GigabitEthernet 1/0/2.

```
[DeviceA] cfd meplist 2001 2002 service-instance 2
[DeviceA] interface gigabitethernet 1/0/2
[DeviceA-GigabitEthernet1/0/2] cfd mep 2001 service-instance 2 outbound
[DeviceA-GigabitEthernet1/0/2] cfd cc service-instance 2 mep 2001 enable
[DeviceA-GigabitEthernet1/0/2] quit
```

Create track entry 1 and associate it with the CC function of CFD for MEP 1001 in service instance 1.

```
[DeviceA] track 1 cfd cc service-instance 1 mep 1001
```

Associate GigabitEthernet 1/0/1 with track entry 1 and bring up the port for ERPS instances 1 and 2.

```
[DeviceA] interface gigabitethernet 1/0/1
[DeviceA-GigabitEthernet1/0/1] port erps ring 1 instance 1 track 1
[DeviceA-GigabitEthernet1/0/1] port erps ring 1 instance 2 track 1
[DeviceA-GigabitEthernet1/0/1] undo shutdown
[DeviceA-GigabitEthernet1/0/1] quit
```

Create track entry 2 and associate it with the CC function of CFD for MEP 2001 in service instance 2.

```
[DeviceA] track 2 cfd cc service-instance 2 mep 2001
```

Associate GigabitEthernet 1/0/2 with track entry 2 and bring up the port for ERPS instances 1 and 2.

```
[DeviceA] interface gigabitethernet 1/0/2
[DeviceA-GigabitEthernet1/0/2] port erps ring 1 instance 1 track 2
[DeviceA-GigabitEthernet1/0/2] port erps ring 1 instance 2 track 2
[DeviceA-GigabitEthernet1/0/2] undo shutdown
[DeviceA-GigabitEthernet1/0/2] quit
```

Enable ERPS.

```
[DeviceA] erps enable
```

2. Configure Device B.

Create VLANs 1 to 60, map VLANs 1 to 30 to MSTI 1, map VLANs 31 to 60 to MSTI 2, and activate the MST region configuration.

```
<DeviceB> system-view
[DeviceB] vlan 1 to 60
[DeviceB] stp region-configuration
[DeviceB-mst-region] instance 1 vlan 1 to 30
[DeviceB-mst-region] instance 2 vlan 31 to 60
[DeviceB-mst-region] active region-configuration
[DeviceB-mst-region] quit
```

Set the link state change suppression interval to 0 seconds on GigabitEthernet 1/0/1.

```
[DeviceB] interface gigabitethernet 1/0/1
[DeviceB-GigabitEthernet1/0/1] link-delay up 0
[DeviceB-GigabitEthernet1/0/1] link-delay down 0
```

Disable the spanning tree feature on the port.

```
[DeviceB-GigabitEthernet1/0/1] undo stp enable
```

Configure the port as a trunk port and assign it to VLANs 1 to 60.

```
[DeviceB-GigabitEthernet1/0/1] port link-type trunk
[DeviceB-GigabitEthernet1/0/1] port trunk permit vlan 1 to 60
[DeviceB-GigabitEthernet1/0/1] quit
```

Configure GigabitEthernet 1/0/2 in the same way GigabitEthernet 1/0/1 is configured.

```
[DeviceB] interface gigabitethernet 1/0/2
[DeviceB-GigabitEthernet1/0/2] link-delay up 0
[DeviceB-GigabitEthernet1/0/2] link-delay down 0
[DeviceB-GigabitEthernet1/0/2] undo stp enable
[DeviceB-GigabitEthernet1/0/2] port link-type trunk
[DeviceB-GigabitEthernet1/0/2] port trunk permit vlan 1 to 60
[DeviceB-GigabitEthernet1/0/2] quit
```

Create ERPS ring 1.

```
[DeviceB] erps ring 1
```

Configure ERPS ring member ports.

```
[DeviceB-erps-ring1] port0 interface gigabitethernet 1/0/1
[DeviceB-erps-ring1] port1 interface gigabitethernet 1/0/2
```

Create ERPS instance 1.

```
[DeviceB-erps-ring1] instance 1
```

Configure the node role.

```
[DeviceB-erps-ring1-inst1] node-role neighbor rpl port0
```

Configure the control VLAN.

```
[DeviceB-erps-ring1-inst1] control-vlan 100
```

Configure the protected VLANs.

```
[DeviceB-erps-ring1-inst1] protected-vlan reference-instance 1
```

Enable ERPS for instance 1.

```
[DeviceB-erps-ring1-inst1] instance enable
[DeviceB-erps-ring1-inst1] quit
[DeviceB-erps-ring1] quit
```

Create ERPS instance 2.

```
[DeviceB-erps-ring1] instance 2
```

Configure the control VLAN.

```
[DeviceB-erps-ring1-inst2] control-vlan 110
```

Configure the protected VLANs.

```
[DeviceB-erps-ring1-inst2] protected-vlan reference-instance 2
```

Enable ERPS for instance 2.

```
[DeviceB-erps-ring1-inst2] instance enable
[DeviceB-erps-ring1-inst2] quit
[DeviceB-erps-ring1] quit
```

Enable CFD, and create a level-5 MD named **MD_A**.

```
[DeviceB] cfd enable
[DeviceB] cfd md MD_A level 5
```

Create service instance 1, in which the MA is identified by a VLAN and serves VLAN 1.

```
[DeviceB] cfd service-instance 1 ma-id vlan-based md MD_A vlan 1
```

Configure a MEP list in service instance 1, create outward-facing MEP 1002 in service instance 1, and enable CCM sending on GigabitEthernet 1/0/1.

```
[DeviceB] cfd meplist 1001 1002 service-instance 1
[DeviceB] interface gigabitethernet 1/0/1
[DeviceB-GigabitEthernet1/0/1] cfd mep 1002 service-instance 1 outbound
[DeviceB-GigabitEthernet1/0/1] cfd cc service-instance 1 mep 1002 enable
[DeviceB-GigabitEthernet1/0/1] quit
```

Create service instance 3, in which the MA is identified by a VLAN and serves VLAN 3.

```
[DeviceB] cfd service-instance 3 ma-id vlan-based md MD_A vlan 3
```

Configure a MEP list in service instance 3, create outward-facing MEP 3002 in service instance 3, and enable CCM sending on GigabitEthernet 1/0/2.

```
[DeviceB] cfd meplist 3001 3002 service-instance 3
[DeviceB] interface gigabitethernet 1/0/2
[DeviceB-GigabitEthernet1/0/2] cfd mep 3002 service-instance 3 outbound
[DeviceB-GigabitEthernet1/0/2] cfd cc service-instance 3 mep 3002 enable
[DeviceB-GigabitEthernet1/0/2] quit
```

Create track entry 1 and associate it with the CC function of CFD for MEP 1002 in service instance 1.

```
[DeviceB] track 1 cfd cc service-instance 1 mep 1002
```

Associate GigabitEthernet 1/0/1 with track entry 1 and bring up the port for ERPS instances 1 and 2.

```
[DeviceB] interface gigabitethernet 1/0/1
[DeviceB-GigabitEthernet1/0/1] port erps ring 1 instance 1 track 1
[DeviceB-GigabitEthernet1/0/1] port erps ring 1 instance 2 track 1
[DeviceB-GigabitEthernet1/0/1] undo shutdown
[DeviceB-GigabitEthernet1/0/1] quit
```

Create track entry 2 and associate it with the CC function of CFD for MEP 3002 in service instance 3.

```
[DeviceB] track 2 cfd cc service-instance 3 mep 3002
```

Associate GigabitEthernet 1/0/2 with track entry 2 and bring up the port for ERPS instances 1 and 2.

```
[DeviceB] interface gigabitethernet 1/0/2
[DeviceB-GigabitEthernet1/0/2] port erps ring 1 instance 1 track 2
```

```
[DeviceB-GigabitEthernet1/0/2] port erps ring 1 instance 2 track 2
[DeviceB-GigabitEthernet1/0/2] undo shutdown
[DeviceB-GigabitEthernet1/0/2] quit
```

Enable ERPS.

```
[DeviceB] erps enable
```

3. Configure Device C.

Create VLANs 1 to 60, map VLANs 1 to 30 to MSTI 1, map VLANs 31 to 60 to MSTI 2, and activate the MST region configuration.

```
<DeviceC> system-view
[DeviceC] vlan 1 to 60
[DeviceC] stp region-configuration
[DeviceC-mst-region] instance 1 vlan 1 to 30
[DeviceC-mst-region] instance 2 vlan 31 to 60
[DeviceC-mst-region] active region-configuration
[DeviceC-mst-region] quit
```

Set the link state change suppression interval to 0 seconds on GigabitEthernet 1/0/1.

```
[DeviceC] interface gigabitethernet 1/0/1
[DeviceC-GigabitEthernet1/0/1] link-delay up 0
[DeviceC-GigabitEthernet1/0/1] link-delay down 0
```

Disable the spanning tree feature on the port.

```
[DeviceC-GigabitEthernet1/0/1] undo stp enable
```

Configure the port as a trunk port and assign it to VLANs 1 to 60.

```
[DeviceC-GigabitEthernet1/0/1] port link-type trunk
[DeviceC-GigabitEthernet1/0/1] port trunk permit vlan 1 to 60
[DeviceC-GigabitEthernet1/0/1] quit
```

Configure GigabitEthernet 1/0/2 in the same way GigabitEthernet 1/0/1 is configured.

```
[DeviceC] interface gigabitethernet 1/0/2
[DeviceC-GigabitEthernet1/0/2] link-delay up 0
[DeviceC-GigabitEthernet1/0/2] link-delay down 0
[DeviceC-GigabitEthernet1/0/2] undo stp enable
[DeviceC-GigabitEthernet1/0/2] port link-type trunk
[DeviceC-GigabitEthernet1/0/2] port trunk permit vlan 1 to 60
[DeviceC-GigabitEthernet1/0/2] quit
```

Create ERPS ring 1.

```
[DeviceC] erps ring 1
```

Configure ERPS ring member ports.

```
[DeviceC-erps-ring1] port0 interface gigabitethernet 1/0/1
[DeviceC-erps-ring1] port1 interface gigabitethernet 1/0/2
```

Create ERPS instance 1.

```
[DeviceC-erps-ring1] instance 1
```

Configure the control VLAN.

```
[DeviceC-erps-ring1-inst1] control-vlan 100
```

Configure the protected VLANs.

```
[DeviceC-erps-ring1-inst1] protected-vlan reference-instance 1
```

Enable ERPS for instance 1.

```
[DeviceC-erps-ring1-inst1] instance enable
[DeviceC-erps-ring1-inst1] quit
```

```
[DeviceC-erps-ring1] quit
```

Create ERPS instance 2.

```
[DeviceC-erps-ring1] instance 2
```

Configure the node role.

```
[DeviceC-erps-ring1-inst2] node-role owner rpl port0
```

Configure the control VLAN.

```
[DeviceC-erps-ring1-inst2] control-vlan 110
```

Configure the protected VLANs.

```
[DeviceC-erps-ring1-inst2] protected-vlan reference-instance 2
```

Enable ERPS for instance 2.

```
[DeviceC-erps-ring1-inst2] instance enable
[DeviceC-erps-ring1-inst2] quit
[DeviceC-erps-ring1] quit
```

Enable CFD, and create a level-5 MD named **MD_A**.

```
[DeviceC] cfd enable
[DeviceC] cfd md MD_A level 5
```

Create service instance 3, in which the MA is identified by a VLAN and serves VLAN 3.

```
[DeviceC] cfd service-instance 3 ma-id vlan-based md MD_A vlan 3
```

Configure a MEP list in service instance 3, create outward-facing MEP 3001 in service instance 3, and enable CCM sending on GigabitEthernet 1/0/2.

```
[DeviceC] cfd meplist 3001 3002 service-instance 3
[DeviceC] interface gigabitethernet 1/0/2
[DeviceC-GigabitEthernet1/0/2] cfd mep 3001 service-instance 3 outbound
[DeviceC-GigabitEthernet1/0/2] cfd cc service-instance 3 mep 3001 enable
[DeviceC-GigabitEthernet1/0/2] quit
```

Create service instance 4, in which the MA is identified by a VLAN and serves VLAN 4.

```
[DeviceC] cfd service-instance 4 ma-id vlan-based md MD_A vlan 4
```

Configure a MEP list in service instance 4, create outward-facing MEP 4001 in service instance 4, and enable CCM sending on GigabitEthernet 1/0/1.

```
[DeviceC] cfd meplist 4001 4002 service-instance 4
[DeviceC] interface gigabitethernet 1/0/1
[DeviceC-GigabitEthernet1/0/1] cfd mep 4001 service-instance 4 outbound
[DeviceC-GigabitEthernet1/0/1] cfd cc service-instance 4 mep 4001 enable
[DeviceC-GigabitEthernet1/0/1] quit
```

Create track entry 1 and associate it with the CC function of CFD for MEP 3001 in service instance 3.

```
[DeviceC] track 1 cfd cc service-instance 3 mep 3001
```

Associate GigabitEthernet 1/0/2 with track entry 1 and bring up the port for ERPS instances 1 and 2.

```
[DeviceC] interface gigabitethernet 1/0/2
[DeviceC-GigabitEthernet1/0/2] port erps ring 1 instance 1 track 1
[DeviceC-GigabitEthernet1/0/2] port erps ring 1 instance 2 track 1
[DeviceC-GigabitEthernet1/0/2] undo shutdown
[DeviceC-GigabitEthernet1/0/2] quit
```

Create track entry 2 and associate it with the CC function of CFD for MEP 4001 in service instance 4.

```
[DeviceC] track 2 cfd cc service-instance 4 mep 4001
```

Associate GigabitEthernet 1/0/1 with track entry 2 and bring up the port for ERPS instances 1 and 2.

```
[DeviceC] interface gigabitethernet 1/0/1
[DeviceC-GigabitEthernet1/0/1] port erps ring 1 instance 1 track 2
[DeviceC-GigabitEthernet1/0/1] port erps ring 1 instance 2 track 2
[DeviceC-GigabitEthernet1/0/1] undo shutdown
[DeviceC-GigabitEthernet1/0/1] quit
```

Enable ERPS.

```
[DeviceC] erps enable
```

4. Configure Device D.

Create VLANs 1 to 60, map VLANs 1 to 30 to MSTI 1, map VLANs 31 to 60 to MSTI 2, and activate the MST region configuration.

```
<DeviceD> system-view
[DeviceD] vlan 1 to 60
[DeviceD] stp region-configuration
[DeviceD-mst-region] instance 1 vlan 1 to 30
[DeviceD-mst-region] instance 2 vlan 31 to 60
[DeviceD-mst-region] active region-configuration
[DeviceD-mst-region] quit
```

Set the link state change suppression interval to 0 seconds on GigabitEthernet 1/0/1.

```
[DeviceD] interface gigabitethernet 1/0/1
[DeviceD-GigabitEthernet1/0/1] link-delay up 0
[DeviceD-GigabitEthernet1/0/1] link-delay down 0
```

Disable the spanning tree feature on the port.

```
[DeviceD-GigabitEthernet1/0/1] undo stp enable
```

Configure the port as a trunk port and assign it to VLANs 1 to 60.

```
[DeviceD-GigabitEthernet1/0/1] port link-type trunk
[DeviceD-GigabitEthernet1/0/1] port trunk permit vlan 1 to 60
[DeviceD-GigabitEthernet1/0/1] quit
```

Configure GigabitEthernet 1/0/2 in the same way GigabitEthernet 1/0/1 is configured.

```
[DeviceD] interface gigabitethernet 1/0/2
[DeviceD-GigabitEthernet1/0/2] link-delay up 0
[DeviceD-GigabitEthernet1/0/2] link-delay down 0
[DeviceD-GigabitEthernet1/0/2] undo stp enable
[DeviceD-GigabitEthernet1/0/2] port link-type trunk
[DeviceD-GigabitEthernet1/0/2] port trunk permit vlan 1 to 60
[DeviceD-GigabitEthernet1/0/2] quit
```

Create ERPS ring 1.

```
[DeviceD] erps ring 1
```

Configure ERPS ring member ports.

```
[DeviceD-erps-ring1] port0 interface gigabitethernet 1/0/1
[DeviceD-erps-ring1] port1 interface gigabitethernet 1/0/2
```

Create ERPS instance 1.

```
[DeviceD-erps-ring1] instance 1
```

Configure the control VLAN.

```
[DeviceD-erps-ring1-inst1] control-vlan 100
```

Configure the protected VLANs.

```
[DeviceD-erps-ring1-inst1] protected-vlan reference-instance 1
```

Enable ERPS for instance 1.

```
[DeviceD-erps-ring1-inst1] instance enable
[DeviceD-erps-ring1-inst1] quit
```

Create ERPS instance 2.

```
[DeviceD-erps-ring1] instance 2
```

Configure the node role.

```
[DeviceD-erps-ring1-inst2] node-role neighbor rpl port0
```

Configure the control VLAN.

```
[DeviceD-erps-ring1-inst2] control-vlan 110
```

Configure the protected VLANs.

```
[DeviceD-erps-ring1-inst2] protected-vlan reference-instance 2
```

Enable ERPS for instance 2.

```
[DeviceD-erps-ring1-inst2] instance enable
[DeviceD-erps-ring1-inst2] quit
[DeviceD-erps-ring1] quit
```

Enable CFD, and create a level-5 MD named **MD_A**.

```
[DeviceD] cfd enable
[DeviceD] cfd md MD_A level 5
```

Create service instance 2, in which the MA is identified by a VLAN and serves VLAN 2.

```
[DeviceD] cfd service-instance 2 ma-id vlan-based md MD_A vlan 2
```

Configure a MEP list in service instance 2, create outward-facing MEP 2002 in service instance 2, and enable CCM sending on GigabitEthernet 1/0/2.

```
[DeviceD] cfd meplist 2001 2002 service-instance 2
[DeviceD] interface gigabitethernet 1/0/2
[DeviceD-GigabitEthernet1/0/2] cfd mep 2002 service-instance 2 outbound
[DeviceD-GigabitEthernet1/0/2] cfd cc service-instance 2 mep 2002 enable
[DeviceD-GigabitEthernet1/0/2] quit
```

Create service instance 4, in which the MA is identified by a VLAN and serves VLAN 4.

```
[DeviceD] cfd service-instance 4 ma-id vlan-based md MD_A vlan 4
```

Configure a MEP list in service instance 4, create outward-facing MEP 4002 in service instance 4, and enable CCM sending on GigabitEthernet 1/0/1.

```
[DeviceD] cfd meplist 4001 4002 service-instance 4
[DeviceD] interface gigabitethernet 1/0/1
[DeviceD-GigabitEthernet1/0/1] cfd mep 4002 service-instance 4 outbound
[DeviceD-GigabitEthernet1/0/1] cfd cc service-instance 4 mep 4002 enable
[DeviceD-GigabitEthernet1/0/1] quit
```

Create track entry 1 and associate it with the CC function of CFD for MEP 2002 in service instance 2.

```
[DeviceD] track 1 cfd cc service-instance 2 mep 2002
```

Associate GigabitEthernet 1/0/2 with track entry 1 and bring up the port for ERPS instances 1 and 2.

```
[DeviceD] interface gigabitethernet 1/0/2
[DeviceD-GigabitEthernet1/0/2] port erps ring 1 instance 1 track 1
[DeviceD-GigabitEthernet1/0/2] port erps ring 1 instance 2 track 1
[DeviceD-GigabitEthernet1/0/2] undo shutdown
[DeviceD-GigabitEthernet1/0/2] quit
```

Create track entry 2 and associate it with the CC function of CFD for MEP 4002 in service instance 4.

```
[DeviceD] track 2 cfd cc service-instance 4 mep 4002
```

Associate GigabitEthernet 1/0/1 with track entry 2 and bring up the port for ERPS instances 1 and 2.

```
[DeviceD] interface gigabitethernet 1/0/1
[DeviceD-GigabitEthernet1/0/1] port erps ring 1 instance 1 track 2
[DeviceD-GigabitEthernet1/0/1] port erps ring 1 instance 2 track 2
[DeviceD-GigabitEthernet1/0/1] undo shutdown
[DeviceD-GigabitEthernet1/0/1] quit
```

Enable ERPS.

```
[DeviceD] erps enable
```

Verifying the configuration

Display information about ERPS instance 1 for Device A.

```
[Device A] display erps detail ring 1
 Ring ID               : 1
 Port0                 : GigabitEthernet1/0/1
 Port1                 : GigabitEthernet1/0/2
 Subring               : No
 Default MAC           : No
 Instance ID           : 1
 Node role             : Owner
 Node state            : Idle
 Connect(ring/instance): -
 Control VLAN          : 100
 Protected VLAN        : Reference-instance 1
 Guard timer           : 500 ms
 Hold-off timer        : 0 ms
 WTR timer             : 5 min
 Revertive operation   : Revertive
 Enable status         : Yes, Active status : Yes
 R-APS level           : 7
 Port                  PortRole               PortStatus
 --------------------------------------------------------------------------------
 Port0                 RPL                    Block
 Port1                 Non-RPL                Up

 Instance ID           : 2
 Node role             : Normal
 Node state            : Idle
 Connect(ring/instance): -
 Control VLAN          : 100
 Protected VLAN        : Reference-instance 2
 Guard timer           : 500 ms
 Hold-off timer        : 0 ms
 WTR timer             : 5 min
 Revertive operation   : Revertive
 Enable status         : Yes, Active status : Yes
 R-APS level           : 7
 Port                  PortRole               PortStatus
```

```
--------------------------------------------------------------------------------
Port0                    Non-RPL                  Up
Port1                    Non-RPL                  Up
```

The output shows the following information:

- For ERPS instance 1:
  - Device A is the owner node.
  - The ERPS ring is in idle state.
  - The RPL port is blocked.
  - The non-RPL port is unblocked.
- For ERPS instance 2:
  - Device A is a normal node.
  - The ERPS ring is in idle state.
  - The non-RPL port is unblocked.

Troubleshooting ERPS

The owner node cannot receive SF packets from a faulty node when the link state is normal

Symptom

The link between the owner node and the faulty node is available, but the owner node cannot receive SF packets sent by the faulty node. The RPL port is blocked.

Analysis

Possible reasons include:

- ERPS is not enabled for some nodes on the ERPS ring.
- The ring IDs are different for the nodes on the same ERPS ring.
- The control VLAN IDs are different for the nodes in the same ERPS instance.
- A port on the ERPS ring is faulty.

Solutions

To resolve the problem:

- Use the **`display erps`** command to examine whether ERPS is enabled for all nodes on the ERPS ring. If ERPS is disabled for some nodes, use the **`erps enable`** command to enable ERPS for the nodes.
- Set the same ring ID for all nodes on a ERPS ring and configure the same control VLAN for all nodes in an ERPS instance.
- Use the **`display erps detail`** command to examine the port status for all nodes. Bring up the ports in down state.
- Use the **`debugging erps`** command on all nodes to view debugging information about packets and node status.

Contents

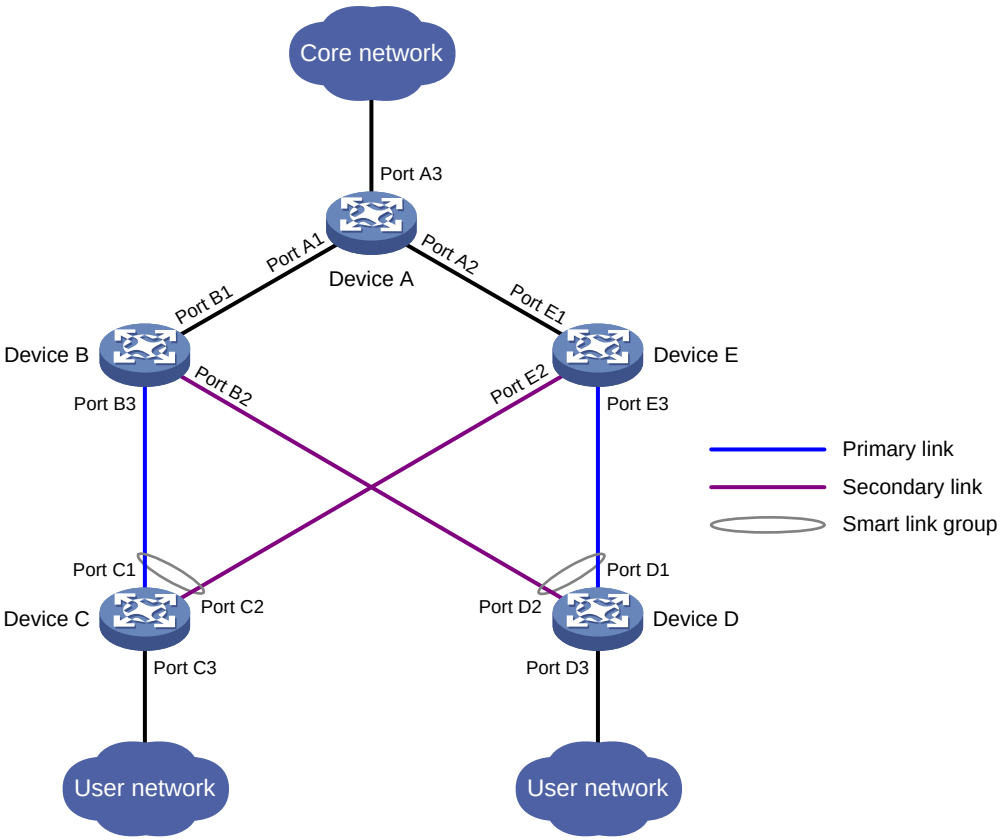
Configuring Smart Link

About Smart Link

Application scenario

Smart Link provides link redundancy and subsecond convergence time in a dual uplink network. As shown in Figure 1, Smart Link is configured on Device C and Device D. The secondary link takes over quickly when the primary link fails.

Figure 1 Dual uplink network diagram



A Smart Link network has the following devices:

- **Smart Link devices**—A Smart Link device has two uplinks. A Smart Link device must be configured with a smart link group and a transmit control VLAN to transmit flush messages. Device C and Device D in Figure 1 are Smart Link devices.
- **Associated devices**—An associated device is an uplink device to which Smart Link devices are connected. An associated device supports Smart Link, and receives flush messages sent from the specified control VLAN. When a primary/secondary link switchover occurs, the associated device updates the MAC address entries and ARP/ND entries according to received flush messages. Device A, Device B, and Device E in Figure 1 are associated devices.

Terminology

Smart link group

A smart link group consists of only two member ports: the primary and the secondary ports. Only one port is active for forwarding at a time, and the other port is blocked and in standby state. When link failure occurs on the active port due to port shutdown or the presence of unidirectional link, the standby port becomes active and takes over. The original active port transits to the blocked state.

As shown in Figure 1, Port C1 and Port C2 of Device C form a smart link group. Port C1 is active, and Port C2 is standby. Port D1 and Port D2 of Device D form another smart link group. Port D1 is active, and Port D2 is standby.

Primary/secondary port

Primary port and secondary port are two port types in a smart link group. When both ports in a smart link group are up, the primary port preferentially transits to the forwarding state. The secondary port stays in standby state. When the primary port fails, the secondary port takes over to forward traffic.

As shown in Figure 1, Port C1 of Device C and Port D1 of Device D are primary ports. Port C2 of Device C and Port D2 of Device D are secondary ports.

Primary/secondary link

The link that connects the primary port in a smart link group is the primary link. The link that connects the secondary port is the secondary link.

Flush message

When link switchover occurs, the smart link group uses flush messages to notify other devices to refresh their MAC address entries and ARP/ND entries. Flush messages are common multicast data packets, and will be dropped by a blocked receiving port.

Protected VLAN

A smart link group controls the forwarding state of protected VLANs. Each smart link group on a port controls a different protected VLAN. The state of the port in a protected VLAN is determined by the state of the port in the smart link group.

Transmit control VLAN

The transmit control VLAN is used for transmitting flush messages. When link switchover occurs, the devices (such as Device C and Device D in Figure 1) send flush messages within the transmit control VLAN.

Receive control VLAN

The receive control VLAN is used for receiving and processing flush messages. When link switchover occurs, the devices (such as Device A, Device B, and Device E in Figure 1) receive and process flush messages in the receive control VLAN. In addition, they refresh their MAC address entries and ARP/ND entries.

How Smart Link works

Link backup

As shown in Figure 1, the link on Port C1 of Device C is the primary link. The link on Port C2 of Device C is the secondary link. Port C1 is in forwarding state, and Port C2 is in standby state. When the primary link fails, Port C2 takes over to forward traffic and Port C1 is blocked and placed in standby state.

When a port switches to the forwarding state, the system outputs log information to notify the user of the port state change.

Topology change

Link switchover might outdate the MAC address entries and ARP/ND entries on all devices. A flush update mechanism is provided to ensure correct packet transmission. With this mechanism, a Smart Link-enabled device updates its information by transmitting flush messages over the backup link to its upstream devices. This mechanism requires the upstream devices to be capable of recognizing Smart Link flush messages to update their MAC address forwarding entries and ARP/ND entries.

Preemption mode

As shown in Figure 1, the link on Port C1 of Device C is the primary link. The link on Port C2 of Device C is the secondary link. When the primary link fails, Port C1 is automatically blocked and placed in standby state, and Port C2 takes over to forward traffic. When the primary link recovers, one of the following actions occurs:

- If the smart link group is not configured with a preemption mode, Port C1 stays blocked to keep traffic forwarding stable. Port C1 does not take over to forward traffic until the next link switchover.
- If the smart link group is configured with a preemption mode and the preemption conditions are met, Port C1 takes over to forward traffic as soon as its link recovers. Port C2 is automatically blocked and placed in standby state.

Load sharing

A ring network might carry traffic of multiple VLANs. Smart Link can forward traffic from different VLANs in different smart link groups for load sharing.

To implement load sharing, you can assign a port to multiple smart link groups. Configure each group with a different protected VLAN. Make sure the state of the port is different in these smart link groups, so traffic from different VLANs can be forwarded along different paths.

You can configure protected VLANs for a smart link group by referencing Multiple Spanning Tree Instances (MSTIs). For more information about MSTIs, see *Layer 2—LAN Switching Configuration Guide*.

Collaboration between Smart Link and Monitor Link for port status detection

Smart Link cannot detect when faults occur on the uplink of the upstream devices or when faults are cleared. You can configure the Monitor Link function to monitor the status of the uplink ports of the upstream devices. Monitor Link adapts the up/down state of downlink ports to uplink ports, and triggers Smart Link to perform link switchover on the downstream device. For more information about Monitor Link, see "Configuring Monitor Link."

Collaboration between Smart Link and Track for link status detection

Smart Link cannot detect unidirectional links, misconnected fibers, or packet loss on intermediate devices or network paths of the uplink. It cannot detect when faults are cleared either. To detect link status, smart link group member ports must use link detection protocols. When a fault is detected or cleared, the link detection protocols inform Smart Link to switch over the links.

Smart Link collaborates with link detection protocols through track entries. It supports only the Continuity Check (CC) function of Connectivity Fault Detection (CFD) to implement link detection. CFD notifies the smart link group member ports of fault detection events by using detection VLANs and detection ports. A port responds to a continuity check event only when the control VLAN of the smart link group to which it belongs matches the detection VLAN. For more information about track entries and the CC function of CFD, see "Configuring Track" and "Configuring CFD."

Restrictions: Hardware compatibility with Smart Link

The following switch series do not support Smart Link:

- S5110V2-SI.
- S5000V3-EI.
- S5000V5-EI.
- S5000E-X.
- S5000X-EI.
- WAS6000.

Restrictions and guidelines: Smart Link configuration

If you configure a port as both an aggregation group member and a smart link group member, only the aggregation group configuration takes effect. The port is not shown in the output from the **`display smart-link group`** command. The smart link group configuration takes effect after the port leaves the aggregation group.

Smart Link tasks at a glance

To configure Smart Link, perform the following tasks:

1. Configuring a Smart Link device
   a. Configuring protected VLANs for a smart link group
   b. Configuring member ports for a smart link group
   c. (Optional.) Configuring a preemption mode for a smart link group
   d. (Optional.) Enabling the sending of flush messages
   e. (Optional.) Configuring collaboration between Smart Link and Track
2. Enabling an associated device to receive flush messages

Configuring a Smart Link device

Prerequisites for Smart Link device configuration

Before configuring a Smart Link device, complete the following tasks:

- To prevent loops, shut down a port before configuring it as a smart link group member. You can bring up the port only after completing the smart link group configuration.
- Disable the spanning tree feature, RRPP, and ERPS on the ports you want to add to the smart link group.

Configuring protected VLANs for a smart link group

Prerequisites

Before you configure protected VLANs, you must configure an MST region and the VLAN-to-instance mapping table. For more information about MST regions, see spanning tree configuration in *Layer 2—LAN Switching Configration Guide*.

Procedure

1. Enter system view.
   system-view
2. Create a smart link group and enter smart link group view.
   smart-link group *group-id*
3. Configure protected VLANs for the smart link group.
   protected-vlan reference-instance *instance-id-list*

Configuring member ports for a smart link group

Restrictions and guidelines

You can configure member ports for a smart link group either in smart link group view or in interface view. The configurations made in these two views have the same effect.

In smart link group view

1. Enter system view.
   system-view
2. Create a smart link group and enter smart link group view.
   smart-link group *group-id*
3. Configure member ports for a smart link group.
   port *interface-type interface-number* { **primary** | **secondary** }
   By default, no member port is configured for a smart link group.

In interface view

1. Enter system view.
   system-view
2. Enter Layer 2 Ethernet interface view or Layer 2 aggregate interface view.
   interface *interface-type interface-number*
3. Configure member ports for a smart link group.
   port smart-link group *group-id* { **primary** | **secondary** }
   By default, an interface is not a smart link group member.

Configuring a preemption mode for a smart link group

1. Enter system view.
   system-view
2. Enter smart link group view.
   smart-link group *group-id*
3. Configure a preemption mode for the smart link group.
   preemption mode { **role** | **speed** [**threshold** *threshold-value*] }

By default, preemption is disabled.

4. Configure the preemption delay.

   preemption delay *delay*

   By default, the preemption delay is 1 second.

   The preemption delay configuration takes effect only after a preemption mode is configured.

Enabling the sending of flush messages

Restrictions and guidelines

- The control VLAN configured for a smart link group must be different from the control VLAN configured for any other smart link group.
- Make sure the configured control VLAN already exists, and assign the smart link group member ports to the control VLAN.
- The control VLAN of a smart link group must also be one of its protected VLANs. Do not remove the control VLAN. Otherwise, flush messages cannot be sent correctly.

Procedure

1. Enter system view.

   system-view

2. Enter smart link group view.

   smart-link group *group-id*

3. Enable flush update.

   flush enable [**control-vlan** *vlan-id*]

   By default, flush update is enabled, and VLAN 1 is the control VLAN.

Configuring collaboration between Smart Link and Track

About collaboration between Smart Link and Track

Smart Link collaborates with the CC function of CFD through track entries to implement link detection.

Prerequisites

Before you configure collaboration between Smart Link and Track on a port, you must assign the port to the smart link group.

Procedure

1. Enter system view.

   system-view

2. Enter Layer 2 Ethernet interface view or Layer 2 aggregate interface view.

   interface *interface-type interface-number*

3. Configure collaboration between Smart Link and Track on the port.

   port smart-link group *group-id* **track** *track-entry-number*

   By default, smart link group member ports do not collaborate with track entries.

Enabling an associated device to receive flush messages

Restrictions and guidelines

- You do not need to enable all ports on the associated devices to receive flush messages. Enable the feature only on all control VLANs of ports on the primary and secondary links between the Smart Link device and the destination device.
- If no control VLAN is specified for processing flush messages, the device forwards the received flush messages without any processing.
- Make sure the receive control VLAN is the same as the transmit control VLAN configured on the Smart Link device. If they are not the same, the associated device will forward the received flush messages directly without any processing.
- Do not remove the control VLANs. Otherwise, flush messages cannot be sent correctly.
- Make sure the control VLANs are existing VLANs, and assign the ports capable of receiving flush messages to the control VLANs.

Prerequisites

Disable the spanning tree feature on the associated device's ports that connect to the member ports of the smart link group. Otherwise, the ports will discard flush messages when they are not in forwarding state if a topology change occurs.

Procedure

1. Enter system view.
   system-view
2. Enter Layer 2 Ethernet interface view or Layer 2 aggregate interface view.
   interface *interface-type interface-number*
3. Configure the control VLANs for receiving flush messages.
   smart-link flush enable [**control-vlan** *vlan-id-list*]
   By default, no control VLAN receives flush messages.

Display and maintenance commands for Smart Link

Execute **display** commands in any view and the **reset** command in user view:

Task	Command
Display information about the received flush messages.	**display smart-link flush**
Display smart link group information.	**display smart-link group** { *group-id* | **all** }
Clear the statistics about flush messages.	**reset smart-link statistics**

Smart Link configuration examples

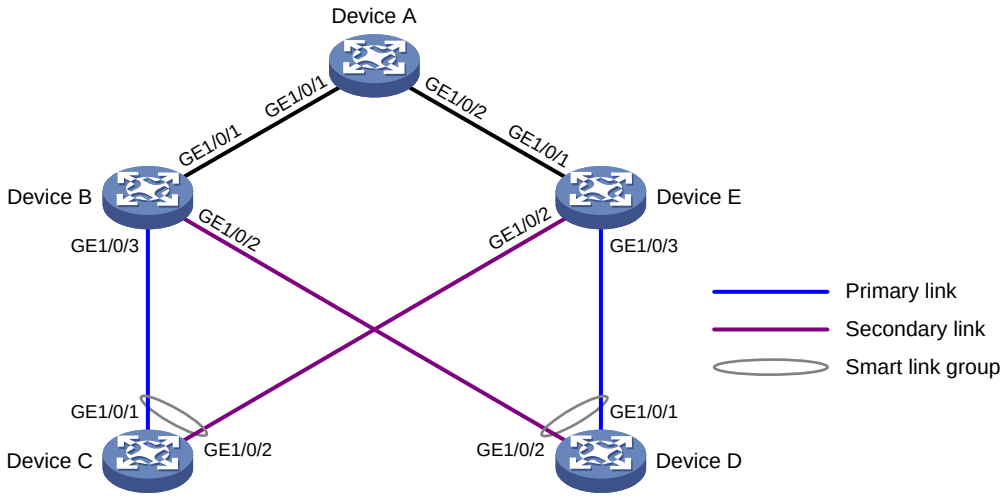
Example: Configuring a single smart link group

Network configuration

As shown in Figure 2:

- Device C and Device D are Smart Link devices. Device A, Device B, and Device E are associated devices. Traffic of VLANs 1 through 30 on Device C and Device D is dually uplinked to Device A.
- Configure Smart Link on Device C and Device D for dual uplink backup.

Figure 2 Network diagram



Procedure

1. Configure Device C:

   # Create VLANs 1 through 30.

   ```
   <DeviceC> system-view
   [DeviceC] vlan 1 to 30
   ```

   # Map these VLANs to MSTI 1.

   ```
   [DeviceC] stp region-configuration
   [DeviceC-mst-region] instance 1 vlan 1 to 30
   ```

   # Activate the MST region configuration.

   ```
   [DeviceC-mst-region] active region-configuration
   [DeviceC-mst-region] quit
   ```

   # Shut down GigabitEthernet 1/0/1.

   ```
   [DeviceC] interface gigabitethernet 1/0/1
   [DeviceC-GigabitEthernet1/0/1] shutdown
   ```

   # Disable the spanning tree feature on the port.

   ```
   [DeviceC-GigabitEthernet1/0/1] undo stp enable
   ```

   # Configure the port as a trunk port.

   ```
   [DeviceC-GigabitEthernet1/0/1] port link-type trunk
   ```

   # Assign the port to VLANs 1 through 30.

   ```
   [DeviceC-GigabitEthernet1/0/1] port trunk permit vlan 1 to 30
   ```

```
[DeviceC-GigabitEthernet1/0/1] quit
```

Configure GigabitEthernet 1/0/2 in the same way GigabitEthernet 1/0/1 is configured.

```
[DeviceC] interface gigabitethernet 1/0/2
[DeviceC-GigabitEthernet1/0/2] shutdown
[DeviceC-GigabitEthernet1/0/2] undo stp enable
[DeviceC-GigabitEthernet1/0/2] port link-type trunk
[DeviceC-GigabitEthernet1/0/2] port trunk permit vlan 1 to 30
[DeviceC-GigabitEthernet1/0/2] quit
```

Create smart link group 1, and configure all VLANs mapped to MSTI 1 as the protected VLANs.

```
[DeviceC] smart-link group 1
[DeviceC-smlk-group1] protected-vlan reference-instance 1
```

Configure GigabitEthernet 1/0/1 as the primary port and GigabitEthernet 1/0/2 as the secondary port for smart link group 1.

```
[DeviceC-smlk-group1] port gigabitethernet 1/0/1 primary
[DeviceC-smlk-group1] port gigabitethernet 1/0/2 secondary
```

Enable flush message sending in smart link group 1, and configure VLAN 10 as the transmit control VLAN.

```
[DeviceC-smlk-group1] flush enable control-vlan 10
[DeviceC-smlk-group1] quit
```

Bring up GigabitEthernet 1/0/1 and GigabitEthernet 1/0/2 again.

```
[DeviceC] interface gigabitethernet 1/0/1
[DeviceC-GigabitEthernet1/0/1] undo shutdown
[DeviceC-GigabitEthernet1/0/1] quit
[DeviceC] interface gigabitethernet 1/0/2
[DeviceC-GigabitEthernet1/0/2] undo shutdown
[DeviceC-GigabitEthernet1/0/2] quit
```

2. Configure Device D:

Create VLANs 1 through 30.

```
<DeviceD> system-view
[DeviceD] vlan 1 to 30
```

Map these VLANs to MSTI 1.

```
[DeviceD] stp region-configuration
[DeviceD-mst-region] instance 1 vlan 1 to 30
```

Activate the MST region configuration.

```
[DeviceD-mst-region] active region-configuration
[DeviceD-mst-region] quit
```

Shut down GigabitEthernet 1/0/1.

```
[DeviceD] interface gigabitethernet 1/0/1
[DeviceD-GigabitEthernet1/0/1] shutdown
```

Disable the spanning tree feature on the port.

```
[DeviceD-GigabitEthernet1/0/1] undo stp enable
```

Configure the port as a trunk port.

```
[DeviceD-GigabitEthernet1/0/1] port link-type trunk
```

Assign the port to VLANs 1 through 30.

```
[DeviceD-GigabitEthernet1/0/1] port trunk permit vlan 1 to 30
[DeviceD-GigabitEthernet1/0/1] quit
```

Configure GigabitEthernet 1/0/2 in the same way GigabitEthernet 1/0/1 is configured.

```
[DeviceD] interface gigabitethernet 1/0/2
[DeviceD-GigabitEthernet1/0/2] shutdown
[DeviceD-GigabitEthernet1/0/2] undo stp enable
[DeviceD-GigabitEthernet1/0/2] port link-type trunk
[DeviceD-GigabitEthernet1/0/2] port trunk permit vlan 1 to 30
[DeviceD-GigabitEthernet1/0/2] quit
```

Create smart link group 1, and configure all VLANs mapped to MSTI 1 as the protected VLANs.

```
[DeviceD] smart-link group 1
[DeviceD-smlk-group1] protected-vlan reference-instance 1
```

Configure GigabitEthernet 1/0/1 as the primary port and GigabitEthernet 1/0/2 as the secondary port for smart link group 1.

```
[DeviceD-smlk-group1] port gigabitethernet 1/0/1 primary
[DeviceD-smlk-group1] port gigabitethernet 1/0/2 secondary
```

Enable flush message sending in smart link group 1, and configure VLAN 20 as the transmit control VLAN.

```
[DeviceD-smlk-group1] flush enable control-vlan 20
[DeviceD-smlk-group1] quit
```

Bring up GigabitEthernet 1/0/1 and GigabitEthernet 1/0/2 again.

```
[DeviceD] interface gigabitethernet 1/0/1
[DeviceD-GigabitEthernet1/0/1] undo shutdown
[DeviceD-GigabitEthernet1/0/1] quit
[DeviceD] interface gigabitethernet 1/0/2
[DeviceD-GigabitEthernet1/0/2] undo shutdown
[DeviceD-GigabitEthernet1/0/2] quit
```

3. Configure Device B:

Create VLANs 1 through 30.

```
<DeviceB> system-view
[DeviceB] vlan 1 to 30
```

Configure GigabitEthernet 1/0/1 as a trunk port.

```
[DeviceB] interface gigabitethernet 1/0/1
[DeviceB-GigabitEthernet1/0/1] port link-type trunk
```

Assign the port to VLANs 1 through 30.

```
[DeviceB-GigabitEthernet1/0/1] port trunk permit vlan 1 to 30
```

Enable flush message receiving and configure VLAN 10 and VLAN 20 as the receive control VLANs on the port.

```
[DeviceB-GigabitEthernet1/0/1] smart-link flush enable control-vlan 10 20
[DeviceB-GigabitEthernet1/0/1] quit
```

Configure GigabitEthernet 1/0/2 as a trunk port.

```
[DeviceB] interface gigabitethernet 1/0/2
[DeviceB-GigabitEthernet1/0/2] port link-type trunk
```

Assign the port to VLANs 1 through 30.

```
[DeviceB-GigabitEthernet1/0/2] port trunk permit vlan 1 to 30
```

Disable the spanning tree feature on the port.

```
[DeviceB-GigabitEthernet1/0/2] undo stp enable
```

Enable flush message receiving and configure VLAN 20 as the receive control VLAN on the port.

```
[DeviceB-GigabitEthernet1/0/2] smart-link flush enable control-vlan 20
[DeviceB-GigabitEthernet1/0/2] quit
```

Configure GigabitEthernet 1/0/3 as a trunk port.

```
[DeviceB] interface gigabitethernet 1/0/3
[DeviceB-GigabitEthernet1/0/3] port link-type trunk
```

Assign the port to VLANs 1 through 30.

```
[DeviceB-GigabitEthernet1/0/3] port trunk permit vlan 1 to 30
```

Disable the spanning tree feature on the port.

```
[DeviceB-GigabitEthernet1/0/3] undo stp enable
```

Enable flush message receiving and configure VLAN 10 as the receive control VLAN on the port.

```
[DeviceB-GigabitEthernet1/0/3] smart-link flush enable control-vlan 10
[DeviceB-GigabitEthernet1/0/3] quit
```

4. Configure Device E:

Create VLANs 1 through 30.

```
<DeviceE> system-view
[DeviceE] vlan 1 to 30
```

Configure GigabitEthernet 1/0/1 as a trunk port.

```
[DeviceE] interface gigabitethernet 1/0/1
[DeviceE-GigabitEthernet1/0/1] port link-type trunk
```

Assign the port to VLANs 1 through 30.

```
[DeviceE-GigabitEthernet1/0/1] port trunk permit vlan 1 to 30
```

Enable flush message receiving and configure VLAN 10 and VLAN 20 as the receive control VLANs on the port.

```
[DeviceE-GigabitEthernet1/0/1] smart-link flush enable control-vlan 10 20
[DeviceE-GigabitEthernet1/0/1] quit
```

Configure GigabitEthernet 1/0/2 as a trunk port.

```
[DeviceE] interface gigabitethernet 1/0/2
[DeviceE-GigabitEthernet1/0/2] port link-type trunk
```

Assign the port to VLANs 1 through 30.

```
[DeviceE-GigabitEthernet1/0/2] port trunk permit vlan 1 to 30
```

Disable the spanning tree feature on the port.

```
[DeviceE-GigabitEthernet1/0/2] undo stp enable
```

Enable flush message receiving and configure VLAN 10 as the receive control VLAN on the port.

```
[DeviceE-GigabitEthernet1/0/2] smart-link flush enable control-vlan 10
[DeviceE-GigabitEthernet1/0/2] quit
```

Configure GigabitEthernet 1/0/3 as a trunk port.

```
[DeviceE] interface gigabitethernet 1/0/3
[DeviceE-GigabitEthernet1/0/3] port link-type trunk
```

Assign the port to VLANs 1 through 30.

```
[DeviceE-GigabitEthernet1/0/3] port trunk permit vlan 1 to 30
```

Disable the spanning tree feature on the port.

```
[DeviceE-GigabitEthernet1/0/3] undo stp enable
```

Enable flush message receiving and configure VLAN 20 as the receive control VLAN on the port.

```
[DeviceE-GigabitEthernet1/0/3] smart-link flush enable control-vlan 20
```

```
[DeviceE-GigabitEthernet1/0/3] quit
```

5. Configure Device A:

   # Create VLANs 1 through 30.

```
<DeviceA> system-view
[DeviceA] vlan 1 to 30
```

   # Configure GigabitEthernet 1/0/1 as a trunk port.

```
[DeviceA] interface gigabitethernet 1/0/1
[DeviceA-GigabitEthernet1/0/1] port link-type trunk
```

   # Assign the port to VLANs 1 through 30.

```
[DeviceA-GigabitEthernet1/0/1] port trunk permit vlan 1 to 30
```

   # Enable flush message receiving and configure VLAN 10 and VLAN 20 as the receive control VLANs on the port.

```
[DeviceA-GigabitEthernet1/0/1] smart-link flush enable control-vlan 10 20
[DeviceA-GigabitEthernet1/0/1] quit
```

   # Configure GigabitEthernet 1/0/2 in the same way GigabitEthernet 1/0/1 is configured.

```
[DeviceA] interface gigabitethernet 1/0/2
[DeviceA-GigabitEthernet1/0/2] port link-type trunk
[DeviceA-GigabitEthernet1/0/2] port trunk permit vlan 1 to 30
[DeviceA-GigabitEthernet1/0/2] smart-link flush enable control-vlan 10 20
[DeviceA-GigabitEthernet1/0/2] quit
```

Verifying the configuration

Display the smart link group configuration on Device C.

```
[DeviceC] display smart-link group 1
Smart link group 1 information:
  Device ID       : 000f-e23d-5af0
  Preemption mode : None
  Preemption delay: 1(s)
  Control VLAN    : 10
  Protected VLAN  : Reference Instance 1

  Member                  Role      State   Flush-count     Last-flush-time
  ------------------------------------------------------------------------------
  GE1/0/1                 PRIMARY   ACTIVE  5               16:45:20 2012/04/21
  GE1/0/2                 SECONDARY STANDBY 1               16:37:20 2012/04/21
```

Display the flush messages received on Device B.

```
[DeviceB] display smart-link flush
 Received flush packets                          : 5
 Receiving interface of the last flush packet    : GigabitEthernet1/0/3
 Receiving time of the last flush packet         : 16:50:21 2012/04/21
 Device ID of the last flush packet              : 000f-e23d-5af0
 Control VLAN of the last flush packet           : 10
```

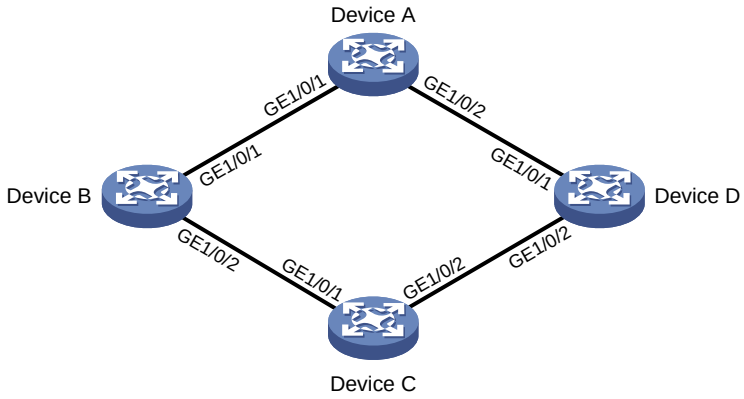
Example: Configuring multiple smart link groups load sharing

Network configuration

As shown in Figure 3:

- Device C is a Smart Link device. Device A, Device B, and Device D are associated devices. Traffic of VLANs 1 through 200 on Device C is dually uplinked to Device A by Device B and Device D.
- Implement dual uplink backup and load sharing on Device C. Traffic of VLANs 1 through 100 is uplinked to Device A by Device B. Traffic of VLANs 101 through 200 is uplinked to Device A by Device D.

Figure 3 Network diagram



Procedure

1. Configure Device C:

Create VLAN 1 through VLAN 200.

```
<DeviceC> system-view
[DeviceC] vlan 1 to 200
```

Map VLANs 1 through 100 to MSTI 1, and VLANs 101 through 200 to MSTI 2.

```
[DeviceC] stp region-configuration
[DeviceC-mst-region] instance 1 vlan 1 to 100
[DeviceC-mst-region] instance 2 vlan 101 to 200
```

Activate the MST region configuration.

```
[DeviceC-mst-region] active region-configuration
[DeviceC-mst-region] quit
```

Shut down GigabitEthernet 1/0/1.

```
[DeviceC] interface gigabitethernet 1/0/1
[DeviceC-GigabitEthernet1/0/1] shutdown
```

Disable the spanning tree feature on the port.

```
[DeviceC-GigabitEthernet1/0/1] undo stp enable
```

Configure the port as a trunk port.

```
[DeviceC-GigabitEthernet1/0/1] port link-type trunk
```

Assign the port to VLAN 1 through VLAN 200.

```
[DeviceC-GigabitEthernet1/0/1] port trunk permit vlan 1 to 200
[DeviceC-GigabitEthernet1/0/1] quit
```

Configure GigabitEthernet 1/0/2 in the same way GigabitEthernet 1/0/1 is configured.

```
[DeviceC] interface gigabitethernet 1/0/2
[DeviceC-GigabitEthernet1/0/2] shutdown
[DeviceC-GigabitEthernet1/0/2] undo stp enable
[DeviceC-GigabitEthernet1/0/2] port link-type trunk
[DeviceC-GigabitEthernet1/0/2] port trunk permit vlan 1 to 200
```

```
[DeviceC-GigabitEthernet1/0/2] quit
```

Create smart link group 1, and configure all VLANs mapped to MSTI 1 as the protected VLANs for smart link group 1.

```
[DeviceC] smart-link group 1
[DeviceC-smlk-group1] protected-vlan reference-instance 1
```

Configure GigabitEthernet 1/0/1 as the primary port and GigabitEthernet 1/0/2 as the secondary port for smart link group 1.

```
[DeviceC-smlk-group1] port gigabitethernet 1/0/1 primary
[DeviceC-smlk-group1] port gigabitethernet 1/0/2 secondary
```

Enable role preemption in smart link group 1, enable flush message sending, and configure VLAN 10 as the transmit control VLAN.

```
[DeviceC-smlk-group1] preemption mode role
[DeviceC-smlk-group1] flush enable control-vlan 10
[DeviceC-smlk-group1] quit
```

Create smart link group 2, and configure all VLANs mapped to MSTI 2 as the protected VLANs for smart link group 2.

```
[DeviceC] smart-link group 2
[DeviceC-smlk-group2] protected-vlan reference-instance 2
```

Configure GigabitEthernet 1/0/1 as the secondary port and GigabitEthernet 1/0/2 as the primary port for smart link group 2.

```
[DeviceC-smlk-group2] port gigabitethernet 1/0/2 primary
[DeviceC-smlk-group2] port gigabitethernet 1/0/1 secondary
```

Enable role preemption in smart link group 2, enable flush message sending, and configure VLAN 110 as the transmit control VLAN.

```
[DeviceC-smlk-group2] preemption mode role
[DeviceC-smlk-group2] flush enable control-vlan 110
[DeviceC-smlk-group2] quit
```

Bring up GigabitEthernet 1/0/1 and GigabitEthernet 1/0/2.

```
[DeviceC] interface gigabitethernet 1/0/1
[DeviceC-GigabitEthernet1/0/1] undo shutdown
[DeviceC-GigabitEthernet1/0/1] quit
[DeviceC] interface gigabitethernet 1/0/2
[DeviceC-GigabitEthernet1/0/2] undo shutdown
[DeviceC-GigabitEthernet1/0/2] quit
```

2. Configure Device B:

Create VLAN 1 through VLAN 200.

```
<DeviceB> system-view
[DeviceB] vlan 1 to 200
```

Configure GigabitEthernet 1/0/1 as a trunk port.

```
[DeviceB] interface gigabitethernet 1/0/1
[DeviceB-GigabitEthernet1/0/1] port link-type trunk
```

Assign the port to VLANs 1 through 200.

```
[DeviceB-GigabitEthernet1/0/1] port trunk permit vlan 1 to 200
```

Enable flush message receiving and configure VLAN 10 and VLAN 110 as the receive control VLANs on the port.

```
[DeviceB-GigabitEthernet1/0/1] smart-link flush enable control-vlan 10 110
[DeviceB-GigabitEthernet1/0/1] quit
```

Configure GigabitEthernet 1/0/2 as a trunk port.

```
[DeviceB] interface gigabitethernet 1/0/2
[DeviceB-GigabitEthernet1/0/2] port link-type trunk
```

Assign the port to VLANs 1 through 200.

```
[DeviceB-GigabitEthernet1/0/2] port trunk permit vlan 1 to 200
```

Disable the spanning tree feature on the port.

```
[DeviceB-GigabitEthernet1/0/2] undo stp enable
```

Enable flush message receiving and configure VLAN 10 and VLAN 110 as the receive control VLANs on the port.

```
[DeviceB-GigabitEthernet1/0/2] smart-link flush enable control-vlan 10 110
[DeviceB-GigabitEthernet1/0/2] quit
```

3. Configure Device D:

Create VLAN 1 through VLAN 200.

```
<DeviceD> system-view
[DeviceD] vlan 1 to 200
```

Configure GigabitEthernet 1/0/1 as a trunk port.

```
[DeviceD] interface gigabitethernet 1/0/1
[DeviceD-GigabitEthernet1/0/1] port link-type trunk
```

Assign the port to VLANs 1 through 200.

```
[DeviceD-GigabitEthernet1/0/1] port trunk permit vlan 1 to 200
```

Enable flush message receiving and configure VLAN 10 and VLAN 110 as the receive control VLANs on the port.

```
[DeviceD-GigabitEthernet1/0/1] smart-link flush enable control-vlan 10 110
[DeviceD-GigabitEthernet1/0/1] quit
```

Configure GigabitEthernet 1/0/2 as a trunk port.

```
[DeviceD] interface gigabitethernet 1/0/2
[DeviceD-GigabitEthernet1/0/2] port link-type trunk
```

Assign the port to VLANs 1 through 200.

```
[DeviceD-GigabitEthernet1/0/2] port trunk permit vlan 1 to 200
```

Disable the spanning tree feature on the port.

```
[DeviceD-GigabitEthernet1/0/2] undo stp enable
```

Enable flush message receiving and configure VLAN 10 and VLAN 110 as the receive control VLANs on the port.

```
[DeviceD-GigabitEthernet1/0/2] smart-link flush enable control-vlan 10 110
[DeviceD-GigabitEthernet1/0/2] quit
```

4. Configure Device A:

Create VLAN 1 through VLAN 200.

```
<DeviceA> system-view
[DeviceA] vlan 1 to 200
```

Configure GigabitEthernet 1/0/1 as a trunk port.

```
[DeviceA] interface gigabitethernet 1/0/1
[DeviceA-GigabitEthernet1/0/1] port link-type trunk
```

Assign the port to VLANs 1 through 200.

```
[DeviceA-GigabitEthernet1/0/1] port trunk permit vlan 1 to 200
```

Enable flush message receiving and configure VLAN 10 and VLAN 110 as the receive control VLANs on the port.

```
[DeviceA-GigabitEthernet1/0/1] smart-link flush enable control-vlan 10 110
[DeviceA-GigabitEthernet1/0/1] quit
```

Configure GigabitEthernet 1/0/2 in the same way GigabitEthernet 1/0/1 is configured.

```
[DeviceA] interface gigabitethernet 1/0/2
[DeviceA-GigabitEthernet1/0/2] port link-type trunk
[DeviceA-GigabitEthernet1/0/2] port trunk permit vlan 1 to 200
[DeviceA-GigabitEthernet1/0/2] smart-link flush enable control-vlan 10 110
[DeviceA-GigabitEthernet1/0/2] quit
```

Verifying the configuration

Display the smart link group configuration on Device C.

```
[DeviceC] display smart-link group all
Smart link group 1 information:
  Device ID       : 000f-e23d-5af0
  Preemption mode : Role
  Preemption delay: 1(s)
  Control VLAN    : 10
  Protected VLAN  : Reference Instance 1

  Member                  Role      State   Flush-count     Last-flush-time
  ------------------------------------------------------------------------------
  GE1/0/1                 PRIMARY   ACTIVE  5               16:45:20 2012/04/21
  GE1/0/2                 SECONDARY STANDBY 1               16:37:20 2012/04/21

Smart link group 2 information:
  Device ID       : 000f-e23d-5af0
  Preemption mode : Role
  Preemption delay: 1(s)
  Control VLAN    : 110
  Protected VLAN  : Reference Instance 2

  Member                  Role      State   Flush-count     Last-flush-time
  ------------------------------------------------------------------------------
  GE1/0/2                 PRIMARY   ACTIVE  5               16:45:20 2012/04/21
  GE1/0/1                 SECONDARY STANDBY 1               16:37:20 2012/04/21
```

Display the flush messages received on Device B.

```
[DeviceB] display smart-link flush
 Received flush packets                          : 5
 Receiving interface of the last flush packet    : GigabitEthernet1/0/2
 Receiving time of the last flush packet         : 16:25:21 2012/04/21
 Device ID of the last flush packet              : 000f-e23d-5af0
 Control VLAN of the last flush packet           : 10
```

Example: Configuring Smart Link and Track collaboration

Network configuration

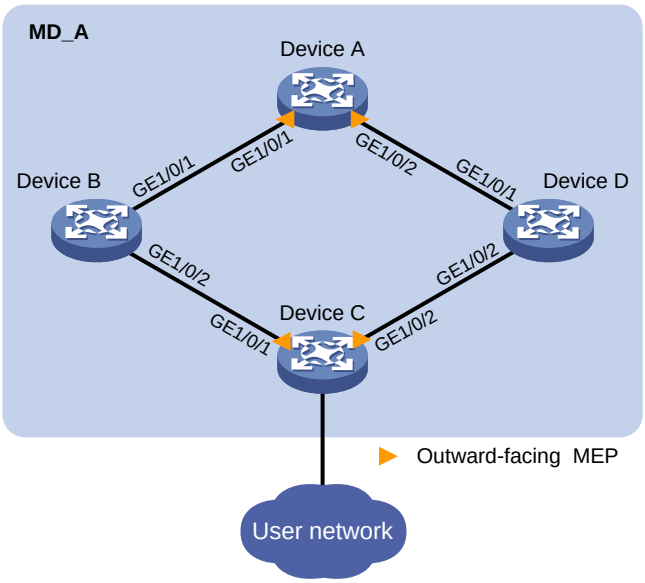
As shown in Figure 4:

- Device A, Device B, Device C, and Device D form maintenance domain (MD) **MD_A** of level 5. Device C is a Smart Link device, and Device A, Device B, and Device D are associated devices. Traffic of VLANs 1 through 200 on Device C is dually uplinked to Device A by Device B and Device D.

- Configure collaboration between Smart Link and the CC function of CFD through track entries to meet the following requirements:
  - Traffic of VLANs 1 through 100 is uplinked to Device A by Device C through GigabitEthernet 1/0/1 (primary port of smart link group 1).
  - Traffic of VLANs 101 through 200 is uplinked to Device A by Device C through GigabitEthernet 1/0/2 (primary port of smart link group 2).
  - When the link between Device C and Device A fails, traffic is quickly switched to the secondary port of each smart link group. After the fault is cleared, traffic is switched back to the primary ports.

For more information about CFD, see "Configuring CFD."

Figure 4 Network diagram



Procedure

1. Configure Device A:

Create VLAN 1 through VLAN 200.

```
<DeviceA> system-view
[DeviceA] vlan 1 to 200
```

Configure GigabitEthernet 1/0/1 as a trunk port.

```
[DeviceA] interface gigabitethernet 1/0/1
[DeviceA-GigabitEthernet1/0/1] port link-type trunk
```

Assign the port to VLANs 1 through 200.

```
[DeviceA-GigabitEthernet1/0/1] port trunk permit vlan 1 to 200
```

Enable flush message receiving and configure VLAN 10 and VLAN 110 as the receive control VLANs on the port.

```
[DeviceA-GigabitEthernet1/0/1] smart-link flush enable control-vlan 10 110
[DeviceA-GigabitEthernet1/0/1] quit
```

Configure GigabitEthernet 1/0/2 in the same way GigabitEthernet 1/0/1 is configured.

```
[DeviceA] interface gigabitethernet 1/0/2
[DeviceA-GigabitEthernet1/0/2] port link-type trunk
[DeviceA-GigabitEthernet1/0/2] port trunk permit vlan 1 to 200
[DeviceA-GigabitEthernet1/0/2] smart-link flush enable control-vlan 10 110
[DeviceA-GigabitEthernet1/0/2] quit
```

Enable CFD and create MD **MD_A** of level 5.

```
[DeviceA] cfd enable
[DeviceA] cfd md MD_A level 5
```

Create service instance 1 in which the MA name is based on the VLAN ID in **MD_A** and configure the MA to serve VLAN 10.

```
[DeviceA] cfd service-instance 1 ma-id vlan-based md MD_A vlan 10
```

Create a MEP list in service instance 1, create outward-facing MEP 1002, and enable CCM sending in service instance 1 on GigabitEthernet 1/0/1.

```
[DeviceA] cfd meplist 1001 1002 service-instance 1
[DeviceA] interface gigabitethernet 1/0/1
[DeviceA-GigabitEthernet1/0/1] cfd mep 1002 service-instance 1 outbound
[DeviceA-GigabitEthernet1/0/1] cfd cc service-instance 1 mep 1002 enable
[DeviceA-GigabitEthernet1/0/1] quit
```

Create service instance 2 in which the MA name is based on the VLAN ID in **MD_A** and configure the MA to serve VLAN 110.

```
[DeviceA] cfd service-instance 2 ma-id vlan-based md MD_A vlan 110
```

Create a MEP list in service instance 2, create outward-facing MEP 1002, and enable CCM sending in service instance 2 on GigabitEthernet 1/0/2.

```
[DeviceA] cfd meplist 2001 2002 service-instance 2
[DeviceA] interface gigabitethernet 1/0/2
[DeviceA-GigabitEthernet1/0/2] cfd mep 2002 service-instance 2 outbound
[DeviceA-GigabitEthernet1/0/2] cfd cc service-instance 2 mep 2002 enable
[DeviceA-GigabitEthernet1/0/2] quit
```

2. Configure Device B:

Create VLAN 1 through VLAN 200.

```
<DeviceB> system-view
[DeviceB] vlan 1 to 200
```

Configure GigabitEthernet 1/0/1 as a trunk port.

```
[DeviceB] interface gigabitethernet 1/0/1
[DeviceB-GigabitEthernet1/0/1] port link-type trunk
```

Assign the port to VLANs 1 through 200.

```
[DeviceB-GigabitEthernet1/0/1] port trunk permit vlan 1 to 200
```

Enable flush message receiving and configure VLAN 10 and VLAN 110 as the receive control VLANs on the port.

```
[DeviceB-GigabitEthernet1/0/1] smart-link flush enable control-vlan 10 110
[DeviceB-GigabitEthernet1/0/1] quit
```

Configure GigabitEthernet 1/0/2 as a trunk port.

```
[DeviceB] interface gigabitethernet 1/0/2
[DeviceB-GigabitEthernet1/0/2] port link-type trunk
```

Assign the port to VLANs 1 through 200.

```
[DeviceB-GigabitEthernet1/0/2] port trunk permit vlan 1 to 200
```

Disable the spanning tree feature on the port.

```
[DeviceB-GigabitEthernet1/0/2] undo stp enable
```

Enable flush message receiving and configure VLAN 10 and VLAN 110 as the receive control VLANs on the port.

```
[DeviceB-GigabitEthernet1/0/2] smart-link flush enable control-vlan 10 110
[DeviceB-GigabitEthernet1/0/2] quit
```

3. Configure Device C:

Create VLAN 1 through VLAN 200.

```
<DeviceC> system-view
[DeviceC] vlan 1 to 200
```

Map VLANs 1 through 100 to MSTI 1 and VLANs 101 through 200 to MSTI 2.

```
[DeviceC] stp region-configuration
[DeviceC-mst-region] instance 1 vlan 1 to 100
[DeviceC-mst-region] instance 2 vlan 101 to 200
```

Activate the MST region configuration.

```
[DeviceC-mst-region] active region-configuration
[DeviceC-mst-region] quit
```

Shut down GigabitEthernet 1/0/1.

```
[DeviceC] interface gigabitethernet 1/0/1
[DeviceC-GigabitEthernet1/0/1] shutdown
```

Disable the spanning tree feature on the port.

```
[DeviceC-GigabitEthernet1/0/1] undo stp enable
```

Configure the port as a trunk port.

```
[DeviceC-GigabitEthernet1/0/1] port link-type trunk
```

Assign the port to VLANs 1 through 200.

```
[DeviceC-GigabitEthernet1/0/1] port trunk permit vlan 1 to 200
[DeviceC-GigabitEthernet1/0/1] quit
```

Configure GigabitEthernet 1/0/2 in the same way GigabitEthernet 1/0/1 is configured.

```
[DeviceC] interface gigabitethernet 1/0/2
[DeviceC-GigabitEthernet1/0/2] shutdown
[DeviceC-GigabitEthernet1/0/2] undo stp enable
[DeviceC-GigabitEthernet1/0/2] port link-type trunk
[DeviceC-GigabitEthernet1/0/2] port trunk permit vlan 1 to 200
[DeviceC-GigabitEthernet1/0/2] quit
```

Create smart link group 1, and configure all VLANs mapped to MSTI 1 as the protected VLANs for smart link group 1.

```
[DeviceC] smart-link group 1
[DeviceC-smlk-group1] protected-vlan reference-instance 1
```

Configure GigabitEthernet 1/0/1 as the primary port and GigabitEthernet 1/0/2 as the secondary port for smart link group 1.

```
[DeviceC-smlk-group1] port gigabitethernet 1/0/1 primary
[DeviceC-smlk-group1] port gigabitethernet 1/0/2 secondary
```

Enable role preemption in smart link group 1, enable flush message sending, and configure VLAN 10 as the transmit control VLAN.

```
[DeviceC-smlk-group1] preemption mode role
[DeviceC-smlk-group1] flush enable control-vlan 10
[DeviceC-smlk-group1] quit
```

Create smart link group 2, and configure all VLANs mapped to MSTI 2 as the protected VLANs for smart link group 2.

```
[DeviceC] smart-link group 2
[DeviceC-smlk-group2] protected-vlan reference-instance 2
```

Configure GigabitEthernet 1/0/1 as the secondary port and GigabitEthernet 1/0/2 as the primary port for smart link group 2.

```
[DeviceC-smlk-group2] port gigabitethernet 1/0/2 primary
[DeviceC-smlk-group2] port gigabitethernet 1/0/1 secondary
```

Enable role preemption in smart link group 2, enable flush message sending, and configure VLAN 110 as the transmit control VLAN.

```
[DeviceC-smlk-group2] preemption mode role
[DeviceC-smlk-group2] flush enable control-vlan 110
[DeviceC-smlk-group2] quit
```

Enable CFD and create MD **MD_A** of level 5.

```
[DeviceC] cfd enable
[DeviceC] cfd md MD_A level 5
```

Create service instance 1 in which the MA name is based on the VLAN ID in **MD_A** and configure the MA to serve VLAN 10.

```
[DeviceC] cfd service-instance 1 ma-id vlan-based md MD_A vlan 10
```

Create a MEP list in service instance 1. Create outward-facing MEP 1001, and enable CCM sending in service instance 1 on GigabitEthernet 1/0/1.

```
[DeviceC] cfd meplist 1001 1002 service-instance 1
[DeviceC] interface gigabitethernet 1/0/1
[DeviceC-GigabitEthernet1/0/1] cfd mep 1001 service-instance 1 outbound
[DeviceC-GigabitEthernet1/0/1] cfd cc service-instance 1 mep 1001 enable
[DeviceC-GigabitEthernet1/0/1] quit
```

Create service instance 2 in which the MA name is based on the VLAN ID in **MD_A** and configure the MA to serve VLAN 110.

```
[DeviceC] cfd service-instance 2 ma-id vlan-based md MD_A vlan 110
```

Create a MEP list in service instance 2. Create outward-facing MEP 2001. Enable CCM sending in service instance 2 on GigabitEthernet 1/0/2.

```
[DeviceC] cfd meplist 2001 2002 service-instance 2
[DeviceC] interface gigabitethernet 1/0/2
[DeviceC-GigabitEthernet1/0/2] cfd mep 2001 service-instance 2 outbound
[DeviceC-GigabitEthernet1/0/2] cfd cc service-instance 2 mep 2001 enable
[DeviceC-GigabitEthernet1/0/2] quit
```

Create track entry 1 that is associated with the CFD CC function of MEP 1001 in service instance 1.

```
[DeviceC] track 1 cfd cc service-instance 1 mep 1001
```

Configure collaboration between the primary port GigabitEthernet 1/0/1 of smart link group 1 and the CC function of CFD through track entry 1, and bring up the port.

```
[DeviceC] interface gigabitethernet 1/0/1
[DeviceC-GigabitEthernet1/0/1] port smart-link group 1 track 1
[DeviceC-GigabitEthernet1/0/1] undo shutdown
[DeviceC-GigabitEthernet1/0/1] quit
```

Create track entry 1 that is associated with the CFD CC function of MEP 1001 in service instance 1.

```
[DeviceC] track 2 cfd cc service-instance 2 mep 2001
```

Configure collaboration between the primary port GigabitEthernet 1/0/2 of smart link group 2 and the CC function of CFD through track entry 2, and bring up the port.

```
[DeviceC] interface gigabitethernet 1/0/2
[DeviceC-GigabitEthernet1/0/2] port smart-link group 2 track 2
[DeviceC-GigabitEthernet1/0/2] undo shutdown
[DeviceC-GigabitEthernet1/0/2] quit
```

4. Configure Device D:

Create VLAN 1 through VLAN 200.

```
<DeviceD> system-view
```

```
[DeviceD] vlan 1 to 200
```

Configure GigabitEthernet 1/0/1 as a trunk port.

```
[DeviceD] interface gigabitethernet 1/0/1
[DeviceD-GigabitEthernet1/0/1] port link-type trunk
```

Assign the port to VLANs 1 through 200.

```
[DeviceD-GigabitEthernet1/0/1] port trunk permit vlan 1 to 200
```

Enable flush message receiving and configure VLAN 10 and VLAN 110 as the receive control VLANs on the port.

```
[DeviceD-GigabitEthernet1/0/1] smart-link flush enable control-vlan 10 110
[DeviceD-GigabitEthernet1/0/1] quit
```

Configure GigabitEthernet 1/0/2 as a trunk port.

```
[DeviceD] interface gigabitethernet 1/0/2
[DeviceD-GigabitEthernet1/0/2] port link-type trunk
```

Assign the port to VLANs 1 through 200.

```
[DeviceD-GigabitEthernet1/0/2] port trunk permit vlan 1 to 200
```

Disable the spanning tree feature on the port.

```
[DeviceD-GigabitEthernet1/0/2] undo stp enable
```

Enable flush message receiving and configure VLAN 10 and VLAN 110 as the receive control VLANs on the port.

```
[DeviceD-GigabitEthernet1/0/2] smart-link flush enable control-vlan 10 110
[DeviceD-GigabitEthernet1/0/2] quit
```

Verifying the configuration

When the optical fiber between Device A and Device B fails, display the smart link group configuration on Device C.

```
[DeviceC] display smart-link group all
Smart link group 1 information:
  Device ID       : 000f-e23d-5af0
  Preemption mode : Role
  Preemption delay: 1(s)
  Control VLAN    : 10
  Protected VLAN  : Reference Instance 1

  Member                  Role      State   Flush-count     Last-flush-time
  ------------------------------------------------------------------------------
  GE1/0/1                 PRIMARY   DOWN    5               16:45:20 2012/04/21
  GE1/0/2                 SECONDARY ACTIVE  1               16:37:20 2012/04/21

Smart link group 2 information:
  Device ID       : 000f-e23d-5af0
  Preemption mode : Role
  Preemption delay: 1(s)
  Control VLAN    : 110
  Protected VLAN  : Reference Instance 2

  Member                  Role      State   Flush-count     Last-flush-time
  ------------------------------------------------------------------------------
  GE1/0/2                 PRIMARY   ACTIVE  5               16:45:20 2012/04/21
  GE1/0/1                 SECONDARY STANDBY 1               16:37:20 2012/04/21
```

The output shows that primary port GigabitEthernet 1/0/1 of smart link group 1 fails, and secondary port GigabitEthernet 1/0/2 is in forwarding state.

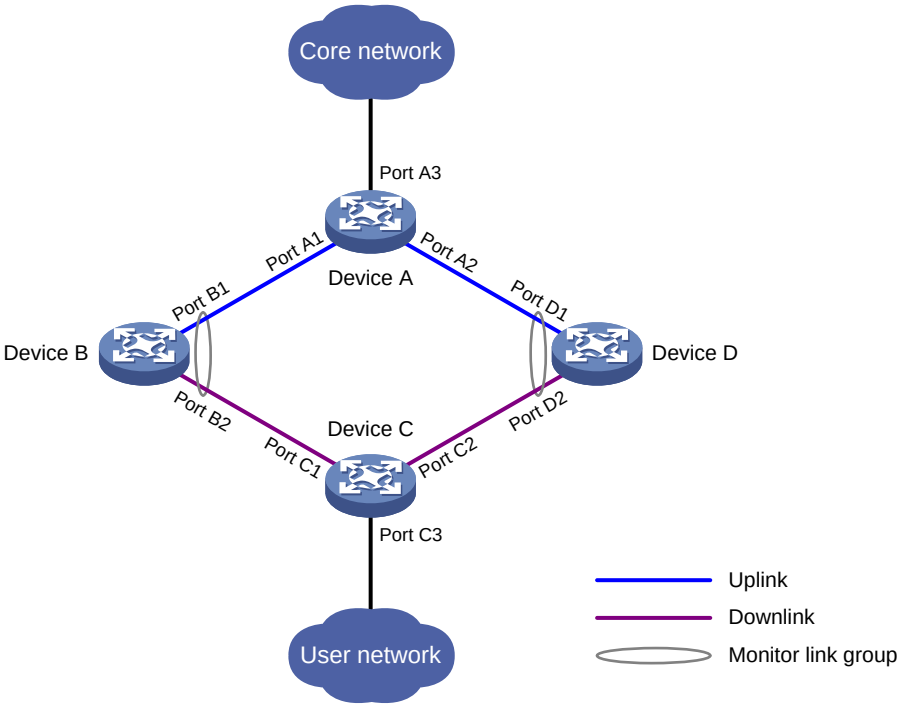
Contents

Configuring Monitor Link

About Monitor Link

Monitor Link associates the state of downlink interfaces with the state of uplink interfaces in a monitor link group. When Monitor Link shuts down the downlink interfaces because of an uplink failure, the downstream device changes connectivity to another link.

Figure 1 Monitor Link application scenario



A monitor link group contains uplink and downlink interfaces. An interface can belong to only one monitor link group.

- Uplink interfaces are the monitored interfaces.
- Downlink interfaces are the monitoring interfaces.

As shown in Figure 1:

- Port B1 and Port B2 of Device B form a monitor link group. Port B1 is an uplink interface, and Port B2 is a downlink interface.
- Port D1 and Port D2 of Device D form another monitor link group. Port D1 is an uplink interface, and Port D2 is a downlink interface.

A monitor link group works independently of other monitor link groups. When a monitor link group does not contain any uplink interface or all its uplink interfaces are down, the monitor link group goes down. It forces all downlink interfaces down at the same time. When any uplink interface comes up, the monitor link group comes up and brings up all the downlink interfaces.

Restrictions and guidelines: Monitor Link configuration

Follow these restrictions and guidelines when you configure Monitor Link:

- Do not manually shut down or bring up the downlink interfaces in a monitor link group.
- To avoid frequent state changes of downlink interfaces in the event that uplink interfaces in the monitor link group flap, you can configure a switchover delay. The switchover delay is the time that the downlink interfaces wait before they come up following an uplink interface.

Monitor Link tasks at a glance

To configure Monitor Link, perform the following tasks:

- Enabling Monitor Link globally
- Creating a monitor link group
- Configuring monitor link group member interfaces
- (Optional.) Configuring the uplink interface threshold for triggering monitor link group state switchover
- (Optional.) Configuring the switchover delay for the downlink interfaces in a monitor link group

Enabling Monitor Link globally

About enabling Monitor Link globally

All monitor link groups can operate only after you enable Monitor Link globally. When you disable Monitor Link globally, all monitor link groups cannot operate and the downlink interfaces brought down by the monitor link groups resume their original states.

Procedure

1. Enter system view.
   `system-view`
2. Enable Monitor Link globally.
   `undo monitor-link disable`
   By default, Monitor Link is enabled globally.

Creating a monitor link group

1. Enter system view.
   `system-view`
2. Create a monitor link group and enter monitor link group view.
   `monitor-link group` *`group-id`*

Configuring monitor link group member interfaces

Restrictions and guidelines

- An interface can be assigned to only one monitor link group.
- To avoid undesired down/up state changes on the downlink interfaces, configure uplink interfaces before you configure downlink interfaces.
- If you have configured a Selected port of an aggregation group as the downlink interface of a monitor link group, do not configure an Unselected port of the aggregation group as the uplink interface of the monitor link group.
- Do not add an aggregate interface and its member ports to the same monitor link group.
- You can configure member interfaces for a monitor link group in monitor link group view or interface view. Configurations made in these views have the same effect. The configuration is supported by the following interfaces:
  - Layer 2 Ethernet interfaces.
  - Layer 2 aggregate interfaces.

Configuring monitor link group member interfaces in monitor link group view

1. Enter system view.
   system-view
2. Enter monitor link group view.
   monitor-link group *group-id*
3. Configure member interfaces for the monitor link group.
   port *interface-type interface-number* { **downlink** | **uplink** }
   By default, no member interfaces exist in a monitor link group.

Configuring monitor link group member interfaces in interface view

1. Enter system view.
   system-view
2. Enter interface view.
   interface *interface-type interface-number*
3. Configure the interface as a member of a monitor link group.
   port monitor-link group *group-id* { **downlink** | **uplink** }
   By default, the interface is not a monitor link group member.

Configuring the uplink interface threshold for triggering monitor link group state switchover

1. Enter system view.
   system-view

2. Enter monitor link group view.
   monitor-link group *group-id*
3. Configure the uplink interface threshold for triggering monitor link group state switchover.
   uplink up-port-threshold *number-of-port*
   By default, the uplink interface threshold for triggering monitor link group state switchover is 1.

Configuring the switchover delay for the downlink interfaces in a monitor link group

1. Enter system view.
   system-view
2. Enter monitor link group view.
   monitor-link group *group-id*
3. Configure the switchover delay for the downlink interfaces in the monitor link group.
   downlink up-delay *delay*
   By default, the switchover delay is 0 seconds. The downlink interfaces come up as soon as an uplink interface comes up.

Display and maintenance commands for Monitor Link

Execute the **display** command in any view:

Task	Command
Display monitor link group information.	**display monitor-link group** { *group-id* | **all** }

Monitor Link configuration examples

Example: Configuring Monitor Link

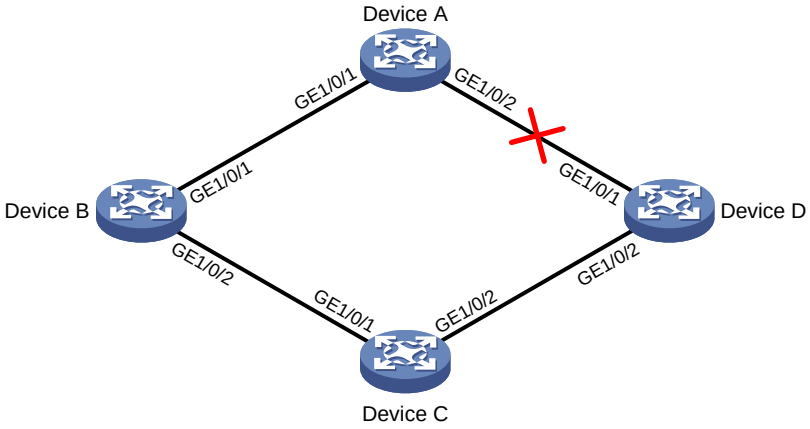
Network configuration

As shown in Figure 2:

- Device C is a Smart Link device, and Device A, Device B, and Device D are associated devices. Traffic of VLANs 1 through 30 on Device C is dual-uplinked to Device A through a smart link group.
- Implement dual uplink backup on Device C. When the link between Device A and Device B (or Device D) fails, Device C can detect the link fault. It then performs uplink switchover in the smart link group.

For more information about Smart Link, see "Configuring Smart Link."

Figure 2 Network diagram



Procedure

1. Configure Device C:

Create VLANs 1 through 30.

```
<DeviceC> system-view
[DeviceC] vlan 1 to 30
```

Map these VLANs to MSTI 1.

```
[DeviceC] stp region-configuration
[DeviceC-mst-region] instance 1 vlan 1 to 30
```

Activate MST region configuration.

```
[DeviceC-mst-region] active region-configuration
[DeviceC-mst-region] quit
```

Shut down GigabitEthernet 1/0/1.

```
[DeviceC] interface gigabitethernet 1/0/1
[DeviceC-GigabitEthernet1/0/1] shutdown
```

Disable the spanning tree feature on the interface.

```
[DeviceC-GigabitEthernet1/0/1] undo stp enable
```

Configure the interface as a trunk port.

```
[DeviceC-GigabitEthernet1/0/1] port link-type trunk
```

Assign the interface to VLANs 1 through 30.

```
[DeviceC-GigabitEthernet1/0/1] port trunk permit vlan 1 to 30
[DeviceC-GigabitEthernet1/0/1] quit
```

Configure GigabitEthernet 1/0/2 in the same way GigabitEthernet 1/0/1 is configured.

```
[DeviceC] interface gigabitethernet 1/0/2
[DeviceC-GigabitEthernet1/0/2] shutdown
[DeviceC-GigabitEthernet1/0/2] undo stp enable
[DeviceC-GigabitEthernet1/0/2] port link-type trunk
[DeviceC-GigabitEthernet1/0/2] port trunk permit vlan 1 to 30
[DeviceC-GigabitEthernet1/0/2] quit
```

Create smart link group 1, and configure all the VLANs mapped to MSTI 1 as the protected VLANs for smart link group 1.

```
[DeviceC] smart-link group 1
[DeviceC-smlk-group1] protected-vlan reference-instance 1
```

Configure GigabitEthernet 1/0/1 as the primary port and GigabitEthernet 1/0/2 as the secondary port for smart link group 1.

```
[DeviceC-smlk-group1] port gigabitethernet 1/0/1 primary
[DeviceC-smlk-group1] port gigabitethernet 1/0/2 secondary
```

Enable the smart link group to transmit flush messages.

```
[DeviceC-smlk-group1] flush enable
[DeviceC-smlk-group1] quit
```

Bring up GigabitEthernet 1/0/1 and GigabitEthernet 1/0/2.

```
[DeviceC] interface gigabitethernet 1/0/1
[DeviceC-GigabitEthernet1/0/1] undo shutdown
[DeviceC-GigabitEthernet1/0/1] quit
[DeviceC] interface gigabitethernet 1/0/2
[DeviceC-GigabitEthernet1/0/2] undo shutdown
[DeviceC-GigabitEthernet1/0/2] quit
```

2. Configure Device A:

Create VLANs 1 through 30.

```
<DeviceA> system-view
[DeviceA] vlan 1 to 30
```

Configure GigabitEthernet 1/0/1 as a trunk port.

```
[DeviceA] interface gigabitethernet 1/0/1
[DeviceA-GigabitEthernet1/0/1] port link-type trunk
```

Assign the interface to VLANs 1 through 30.

```
[DeviceA-GigabitEthernet1/0/1] port trunk permit vlan 1 to 30
```

Enable flush message receiving on the interface.

```
[DeviceA-GigabitEthernet1/0/1] smart-link flush enable
[DeviceA-GigabitEthernet1/0/1] quit
```

Configure GigabitEthernet 1/0/2 in the same way GigabitEthernet 1/0/1 is configured.

```
[DeviceA] interface gigabitethernet 1/0/2
[DeviceA-GigabitEthernet1/0/2] port link-type trunk
[DeviceA-GigabitEthernet1/0/2] port trunk permit vlan 1 to 30
[DeviceA-GigabitEthernet1/0/2] smart-link flush enable
[DeviceA-GigabitEthernet1/0/2] quit
```

3. Configure Device B:

Create VLANs 1 through 30.

```
<DeviceB> system-view
[DeviceB] vlan 1 to 30
```

Configure GigabitEthernet 1/0/1 as a trunk port.

```
[DeviceB] interface gigabitethernet 1/0/1
[DeviceB-GigabitEthernet1/0/1] port link-type trunk
```

Assign the interface to VLANs 1 through 30.

```
[DeviceB-GigabitEthernet1/0/1] port trunk permit vlan 1 to 30
```

Enable flush message receiving on the interface.

```
[DeviceB-GigabitEthernet1/0/1] smart-link flush enable
[DeviceB-GigabitEthernet1/0/1] quit
```

Disable the spanning tree feature on GigabitEthernet 1/0/2.

```
[DeviceB] interface gigabitethernet 1/0/2
[DeviceB-GigabitEthernet1/0/2] undo stp enable
```

Configure the interface as a trunk port.

```
[DeviceB-GigabitEthernet1/0/2] port link-type trunk
```

Assign the interface to VLANs 1 through 30.

```
[DeviceB-GigabitEthernet1/0/2] port trunk permit vlan 1 to 30
```

Enable flush message receiving on the interface.

```
[DeviceB-GigabitEthernet1/0/2] smart-link flush enable
[DeviceB-GigabitEthernet1/0/2] quit
```

Create monitor link group 1.

```
[DeviceB] monitor-link group 1
```

Configure GigabitEthernet 1/0/1 as an uplink interface for monitor link group 1.

```
[DeviceB-mtlk-group1] port gigabitethernet 1/0/1 uplink
```

Configure GigabitEthernet 1/0/2 as a downlink interface for monitor link group 1.

```
[DeviceB-mtlk-group1] port gigabitethernet 1/0/2 downlink
[DeviceB-mtlk-group1] quit
```

4. Configure Device D:

Create VLANs 1 through 30.

```
<DeviceD> system-view
[DeviceD] vlan 1 to 30
```

Configure GigabitEthernet 1/0/1 as a trunk port.

```
[DeviceD] interface gigabitethernet 1/0/1
[DeviceD-GigabitEthernet1/0/1] port link-type trunk
```

Assign the interface to VLANs 1 through 30.

```
[DeviceD-GigabitEthernet1/0/1] port trunk permit vlan 1 to 30
```

Enable flush message receiving on the interface.

```
[DeviceD-GigabitEthernet1/0/1] smart-link flush enable
[DeviceD-GigabitEthernet1/0/1] quit
```

Disable the spanning tree feature on GigabitEthernet 1/0/2.

```
[DeviceD] interface gigabitethernet 1/0/2
[DeviceD-GigabitEthernet1/0/2] undo stp enable
```

Configure the interface as a trunk port.

```
[DeviceD-GigabitEthernet1/0/2] port link-type trunk
```

Assign the interface to VLANs 1 through 30.

```
[DeviceD-GigabitEthernet1/0/2] port trunk permit vlan 1 to 30
```

Enable flush message receiving on the interface.

```
[DeviceD-GigabitEthernet1/0/2] smart-link flush enable
[DeviceD-GigabitEthernet1/0/2] quit
```

Create monitor link group 1.

```
[DeviceD] monitor-link group 1
```

Configure GigabitEthernet 1/0/1 as an uplink interface for monitor link group 1.

```
[DeviceD-mtlk-group1] port gigabitethernet 1/0/1 uplink
```

Configure GigabitEthernet 1/0/2 as a downlink interface for monitor link group 1.

```
[DeviceD-mtlk-group1] port gigabitethernet 1/0/2 downlink
[DeviceD-mtlk-group1] quit
```

Verifying the configuration

When GigabitEthernet 1/0/2 on Device A goes down because of a link fault, verify information about monitor link group 1 on Device B.

```
[DeviceB] display monitor-link group 1
Monitor link group 1 information:
  Group status     : UP
  Downlink up-delay: 0(s)
  Last-up-time     : 16:38:26 2012/4/21
  Last-down-time   : 16:37:20 2012/4/21
  Up-port-threshold: 1

  Member                    Role       Status
  ------------------------------------------------
  GE1/0/1                   UPLINK     UP
  GE1/0/2                   DOWNLINK   UP
```

Verify information about monitor link group 1 on Device D.

```
[DeviceD] display monitor-link group 1
Monitor link group 1 information:
  Group status     : DOWN
  Downlink up-delay: 0(s)
  Last-up-time     : 16:37:20 2012/4/21
  Last-down-time   : 16:38:26 2012/4/21
  Up-port-threshold: 1

  Member                    Role       Status
  ------------------------------------------------
  GE1/0/1                   UPLINK     DOWN
  GE1/0/2                   DOWNLINK   DOWN
```

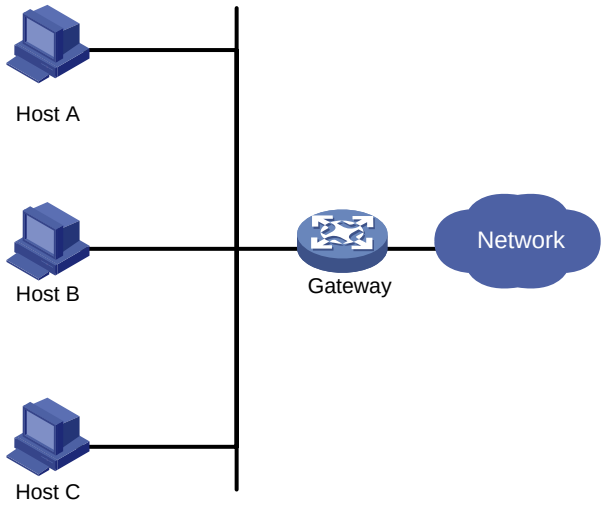
Contents

Configuring VRRP

About VRRP

Typically, you can configure a default gateway for every host on a LAN. All packets destined for other networks are sent through the default gateway. As shown in Figure 1, when the default gateway fails, no hosts can communicate with external networks.

Figure 1 LAN networking



Using a default gateway facilitates your configuration but requires high availability. Using more egress gateways improves link availability but introduces the problem of routing among the egresses.

Virtual Router Redundancy Protocol (VRRP) is designed to address this issue. VRRP adds a group of network gateways to a VRRP group called a virtual router. The VRRP group has one master and multiple backups, and provides a virtual IP address. The hosts on the subnet use the virtual IP address as their default network gateway to communicate with external networks.

VRRP avoids single points of failure and simplifies the configuration on hosts. When the master in the VRRP group on a multicast or broadcast LAN (for example, an Ethernet network) fails, another router in the VRRP group takes over. The switchover is complete without causing dynamic route recalculation, route re-discovery, gateway reconfiguration on the hosts, or traffic interruption.

VRRP operates in either of the following modes:

- **Standard mode**—Implemented based on RFCs. For more information, see "VRRP standard mode."
- **Load balancing mode**—Extends the VRRP standard mode to distribute load across VRRP group members. For more information, see "VRRP load balancing mode."

VRRP has two versions: VRRPv2 and VRRPv3. VRRPv2 supports IPv4 VRRP. VRRPv3 supports IPv4 VRRP and IPv6 VRRP.

VRRP group

VRRP adds a group of network gateways to a VRRP group called a virtual router. The VRRP group has one master and multiple backups, and provides a virtual IP address. The hosts on the subnet use the virtual IP address as their default network gateway to communicate with external networks.

The administrator can add a router to a VRRP group by creating the VRRP group on a Layer 3 interface on the router.

NOTE:

On a device, the interfaces added to VRRP groups having the same VRRP group number belong to different VRRP groups.

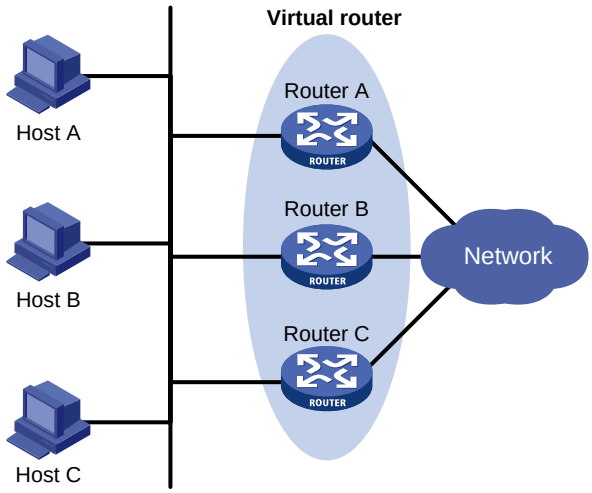
VRRP standard mode

VRRP networking

As shown in Figure 2, Router A, Router B, and Router C form a virtual router, which has a manually configured virtual IP address. Hosts on the subnet use the virtual router as the default gateway.

The router with the highest priority among the three routers is elected as the master, and the other two are backups. Only the master in the VRRP group can provide gateway service. When the master fails, the backup routers elect a new master to take over for nonstop gateway service.

Figure 2 VRRP networking



Virtual IP address and IP address owner

The virtual IP address of the virtual router can be either of the following IP addresses:

- Unused IP address on the subnet where the VRRP group resides.
- IP address of an interface on a router in the VRRP group.

In the latter case, the router is called the IP address owner. A VRRP group can have only one IP address owner.

Router priority in a VRRP group

VRRP determines the role (master or backup) of each router in a VRRP group by priority. A router with higher priority is more likely to become the master.

A VRRP priority can be in the range of 0 to 255, and a greater number represents a higher priority. Priorities 1 to 254 are configurable. Priority 0 is reserved for special uses, and priority 255 is for the

IP address owner. The IP address owner in a VRRP group always has a running priority of 255 and acts as the master as long as it operates correctly.

Preemption

A router in a VRRP group operates in either non-preemptive mode or preemptive mode.

- **Non-preemptive mode**—The master router acts as the master as long as it operates correctly, even if a backup router is later assigned a higher priority. Non-preemptive mode helps avoid frequent switchover between the master and backup routers.
- **Preemptive mode**—A backup starts a new master election and takes over as master when it detects that it has a higher priority than the current master. Preemptive mode ensures that the router with the highest priority in a VRRP group always acts as the master.

Authentication method

To avoid attacks from unauthorized users, VRRP member routers add authentication keys in VRRP packets to authenticate one another. VRRP provides the following authentication methods:

- Simple authentication

  The sender fills an authentication key into the VRRP packet, and the receiver compares the received authentication key with its local authentication key. If the two authentication keys match, the received VRRP packet is legitimate. Otherwise, the received packet is illegitimate and gets discarded.
- MD5 authentication

  The sender computes a digest for the VRRP packet by using the authentication key and MD5 algorithm, and saves the result to the packet. The receiver performs the same operation with the authentication key and MD5 algorithm, and compares the result with the content in the authentication header. If the results match, the received VRRP packet is legitimate. Otherwise, the received packet is illegitimate and gets discarded.

On a secure network, you can choose to not authenticate VRRP packets.

NOTE:

IPv4 VRRPv3 and IPv6 VRRPv3 do not support VRRP packet authentication.

VRRP timers

Skew_Time

Skew_Time helps avoid the situation that multiple backups in a VRRP group become the master when the master in the VRRP group fails.

Skew_Time is not configurable; its value depends on the VRRP version.

- In VRRPv2 (described in RFC 3768), Skew_Time is (256 – Router priority)/256.
- In VRRPv3 (described in RFC 5798), Skew_Time is ((256 – Router priority) × VRRP advertisement interval)/256.

VRRP advertisement interval

The master in a VRRP group periodically sends VRRP advertisements to declare its presence.

You can configure the interval at which the master sends VRRP advertisements. If a backup does not receive any VRRP advertisement when the timer (3 × VRRP advertisement interval + Skew_Time) expires, it takes over as the master.

VRRP preemption delay timer

You can configure the VRRP preemption delay timer for the following purposes:

- Avoid frequent state changes among members in a VRRP group.
- Provide the backups with enough time to collect information (such as routing information).

In preempt mode, a backup does not immediately become the master after it receives an advertisement with lower priority than the local priority. Instead, it waits for a period of time (preemption delay time + Skew_Time) before taking over as the master.

Master election

Routers in a VRRP group determine their roles by priority. When a router joins a VRRP group, it has a backup role. The router role changes according to the following situations:

- If the backup does not receive any VRRP advertisement when the timer (3 × advertisement interval + Skew_Time) expires, it becomes the master.
- If the backup receives a VRRP advertisement with the same or greater priority within the timer (3 × advertisement interval + Skew_Time), it remains a backup.
- If the backup receives a VRRP advertisement with a smaller priority within the timer (3 × advertisement interval + Skew_Time), the following results apply:
  - It remains a backup when operating in non-preemptive mode.
  - It becomes the master when operating in preemptive mode.

The elected master starts a VRRP advertisement interval to periodically send VRRP advertisements to notify the backups that it is operating correctly. Each of the backups starts a timer to wait for advertisements from the master.

When multiple routers in a VRRP group declare that they are the master because of network problems, the one with the highest priority becomes the master. If two routers have the same priority, the one with the highest IP address becomes the master.

VRRP tracking

The VRRP tracking function uses network quality analyzer (NQA) or bidirectional forwarding detection (BFD) to monitor the state of the master or the upstream link. The collaboration between VRRP and NQA or BFD through a track entry implements the following functions:

- Monitors the upstream link and changes the priority of the router according to the state of the link. If the upstream link fails, the hosts on the subnet cannot access external networks through the router and the state of the track entry becomes Negative. The priority of the master decreases by a specified value, and a router with a higher priority in the VRRP group becomes the master. The switchover ensures uninterrupted communication between the hosts on the subnet and external networks.
- Monitors the state of the master on the backups. When the master fails, a backup immediately takes over to ensure uninterrupted communication.

When the track entry changes from Negative to Positive or Notready, the router automatically restores its priority. For more information about track entries, see "Configuring Track."

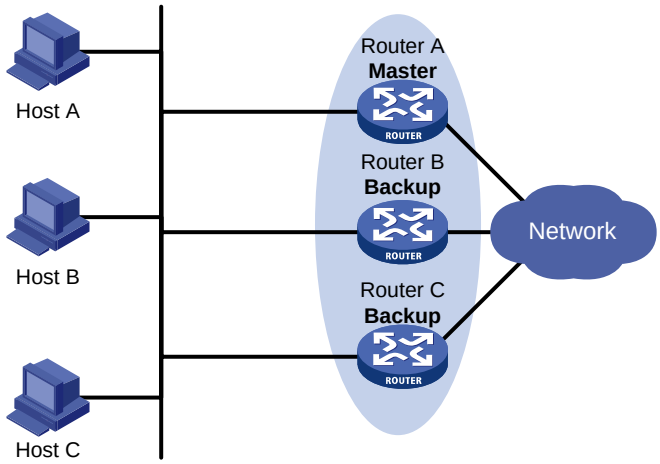
To enable VRRP tracking, configure the routers in the VRRP group to operate in preemptive mode first. This configuration ensures that only the router with the highest priority operates as the master.

VRRP application

Master/backup

In master/backup mode, only the master forwards packets, as shown in Figure 3. When the master fails, a new master is elected from among the backups. This mode requires only one VRRP group, and each router in the group has a different priority. The one with the highest priority becomes the master.

Figure 3 VRRP in master/backup mode



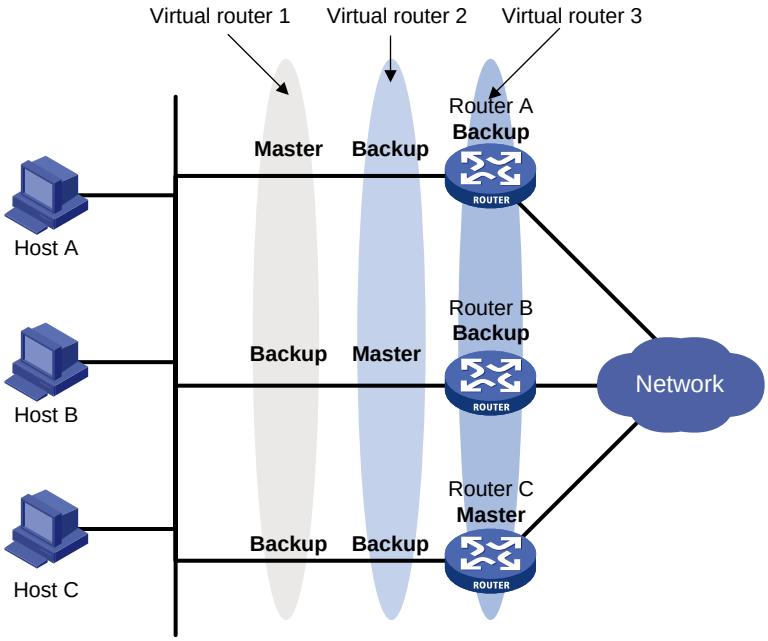
Assume that Router A is acting as the master to forward packets to external networks, and Router B and Router C are backups in listening state. When Router A fails, Router B and Router C elect a new master to forward packets for hosts on the subnet.

Load sharing

A router can join multiple VRRP groups. With different priorities in different VRRP groups, the router can act as the master in one VRRP group and a backup in another.

In load sharing mode, multiple VRRP groups provide gateway services. This mode requires a minimum of two VRRP groups, and each group has one master and multiple backups. The master roles in the VRRP groups are assumed by different routers, as shown in Figure 4.

Figure 4 Load sharing of VRRP



A router can be in multiple VRRP groups and have a different priority in each group.

As shown in Figure 4, the following VRRP groups exist:

- **VRRP group 1**—Router A is the master. Router B and Router C are the backups.
- **VRRP group 2**—Router B is the master. Router A and Router C are the backups.
- **VRRP group 3**—Router C is the master. Router A and Router B are the backups.

To implement load sharing among Router A, Router B, and Router C, perform the following tasks:

- Configure the virtual IP addresses of VRRP group 1, 2, and 3 as default gateway IP addresses for hosts on the subnet.
- Assign the highest priority to Router A, B, and C in VRRP group 1, 2, and 3, respectively.

VRRP load balancing mode

In a standard-mode VRRP group, only the master can forward packets and backups are in listening state. You can create multiple VRRP groups to share traffic, but you must configure different gateways for hosts on the subnet.

In load balancing mode, a VRRP group maps its virtual IP address to multiple virtual MAC addresses, assigning one virtual MAC address to each member router. Every router in this VRRP group can forward traffic and respond to IPv4 ARP requests or IPv6 ND requests from hosts. Because their virtual MAC addresses are different, traffic from hosts is distributed across the VRRP group members. Load balancing mode simplifies configuration and improves forwarding efficiency.

VRRP load balancing mode uses the same master election, preemption, and tracking mechanisms as the standard mode. New mechanisms have been introduced to VRRP load balancing mode, as described in the following sections.

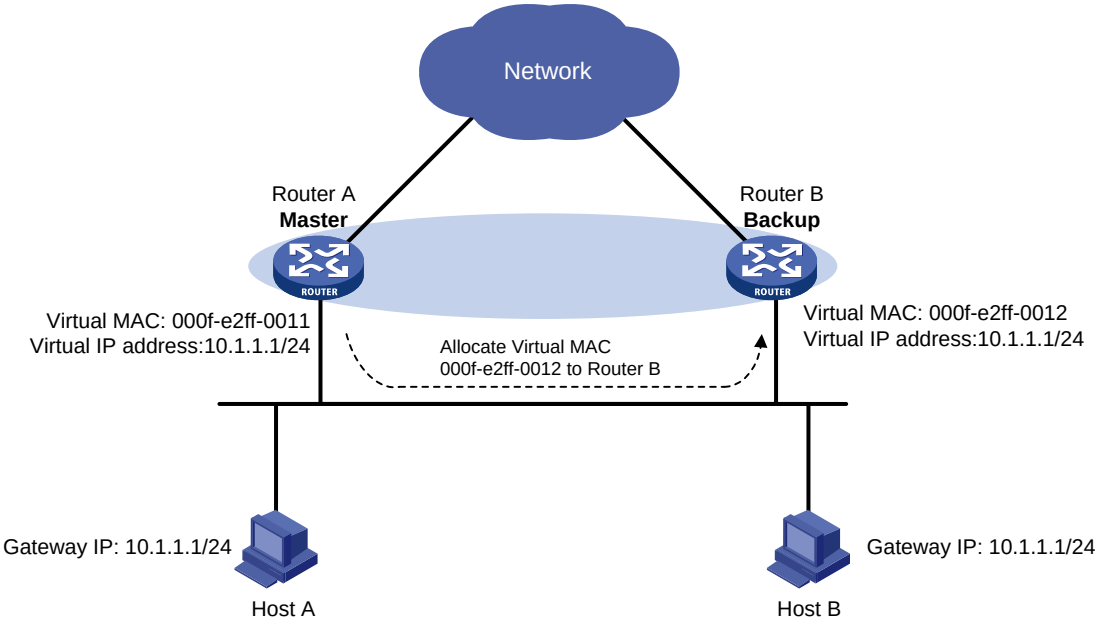
Virtual MAC address assignment

In load balancing mode, the master assigns virtual MAC addresses to routers in the VRRP group. The master uses different MAC addresses to respond to ARP requests or ND requests from different hosts. The backup routers, however, do not answer ARP requests or ND requests from hosts.

In an IPv4 network, a load balanced VRRP group works as follows:

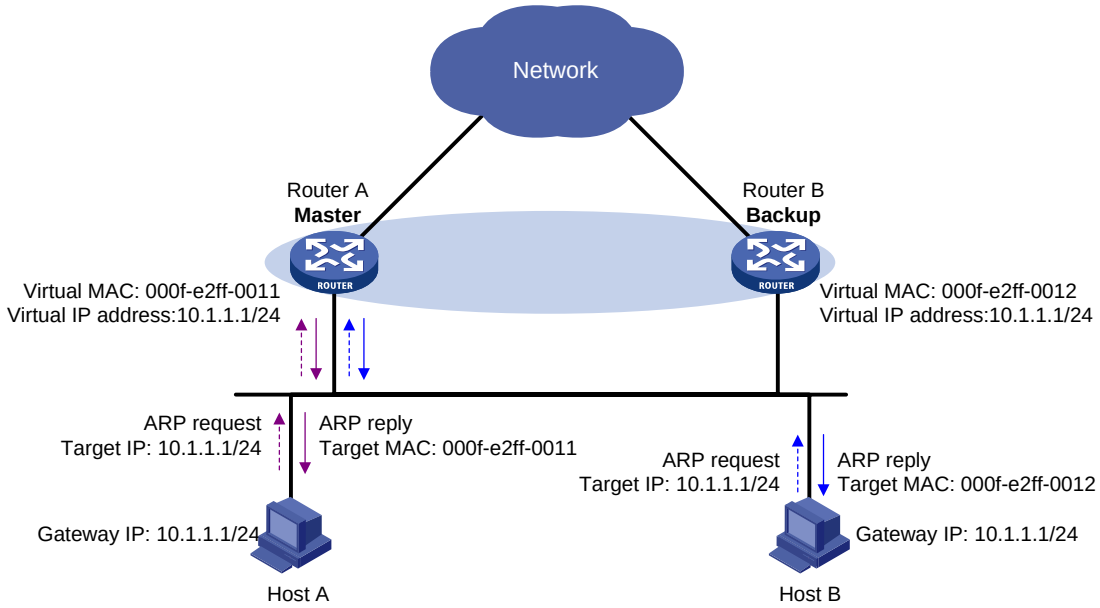
1. The master assigns virtual MAC addresses to all member routers, including itself. This example assumes that the virtual IP address of the VRRP group is 10.1.1.1/24, Router A is the master, and Router B is the backup. Router A assigns 000f-e2ff-0011 for itself and 000f-e2ff-0012 for Router B. See Figure 5.

   Figure 5 Virtual MAC address assignment



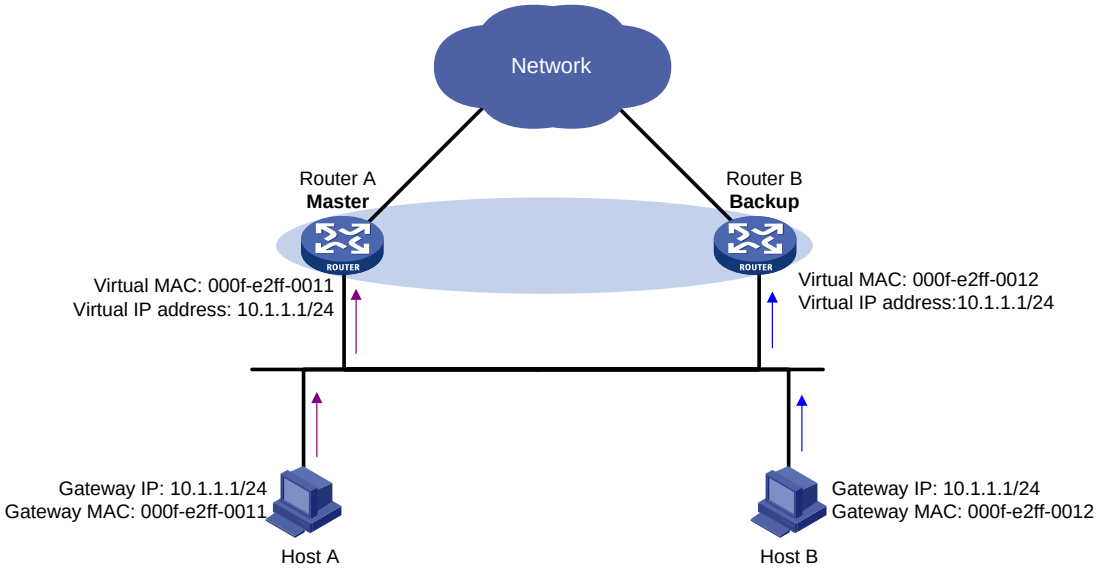
2. When an ARP request arrives, the master (Router A) selects a virtual MAC address based on the load balancing algorithm to answer the ARP request. In this example, Router A returns the virtual MAC address of itself in response to the ARP request from Host A. Router A returns the virtual MAC address of Router B in response to the ARP request from Host B. See Figure 6.

   Figure 6 Answering ARP requests



3. Each host sends packets to the returned MAC address. As shown in Figure 7, Host A sends packets to Router A and Host B sends packets to Router B.

Figure 7 Sending packets to different routers for forwarding



In the ARP reply sent by the master, the source MAC address in the Ethernet header is different from the sender MAC address in the message body. For the Layer 2 device to forward the ARP packet, follow these configuration guidelines on the Layer 2 device:

- Do not enable ARP packet source MAC address consistency check.
- Do not specify the **src-mac** keyword when you enable ARP packet validity check for ARP detection.

For more information about ARP packet source MAC address consistency check and ARP detection, see *Security Configuration Guide*.

Virtual forwarder

Virtual forwarder creation

Virtual MAC addresses enable traffic distribution across routers in a VRRP group. To enable routers in the VRRP group to forward packets, VFs must be created on them. Each VF is associated with a virtual MAC address in the VRRP group and forwards packets that are sent to this virtual MAC address.

VFs are created on routers in a VRRP group, as follows:

1. The master assigns virtual MAC addresses to all routers in the VRRP group. Each member router creates a VF for this MAC address and becomes the owner of this VF.
2. Each VF owner advertises its VF information to the other member routers.
3. After receiving the VF advertisement, each of the other routers creates the advertised VF.

Eventually, every member router maintains one VF for each virtual MAC address in the VRRP group.

VF weight and priority

The weight of a VF indicates the forwarding capability of a VF. A higher weight means higher forwarding capability. When the weight is lower than the lower limit of failure, the VF cannot forward packets.

The priority of a VF determines the VF state. Among the VFs created on different member routers for the same virtual MAC address, the VF with the highest priority is in active state. This VF, known as the active virtual forwarder (AVF), forwards packets. All other VFs listen to the state of the AVF and are known as the listening virtual forwarders (LVFs). VF priority is in the range of 0 to 255, where 255

is reserved for the VF owner. When the weight of a VF owner is higher than or equal to the lower limit of failure, the priority of the VF owner is 255.

The priority of a VF is calculated based on its weight.

- If the VF weight is higher than or equal to the lower limit of failure, the following VF priorities apply:
  - On a VF owner, the VF priority is 255.
  - On a non-VF owner, the VF priority is calculated as weight/(number of local AVFs + 1).
- If the VF weight is lower than the lower limit of failure, the VF priority is 0.

VF backup

The VFs corresponding to a virtual MAC address on different routers in the VRRP group back up one another.

Figure 8 VF information

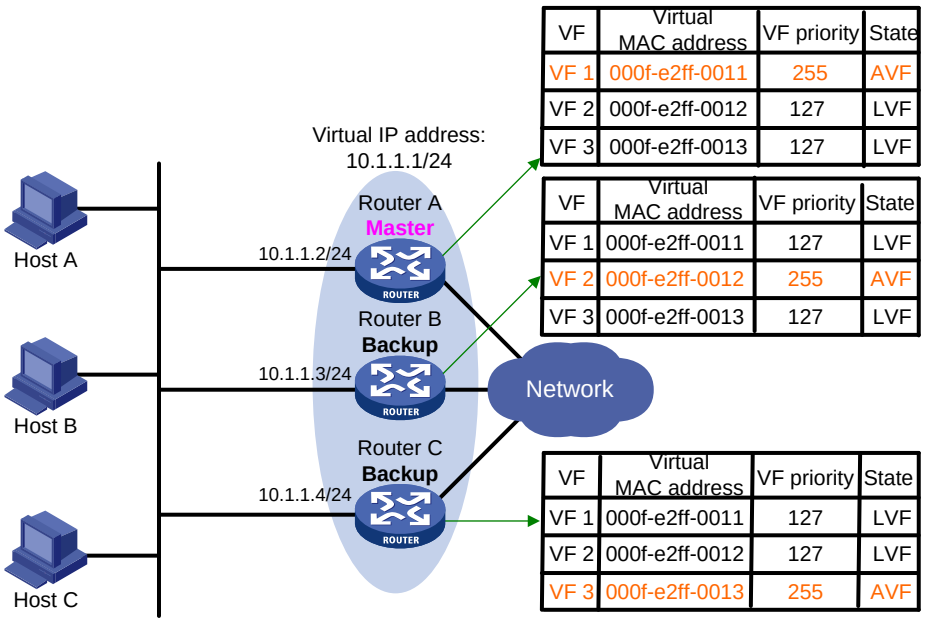


Figure 8 shows the VF table on each router in the VRRP group and how the VFs back up one another. The master, Router A, assigns virtual MAC addresses 000f-e2ff-0011, 000f-e2ff-0012, and 000f-e2ff-0013 to itself, Router B, and Router C, respectively. Each router creates VF 1, VF 2, and VF 3 for virtual MAC addresses 000f-e2ff-0011, 000f-e2ff-0012, and 000f-e2ff-0013, respectively. The VFs for the same virtual MAC address on different routers back up one another. For example, the VF 1 instances on Router A, Router B, and Router C back up one another.

- The VF 1 instance on Router A (the VF 1 owner) has priority 255. It acts as the AVF to forward packets sent to virtual MAC address 000f-e2ff-0011.
- The VF 1 instances on Router B and Router C have a priority of 255/(1 + 1), or 127. Because their priorities are lower than the priority of the VF 1 instance on Router A, they act as LVFs. These LVFs listen to the state of the VF 1 instance on Router A.
- When the VF 1 instance on Router A fails, the VF 1 instances on Router B and Router C elect the one with higher priority as the new AVF. This AVF forwards packets destined for virtual MAC address 000f-e2ff-0011. If the two LVFs' priorities are the same, the LVF with a greater device MAC address becomes the new AVF.

A VF always operates in preemptive mode. When an LVF finds its priority value higher than the one advertised by the AVF, the LVF declares itself as the AVF.

VF timers

When the AVF on a router fails, the new AVF on another router creates the following timers for the failed AVF:

- **Redirect timer**—Before this timer expires, the master still uses the virtual MAC address corresponding to the failed AVF to respond to ARP/ND requests from hosts. The VF owner can share traffic load if the VF owner resumes normal operation within this time. When this timer expires, the master stops using the virtual MAC address corresponding to the failed AVF to respond to ARP/ND requests from hosts.
- **Timeout timer**—The duration after which the new AVF takes over responsibilities of the failed VF owner. Before this timer expires, all routers in the VRRP group keep the VFs that correspond to the failed AVF. The new AVF forwards packets destined for the virtual MAC address of the failed AVF. When this timer expires, all routers in the VRRP group remove the VFs that correspond to the failed AVF, including the new AVF. Packets destined for the virtual MAC address of the failed AVF are not forwarded any longer.

VF tracking

An AVF forwards packets destined for the MAC address of the AVF. If the AVF's upstream link fails but no LVF takes over, the hosts that use the AVF's MAC address as their gateway MAC address cannot access the external network.

The VF tracking function can solve this problem. You can use NQA or BFD to monitor the upstream link state of the VF owner, and associate the VFs with NQA or BFD through the tracking function. This enables the collaboration between VRRP and NQA or BFD through the Track module. When the upstream link fails, the state of the track entry changes to Negative. The weights of the VFs (including the AVF) on the router decrease by a specific value. The corresponding LVF with a higher priority on another router becomes the AVF and forwards packets.

Protocols and standards

- RFC 3768, *Virtual Router Redundancy Protocol (VRRP)*
- RFC 5798, *Virtual Router Redundancy Protocol (VRRP) Version 3 for IPv4 and IPv6*

Restrictions: Hardware compatibility with VRRP

The S5110V2, S5110V2-SI, S5120V3-LI, S5000V3-EI, S5000V5-EI, S5000E-X, S5000X-EI, WS5810-WiNet, and WAS6000 switch series do not support VRRP.

Configuring IPv4 VRRP

Restrictions and guidelines: IPv4 VRRP configuration

IPv4 VRRP does not take effect on member ports of aggregation groups.

Configuration on the routers in an IPv4 VRRP group must be consistent.

Each IPv4 VRRP group corresponds to a virtual MAC address. The maximum number of IPv4 VRRP groups supported on an interface depends on the maximum number of virtual MAC addresses supported on the interface.

IPv4 VRRP tasks at a glance

To configure IPv4 VRRP, perform the following tasks:

1. Specifying an IPv4 VRRP operating mode
2. (Optional.) Specifying the IPv4 VRRP version
3. Configuring an IPv4 VRRP group
4. (Optional.) Configuring IPv4 VRRP packet attributes
5. (Optional.) Configuring VF tracking

   This configuration takes effect only in VRRP load balancing mode.
6. (Optional.) Setting the packet sending mode for IPv4 VRRPv3
7. (Optional.) Enabling periodic sending of gratuitous ARP packets for IPv4 VRRP
8. (Optional.) Configuring a subordinate IPv4 VRRP group to follow a master IPv4 VRRP group
9. (Optional.) Enabling SNMP notifications for VRRP

Specifying an IPv4 VRRP operating mode

Restrictions and guidelines

After an IPv4 VRRP operating mode is configured on a router, all IPv4 VRRP groups on the router operate in the specified operating mode.

Procedure

1. Enter system view.

   system-view
2. Specify an IPv4 VRRP operating mode.
   - Specify the standard mode.

     undo vrrp mode
   - Specify the load balancing mode.

     vrrp mode load-balance [**version-8**]

   By default, VRRP operates in standard mode.

Specifying the IPv4 VRRP version

About IPv4 VRRP versions

IPv4 VRRP can use VRRPv2 and VRRPv3.

Restrictions and guidelines

For an IPv4 VRRP group to operate correctly, make sure the same VRRP version is used on all routers in the IPv4 VRRP group.

Procedure

1. Enter system view.

   system-view
2. Enter interface view.

   interface *interface-type interface-number*
3. Specify the version of VRRP.

   vrrp version *version-number*

   By default, VRRPv3 is used.

Configuring an IPv4 VRRP group

About IPv4 VRRP group

A VRRP group can operate correctly after you create it and assign a minimum of one virtual IP address to it. You can configure multiple virtual IP addresses for the VRRP group on an interface that connects to multiple subnets for router backup on different subnets.

If you disable an IPv4 VRRP group, the VRRP group enters **Initialize** state, and the existing configuration on the VRRP group remains unchanged. You can modify the configuration of the VRRP group. The modification takes effect when you enable the VRRP group again.

Restrictions and guidelines

Item	Remarks
Maximum number of VRRP groups and virtual IP addresses	In VRRP load balancing mode, the device supports a maximum of *MaxVRNum/N* VRRP groups. *MaxVRNum* refers to the maximum number of VRRP groups supported by the device in VRRP standard mode. *N* refers to the number of devices in the VRRP group.
Virtual IP address	When VRRP is operating in standard mode, the virtual IP address of a VRRP group can be either of the following addresses: • Unused IP address on the subnet where the VRRP group resides. • IP address of an interface on a router in the VRRP group. In load balancing mode, the virtual IP address of a VRRP group can be any unassigned IP address of the subnet where the VRRP group resides. It cannot be the IP address of any interfaces in the VRRP group. No IP address owner can exist in a VRRP group. An IPv4 VRRP group without virtual IP addresses configured can exist on a device provided that other settings (for example, priority and preemption mode) are available. Such a VRRP group stays in inactive state and does not function. For hosts in the subnet to access external networks, as a best practice, configure the following addresses in the same subnet: • Virtual IP address of an IPv4 VRRP group. • Downlink interface IP addresses of the VRRP group members.
IP address owner	On an IP address owner, as a best practice, do not use the **network** command to enable OSPF on the interface owning the virtual IP address of the VRRP group. For more information about the **network** command, see *Layer 3—IP Routing Command Reference*. Removal of the VRRP group on the IP address owner causes IP address collision. To avoid the collision, change the IP address of the interface on the IP address owner before you remove the VRRP group from the interface. The running priority of an IP address owner is always 255, and you do not need to configure it. An IP address owner always operates in preemptive mode. If you configure the **vrrp vrid track priority reduced** or **vrrp vrid track switchover** command on an IP address owner, the configuration does not take effect until the router becomes a non-IP address owner.
VRRP association with a track entry	When the track entry changes from Negative to Positive or Notready, the router automatically restores its priority or the failed master router becomes the master again.

Creating a VRRP group and assigning a virtual IP address

1. Enter system view.
   system-view
2. Enter interface view.
   interface *interface-type interface-number*
3. Create a VRRP group and assign a virtual IP address.
   vrrp vrid *virtual-router-id* **virtual-ip** *virtual-address*

Configuring an IPv4 VRRP group

1. Enter system view.
   system-view
2. Enter interface view.
   interface *interface-type interface-number*
3. Set the priority of the router in the VRRP group.
   vrrp vrid *virtual-router-id* **priority** *priority-value*

   The default setting is 100.
4. Enable the preemptive mode for the router in a VRRP group and set the preemption delay time.
   vrrp vrid *virtual-router-id* **preempt-mode** [**delay** *delay-value*]

   By default, the router in a VRRP group operates in preemptive mode and the preemption delay time is 0 centiseconds, which means an immediate preemption.
5. Associate a VRRP group with a track entry.
   vrrp vrid *virtual-router-id* **track** *track-entry-number* { **forwarder-switchover member-ip** *ip-address* | **priority reduced** [*priority-reduced*] | **switchover** | **weight reduced** [*weight-reduced*] }

   By default, a VRRP group is not associated with any track entries.

Disabling an IPv4 VRRP group

1. Enter system view.
   system-view
2. Enter interface view.
   interface *interface-type interface-number*
3. Disable a VRRP group.
   vrrp vrid *virtual-router-id* **shutdown**

Configuring IPv4 VRRP packet attributes

Restrictions and guidelines

- You can configure different authentication modes and authentication keys for VRRP groups on an interface. However, members of the same VRRP group must use the same authentication mode and authentication key.
- In VRRPv2, all routers in a VRRP group must have the same VRRP advertisement interval.
- In VRRPv3, authentication mode and authentication key settings do not take effect.
- In VRRPv3, routers in an IPv4 VRRP group can have different intervals for sending VRRP advertisements. The master in the VRRP group sends VRRP advertisements at specified intervals, and carries the interval in the advertisements. After a backup receives the advertisement, it records the interval in the advertisement. If the backup does not receive a VRRP advertisement before the timer (3 x recorded interval + Skew_Time) expires, it regards the master as failed and takes over.

Procedure

1. Enter system view.

   system-view

2. Enter interface view.

   interface *interface-type interface-number*

3. Configure the authentication mode and authentication key for an IPv4 VRRP group to send and receive VRRP packets.

   vrrp vrid *virtual-router-id* **authentication-mode** { **md5** | **simple** } { **cipher** | **plain** } *string*

   By default, authentication is disabled.

4. Set the interval at which the master in an IPv4 VRRP group sends VRRP advertisements.

   vrrp vrid *virtual-router-id* **timer advertise** *adver-interval*

   The default setting is 100 centiseconds.

   As a best practice to maintain system stability, set the VRRP advertisement interval to be greater than 100 centiseconds.

5. Specify the source interface for receiving and sending VRRP packets.

   vrrp vrid *virtual-router-id* **source-interface** *interface-type interface-number*

   By default, the source interface for receiving and sending VRRP packets is not specified. The interface where the VRRP group resides sends and receives VRRP packets.

6. Enable TTL check for IPv4 VRRP packets.

   vrrp check-ttl enable

   By default, TTL check for IPv4 VRRP packets is enabled.

7. Return to system view.

   quit

8. Set a DSCP value for VRRP packets.

   vrrp dscp *dscp-value*

   By default, the DSCP value for VRRP packets is 48.

   The DSCP value identifies the packet priority during transmission.

Configuring VF tracking

About VF tracking

You can configure VF tracking in both standard mode and load balancing mode, but the function takes effect only in load balancing mode.

In load balancing mode, you can establish the collaboration between the VFs and NQA or BFD through the tracking function. When the state of the track entry transits to Negative, the weights of all VFs in the VRRP group on the router decrease by a specific value. When the state of the track entry transits to Positive or Notready, the original weight values of the VFs restore.

Restrictions and guidelines

- By default, the weight of a VF is 255, and its lower limit of failure is 10.
- When the weight of a VF owner is higher than or equal to the lower limit of failure, its priority is always 255. The priority does not change with the weight. When the upstream link of the VF owner fails, an LVF must take over as the AVF. The switchover happens when the weight of the VF owner drops below the lower limit of failure. This requires that the reduced weight for the VF owner be higher than 245.

Procedure

1. Enter system view.
   system-view
2. Enter interface view.
   interface *interface-type interface-number*
3. Configure the VFs in a VRRP group to monitor a track entry.
   vrrp vrid *virtual-router-id* **track** *track-entry-number* { **forwarder-switchover member-ip** *ip-address* | **priority reduced** [*priority-reduced*] | **switchover** | **weight reduced** [*weight-reduced*] }
   By default, no track entry is specified.

Setting the packet sending mode for IPv4 VRRPv3

About the packet sending mode for IPv4 VRRPv3

A router configured with VRRPv3 can process incoming VRRPv2 packets, but a router configured with VRRPv2 cannot process incoming VRRPv3 packets. When the VRRP version of the routers in a VRRP group is changed from VRRPv2 to VRRPv3, multiple masters might be elected in the VRRP group. To resolve the problem, you can set the packet sending mode for IPv4 VRRPv3. This task enables a router configured with VRRPv3 to send VRRPv2 packets and communicate with routers configured with VRRPv2.

Restrictions and guidelines

- The packet sending mode for IPv4 VRRPv3 takes effect only on outgoing VRRP packets. A router configured with VRRPv3 can process incoming VRRPv2 and VRRPv3 packets.
- If you set the packet sending mode for IPv4 VRRPv3 and configure VRRP packet authentication, authentication information will be carried in outgoing VRRPv2 packets but not in outgoing VRRPv3 packets.
- The VRRP advertisement interval is set in centiseconds by using the **vrrp vrid timer advertise** command. The VRRP advertisement interval carried in VRRPv2 packets sent from routers configured with VRRPv3 might be different from the configured value. For information about the VRRP advertisement interval, see the **vrrp vrid timer advertise** command in *High Availability Command Reference*.

Procedure

1. Enter system view.
   system-view
2. Enter interface view.
   interface *interface-type interface-number*
3. Set the packet sending mode for IPv4 VRRPv3.
   vrrp vrid *virtual-router-id* **vrrpv3-send-packet** { **v2-only** | **v2v3-both** }
   By default, a router configured with VRRPv3 sends only VRRPv3 packets.

Enabling periodic sending of gratuitous ARP packets for IPv4 VRRP

About periodic sending of gratuitous ARP packets for IPv4 VRRP

This feature enables the master router in a VRRP group to periodically send gratuitous ARP packets. Then the downstream devices can update the MAC address entry for the virtual MAC address of the VRRP group in a timely manner.

Restrictions and guidelines

- This feature takes effect only in VRRP standard mode.
- If you change the sending interval for gratuitous ARP packets, the configuration takes effect at the next sending interval.
- The master sends the first gratuitous ARP packet at a random time in the second half of the set interval after you execute the **vrrp send-gratuitous-arp** command. This prevents too many gratuitous ARP packets from being sent at the same time.
- The sending interval for gratuitous ARP packets might be much longer than the set interval when the following conditions are met:
  - Multiple VRRP groups exist on the device.
  - A short sending interval is set.

Procedure

1. Enter system view.

   system-view
2. Enable periodic sending of gratuitous ARP packets for IPv4 VRRP.

   vrrp send-gratuitous-arp [**interval** *interval*]

   By default, periodic sending of gratuitous ARP packets is disabled for IPv4 VRRP.

Configuring a subordinate IPv4 VRRP group to follow a master IPv4 VRRP group

About master and subordinate IPv4 VRRP groups

Each VRRP group determines the device role (master or backup) by exchanging VRRP packets among member devices, which might consume excessive bandwidth and CPU resources. To reduce the number of VRRP packets in the network, you can configure a subordinate VRRP group to follow a master VRRP group.

A master VRRP group determines the device role through exchanging VRRP packets among member devices. A VRRP group that follows a master group, called a subordinate VRRP group, does not exchange VRRP packets among its member devices. The state of the subordinate VRRP group follows the state of the master group.

Restrictions and guidelines

- To ensure the master router election, configure the settings such as the router priority, preemptive mode, and tracking function for the master IPv4 VRRP group. The settings are not required for subordinate IPv4 VRRP groups.
- You can configure a subordinate VRRP group to follow a master VRRP group in both VRRP standard and load balancing modes. The configuration takes effect only in VRRP standard mode.
- An IPv4 VRRP group cannot be both a master group and a subordinate group.
- An IPv4 VRRP group stays in **Inactive** state if it is configured to follow a nonexistent master group.
- If an IPv4 VRRP group in **Inactive** or **Initialize** state follows a master group that is not in **Inactive** state, the state of the VRRP group does not change.
- A subordinate IPv4 VRRP group does not exchange VRRP packets, which might cause the MAC address entry for its virtual MAC address not to be updated on downstream devices. As a best practice, enable periodic sending of gratuitous ARP packets for IPv4 VRRP by using the **vrrp send-gratuitous-arp** command.

Procedure

1. Enter system view.
   system-view
2. Enter interface view.
   interface *interface-type interface-number*
3. Configure an IPv4 VRRP group as a master group and assign a name to it.
   vrrp vrid *virtual-router-id* **name** *name*
   By default, an IPv4 VRRP group does not act as a master group.
4. Return to system view.
   quit
5. Enter interface view.
   interface *interface-type interface-number*
6. Configure an IPv4 VRRP group to follow a master group.
   vrrp vrid *virtual-router-id* **follow** *name*
   By default, an IPv4 VRRP group does not follow a master VRRP group.

Enabling SNMP notifications for VRRP

About SNMP notifications for VRRP

To report critical VRRP events to an NMS, enable SNMP notifications for VRRP. For VRRP event notifications to be sent correctly, you must also configure SNMP on the device. For more information about SNMP configuration, see the network management and monitoring configuration guide for the device.

Procedure

1. Enter system view.
   system-view
2. Enable SNMP notifications for VRRP.
   snmp-agent trap enable vrrp [**auth-failure** | **new-master**]
   By default, SNMP notifications for VRRP are enabled.

Display and maintenance commands for IPv4 VRRP

Execute **display** commands in any view and the **reset** command in user view.

Task	Command
Display states of IPv4 VRRP groups.	**display vrrp** [**interface** *interface-type interface-number* [**vrid** *virtual-router-id*]] [**verbose**]
Display master-to-subordinate IPv4 VRRP group bindings.	**display vrrp binding** [**interface** *interface-type interface-number* [**vrid** *virtual-router-id*] | **name** *name*]
Display statistics for IPv4 VRRP groups.	**display vrrp statistics** [**interface** *interface-type interface-number* [**vrid** *virtual-router-id*]]
Clear statistics for IPv4 VRRP	**reset vrrp statistics** [**interface**

Task	Command
groups.	*interface-type interface-number* [**vrid** *virtual-router-id*]]

Configuring IPv6 VRRP

Restrictions and guidelines: IPv6 VRRP configuration

IPv6 VRRP does not take effect on member ports of aggregation groups.

Configuration on the routers in an IPv6 VRRP group must be consistent.

Each IPv6 VRRP group corresponds to a virtual MAC address. The maximum number of IPv6 VRRP groups supported on an interface depends on the maximum number of virtual MAC addresses supported on the interface.

IPv6 VRRP tasks at a glance

To configure IPv6 VRRP, perform the following tasks:

1. Specifying an IPv6 VRRP operating mode
2. Configuring an IPv6 VRRP group
3. (Optional.) Configuring VF tracking

   This configuration takes effect only in VRRP load balancing mode.
4. (Optional.) Configuring IPv6 VRRP packet attributes
5. (Optional.) Enabling periodic sending of ND packets for IPv6 VRRP
6. (Optional.) Configuring a subordinate IPv6 VRRP group to follow a master IPv6 VRRP group

Specifying an IPv6 VRRP operating mode

Restrictions and guidelines

After the IPv6 VRRP operating mode is specified on a router, all IPv6 VRRP groups on the router operate in the specified operating mode.

Procedure

1. Enter system view.

   system-view
2. Specify an IPv6 VRRP operating mode.
   - Specify the standard mode.

     undo vrrp ipv6 mode
   - Specify the load balancing mode.

     vrrp ipv6 mode load-balance

   By default, VRRP operates in standard mode.

Configuring an IPv6 VRRP group

About IPv6 VRRP group

A VRRP group can work correctly after you create it and assign a minimum of one virtual IPv6 address for it. You can configure multiple virtual IPv6 addresses for the VRRP group on an interface that connects to multiple subnets for router backup.

If you disable an IPv6 VRRP group, the VRRP group enters **Initialize** state, and the existing configuration on the VRRP group remains unchanged. You can modify the configuration of the VRRP group. The modification takes effect when you enable the VRRP group again.

Restrictions and guidelines

Item	Remarks
Maximum number of VRRP groups and virtual IPv6 addresses	In VRRP load balancing mode, the device supports a maximum of *MaxVRNum/N* VRRP groups. *MaxVRNum* refers to the maximum number of VRRP groups supported by the device in VRRP standard mode. *N* refers to the number of devices in the VRRP group.
Virtual IPv6 address	In load balancing mode, the virtual IPv6 address of a VRRP group cannot be the same as the IPv6 address of any interfaces in the VRRP group. No IP address owner can exist in a VRRP group. An IPv6 VRRP group without virtual IPv6 addresses configured can exist on a device provided that other settings (for example, priority and preemption mode) are available. Such a VRRP group stays in inactive state and does not function. For hosts in the subnet to access external networks, as a best practice, configure the following addresses in the same subnet: • Virtual IPv6 address of an IPv6 VRRP group. • Downlink interface IPv6 addresses of the VRRP group members.
IP address owner	On an IP address owner, as a best practice, do not use the **ospfv3 area** command to enable OSPF on the interface owning the virtual IPv6 address of the VRRP group. For more information about the **ospfv3 area** command, see *Layer 3—IP Routing Command Reference*. Removal of the VRRP group on the IP address owner causes IP address collision. To avoid the collision, change the IPv6 address of the interface on the IP address owner before you remove the VRRP group from the interface. The running priority of an IP address owner is always 255, and you do not need to configure it. An IP address owner always operates in preemptive mode. If you configure the **vrrp ipv6 vrid track priority reduced** or **vrrp ipv6 vrid track switchover** command on an IP address owner, the configuration does not take effect until the router becomes a non-IP address owner. On an IP address owner, disable Duplicate Address Detection (DAD) on the interface configured with VRRP. To disable DAD, set the *interval* argument to 0 for the **ipv6 nd dad attempts** command. For more information about the command, see IPv6 basics commands in *Layer 3—IP Services Command Reference*.
VRRP association with a track entry	When the track entry changes from Negative to Positive or Notready, the router automatically restores its priority or the failed master router becomes the master again.

Creating a VRRP group and assign a virtual IPv6 address

1. Enter system view.

   system-view

2. Enter interface view.

   interface *interface-type interface-number*

3. Create a VRRP group and assign a virtual IPv6 address, which is a link-local address.

   vrrp ipv6 vrid *virtual-router-id* **virtual-ip** *virtual-address* **link-local**

   The first virtual IPv6 address that you assign to an IPv6 VRRP group must be a link-local address. It must be the last address you remove. Only one link-local address is allowed in a VRRP group.

Configuring an IPv6 VRRP group

1. Enter system view.

   system-view

2. Enter interface view.

   interface *interface-type interface-number*

3. Assign a virtual IPv6 address, which is a global unicast address.

   vrrp ipv6 vrid *virtual-router-id* **virtual-ip** *virtual-address*

   By default, no global unicast address is assigned to an IPv6 VRRP group.

4. Set the priority of the router in the VRRP group.

   vrrp ipv6 vrid *virtual-router-id* **priority** *priority-value*

   The default setting is 100.

5. Enable the preemptive mode for the router in a VRRP group and set the preemption delay time.

   vrrp ipv6 vrid *virtual-router-id* **preempt-mode** [**delay** *delay-value*]

   By default, the router in a VRRP group operates in preemptive mode and the preemption delay time is 0 centiseconds, which means an immediate preemption.

6. Associate a VRRP group with a track entry.

   vrrp ipv6 vrid *virtual-router-id* **track** *track-entry-number* { **forwarder-switchover member-ip** *ipv6-address* | **priority reduced** [*priority-reduced*] | **switchover** | **weight reduced** [*weight-reduced*] }

   By default, a VRRP group is not associated with any track entries.

Disabling an IPv6 VRRP group

1. Enter system view.

   system-view

2. Enter interface view.

   interface *interface-type interface-number*

3. Disable an IPv6 VRRP group.

   vrrp ipv6 vrid *virtual-router-id* **shutdown**

   By default, an IPv6 VRRP group is enabled.

Configuring VF tracking

About VF tracking

You can configure VF tracking in both standard mode and load balancing mode, but the function takes effect only in load balancing mode.

In load balancing mode, you can configure the VFs in a VRRP group to monitor a track entry. When the state of the track entry transits to Negative, the weights of all VFs in the VRRP group on the router decrease by a specific value. When the state of the track entry transits to Positive or Notready, the original weights of the VFs restore.

Restrictions and guidelines

- By default, the weight of a VF is 255, and its lower limit of failure is 10.
- When the weight of a VF owner is higher than or equal to the lower limit of failure, its priority is always 255. The priority does not change with the weight. When the upstream link of the VF owner fails, an LVF must take over as the AVF. The switchover happens when the weight of the VF owner drops below the lower limit of failure. This requires that the reduced weight for the VF owner be higher than 245.

Procedure

1. Enter system view.

   system-view

2. Enter interface view.

   interface *interface-type interface-number*

3. Configure the VFs in a VRRP group to monitor a track entry.

   vrrp ipv6 vrid *virtual-router-id* **track** *track-entry-number* { **forwarder-switchover member-ip** *ipv6-address* | **priority reduced** [*priority-reduced*] | **switchover** | **weight reduced** [*weight-reduced*] }

   By default, no track entry is specified.

Configuring IPv6 VRRP packet attributes

Restrictions and guidelines

- The routers in an IPv6 VRRP group can have different intervals for sending VRRP advertisements. The master in the VRRP group sends VRRP advertisements at the specified interval and carries the interval attribute in the advertisements. After a backup receives the advertisement, it records the interval in the advertisement. If the backup does not receive a VRRP advertisement before the timer (3 x recorded interval + Skew_Time) expires, it regards the master as failed and takes over.
- A high volume of network traffic might cause a backup to fail to receive VRRP advertisements from the master within the specified time. As a result, an unexpected master switchover occurs. To solve this problem, configure a larger interval.

Procedure

1. Enter system view.

   system-view

2. Enter interface view.

   interface *interface-type interface-number*

3. Set the IPv6 VRRP advertisement interval.

   vrrp ipv6 vrid *virtual-router-id* **timer advertise** *adver-interval*

   The default setting is 100 centiseconds.

   As a best practice to maintain system stability, set the VRRP advertisement interval to be greater than 100 centiseconds.

4. Return to system view.

   quit

5. Set a DSCP value for IPv6 VRRP packets.

vrrp ipv6 dscp *dscp-value*

By default, the DSCP value for IPv6 VRRP packets is 56.

The DSCP value identifies the packet priority during transmission.

Enabling periodic sending of ND packets for IPv6 VRRP

About periodic sending of ND packets for IPv6 VRRP

This feature enables the master router in an IPv6 VRRP group to periodically send ND packets. Then the downstream devices can update the MAC address entry for the virtual MAC address of the IPv6 VRRP group in a timely manner.

Restrictions and guidelines

- This feature takes effect only in VRRP standard mode.
- If you change the sending interval for ND packets, the configuration takes effect at the next sending interval.
- The master sends the first ND packet at a random time in the second half of the set interval after you execute the **vrrp ipv6 send-nd** command. This prevents too many ND packets from being sent at the same time.
- The sending interval for ND packets might be much longer than the set interval when the following conditions are met:
  - Multiple IPv6 VRRP groups exist on the device.
  - A short sending interval is set.

Procedure

1. Enter system view.

   system-view
2. Enable periodic sending of ND packets for IPv6 VRRP.

   vrrp ipv6 send-nd [**interval** *interval*]

   By default, periodic sending of ND packets is disabled for IPv6 VRRP.

Configuring a subordinate IPv6 VRRP group to follow a master IPv6 VRRP group

About master and subordinate IPv6 VRRP groups

Each IPv6 VRRP group determines the device role (master or backup) by exchanging VRRP packets among member devices, which might consume excessive bandwidth and CPU resources. To reduce the number of VRRP packets in the network, you can configure a subordinate IPv6 VRRP group to follow a master IPv6 VRRP group.

A master IPv6 VRRP group determines the device role through exchanging VRRP packets among member devices. An IPv6 VRRP group that follows a master group, called a subordinate VRRP group, does not exchange VRRP packets among its member devices. The state of the subordinate VRRP group follows the state of the master group.

Restrictions and guidelines

- To ensure the master router election, configure the settings such as the router priority, preemptive mode, and tracking function for the master IPv6 VRRP group. The settings are not required for subordinate IPv6 VRRP groups.

- You can configure a subordinate IPv6 VRRP group to follow a master IPv6 VRRP group in both VRRP standard and load balancing modes. The configuration takes effect only in VRRP standard mode.
- An IPv6 VRRP group cannot be both a master group and a subordinate group.
- An IPv6 VRRP group stays in **Inactive** state if it is configured to follow a nonexistent master IPv6 VRRP group.
- If an IPv6 VRRP group in **Inactive** or **Initialize** state follows a master group that is not in **Inactive** state, the state of the VRRP group does not change.
- A subordinate IPv6 VRRP group does not exchange VRRP packets, which might cause the MAC address entry for its virtual MAC address not to be updated on downstream devices. As a best practice, enable periodic sending of ND packets for IPv6 VRRP by using the **vrrp ipv6 send-nd** command.

Procedure

1. Enter system view.
   system-view
2. Enter interface view.
   interface *interface-type interface-number*
3. Configure an IPv6 VRRP group as a master group and assign a name to it.
   vrrp ipv6 vrid *virtual-router-id* **name** *name*
   By default, an IPv6 VRRP group does not act as a master group.
4. Return to system view.
   quit
5. Enter interface view.
   interface *interface-type interface-number*
6. Configure an IPv6 VRRP group to follow a master group.
   vrrp ipv6 vrid *virtual-router-id* **follow** *name*
   By default, an IPv6 VRRP group does not follow a master VRRP group.

Display and maintenance commands for IPv6 VRRP

Execute **display** commands in any view and the **reset** command in user view.

Task	Command
Display the states of IPv6 VRRP groups.	**display vrrp ipv6** [**interface** *interface-type interface-number* [**vrid** *virtual-router-id*]] [**verbose**]
Display master-to-subordinate IPv6 VRRP group bindings.	**display vrrp ipv6 binding** [**interface** *interface-type interface-number* [**vrid** *virtual-router-id*] | **name** *name*]
Display statistics for IPv6 VRRP groups.	**display vrrp ipv6 statistics** [**interface** *interface-type interface-number* [**vrid** *virtual-router-id*]]
Clear statistics for IPv6 VRRP groups.	**reset vrrp ipv6 statistics** [**interface** *interface-type interface-number* [**vrid** *virtual-router-id*]]

IPv4 VRRP configuration examples

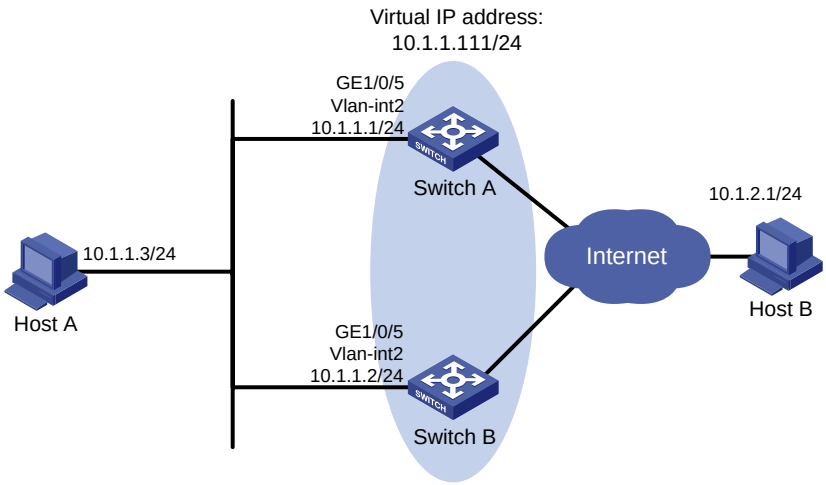
Example: Configuring a single VRRP group

Network configuration

As shown in Figure 9, Switch A and Switch B form a VRRP group. They use the virtual IP address 10.1.1.111/24 to provide gateway service for the subnet where Host A resides.

Switch A operates as the master to forward packets from Host A to Host B. When Switch A fails, Switch B takes over to forward packets for Host A.

Figure 9 Network diagram



Procedure

1. Configure Switch A:

   # Configure VLAN 2.

   ```
   <SwitchA> system-view
   [SwitchA] vlan 2
   [SwitchA-vlan2] port gigabitethernet 1/0/5
   [SwitchA-vlan2] quit
   [SwitchA] interface vlan-interface 2
   [SwitchA-Vlan-interface2] ip address 10.1.1.1 255.255.255.0
   ```

   # Create VRRP group 1 on VLAN-interface 2, and set its virtual IP address to 10.1.1.111.

   ```
   [SwitchA-Vlan-interface2] vrrp vrid 1 virtual-ip 10.1.1.111
   ```

   # Assign Switch A a higher priority than Switch B in VRRP group 1, so Switch A can become the master.

   ```
   [SwitchA-Vlan-interface2] vrrp vrid 1 priority 110
   ```

   # Configure Switch A to operate in preemptive mode, so it can become the master whenever it operates correctly. Set the preemption delay to 5000 centiseconds to avoid frequent status switchover.

   ```
   [SwitchA-Vlan-interface2] vrrp vrid 1 preempt-mode delay 5000
   ```

2. Configure Switch B:

   # Configure VLAN 2.

   ```
   <SwitchB> system-view
   [SwitchB] vlan 2
   ```

```
[SwitchB-Vlan2] port gigabitethernet 1/0/5
[SwitchB-vlan2] quit
[SwitchB] interface vlan-interface 2
[SwitchB-Vlan-interface2] ip address 10.1.1.2 255.255.255.0
```

Create VRRP group 1 on VLAN-interface 2, and set its virtual IP address to 10.1.1.111.

```
[SwitchB-Vlan-interface2] vrrp vrid 1 virtual-ip 10.1.1.111
```

Set the priority of Router B to 100 in VRRP group 1.

```
[SwitchB-Vlan-interface2] vrrp vrid 1 priority 100
```

Configure Switch B to operate in preemptive mode, and set the preemption delay to 5000 centiseconds.

```
[SwitchB-Vlan-interface2] vrrp vrid 1 preempt-mode delay 5000
```

Verifying the configuration

Ping Host B from Host A. (Details not shown.)

Display detailed information about VRRP group 1 on Switch A.

```
[SwitchA-Vlan-interface2] display vrrp verbose
IPv4 Virtual Router Information:
 Running Mode      : Standard
 Total number of virtual routers : 1
   Interface Vlan-interface2
     VRID             : 1                  Adver Timer  : 100
     Admin Status     : Up                 State        : Master
     Config Pri       : 110                Running Pri  : 110
     Preempt Mode     : Yes                Delay Time   : 5000
     Auth Type        : None
     Virtual IP       : 10.1.1.111
     Virtual MAC      : 0000-5e00-0101
     Master IP        : 10.1.1.1
```

Display detailed information about VRRP group 1 on Switch B.

```
[SwitchB-Vlan-interface2] display vrrp verbose
IPv4 Virtual Router Information:
 Running Mode      : Standard
 Total number of virtual routers : 1
   Interface Vlan-interface2
     VRID             : 1                  Adver Timer  : 100
     Admin Status     : Up                 State        : Backup
     Config Pri       : 100                Running Pri  : 100
     Preempt Mode     : Yes                Delay Time   : 5000
     Become Master    : 401ms left
     Auth Type        : None
     Virtual IP       : 10.1.1.111
     Virtual MAC      : 0000-5e00-0101
     Master IP        : 10.1.1.1
```

The output shows that Switch A is operating as the master in VRRP group 1 to forward packets from Host A to Host B.

Disconnect the link between Host A and Switch A, and verify that Host A can still ping Host B. (Details not shown.)

Display detailed information about VRRP group 1 on Switch B.

```
[SwitchB-Vlan-interface2] display vrrp verbose
IPv4 Virtual Router Information:
 Running Mode      : Standard
 Total number of virtual routers : 1
   Interface Vlan-interface2
     VRID             : 1                 Adver Timer  : 100
     Admin Status     : Up                State        : Master
     Config Pri       : 100               Running Pri  : 100
     Preempt Mode     : Yes               Delay Time   : 5000
     Auth Type        : None
     Virtual IP       : 10.1.1.111
     Virtual MAC      : 0000-5e00-0101
     Master IP        : 10.1.1.2
```

The output shows that when Switch A fails, Switch B takes over to forward packets from Host A to Host B.

Recover the link between Host A and Switch A, and display detailed information about VRRP group 1 on Switch A.

```
[SwitchA-Vlan-interface2] display vrrp verbose
IPv4 Virtual Router Information:
 Running Mode      : Standard
 Total number of virtual routers : 1
   Interface Vlan-interface2
     VRID             : 1                 Adver Timer  : 100
     Admin Status     : Up                State        : Master
     Config Pri       : 110               Running Pri  : 110
     Preempt Mode     : Yes               Delay Time   : 5000
     Auth Type        : None
     Virtual IP       : 10.1.1.111
     Virtual MAC      : 0000-5e00-0101
     Master IP        : 10.1.1.1
```

The output shows that after Switch A resumes normal operation, it becomes the master to forward packets from Host A to Host B.

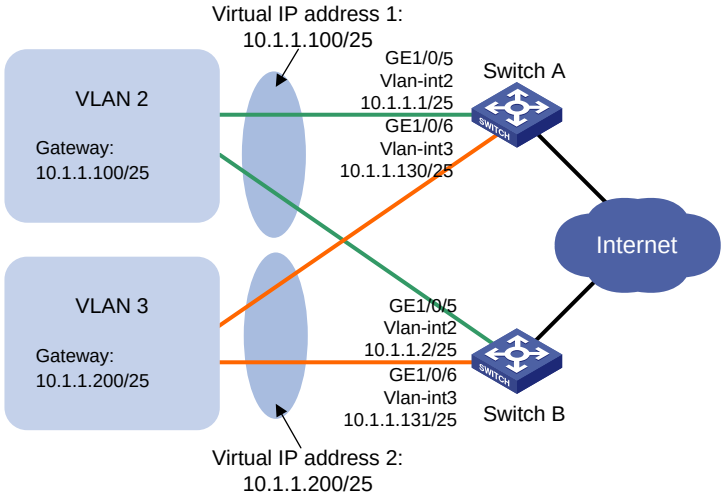
Example: Configuring multiple VRRP groups

Network configuration

As shown in Figure 10, Switch A and Switch B form two VRRP groups. VRRP group 1 uses the virtual IP address 10.1.1.100/25 to provide gateway service for hosts in VLAN 2, and VRRP group 2 uses the virtual IP address 10.1.1.200/25 to provide gateway service for hosts in VLAN 3.

Assign a higher priority to Switch A than Switch B in VRRP group 1, but a lower priority in VRRP group 2. Traffic from VLAN 2 and VLAN 3 can then be distributed between the two switches. When one of the switches fails, the healthy switch provides gateway service for both VLANs.

Figure 10 Network diagram



Procedure

1. Configure Switch A:

   # Configure VLAN 2.

   ```
   <SwitchA> system-view
   [SwitchA] vlan 2
   [SwitchA-vlan2] port gigabitethernet 1/0/5
   [SwitchA-vlan2] quit
   [SwitchA] interface vlan-interface 2
   [SwitchA-Vlan-interface2] ip address 10.1.1.1 255.255.255.128
   ```

   # Create VRRP group 1, and set its virtual IP address to 10.1.1.100.

   ```
   [SwitchA-Vlan-interface2] vrrp vrid 1 virtual-ip 10.1.1.100
   ```

   # Assign Switch A a higher priority than Switch B in VRRP group 1, so Switch A can become the master in the group.

   ```
   [SwitchA-Vlan-interface2] vrrp vrid 1 priority 110
   [SwitchA-Vlan-interface2] quit
   ```

   # Configure VLAN 3.

   ```
   [SwitchA] vlan 3
   [SwitchA-vlan3] port gigabitethernet 1/0/6
   [SwitchA-vlan3] quit
   [SwitchA] interface vlan-interface 3
   [SwitchA-Vlan-interface3] ip address 10.1.1.130 255.255.255.128
   ```

   # Create VRRP group 2, and set its virtual IP address to 10.1.1.200.

   ```
   [SwitchA-Vlan-interface3] vrrp vrid 2 virtual-ip 10.1.1.200
   ```

2. Configure Switch B:

   # Configure VLAN 2.

   ```
   <SwitchB> system-view
   [SwitchB] vlan 2
   [SwitchB-vlan2] port gigabitethernet 1/0/5
   [SwitchB-vlan2] quit
   [SwitchB] interface vlan-interface 2
   [SwitchB-Vlan-interface2] ip address 10.1.1.2 255.255.255.128
   ```

Create VRRP group 1, and set its virtual IP address to 10.1.1.100.

```
[SwitchB-Vlan-interface2] vrrp vrid 1 virtual-ip 10.1.1.100
[SwitchB-Vlan-interface2] quit
```

Configure VLAN 3.

```
[SwitchB] vlan 3
[SwitchB-vlan3] port gigabitethernet 1/0/6
[SwitchB-vlan3] quit
[SwitchB] interface vlan-interface 3
[SwitchB-Vlan-interface3] ip address 10.1.1.131 255.255.255.128
```

Create VRRP group 2, and set its virtual IP address to 10.1.1.200.

```
[SwitchB-Vlan-interface3] vrrp vrid 2 virtual-ip 10.1.1.200
```

Assign Switch B a higher priority than Switch A in VRRP group 2, so Switch B can become the master in the group.

```
[SwitchB-Vlan-interface3] vrrp vrid 2 priority 110
```

Verifying the configuration

Display detailed information about the VRRP groups on Switch A.

```
[SwitchA-Vlan-interface3] display vrrp verbose
IPv4 Virtual Router Information:
 Running Mode      : Standard
 Total number of virtual routers : 2
   Interface Vlan-interface2
     VRID              : 1                 Adver Timer  : 100
     Admin Status      : Up                State        : Master
     Config Pri        : 110               Running Pri  : 110
     Preempt Mode      : Yes               Delay Time   : 0
     Auth Type         : None
     Virtual IP        : 10.1.1.100
     Virtual MAC       : 0000-5e00-0101
     Master IP         : 10.1.1.1

   Interface Vlan-interface3
     VRID              : 2                 Adver Timer  : 100
     Admin Status      : Up                State        : Backup
     Config Pri        : 100               Running Pri  : 100
     Preempt Mode      : Yes               Delay Time   : 0
     Become Master     : 203ms left
     Auth Type         : None
     Virtual IP        : 10.1.1.200
     Virtual MAC       : 0000-5e00-0102
     Master IP         : 10.1.1.131
```

Display detailed information about the VRRP groups on Switch B.

```
[SwitchB-Vlan-interface3] display vrrp verbose
IPv4 Virtual Router Information:
 Running Mode      : Standard
 Total number of virtual routers : 2
   Interface Vlan-interface2
     VRID              : 1                 Adver Timer  : 100
     Admin Status      : Up                State        : Backup
```

```
  Config Pri       : 100                 Running Pri  : 100
  Preempt Mode     : Yes                 Delay Time   : 0
  Become Master    : 211ms left
  Auth Type        : None
  Virtual IP       : 10.1.1.100
  Virtual MAC      : 0000-5e00-0101
  Master IP        : 10.1.1.1

Interface Vlan-interface3
  VRID             : 2                   Adver Timer  : 100
  Admin Status     : Up                  State        : Master
  Config Pri       : 110                 Running Pri  : 110
  Preempt Mode     : Yes                 Delay Time   : 0
  Auth Type        : None
  Virtual IP       : 10.1.1.200
  Virtual MAC      : 0000-5e00-0102
  Master IP        : 10.1.1.131
```

The output shows the following information:

- Switch A is operating as the master in VRRP group 1 to forward Internet traffic for hosts that use the default gateway 10.1.1.100/25.
- Switch B is operating as the master in VRRP group 2 to forward Internet traffic for hosts that use the default gateway 10.1.1.200/25.

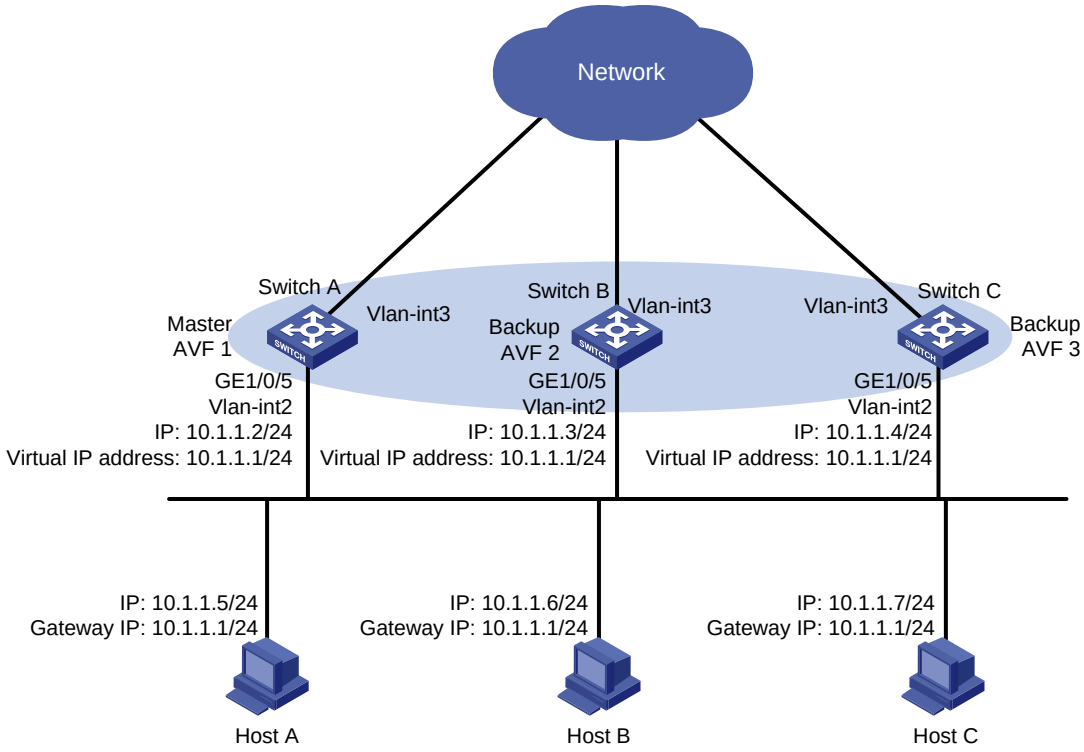
Example: Configuring VRRP load balancing

Network configuration

As shown in Figure 11, Switch A, Switch B, and Switch C form a load-balanced VRRP group. They use the virtual IP address 10.1.1.1/24 to provide gateway service for subnet 10.1.1.0/24.

Configure VFs on Switch A, Switch B, and Switch C to monitor their respective VLAN-interface 3. When the interface on any one of them fails, the weights of the VFs on the problematic switch decrease so another AVF can take over.

Figure 11 Network diagram



Procedure

1. Configure Switch A:

   # Configure VLAN 2.

   ```
   <SwitchA> system-view
   [SwitchA] vlan 2
   [SwitchA-vlan2] port gigabitethernet 1/0/5
   [SwitchA-vlan2] quit
   ```

   # Configure VRRP to operate in load balancing mode.

   ```
   [SwitchA] vrrp mode load-balance
   ```

   # Create VRRP group 1, and set its virtual IP address to 10.1.1.1.

   ```
   [SwitchA] interface vlan-interface 2
   [SwitchA-Vlan-interface2] ip address 10.1.1.2 24
   [SwitchA-Vlan-interface2] vrrp vrid 1 virtual-ip 10.1.1.1
   ```

   # Assign Switch A the highest priority in VRRP group 1, so Switch A can become the master.

   ```
   [SwitchA-Vlan-interface2] vrrp vrid 1 priority 120
   ```

   # Configure Switch A to operate in preemptive mode, so it can become the master whenever it operates correctly. Set the preemption delay to 5000 centiseconds to avoid frequent status switchover.

   ```
   [SwitchA-Vlan-interface2] vrrp vrid 1 preempt-mode delay 5000
   [SwitchA-Vlan-interface2] quit
   ```

   # Create track entry 1 to monitor the upstream link status of VLAN-interface 3. When the upstream link fails, the track entry transits to Negative.

   ```
   [SwitchA] track 1 interface vlan-interface 3
   ```

   # Configure the VFs in VRRP group 1 to monitor track entry 1, and decrease their weights by 250 when the track entry transits to Negative.

```
[SwitchA] interface vlan-interface 2
[SwitchA-Vlan-interface2] vrrp vrid 1 track 1 weight reduced 250
```

2. Configure Switch B:

Configure VLAN 2.

```
<SwitchB> system-view
[SwitchB] vlan 2
[SwitchB-vlan2] port gigabitethernet 1/0/5
[SwitchB-vlan2] quit
```

Configure VRRP to operate in load balancing mode.

```
[SwitchB] vrrp mode load-balance
```

Create VRRP group 1, and set its virtual IP address to 10.1.1.1.

```
[SwitchB] interface vlan-interface 2
[SwitchB-Vlan-interface2] ip address 10.1.1.3 24
[SwitchB-Vlan-interface2] vrrp vrid 1 virtual-ip 10.1.1.1
```

Assign Switch B a higher priority than Switch C in VRRP group 1, so Switch B can become the master when Switch A fails.

```
[SwitchB-Vlan-interface2] vrrp vrid 1 priority 110
```

Configure Switch B to operate in preemptive mode, and set the preemption delay to 5000 centiseconds.

```
[SwitchB-Vlan-interface2] vrrp vrid 1 preempt-mode delay 5000
[SwitchB-Vlan-interface2] quit
```

Create track entry 1 to monitor the upstream link status of VLAN-interface 3. When the upstream link fails, the track entry transits to Negative.

```
[SwitchB] track 1 interface vlan-interface 3
```

Configure the VFs in VRRP group 1 to monitor track entry 1, and decrease their weights by 250 when the track entry transits to Negative.

```
[SwitchB] interface vlan-interface 2
[SwitchB-Vlan-interface2] vrrp vrid 1 track 1 weight reduced 250
```

3. Configure Switch C:

Configure VLAN 2.

```
<SwitchC> system-view
[SwitchC] vlan 2
[SwitchC-vlan2] port gigabitethernet 1/0/5
[SwitchC-vlan2] quit
```

Configure VRRP to operate in load balancing mode.

```
[SwitchC] vrrp mode load-balance
```

Create VRRP group 1, and set its virtual IP address to 10.1.1.1.

```
[SwitchC] interface vlan-interface 2
[SwitchC-Vlan-interface2] ip address 10.1.1.4 24
[SwitchC-Vlan-interface2] vrrp vrid 1 virtual-ip 10.1.1.1
```

Configure Switch C to operate in preemptive mode, and set the preemption delay to 5000 centiseconds.

```
[SwitchC-Vlan-interface2] vrrp vrid 1 preempt-mode delay 5000
[SwitchC-Vlan-interface2] quit
```

Create track entry 1 to monitor the upstream link status of VLAN-interface 3. When the upstream link fails, the track entry transits to Negative.

```
[SwitchC] track 1 interface vlan-interface 3
```

Configure the VFs in VRRP group 1 to monitor track entry 1, and decrease their weights by 250 when the track entry transits to Negative.

```
[SwitchC] interface vlan-interface 2
[SwitchC-Vlan-interface2] vrrp vrid 1 track 1 weight reduced 250
```

Verifying the configuration

Verify that Host A can ping the external network. (Details not shown.)

Display detailed information about VRRP group 1 on Switch A.

```
[SwitchA-Vlan-interface2] display vrrp verbose
IPv4 Virtual Router Information:
 Running Mode      : Load Balance
 Total number of virtual routers : 1
   Interface Vlan-interface2
     VRID             : 1                    Adver Timer  : 100
     Admin Status     : Up                   State        : Master
     Config Pri       : 120                  Running Pri  : 120
     Preempt Mode     : Yes                  Delay Time   : 5000
     Auth Type        : None
     Virtual IP       : 10.1.1.1
     Member IP List   : 10.1.1.2 (Local, Master)
                        10.1.1.3 (Backup)
                        10.1.1.4 (Backup)
   Forwarder Information: 3 Forwarders 1 Active
     Config Weight  : 255
     Running Weight : 255
    Forwarder 01
     State          : Active
     Virtual MAC    : 000f-e2ff-0011 (Owner)
     Owner ID       : 0000-5e01-1101
     Priority       : 255
     Active         : local
    Forwarder 02
     State          : Listening
     Virtual MAC    : 000f-e2ff-0012 (Learnt)
     Owner ID       : 0000-5e01-1103
     Priority       : 127
     Active         : 10.1.1.3
    Forwarder 03
     State          : Listening
     Virtual MAC    : 000f-e2ff-0013 (Learnt)
     Owner ID       : 0000-5e01-1105
     Priority       : 127
     Active         : 10.1.1.4
   Forwarder Weight Track Information:
     Track Object   : 1          State : Positive   Weight Reduced : 250
```

Display detailed information about VRRP group 1 on Switch B.

```
[SwitchB-Vlan-interface2] display vrrp verbose
IPv4 Virtual Router Information:
 Running Mode      : Load Balance
```

```
 Total number of virtual routers : 1
   Interface Vlan-interface2
     VRID              : 1                   Adver Timer  : 100
     Admin Status      : Up                  State        : Backup
     Config Pri        : 110                 Running Pri  : 110
     Preempt Mode      : Yes                 Delay Time   : 5000
     Become Master     : 410ms left
     Auth Type         : None
     Virtual IP        : 10.1.1.1
     Member IP List    : 10.1.1.3 (Local, Backup)
                         10.1.1.2 (Master)
                         10.1.1.4 (Backup)
   Forwarder Information: 3 Forwarders 1 Active
     Config Weight  : 255
     Running Weight : 255
    Forwarder 01
     State           : Listening
     Virtual MAC     : 000f-e2ff-0011 (Learnt)
     Owner ID        : 0000-5e01-1101
     Priority        : 127
     Active          : 10.1.1.2
    Forwarder 02
     State           : Active
     Virtual MAC     : 000f-e2ff-0012 (Owner)
     Owner ID        : 0000-5e01-1103
     Priority        : 255
     Active          : local
    Forwarder 03
     State           : Listening
     Virtual MAC     : 000f-e2ff-0013 (Learnt)
     Owner ID        : 0000-5e01-1105
     Priority        : 127
     Active          : 10.1.1.4
   Forwarder Weight Track Information:
     Track Object    : 1          State : Positive   Weight Reduced : 250
```

Display detailed information about VRRP group 1 on Switch C.

```
[SwitchC-Vlan-interface2] display vrrp verbose
IPv4 Virtual Router Information:
 Running Mode      : Load Balance
 Total number of virtual routers : 1
   Interface Vlan-interface2
     VRID              : 1                   Adver Timer  : 100
     Admin Status      : Up                  State        : Backup
     Config Pri        : 100                 Running Pri  : 100
     Preempt Mode      : Yes                 Delay Time   : 5000
     Become Master     : 401ms left
     Auth Type         : None
     Virtual IP        : 10.1.1.1
```

```
    Member IP List   : 10.1.1.4 (Local, Backup)
                       10.1.1.2 (Master)
                       10.1.1.3 (Backup)
  Forwarder Information: 3 Forwarders 1 Active
    Config Weight  : 255
    Running Weight : 255
   Forwarder 01
    State          : Listening
    Virtual MAC    : 000f-e2ff-0011 (Learnt)
    Owner ID       : 0000-5e01-1101
    Priority       : 127
    Active         : 10.1.1.2
   Forwarder 02
    State          : Listening
    Virtual MAC    : 000f-e2ff-0012 (Learnt)
    Owner ID       : 0000-5e01-1103
    Priority       : 127
    Active         : 10.1.1.3
   Forwarder 03
    State          : Active
    Virtual MAC    : 000f-e2ff-0013 (Owner)
    Owner ID       : 0000-5e01-1105
    Priority       : 255
    Active         : local
  Forwarder Weight Track Information:
    Track Object   : 1          State : Positive   Weight Reduced : 250
```

The output shows that Switch A is the master in VRRP group 1, and each of the three switches has one AVF and two LVFs.

Disconnect the link of VLAN-interface 3 on Switch A, and display detailed information about VRRP group 1 on Switch A.

```
[SwitchA-Vlan-interface2] display vrrp verbose
IPv4 Virtual Router Information:
 Running Mode      : Load Balance
 Total number of virtual routers : 1
   Interface Vlan-interface2
     VRID             : 1                   Adver Timer  : 100
     Admin Status     : Up                  State        : Master
     Config Pri       : 120                 Running Pri  : 120
     Preempt Mode     : Yes                 Delay Time   : 5000
     Auth Type        : None
     Virtual IP       : 10.1.1.1
     Member IP List   : 10.1.1.2 (Local, Master)
                        10.1.1.3 (Backup)
                        10.1.1.4 (Backup)
   Forwarder Information: 3 Forwarders 0 Active
     Config Weight  : 255
     Running Weight : 5
    Forwarder 01
```

```
    State           : Initialize
    Virtual MAC     : 000f-e2ff-0011 (Owner)
    Owner ID        : 0000-5e01-1101
    Priority        : 0
    Active          : 10.1.1.4
  Forwarder 02
    State           : Initialize
    Virtual MAC     : 000f-e2ff-0012 (Learnt)
    Owner ID        : 0000-5e01-1103
    Priority        : 0
    Active          : 10.1.1.3
  Forwarder 03
    State           : Initialize
    Virtual MAC     : 000f-e2ff-0013 (Learnt)
    Owner ID        : 0000-5e01-1105
    Priority        : 0
    Active          : 10.1.1.4
 Forwarder Weight Track Information:
    Track Object    : 1          State : Negative   Weight Reduced : 250
```

Display detailed information about VRRP group 1 on Switch C.

```
[SwitchC-Vlan-interface2] display vrrp verbose
IPv4 Virtual Router Information:
 Running Mode      : Load Balance
 Total number of virtual routers : 1
   Interface Vlan-interface2
     VRID             : 1                  Adver Timer  : 100
     Admin Status     : Up                 State        : Backup
     Config Pri       : 100                Running Pri  : 100
     Preempt Mode     : Yes                Delay Time   : 5000
     Become Master    : 401ms left
     Auth Type        : None
     Virtual IP       : 10.1.1.1
     Member IP List   : 10.1.1.4 (Local, Backup)
                        10.1.1.2 (Master)
                        10.1.1.3 (Backup)
   Forwarder Information: 3 Forwarders 2 Active
     Config Weight  : 255
     Running Weight : 255
    Forwarder 01
     State           : Active
     Virtual MAC     : 000f-e2ff-0011 (Take Over)
     Owner ID        : 0000-5e01-1101
     Priority        : 85
     Active          : local
    Forwarder 02
     State           : Listening
     Virtual MAC     : 000f-e2ff-0012 (Learnt)
     Owner ID        : 0000-5e01-1103
```

```
    Priority       : 85
    Active         : 10.1.1.3
   Forwarder 03
    State          : Active
    Virtual MAC    : 000f-e2ff-0013 (Owner)
    Owner ID       : 0000-5e01-1105
    Priority       : 255
    Active         : local
  Forwarder Weight Track Information:
    Track Object   : 1          State : Positive   Weight Reduced : 250
```

The output shows that when VLAN-interface 3 on Switch A fails, the weights of the VFs on Switch A drop below the lower limit of failure. All VFs on Switch A transit to the **Initialize** state and cannot forward traffic. The VF for MAC address 000f-e2ff-0011 on Switch C becomes the AVF to forward traffic.

When the timeout timer (about 1800 seconds) expires, display detailed information about VRRP group 1 on Switch C.

```
[SwitchC-Vlan-interface2] display vrrp verbose
IPv4 Virtual Router Information:
 Running Mode      : Load Balance
 Total number of virtual routers : 1
   Interface Vlan-interface2
     VRID             : 1                   Adver Timer  : 100
     Admin Status     : Up                  State        : Backup
     Config Pri       : 100                 Running Pri  : 100
     Preempt Mode     : Yes                 Delay Time   : 5000
     Become Master    : 402ms left
     Auth Type        : None
     Virtual IP       : 10.1.1.1
     Member IP List   : 10.1.1.4 (Local, Backup)
                        10.1.1.2 (Master)
                        10.1.1.3 (Backup)
   Forwarder Information: 2 Forwarders 1 Active
     Config Weight  : 255
     Running Weight : 255
    Forwarder 02
     State          : Listening
     Virtual MAC    : 000f-e2ff-0012 (Learnt)
     Owner ID       : 0000-5e01-1103
     Priority       : 127
     Active         : 10.1.1.3
    Forwarder 03
     State          : Active
     Virtual MAC    : 000f-e2ff-0013 (Owner)
     Owner ID       : 0000-5e01-1105
     Priority       : 255
     Active         : local
   Forwarder Weight Track Information:
     Track Object   : 1          State : Positive   Weight Reduced : 250
```

The output shows that when the timeout timer expires, the VF for virtual MAC address 000f-e2ff-0011 is removed. The VF no longer forwards the packets destined for the MAC address.

When Switch A fails, display detailed information about VRRP group 1 on Switch B.

```
[SwitchB-Vlan-interface2] display vrrp verbose
IPv4 Virtual Router Information:
 Running Mode      : Load Balance
 Total number of virtual routers : 1
   Interface Vlan-interface2
     VRID             : 1                   Adver Timer  : 100
     Admin Status     : Up                  State        : Master
     Config Pri       : 110                 Running Pri  : 110
     Preempt Mode     : Yes                 Delay Time   : 5000
     Auth Type        : None
     Virtual IP       : 10.1.1.1
     Member IP List   : 10.1.1.3 (Local, Master)
                        10.1.1.4 (Backup)
   Forwarder Information: 2 Forwarders 1 Active
     Config Weight  : 255
     Running Weight : 255
    Forwarder 02
     State          : Active
     Virtual MAC    : 000f-e2ff-0012 (Owner)
     Owner ID       : 0000-5e01-1103
     Priority       : 255
     Active         : local
    Forwarder 03
     State          : Listening
     Virtual MAC    : 000f-e2ff-0013 (Learnt)
     Owner ID       : 0000-5e01-1105
     Priority       : 127
     Active         : 10.1.1.4
   Forwarder Weight Track Information:
     Track Object   : 1          State : Positive   Weight Reduced : 250
```

The output shows the following information:

- When Switch A fails, Switch B becomes the master because it has a higher priority than Switch C.
- The VF for virtual MAC address 000f-e2ff-0011 is removed.

IPv6 VRRP configuration examples

Example: Configuring a single VRRP group

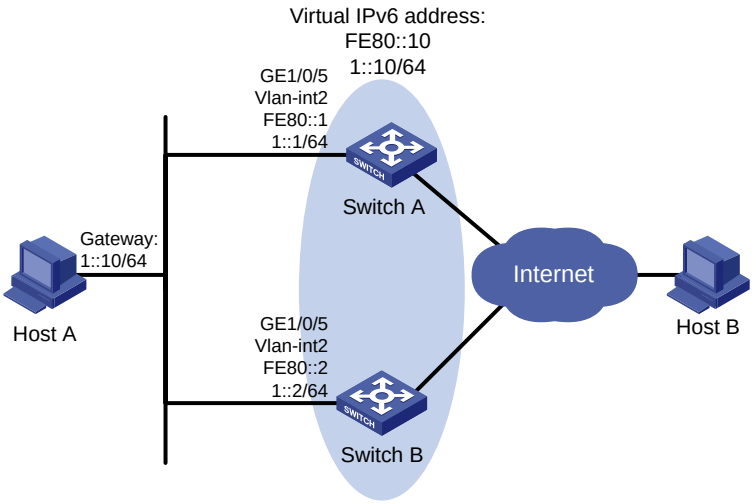
Network configuration

As shown in Figure 12, Switch A and Switch B form a VRRP group. They use the virtual IP addresses 1::10/64 and FE80::10 to provide gateway service for the subnet where Host A resides.

Host A learns 1::10/64 as its default gateway from RA messages sent by the switches.

Switch A operates as the master to forward packets from Host A to Host B. When Switch A fails, Switch B takes over to forward packets for Host A.

Figure 12 Network diagram



Procedure

1. Configure Switch A:

   # Configure VLAN 2.

   ```
   <SwitchA> system-view
   [SwitchA] vlan 2
   [SwitchA-vlan2] port gigabitethernet 1/0/5
   [SwitchA-vlan2] quit
   [SwitchA] interface vlan-interface 2
   [SwitchA-Vlan-interface2] ipv6 address fe80::1 link-local
   [SwitchA-Vlan-interface2] ipv6 address 1::1 64
   ```

   # Create VRRP group 1, and set its virtual IPv6 addresses to FE80::10 and 1::10.

   ```
   [SwitchA-Vlan-interface2] vrrp ipv6 vrid 1 virtual-ip fe80::10 link-local
   [SwitchA-Vlan-interface2] vrrp ipv6 vrid 1 virtual-ip 1::10
   ```

   # Assign Switch A a higher priority than Switch B in VRRP group 1, so Switch A can become the master.

   ```
   [SwitchA-Vlan-interface2] vrrp ipv6 vrid 1 priority 110
   ```

   # Configure Switch A to operate in preemptive mode, so it can become the master whenever it operates correctly. Set the preemption delay to 5000 centiseconds to avoid frequent status switchover.

   ```
   [SwitchA-Vlan-interface2] vrrp ipv6 vrid 1 preempt-mode delay 5000
   ```

   # Enable Switch A to send RA messages, so Host A can learn the default gateway address.

   ```
   [SwitchA-Vlan-interface2] undo ipv6 nd ra halt
   ```

2. Configure Switch B:

   # Configure VLAN 2.

   ```
   <SwitchB> system-view
   [SwitchB] vlan 2
   [SwitchB-vlan2] port gigabitethernet 1/0/5
   [SwitchB-vlan2] quit
   [SwitchB] interface vlan-interface 2
   [SwitchB-Vlan-interface2] ipv6 address fe80::2 link-local
   ```

```
[SwitchB-Vlan-interface2] ipv6 address 1::2 64
```

Create VRRP group 1 and set its virtual IPv6 addresses to FE80::10 and 1::10.

```
[SwitchB-Vlan-interface2] vrrp ipv6 vrid 1 virtual-ip fe80::10 link-local
[SwitchB-Vlan-interface2] vrrp ipv6 vrid 1 virtual-ip 1::10
```

Configure Switch B to operate in preemptive mode, and set the preemption delay to 5000 centiseconds.

```
[SwitchB-Vlan-interface2] vrrp ipv6 vrid 1 preempt-mode delay 5000
```

Enable Switch B to send RA messages, so Host A can learn the default gateway address.

```
[SwitchB-Vlan-interface2] undo ipv6 nd ra halt
```

Verifying the configuration

Ping Host B from Host A. (Details not shown.)

Display detailed information about VRRP group 1 on Switch A.

```
[SwitchA-Vlan-interface2] display vrrp ipv6 verbose
IPv6 Virtual Router Information:
 Running Mode      : Standard
 Total number of virtual routers : 1
   Interface Vlan-interface2
     VRID             : 1                  Adver Timer  : 100
     Admin Status     : Up                 State        : Master
     Config Pri       : 110                Running Pri  : 110
     Preempt Mode     : Yes                Delay Time   : 5000
     Auth Type        : None
     Virtual IP       : FE80::10
                        1::10
     Virtual MAC      : 0000-5e00-0201
     Master IP        : FE80::1
```

Display detailed information about VRRP group 1 on Switch B.

```
[SwitchB-Vlan-interface2] display vrrp ipv6 verbose
IPv6 Virtual Router Information:
 Running Mode        : Standard
 Total number of virtual routers : 1
   Interface Vlan-interface2
     VRID             : 1                  Adver Timer  : 100
     Admin Status     : Up                 State        : Backup
     Config Pri       : 100                Running Pri  : 100
     Preempt Mode     : Yes                Delay Time   : 5000
     Become Master    : 403ms left
     Auth Type        : None
     Virtual IP       : FE80::10
                        1::10
     Virtual MAC      : 0000-5e00-0201
     Master IP        : FE80::1
```

The output shows that Switch A is operating as the master in VRRP group 1 to forward packets from Host A to Host B.

Disconnect the link between Host A and Switch A, and verify that Host A can still ping Host B. (Details not shown.)

Display detailed information about VRRP group 1 on Switch B.

```
[SwitchB-Vlan-interface2] display vrrp ipv6 verbose
IPv6 Virtual Router Information:
 Running Mode      : Standard
 Total number of virtual routers : 1
   Interface Vlan-interface2
     VRID             : 1                  Adver Timer  : 100
     Admin Status     : Up                 State        : Master
     Config Pri       : 100                Running Pri  : 100
     Preempt Mode     : Yes                Delay Time   : 5000
     Auth Type        : None
     Virtual IP       : FE80::10
                        1::10
     Virtual MAC      : 0000-5e00-0201
     Master IP        : FE80::2
```

The output shows that when Switch A fails, Switch B takes over to forward packets from Host A to Host B.

Recover the link between Host A and Switch A, and display detailed information about VRRP group 1 on Switch A.

```
[SwitchA-Vlan-interface2] display vrrp ipv6 verbose
IPv6 Virtual Router Information:
 Running Mode      : Standard
 Total number of virtual routers : 1
   Interface Vlan-interface2
     VRID             : 1                  Adver Timer  : 100
     Admin Status     : Up                 State        : Master
     Config Pri       : 110                Running Pri  : 110
     Preempt Mode     : Yes                Delay Time   : 5000
     Auth Type        : None
     Virtual IP       : FE80::10
                        1::10
     Virtual MAC      : 0000-5e00-0201
     Master IP        : FE80::1
```

The output shows that after Switch A resumes normal operation, it becomes the master to forward packets from Host A to Host B.

Example: Configuring multiple VRRP groups

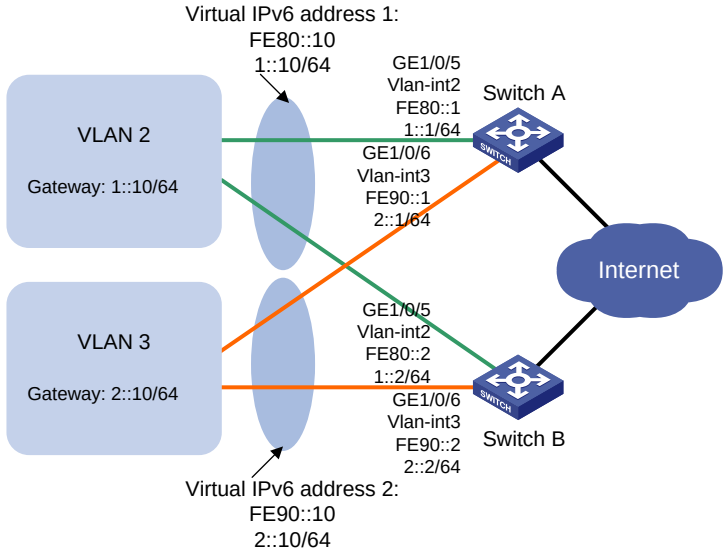
Network configuration

As shown in Figure 13, Switch A and Switch B form two VRRP groups. VRRP group 1 uses the virtual IPv6 addresses 1::10/64 and FE80::10 to provide gateway service for hosts in VLAN 2. VRRP group 2 uses the virtual IPv6 addresses 2::10/64 and FE90::10 to provide gateway service for hosts in VLAN 3.

From RA messages sent by the switches, hosts in VLAN 2 learn 1::10/64 as their default gateway. Hosts in VLAN 3 learn 2::10/64 as their default gateway.

Assign Switch A a higher priority than Switch B in VRRP group 1 but a lower priority in VRRP group 2. Traffic from VLAN 2 and VLAN 3 can then be distributed between the two switches. When one of the switches fails, the healthy switch provides gateway service for both VLANs.

Figure 13 Network diagram



Procedure

1. Configure Switch A:

Configure VLAN 2.

```
<SwitchA> system-view
[SwitchA] vlan 2
[SwitchA-vlan2] port gigabitethernet 1/0/5
[SwitchA-vlan2] quit
[SwitchA] interface vlan-interface 2
[SwitchA-Vlan-interface2] ipv6 address fe80::1 link-local
[SwitchA-Vlan-interface2] ipv6 address 1::1 64
```

Create VRRP group 1, and set its virtual IPv6 addresses to FE80::10 to 1::10.

```
[SwitchA-Vlan-interface2] vrrp ipv6 vrid 1 virtual-ip fe80::10 link-local
[SwitchA-Vlan-interface2] vrrp ipv6 vrid 1 virtual-ip 1::10
```

Assign Switch A a higher priority than Switch B in VRRP group 1, so Switch A can become the master in the group.

```
[SwitchA-Vlan-interface2] vrrp ipv6 vrid 1 priority 110
```

Enable Switch A to send RA messages, so hosts in VLAN 2 can learn the default gateway address.

```
[SwitchA-Vlan-interface2] undo ipv6 nd ra halt
[SwitchA-Vlan-interface2] quit
```

Configure VLAN 3.

```
[SwitchA] vlan 3
[SwitchA-vlan3] port gigabitethernet 1/0/6
[SwitchA-vlan3] quit
[SwitchA] interface vlan-interface 3
[SwitchA-Vlan-interface3] ipv6 address fe90::1 link-local
[SwitchA-Vlan-interface3] ipv6 address 2::1 64
```

Create VRRP group 2, and set its virtual IPv6 addresses to FE90::10 and 2::10.

```
[SwitchA-Vlan-interface3] vrrp ipv6 vrid 2 virtual-ip fe90::10 link-local
[SwitchA-Vlan-interface3] vrrp ipv6 vrid 2 virtual-ip 2::10
```

Enable Switch A to send RA messages, so hosts in VLAN 3 can learn the default gateway address.

```
[SwitchA-Vlan-interface3] undo ipv6 nd ra halt
```

2. Configure Switch B:

Configure VLAN 2.

```
<SwitchB> system-view
[SwitchB-vlan2] port gigabitethernet 1/0/5
[SwitchB-vlan2] quit
[SwitchB] interface vlan-interface 2
[SwitchB-Vlan-interface2] ipv6 address fe80::2 link-local
[SwitchB-Vlan-interface2] ipv6 address 1::2 64
```

Create VRRP group 1, and set its virtual IPv6 addresses to FE80::10 and 1::10.

```
[SwitchB-Vlan-interface2] vrrp ipv6 vrid 1 virtual-ip fe80::10 link-local
[SwitchB-Vlan-interface2] vrrp ipv6 vrid 1 virtual-ip 1::10
```

Enable Switch B to send RA messages, so hosts in VLAN 2 can learn the default gateway address.

```
[SwitchB-Vlan-interface2] undo ipv6 nd ra halt
[SwitchB-Vlan-interface2] quit
```

Configure VLAN 3.

```
[SwitchB] vlan 3
[SwitchB-vlan3] port gigabitethernet 1/0/6
[SwitchB-vlan3] quit
[SwitchB] interface vlan-interface 3
[SwitchB-Vlan-interface3] ipv6 address fe90::2 link-local
[SwitchB-Vlan-interface3] ipv6 address 2::2 64
```

Create VRRP group 2, and set its virtual IPv6 addresses to FE90::10 and 2::10.

```
[SwitchB-Vlan-interface3] vrrp ipv6 vrid 2 virtual-ip fe90::10 link-local
[SwitchB-Vlan-interface3] vrrp ipv6 vrid 2 virtual-ip 2::10
```

Assign Switch B a higher priority than Switch A in VRRP group 2, so Switch B can become the master in the group.

```
[SwitchB-Vlan-interface3] vrrp ipv6 vrid 2 priority 110
```

Enable Switch B to send RA messages, so hosts in VLAN 3 can learn the default gateway address.

```
[SwitchB-Vlan-interface3] undo ipv6 nd ra halt
```

Verifying the configuration

Display detailed information about the VRRP groups on Switch A.

```
[SwitchA-Vlan-interface3] display vrrp ipv6 verbose
IPv6 Virtual Router Information:
 Running Mode      : Standard
 Total number of virtual routers : 2
   Interface Vlan-interface2
     VRID             : 1                 Adver Timer  : 100
     Admin Status     : Up                State        : Master
     Config Pri       : 110               Running Pri  : 110
     Preempt Mode     : Yes               Delay Time   : 0
     Auth Type        : None
     Virtual IP       : FE80::10
                        1::10
```

```
    Virtual MAC      : 0000-5e00-0201
    Master IP        : FE80::1

  Interface Vlan-interface3
    VRID             : 2                 Adver Timer  : 100
    Admin Status     : Up                State        : Backup
    Config Pri       : 100               Running Pri  : 100
    Preempt Mode     : Yes               Delay Time   : 0
    Become Master    : 402ms left
    Auth Type        : None
    Virtual IP       : FE90::10
                       2::10
    Virtual MAC      : 0000-5e00-0202
    Master IP        : FE90::2
```

Display detailed information about the VRRP groups on Switch B.

```
[SwitchB-Vlan-interface3] display vrrp ipv6 verbose
IPv6 Virtual Router Information:
 Running Mode      : Standard
 Total number of virtual routers : 2
   Interface Vlan-interface2
     VRID             : 1                 Adver Timer  : 100
     Admin Status     : Up                State        : Backup
     Config Pri       : 100               Running Pri  : 100
     Preempt Mode     : Yes               Delay Time   : 0
     Become Master    : 401ms left
     Auth Type        : None
     Virtual IP       : FE80::10
                        1::10
     Virtual MAC      : 0000-5e00-0201
     Master IP        : FE80::1

   Interface Vlan-interface3
     VRID             : 2                 Adver Timer  : 100
     Admin Status     : Up                State        : Master
     Config Pri       : 110               Running Pri  : 110
     Preempt Mode     : Yes               Delay Time   : 0
     Auth Type        : None
     Virtual IP       : FE90::10
                        2::10
     Virtual MAC      : 0000-5e00-0202
     Master IP        : FE90::2
```

The output shows the following information:

- Switch A is operating as the master in VRRP group 1 to forward Internet traffic for hosts that use the default gateway 1::10/64.
- Switch B is operating as the master in VRRP group 2 to forward Internet traffic for hosts that use the default gateway 2::10/64.

Example: Configuring VRRP load balancing

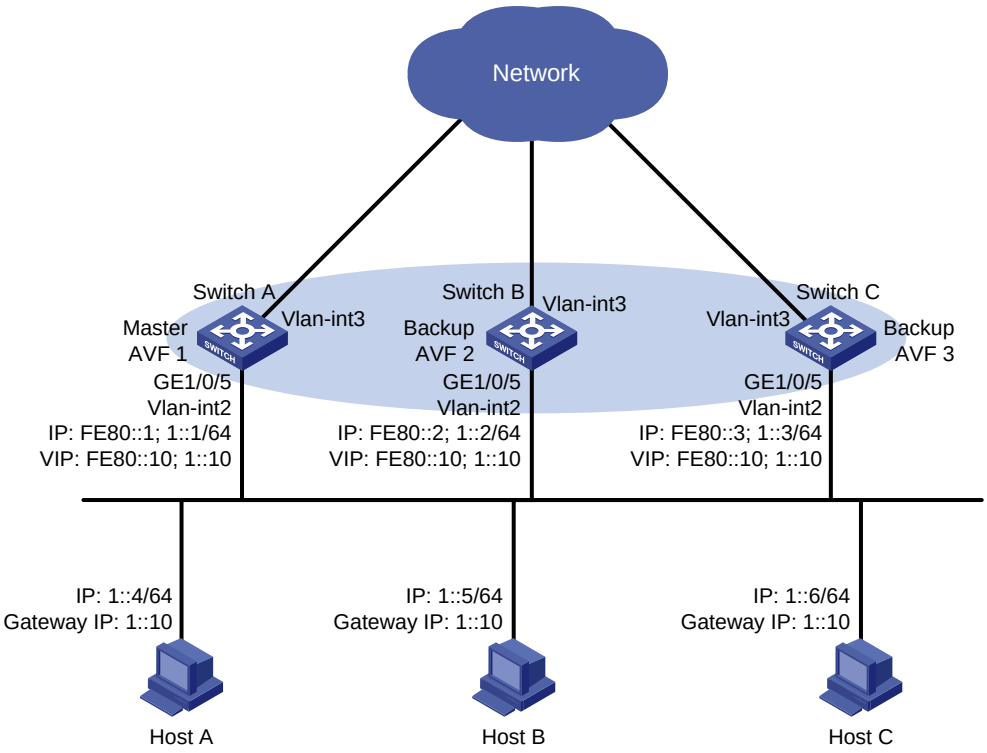
Network configuration

As shown in Figure 14, Switch A, Switch B, and Switch C form a load balanced VRRP group. They use the virtual IPv6 addresses FE80::10 and 1::10 to provide gateway service for subnet 1::/64.

Hosts on subnet 1::/64 learn 1::10 as their default gateway from RA messages sent by the switches.

Configure VFs on Switch A, Switch B, or Switch C to monitor their respective VLAN-interface 3. When the interface on any of them fails, the weights of the VFs on the problematic switch decrease so another AVF can take over.

Figure 14 Network diagram



Procedure

1. Configure Switch A:

   # Configure VLAN 2.

   ```
   <SwitchA> system-view
   [SwitchA] vlan 2
   [SwitchA-vlan2] port gigabitethernet 1/0/5
   [SwitchA-vlan2] quit
   ```

   # Configure VRRP to operate in load balancing mode.

   ```
   [SwitchA] vrrp ipv6 mode load-balance
   ```

   # Create VRRP group 1, and set its virtual IPv6 addresses to FE80::10 and 1::10.

   ```
   [SwitchA] interface vlan-interface 2
   [SwitchA-Vlan-interface2] ipv6 address fe80::1 link-local
   [SwitchA-Vlan-interface2] ipv6 address 1::1 64
   [SwitchA-Vlan-interface2] vrrp ipv6 vrid 1 virtual-ip fe80::10 link-local
   [SwitchA-Vlan-interface2] vrrp ipv6 vrid 1 virtual-ip 1::10
   ```

Assign Switch A the highest priority in VRRP group 1, so Switch A can become the master.

```
[SwitchA-Vlan-interface2] vrrp ipv6 vrid 1 priority 120
```

Configure Switch A to operate in preemptive mode, so it can become the master whenever it operates correctly. Set the preemption delay to 5000 centiseconds to avoid frequent status switchover.

```
[SwitchA-Vlan-interface2] vrrp ipv6 vrid 1 preempt-mode delay 5000
```

Enable Switch A to send RA messages, so hosts on subnet 1::/64 can learn the default gateway address.

```
[SwitchA-Vlan-interface2] undo ipv6 nd ra halt
[SwitchA-Vlan-interface2] quit
```

Create track entry 1 to monitor the upstream link status of VLAN-interface 3. When the upstream link fails, the track entry transits to Negative.

```
[SwitchA] track 1 interface vlan-interface 3
```

Configure the VFs in VRRP group 1 to monitor track entry 1, and decrease their weights by 250 when the track entry transits to Negative.

```
[SwitchA] interface vlan-interface 2
[SwitchA-Vlan-interface2] vrrp ipv6 vrid 1 track 1 weight reduced 250
```

2. Configure Switch B:

Configure VLAN 2.

```
<SwitchB> system-view
[SwitchB] vlan 2
[SwitchB-vlan2] port gigabitethernet 1/0/5
[SwitchB-vlan2] quit
```

Configure VRRP to operate in load balancing mode.

```
[SwitchB] vrrp ipv6 mode load-balance
```

Create VRRP group 1, and set its virtual IPv6 addresses to FE80::10 and 1::10.

```
[SwitchB] interface vlan-interface 2
[SwitchB-Vlan-interface2] ipv6 address fe80::2 link-local
[SwitchB-Vlan-interface2] ipv6 address 1::2 64
[SwitchB-Vlan-interface2] vrrp ipv6 vrid 1 virtual-ip fe80::10 link-local
[SwitchB-Vlan-interface2] vrrp ipv6 vrid 1 virtual-ip 1::10
```

Assign Switch B a higher priority than Switch C in VRRP group 1, so Switch B can become the master when Switch A fails.

```
[SwitchB-Vlan-interface2] vrrp ipv6 vrid 1 priority 110
```

Configure Switch B to operate in preemptive mode, and set the preemption delay to 5000 centiseconds.

```
[SwitchB-Vlan-interface2] vrrp ipv6 vrid 1 preempt-mode delay 5000
```

Enable Switch B to send RA messages so hosts on subnet 1::/64 can learn the default gateway address.

```
[SwitchB-Vlan-interface2] undo ipv6 nd ra halt
[SwitchB-Vlan-interface2] quit
```

Create track entry 1 to monitor the upstream link status of VLAN-interface 3. When the upstream link fails, the track entry transits to Negative.

```
[SwitchB] track 1 interface vlan-interface 3
```

Configure the VFs in VRRP group 1 to monitor track entry 1, and decrease their weights by 250 when the track entry transits to Negative.

```
[SwitchB] interface vlan-interface 2
[SwitchB-Vlan-interface2] vrrp ipv6 vrid 1 track 1 weight reduced 250
```

3. Configure Switch C:

Configure VLAN 2.

```
<SwitchC> system-view
[SwitchC] vlan 2
[SwitchC-vlan2] port gigabitethernet 1/0/5
[SwitchC-vlan2] quit
```

Configure VRRP to operate in load balancing mode.

```
[SwitchC] vrrp ipv6 mode load-balance
```

Create VRRP group 1, and set its virtual IPv6 addresses to FE80::10 and 1::10.

```
[SwitchC] interface vlan-interface 2
[SwitchC-Vlan-interface2] ipv6 address fe80::3 link-local
[SwitchC-Vlan-interface2] ipv6 address 1::3 64
[SwitchC-Vlan-interface2] vrrp ipv6 vrid 1 virtual-ip fe80::10 link-local
[SwitchC-Vlan-interface2] vrrp ipv6 vrid 1 virtual-ip 1::10
```

Configure Switch C to operate in preemptive mode, and set the preemption delay to 5000 centiseconds.

```
[SwitchC-Vlan-interface2] vrrp ipv6 vrid 1 preempt-mode delay 5000
```

Enable Switch C to send RA messages, so the hosts on the subnet 1::/64 can learn the default gateway address.

```
[SwitchC-Vlan-interface2] undo ipv6 nd ra halt
[SwitchC-Vlan-interface2] quit
```

Create track entry 1 to monitor the upstream link status of VLAN-interface 3. When the upstream link fails, the track entry transits to Negative.

```
[SwitchC] track 1 interface vlan-interface 3
```

Configure the VFs in VRRP group 1 to monitor track entry 1, and decrease their weights by 250 when the track entry transits to Negative.

```
[SwitchC] interface vlan-interface 2
[SwitchC-Vlan-interface2] vrrp ipv6 vrid 1 track 1 weight reduced 250
```

Verifying the configuration

Verify that Host A can ping the external network. (Details not shown.)

Display detailed information about VRRP group 1 on Switch A.

```
[SwitchA-Vlan-interface2] display vrrp ipv6 verbose
IPv6 Virtual Router Information:
 Running Mode      : Load Balance
 Total number of virtual routers : 1
   Interface Vlan-interface2
     VRID             : 1                    Adver Timer  : 100
     Admin Status     : Up                   State        : Master
     Config Pri       : 120                  Running Pri  : 120
     Preempt Mode     : Yes                  Delay Time   : 5000
     Auth Type        : None
     Virtual IP       : FE80::10
                        1::10
     Member IP List   : FE80::1 (Local, Master)
                        FE80::2 (Backup)
                        FE80::3 (Backup)
   Forwarder Information: 3 Forwarders 1 Active
     Config Weight  : 255
     Running Weight : 255
```

```
    Forwarder 01
      State           : Active
      Virtual MAC     : 000f-e2ff-4011 (Owner)
      Owner ID        : 0000-5e01-1101
      Priority        : 255
      Active          : local
    Forwarder 02
      State           : Listening
      Virtual MAC     : 000f-e2ff-4012 (Learnt)
      Owner ID        : 0000-5e01-1103
      Priority        : 127
      Active          : FE80::2
    Forwarder 03
      State           : Listening
      Virtual MAC     : 000f-e2ff-4013 (Learnt)
      Owner ID        : 0000-5e01-1105
      Priority        : 127
      Active          : FE80::3
  Forwarder Weight Track Information:
    Track Object    : 1          State : Positive   Weight Reduced : 250
```

Display detailed information about VRRP group 1 on Switch B.

```
[SwitchB-Vlan-interface2] display vrrp ipv6 verbose
IPv6 Virtual Router Information:
 Running Mode      : Load Balance
 Total number of virtual routers : 1
   Interface Vlan-interface2
     VRID             : 1                   Adver Timer  : 100
     Admin Status     : Up                  State        : Backup
     Config Pri       : 110                 Running Pri  : 110
     Preempt Mode     : Yes                 Delay Time   : 5000
     Become Master    : 401ms left
     Auth Type        : None
     Virtual IP       : FE80::10
                        1::10
     Member IP List   : FE80::2 (Local, Backup)
                        FE80::1 (Master)
                        FE80::3 (Backup)
   Forwarder Information: 3 Forwarders 1 Active
     Config Weight  : 255
     Running Weight : 255
    Forwarder 01
     State           : Listening
     Virtual MAC     : 000f-e2ff-4011 (Learnt)
     Owner ID        : 0000-5e01-1101
     Priority        : 127
     Active          : FE80::1
    Forwarder 02
     State           : Active
```

```
    Virtual MAC    : 000f-e2ff-4012 (Owner)
    Owner ID       : 0000-5e01-1103
    Priority       : 255
    Active         : local
   Forwarder 03
    State          : Listening
    Virtual MAC    : 000f-e2ff-4013 (Learnt)
    Owner ID       : 0000-5e01-1105
    Priority       : 127
    Active         : FE80::3
  Forwarder Weight Track Information:
    Track Object   : 1          State : Positive   Weight Reduced : 250
```

Display detailed information about VRRP group 1 on Switch C.

```
[SwitchC-Vlan-interface2] display vrrp ipv6 verbose
IPv6 Virtual Router Information:
 Running Mode      : Load Balance
 Total number of virtual routers : 1
   Interface Vlan-interface2
     VRID             : 1                   Adver Timer  : 100
     Admin Status     : Up                  State        : Backup
     Config Pri       : 100                 Running Pri  : 100
     Preempt Mode     : Yes                 Delay Time   : 5000
     Become Master    : 402ms left
     Auth Type        : None
     Virtual IP       : FE80::10
                        1::10
     Member IP List   : FE80::3 (Local, Backup)
                        FE80::1 (Master)
                        FE80::2 (Backup)
   Forwarder Information: 3 Forwarders 1 Active
     Config Weight  : 255
     Running Weight : 255
    Forwarder 01
     State          : Listening
     Virtual MAC    : 000f-e2ff-4011 (Learnt)
     Owner ID       : 0000-5e01-1101
     Priority       : 127
     Active         : FE80::1
    Forwarder 02
     State          : Listening
     Virtual MAC    : 000f-e2ff-4012 (Learnt)
     Owner ID       : 0000-5e01-1103
     Priority       : 127
     Active         : FE80::2
    Forwarder 03
     State          : Active
     Virtual MAC    : 000f-e2ff-4013 (Owner)
     Owner ID       : 0000-5e01-1105
```

```
    Priority       : 255
    Active         : local
  Forwarder Weight Track Information:
    Track Object   : 1          State : Positive   Weight Reduced : 250
```

The output shows that Switch A is the master in VRRP group 1, and each of the three switches has one AVF and two LVFs.

Disconnect the link of VLAN-interface 3 on Switch A and display detailed information about VRRP group 1 on Switch A.

```
[SwitchA-Vlan-interface2] display vrrp ipv6 verbose
IPv6 Virtual Router Information:
 Running Mode      : Load Balance
 Total number of virtual routers : 1
   Interface Vlan-interface2
     VRID             : 1                   Adver Timer  : 100
     Admin Status     : Up                  State        : Master
     Config Pri       : 120                 Running Pri  : 120
     Preempt Mode     : Yes                 Delay Time   : 5000
     Auth Type        : None
     Virtual IP       : FE80::10
                        1::10
     Member IP List   : FE80::1 (Local, Master)
                        FE80::2 (Backup)
                        FE80::3 (Backup)
   Forwarder Information: 3 Forwarders 0 Active
     Config Weight  : 255
     Running Weight : 5
    Forwarder 01
     State          : Initialize
     Virtual MAC    : 000f-e2ff-4011 (Owner)
     Owner ID       : 0000-5e01-1101
     Priority       : 0
     Active         : FE80::3
    Forwarder 02
     State          : Initialize
     Virtual MAC    : 000f-e2ff-4012 (Learnt)
     Owner ID       : 0000-5e01-1103
     Priority       : 0
     Active         : FE80::2
    Forwarder 03
     State          : Initialize
     Virtual MAC    : 000f-e2ff-4013 (Learnt)
     Owner ID       : 0000-5e01-1105
     Priority       : 0
     Active         : FE80::3
   Forwarder Weight Track Information:
     Track Object   : 1          State : Negative   Weight Reduced : 250
```

Display detailed information about VRRP group 1 on Switch C.

```
[SwitchC-Vlan-interface2] display vrrp ipv6 verbose
```

```
IPv6 Virtual Router Information:
 Running Mode      : Load Balance
 Total number of virtual routers : 1
   Interface Vlan-interface2
     VRID             : 1                   Adver Timer  : 100
     Admin Status     : Up                  State        : Backup
     Config Pri       : 100                 Running Pri  : 100
     Preempt Mode     : Yes                 Delay Time   : 5000
     Become Master    : 410ms left
     Auth Type        : None
     Virtual IP       : FE80::10
                        1::10
     Member IP List   : FE80::3 (Local, Backup)
                        FE80::1 (Master)
                        FE80::2 (Backup)
   Forwarder Information: 3 Forwarders 2 Active
     Config Weight  : 255
     Running Weight : 255
    Forwarder 01
     State          : Active
     Virtual MAC    : 000f-e2ff-4011 (Take Over)
     Owner ID       : 0000-5e01-1101
     Priority       : 85
     Active         : local
    Forwarder 02
     State          : Listening
     Virtual MAC    : 000f-e2ff-4012 (Learnt)
     Owner ID       : 0000-5e01-1103
     Priority       : 85
     Active         : FE80::2
    Forwarder 03
     State          : Active
     Virtual MAC    : 000f-e2ff-4013 (Owner)
     Owner ID       : 0000-5e01-1105
     Priority       : 255
     Active         : local
   Forwarder Weight Track Information:
     Track Object   : 1          State : Positive   Weight Reduced : 250
```

The output shows that when VLAN-interface 3 on Switch A fails, the weights of the VFs on Switch A drop below the lower limit of failure. All VFs on Switch A transit to the **Initialize** state and cannot forward traffic. The VF for MAC address 000f-e2ff-4011 on Switch C becomes the AVF to forward traffic.

When the timeout timer (about 1800 seconds) expires, display detailed information about VRRP group 1 on Switch C.

```
[SwitchC-Vlan-interface2] display vrrp ipv6 verbose
IPv6 Virtual Router Information:
 Running Mode      : Load Balance
 Total number of virtual routers : 1
   Interface Vlan-interface2
```

```
    VRID             : 1                    Adver Timer  : 100
    Admin Status     : Up                   State        : Backup
    Config Pri       : 100                  Running Pri  : 100
    Preempt Mode     : Yes                  Delay Time   : 5000
    Become Master    : 400ms left
    Auth Type        : None
    Virtual IP       : FE80::10
                       1::10
    Member IP List   : FE80::3 (Local, Backup)
                       FE80::1 (Master)
                       FE80::2 (Backup)
  Forwarder Information: 2 Forwarders 1 Active
    Config Weight  : 255
    Running Weight : 255
   Forwarder 02
    State          : Listening
    Virtual MAC    : 000f-e2ff-4012 (Learnt)
    Owner ID       : 0000-5e01-1103
    Priority       : 127
    Active         : FE80::2
   Forwarder 03
    State          : Active
    Virtual MAC    : 000f-e2ff-4013 (Owner)
    Owner ID       : 0000-5e01-1105
    Priority       : 255
    Active         : local
  Forwarder Weight Track Information:
    Track Object   : 1          State : Positive   Weight Reduced : 250
```

The output shows that when the timeout timer expires, the VF for virtual MAC address 000f-e2ff-4011 is removed. The VF no longer forwards the packets destined for the MAC address.

When Switch A fails, display detailed information about VRRP group 1 on Switch B.

```
[SwitchB-Vlan-interface2] display vrrp ipv6 verbose
IPv6 Virtual Router Information:
 Running Mode      : Load Balance
 Total number of virtual routers : 1
   Interface Vlan-interface2
     VRID             : 1                    Adver Timer  : 100
     Admin Status     : Up                   State        : Master
     Config Pri       : 110                  Running Pri  : 110
     Preempt Mode     : Yes                  Delay Time   : 5000
     Auth Type        : None
     Virtual IP       : FE80::10
                        1::10
     Member IP List   : FE80::2 (Local, Master)
                        FE80::3 (Backup)
   Forwarder Information: 2 Forwarders 1 Active
     Config Weight  : 255
     Running Weight : 255
```

```
Forwarder 02
 State           : Active
 Virtual MAC     : 000f-e2ff-4012 (Owner)
 Owner ID        : 0000-5e01-1103
 Priority        : 255
 Active          : local
Forwarder 03
 State           : Listening
 Virtual MAC     : 000f-e2ff-4013 (Learnt)
 Owner ID        : 0000-5e01-1105
 Priority        : 127
 Active          : FE80::3
Forwarder Weight Track Information:
  Track Object   : 1          State : Positive   Weight Reduced : 250
```

The output shows the following information:

- When Switch A fails, Switch B becomes the master because it has a higher priority than Switch C.
- The VF for virtual MAC address 000f-e2ff-4011 is removed.

Troubleshooting VRRP

An error prompt is displayed

Symptom

An error prompt "The virtual router detected a VRRP configuration error." is displayed during configuration.

Analysis

This symptom is probably caused by the following reasons:

- The VRRP advertisement interval in the packet is not the same as that for the current VRRP group (in VRRPv2 only).
- The number of virtual IP addresses in the packet is not the same as that for the current VRRP group.
- The virtual IP address list is not the same as that for the current VRRP group.
- A device in the VRRP group receives illegitimate VRRP packets. For example, the IP address owner receives a VRRP packet with the priority 255.

Solution

To resolve the problem:

1. Modify the configuration on routers in VRRP groups to ensure consistent configuration.
2. Take fault location and anti-attack measures to eliminate potential threats.
3. If the problem persists, contact H3C Support.

Multiple masters appear in a VRRP group

Symptom

Multiple masters appear in a VRRP group.

Analysis

It is normal for a VRRP group to have multiple masters for a short time, and this situation requires no manual intervention.

If multiple masters coexist for a longer period, check for the following conditions:

- The masters cannot receive advertisements from each other.
- The received advertisements are illegitimate.

Solution

To resolve the problem:

1. Ping between these masters:
   - If the ping operation fails, examine network connectivity.
   - If the ping operation succeeds, check for configuration inconsistencies in the number of virtual IP addresses, virtual IP addresses, and authentication. For IPv4 VRRP, also make sure the same version of VRRP is configured on all routers in the VRRP group. For VRRPv2, make sure the same VRRP advertisement interval is configured on the routers in the VRRP group.
2. If the problem persists, contact H3C Support.

Fast VRRP state flapping

Symptom

Fast VRRP state flapping occurs.

Analysis

The VRRP advertisement interval is set too short.

Solution

To resolve the problem:

1. Increase the interval for sending VRRP advertisements or introduce a preemption delay.
2. If the problem persists, contact H3C Support.

Contents

Configuring BFD

About BFD

Bidirectional forwarding detection (BFD) provides a general-purpose, standard, medium- and protocol-independent fast failure detection mechanism. It can detect and monitor the connectivity of links in IP to detect communication failures quickly so that measures can be taken to ensure service continuity and enhance network availability.

BFD can uniformly and quickly detect the failures of the bidirectional forwarding paths between two devices for upper-layer protocols such as routing protocols. The hello mechanism used by upper-layer protocols needs seconds to detect a link failure, while BFD can provide detection measured in milliseconds.

BFD session establishment and termination

BFD does not provide any neighbor discovery mechanisms. The upper protocol notifies BFD of the routers to which it needs to establish sessions. After establishing a neighborship, the upper protocol notifies BFD of the neighbor information, including destination and source addresses. BFD uses the information to establish a BFD session.

When BFD detects a link failure, it performs the following tasks:

1. BFD clears the neighbor session and notifies the protocol of the failure.
2. The protocol terminates the neighborship on the link.
3. If a backup link is available, the protocol will use it for communication.

Single-hop detection and multihop detection

BFD can be used for single-hop and multihop detections.

- **Single-hop detection**—Detects the IP connectivity between two directly connected systems.
- **Multihop detection**—Detects any of the paths between two systems. These paths have multiple hops, and might overlap.

BFD session modes

BFD sessions use echo packets and control packets.

Echo packet mode

Echo packets are encapsulated into UDP packets with port number 3785.

The local end of the link sends echo packets to establish BFD sessions and monitor link status. The peer end does not establish BFD sessions and only forwards the packets back to the originating end. If the local end does not receive echo packets from the peer end within the detection time, it considers the session to be down.

In echo packet mode, BFD supports only single-hop detection and the BFD sessions are independent of the operating mode.

Control packet mode

Control packets are encapsulated into UDP packets with port number 3784 for single-hop detection or port number 4784 for multihop detection.

Both ends of the link exchange BFD control packets to monitor link status.

Before a BFD session is established, BFD has two operating modes—active and passive.

- **Active mode**—BFD actively sends BFD control packets regardless of whether any BFD control packet is received from the peer.
- **Passive mode**—BFD does not send control packets until a BFD control packet is received from the peer.

At least one end must operate in active mode for a BFD session to be established.

After a BFD session is established, the two ends can operate in the following BFD operating modes:

- **Asynchronous mode**—The device periodically sends BFD control packets. The device considers that the session is down if it does not receive any BFD control packets within a specific interval.
- **Demand mode**—The device periodically sends BFD control packets. If the peer end is operating in Asynchronous mode (default), the peer end stops sending BFD control packets. If the peer end is operating in Demand mode, both ends stop sending BFD control packets. When the connectivity to another system needs to be verified explicitly, a system sends several BFD control packets with the Poll (P) bit set at the negotiated transmit interval. If no response is received within the detection interval, the session is considered down. If the connectivity is found to be up, no more BFD control packets are sent until the next command is issued.

Supported features

Features	Reference
Static routing OSPF RIP IP fast reroute (FRR)	*Layer 3—IP Routing Configuration Guide*
IPv6 static routing OSPFv3	*Layer 3—IP Routing Configuration Guide*
PIM	*IP Multicast Configuration Guide*
Track	"Configuring Track"
Ethernet link aggregation	*Layer 2—LAN Switching Configuration Guide*

Protocols and standards

- RFC 5880, *Bidirectional Forwarding Detection (BFD)*
- RFC 5881, *Bidirectional Forwarding Detection (BFD) for IPv4 and IPv6 (Single Hop)*
- RFC 5882, *Generic Application of Bidirectional Forwarding Detection (BFD)*
- RFC 5883, *Bidirectional Forwarding Detection (BFD) for Multihop Paths*
- RFC 7130, *Bidirectional Forwarding Detection (BFD) on Link Aggregation Group (LAG) Interfaces*

Restrictions and guidelines: BFD configuration

- By default, the device runs BFD version 1 and is compatible with BFD version 0. You cannot change the BFD version to 0 through commands. When the peer device runs BFD version 0, the local device automatically switches to BFD version 0.
- After a BFD session is established, the two ends negotiate BFD parameters, including minimum sending interval, minimum receiving interval, initialization mode, and packet authentication, by exchanging negotiation packets. They use the negotiated parameters without affecting the session status.
- BFD session flapping might occur on an aggregate interface with member ports on different IRF member devices. When the master device, which receives and sends BFD packets, is removed or restarted, a subordinate device might not immediately take over. For example, a subordinate device will not take over when the subordinate device has a short detection time or a large number of BFD sessions.
- In an IRF fabric, if the detection time is smaller than the IRF link down report delay, the BFD session might flap. To prevent this problem, set the IRF link down report delay to be smaller than the detection time. For information about setting the IRF link down report delay, see IRF configuration in *Virtual Technologies Configuration Guide*.

Configuring echo packet mode

Procedure

1. Enter system view.

   system-view
2. Configure the source IP address of echo packets.
   - Configure the source IP address of echo packets.

     bfd echo-source-ip *ip-address*

     By default, no source IPv4 address is configured for echo packets.

     As a best practice, do not configure the source IPv4 address to be on the same network segment as any local interface's IPv4 address. If you configure such a source IPv4 address, a large number of ICMP redirect packets might be sent from the peer, resulting in link congestion.
   - Configure the source IPv6 address of echo packets.

     bfd echo-source-ipv6 *ipv6-address*

     By default, no source IPv6 address is configured for echo packets.

     The source IPv6 address of echo packets can only be a global unicast address.
3. (Optional.) Set the echo packet mode parameters.
   a. Enter interface view.

      interface *interface-type interface-number*

   b. Set the minimum interval for receiving BFD echo packets.

      bfd min-echo-receive-interval *interval*

      The default setting is 400 milliseconds.

   c. Set the detection time multiplier.

      bfd detect-multiplier *value*

      The default setting is 5.

Configuring control packet mode

Restrictions and guidelines

After an upper-layer protocol is configured to support BFD, the device automatically creates BFD sessions in control packet mode. You do not need to perform this task.

BFD version 0 does not support the following commands:

- **bfd session init-mode**.
- **bfd authentication-mode**.
- **bfd demand enable**.
- **bfd echo enable**.

Configuring control packet mode for single-hop detection

1. Enter system view.
   system-view
2. Specify the mode for establishing a BFD session.
   bfd session init-mode { **active** | **passive** }
   By default, **active** is specified.
3. Enter interface view.
   interface *interface-type interface-number*
4. (Optional.) Configure the authentication mode for single-hop control packets.
   bfd authentication-mode { **hmac-md5** | **hmac-mmd5** | **hmac-msha1** | **hmac-sha1** | **m-md5** | **m-sha1** | **md5** | **sha1** | **simple** } *key-id* { **cipher** *cipher-string* | **plain** *plain-string* }
   By default, single-hop BFD packets are not authenticated.
5. Enable the Demand BFD session mode.
   bfd demand enable
   By default, the BFD session is in Asynchronous mode.
6. (Optional.) Enable the echo packet mode.
   bfd echo [**receive** | **send**] **enable**
   By default, the echo packet mode is disabled.
   Configure this command for BFD sessions in which control packets are sent. When you enable the echo packet mode for such a session in up state, BFD periodically sends echo packets to detect link connectivity and decrease control packet receive rate.
7. Set the minimum interval for transmitting and receiving single-hop BFD control packets.
   - Set the minimum interval for transmitting single-hop BFD control packets.
     bfd min-transmit-interval *interval*

   The default setting is 400 milliseconds.
   - Set the minimum interval for receiving single-hop BFD control packets.
     bfd min-receive-interval *interval*

   The default setting is 400 milliseconds.
8. Set the single-hop detection time multiplier.
   bfd detect-multiplier *value*

The default setting is 5.

9. (Optional.) Create a BFD session for detecting the local interface state.

   bfd detect-interface source-ip *ip-address* [**discriminator local** *local-value* **remote** *remote-value*] [**template** *template-name*]

   By default, no BFD session is created for detecting the local interface state.

   This command implements fast collaboration between interface state and BFD session state. When BFD detects a link fault, it sets the link layer protocol state to DOWN(BFD). This behavior helps applications relying on the link layer protocol state achieve fast convergence.

10. (Optional.) Configure the timer that delays reporting the first BFD session establishment failure to the data link layer.

    bfd detect-interface first-fail-timer *seconds*

    By default, the first BFD session establishment failure is not reported to the data link layer.

11. (Optional.) Enable special processing for BFD sessions.

    bfd detect-interface special-processing [**admin-down** | **authentication-change** | **session-up**] *

    By default, all types of special processing for BFD sessions are disabled.

Configuring control packet mode for multihop detection

1. Enter system view.

   system-view

2. Specify the mode for establishing a BFD session.

   bfd session init-mode { **active** | **passive** }

   By default, **active** is specified.

3. (Optional.) Configure the authentication mode for multihop BFD control packets.

   bfd multi-hop authentication-mode { **hmac-md5** | **hmac-mmd5** | **hmac-msha1** | **hmac-sha1** | **m-md5** | **m-sha1** | **md5** | **sha1** | **simple** } *key-id* { **cipher** *cipher-string* | **plain** *plain-string* }

   By default, no authentication is performed.

4. Configure the destination port number for multihop BFD control packets.

   bfd multi-hop destination-port *port-number*

   The default setting is 4784.

5. Set the multihop detection time multiplier.

   bfd multi-hop detect-multiplier *value*

   The default setting is 5.

6. Set the minimum interval for transmitting and receiving multihop BFD control packets.
   - Set the minimum interval for transmitting multihop BFD control packets.

     bfd multi-hop min-transmit-interval *interval*

     The default setting is 400 milliseconds.
   - Set the minimum interval for receiving multihop BFD control packets.

     bfd multi-hop min-receive-interval *interval*

   The default setting is 400 milliseconds.

Configuring a BFD template

About configuring a BFD template

Perform this task to specify BFD parameters in a template for sessions without next hops. You can configure BFD parameters for LSPs and PWs through a BFD template.

You can use a BFD template to adjust session parameters of BFD sessions used for detecting interface states.

Procedure

1. Enter system view.
   system-view
2. Create a BFD template and enter BFD template view.
   bfd template *template-name*
3. (Optional.) Configure the authentication mode for BFD control packets.
   bfd authentication-mode { **hmac-md5** | **hmac-mmd5** | **hmac-msha1** | **hmac-sha1** | **m-md5** | **m-sha1** | **md5** | **sha1** | **simple** } *key-id* { **cipher** *cipher-string* | **plain** *plain-string* }

   By default, no authentication is performed.
4. Set the detection time multiplier.
   bfd detect-multiplier *value*

   The default setting is 5.
5. Set the minimum interval for transmitting and receiving BFD control packets.
   - Set the minimum interval for transmitting BFD control packets.
     bfd min-transmit-interval *interval*

     The default setting is 400 milliseconds.
   - Set the minimum interval for receiving BFD control packets.
     bfd min-receive-interval *interval*

   The default setting is 400 milliseconds.

Enabling SNMP notifications for BFD

About SNMP notifications for BFD

To report critical BFD events to an NMS, enable SNMP notifications for BFD. For BFD event notifications to be sent correctly, you must also configure SNMP as described in *Network Management and Monitoring Configuration Guide*.

Procedure

1. Enter system view.
   system-view
2. Enable SNMP notifications for BFD.
   snmp-agent trap enable bfd

   By default, SNMP notifications are enabled for BFD.

Display and maintenance commands for BFD

Execute the **display** command in any view and the **reset** command in user view.

Task	Command
Display BFD session information.	**display bfd session** [**discriminator** *value* | **verbose**]
Clear BFD session statistics.	**reset bfd session statistics**

Contents

Configuring Track

About Track

The Track module works between application modules and detection modules. It shields the differences between various detection modules from application modules.

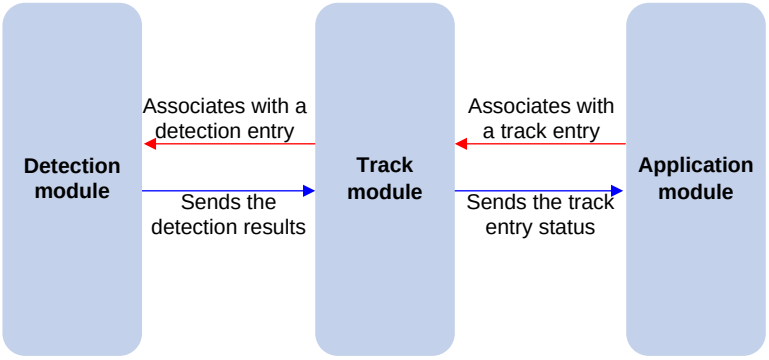
Collaboration mechanism

The Track module collaborates with detection modules and application modules.

As shown in Figure 1, collaboration is enabled when you associate the Track module with a detection module and an application module, and it operates as follows:

1. The detection module probes specific objects such as interface status, link status, network reachability, and network performance, and informs the Track module of detection results.
2. The Track module sends the detection results to the application module.
3. When notified of changes for the tracked object, the application modules can react to avoid communication interruption and network performance degradation.

Figure 1 Collaboration through the Track module



Collaboration between the Track module and a detection module

The detection module sends the detection result of the tracked object to the Track module. The Track module changes the status of the track entry as follows:

- If the tracked object operates correctly, the state of the track entry is Positive. For example, the track entry state is Positive in one of the following conditions:
  - The target interface is up.
  - The target network is reachable.
- If the tracked object does not operate correctly, the state of the track entry is Negative. For example, the track entry state is Negative in one of the following conditions:
  - The target interface is down.
  - The target network is unreachable.
- If the detection result is invalid, the state of the track entry is NotReady. For example, the track entry state is NotReady if its associated NQA operation does not exist.

Collaboration between the Track module and an application module

The track module reports the track entry status changes to the application module. The application module can then take correct actions to avoid communication interruption and network performance degradation.

Supported detection modules

The following detection modules can be associated with the Track module:

- NQA.
- BFD.
- CFD.
- Interface management.
- Route management.
- LLDP.

Supported application modules

The following application modules can be associated with the Track module:

- VRRP.
- Static routing.
- PBR
- Smart Link.
- EAA.
- ERPS.

Restrictions and guidelines: Track configuration

When configuring a track entry for an application module, you can set a notification delay to avoid immediate notification of status changes.

When the delay is not configured and the route convergence is slower than the link state change notification, communication failures occur. For example, when the master in a VRRP group detects an uplink interface failure through Track, Track immediately notifies the master to decrease its priority. A backup with a higher priority then preempts as the new master. When the failed uplink interface recovers, the Track module immediately notifies the original master to restore its priority. If the uplink route has not recovered, forwarding failure will occur.

Collaboration application example

The following is an example of collaboration between NQA, Track, and static routing.

Configure a static route with next hop 192.168.0.88 on the device. If the next hop is reachable, the static route is valid. If the next hop becomes unreachable, the static route is invalid. For this purpose, configure NQA-Track-static routing collaboration as follows:

1. Create an NQA operation to monitor the accessibility of IP address 192.168.0.88.
2. Create a track entry and associate it with the NQA operation.
    - When next hop 192.168.0.88 is reachable, NQA sends the result to the Track module. The Track module sets the track entry to Positive state.
    - When the next hop becomes unreachable, NQA sends the result to the Track module. The Track module sets the track entry to Negative state.
3. Associate the track entry with the static route.
    - When the track entry is in Positive state, the static routing module considers the static route to be valid.

- When the track entry is in Negative state, the static routing module considers the static route to be invalid.

Track tasks at a glance

To implement the collaboration function, establish associations between the Track module and detection modules, and between the Track module and application modules.

To configure the Track module, perform the following tasks:

1. Associating the Track module with a detection module
   - Associating Track with NQA
   - Associating Track with BFD
   - Associating Track with CFD
   - Associating Track with interface management
   - Associating Track with route management
   - Associating Track with LLDP
2. Associating the Track module with an application module
   - Associating Track with VRRP
   - Associating Track with static routing
   - Associating Track with PBR
   - Associating Track with Smart Link
   - Associating Track with EAA
   - Associating Track with ERPS

Associating the Track module with a detection module

Associating Track with NQA

About Track association with NQA

NQA supports multiple operation types to analyze network performance and service quality. For example, an NQA operation can periodically detect whether a destination is reachable, or whether a TCP connection can be established.

An NQA operation operates as follows when it is associated with a track entry:

- If the consecutive probe failures reach the specified threshold, the NQA module notifies the Track module that the tracked object has malfunctioned. The Track module then sets the track entry to Negative state.
- If the specified threshold is not reached, the NQA module notifies the Track module that the tracked object is operating correctly. The Track module then sets the track entry to Positive state.

For more information about NQA, see *Network Management and Monitoring Configuration Guide*.

Restrictions and guidelines

If you associate a track entry with a nonexistent NQA operation or reaction entry, the state of the track entry is NotReady.

Procedure

1. Enter system view.

   system-view

2. Create a track entry associated with an NQA reaction entry, and enter Track view.

   track *track-entry-number* **nqa entry** *admin-name operation-tag* **reaction** *item-number*

3. Set the delay for notifying the application module of track entry state changes.

   delay { **negative** *negative-time* | **positive** *positive-time* } *

   By default, the Track module notifies the application module immediately when the track entry state changes.

Associating Track with BFD

About Track association with BFD

You can associate a track entry with an echo-mode BFD session or a control-mode BFD session. For more information about BFD, see "Configuring BFD."

The associated Track and BFD operate as follows:

- If the BFD detects that the link fails, it informs the Track module of the link failure. The Track module sets the track entry to Negative state.
- If the BFD detects that the link is operating correctly, the Track module sets the track entry to Positive state.

Restrictions and guidelines

When you associate a track entry with BFD, do not configure the virtual IP address of a VRRP group as the local or remote address of the BFD session.

Prerequisites

Before you associate Track with an echo-mode BFD session, configure the source IP address of BFD echo packets. For more information, see "Configuring BFD."

Procedure

1. Enter system view.

   system-view

2. Create a track entry, and associate it with a BFD session. Choose the options to configure as needed:

   - Create a track entry associated with an echo-mode BFD session, and enter Track view.

     track *track-entry-number* **bfd echo interface** *interface-type interface-number* **remote ip** *remote-ip-address* **local ip** *local-ip-address*

   - Create a track entry associated with a control-mode BFD session, and enter Track view.

     track *track-entry-number* **bfd ctrl** [**interface** *interface-type interface-number*] **remote ip** *remote-ip-address* **local ip** *local-ip-address*

3. Set the delay for notifying the application module of track entry state changes.

   delay { **negative** *negative-time* | **positive** *positive-time* } *

   By default, the Track module notifies the application module immediately when the track entry state changes.

Associating Track with CFD

About Track association with CFD

The associated Track and CFD operate as follows:

- If the CFD detects that the link fails, it informs the Track module of the link failure. The Track module then sets the track entry to Negative state.
- If the CFD detects that the link is operating correctly, the Track module sets the track entry to Positive state.

For more information about CFD, see "Configuring CFD."

Prerequisites

Before you associate Track with CFD, enable CFD and create a MEP. For more information, see "Configuring CFD."

Procedure

1. Enter system view.

   system-view
2. Create a track entry associated with CFD, and enter Track view.

   track *track-entry-number* **cfd cc service-instance** *instance-id* **mep** *mep-id*
3. Set the delay for notifying the application module of track entry state changes.

   delay { **negative** *negative-time* | **positive** *positive-time* } *

   By default, the Track module notifies the application module immediately when the track entry state changes.

Associating Track with interface management

About Track association with interface management

The interface management module monitors the link status or network-layer protocol status of interfaces. The associated Track and interface management operate as follows:

- When the link or network-layer protocol status of the interface changes to up, the interface management module informs the Track module of the change. The Track module sets the track entry to Positive state.
- When the link or network-layer protocol status of the interface changes to down, the interface management module informs the Track module of the change. The Track module sets the track entry to Negative state.

Procedure

1. Enter system view.

   system-view
2. Create a track entry associated with interface management, and enter Track view.
   - Create a track entry to monitor the link status of an interface, and enter Track view.

     track *track-entry-number* **interface** *interface-type interface-number*
   - Create a track entry to monitor the physical status of an interface, and enter Track view.

     track *track-entry-number* **interface** *interface-type interface-number* **physical**
   - Create a track entry to monitor the network layer protocol status of an interface, and enter Track view.

track *track-entry-number* **interface** *interface-type interface-number* **protocol** { **ipv4** | **ipv6** }

3. Set the delay for notifying the application module of track entry state changes.

   delay { **negative** *negative-time* | **positive** *positive-time* } *

   By default, the Track module notifies the application module immediately when the track entry state changes.

Associating Track with route management

About Track association with route management

The route management module monitors route entry changes in the routing table. The associated Track and route management operate as follows:

- When a monitored route entry is found in the routing table, the route management module informs the Track module. The Track module sets the track entry to Positive state.
- When a monitored route entry is removed from the routing table, the route management module informs the Track module of the change. The Track module sets the track entry to Negative state.

Procedure

1. Enter system view.

   system-view

2. Create a track entry associated with a route entry, and enter Track view.

   track *track-entry-number* **ip route ip-address** { *mask-length* | *mask* } **reachability**

3. Set the delay for notifying the application module of track entry state changes.

   delay { **negative** *negative-time* | **positive** *positive-time* } *

   By default, the Track module notifies the application module immediately when the track entry state changes.

Associating Track with LLDP

About Track association with LLDP

The LLDP module monitors the neighbor availability of LLDP interfaces. The associated Track and LLDP operate as follows:

- When the neighbor of the monitored LLDP interface is available, the LLDP module informs the Track module. The Track module sets the track entry to Positive state.
- When the neighbor of the monitored LLDP interface is unavailable, the LLDP module informs the Track module. The Track module sets the track entry to Negative state.

For more information about LLDP, see *Layer 2—LAN Switching Configuration Guide*.

Procedure

1. Enter system view.

   system-view

2. Create a track entry associated with an LLDP interface, and enter Track view.

   track *track-entry-number* **lldp neighbor interface** *interface-type interface-number*

3. Set the delay for notifying the application module of track entry state changes.

   delay { **negative** *negative-time* | **positive** *positive-time* } *

By default, the Track module notifies the application module immediately when the track entry state changes.

Associating the Track module with an application module

Before you associate the Track module with an application module, make sure the associated track entry has been created.

Prerequisites for associating the Track module with an application module

Create a track entry first before you associate it with an application module.

An application module might obtain incorrect track entry status information if the associated track entry does not exist.

Associating Track with VRRP

About Track association with VRRP

When VRRP is operating in standard mode or load balancing mode, associate the Track module with the VRRP group to implement the following actions:

- Change the priority of a router according to the status of the uplink. If a fault occurs on the uplink of the router, the VRRP group is not aware of the uplink failure. If the router is the master, hosts in the LAN cannot access the external network. To resolve this problem, configure a detection module-Track-VRRP collaboration. The detection module monitors the status of the uplink of the router and notifies the Track module of the detection result.

  When the uplink fails, the detection module notifies the Track module to change the status of the monitored track entry to Negative. The priority of the master decreases by a user-specified value. A router with a higher priority in the VRRP group becomes the master.
- Monitor the master on a backup. If a fault occurs on the master, the backup operating in switchover mode will switch to the master immediately to maintain normal communication.

When VRRP is operating in load balancing mode, associate the Track module with the VRRP VF to implement the following functions:

- Change the priority of the AVF according to its uplink state. When the uplink of the AVF fails, the track entry changes to Negative state. The weight of the AVF decreases by a user-specified value. The VF with a higher priority becomes the new AVF to forward packets.
- Monitor the AVF status from the LVF. When the AVF fails, the LVF that is operating in switchover mode becomes the new AVF to ensure continuous forwarding.

For more information about configuring VRRP, see "Configuring VRRP."

Restrictions and guidelines for Track association with VRRP

- VRRP tracking does not take effect on an IP address owner. The configuration takes effect when the router does not act as the IP address owner.

  An IP address owner is the router with its interface IP address used as the virtual IP address of the VRRP group.
- When the status of the track entry changes from Negative to Positive or NotReady, the associated router or VF restores its priority automatically.

Associating Track with a VRRP group

1. Enter system view.

   system-view

2. Enter interface view.

   interface *interface-type interface-number*

3. Associate a track entry with a VRRP group.

   vrrp [**ipv6**] **vrid** *virtual-router-id* **track** *track-entry-number* { **forwarder-switchover member-ip** *ip-address* | **priority reduced** [*priority-reduced*] **switchover** | **weight reduced** [*weight-reduced*] }

   By default, no track entry is associated with a VRRP group.

   This command is supported when VRRP is operating in both standard mode and load balancing mode.

Associating Track with a VRRP VF

1. Enter system view.

   system-view

2. Enter interface view.

   interface *interface-type interface-number*

3. Associate Track with a VRRP VF.

   vrrp [**ipv6**] **vrid** *virtual-router-id* **track** *track-entry-number* { **forwarder-switchover member-ip** *ip-address* | **priority reduced** [*priority-reduced*] **switchover** | **weight reduced** [*weight-reduced*] }

   By default, no track entry is associated with a VRRP VF.

   This command is configurable when VRRP is operating in standard mode or load balancing mode. However, the configuration takes effect only when VRRP is operating in load balancing mode.

Associating Track with static routing

About track association with static routing

A static route is a manually configured route to route packets. For more information about static route configuration, see *Layer 3—IP Routing Configuration Guide*.

Static routes cannot adapt to network topology changes. Link failures or network topological changes can make the routes unreachable and cause communication interruption.

To resolve this problem, configure another route to back up the static route. When the static route is reachable, packets are forwarded through the static route. When the static route is unreachable, packets are forwarded through the backup route.

To check the accessibility of a static route in real time, associate the Track module with the static route.

If you specify the next hop but not the output interface when configuring a static route, you can configure the static routing-Track-detection module collaboration. This collaboration enables you to verify the accessibility of the static route based on the track entry state.

- If the track entry is in Positive state, the following conditions exist:
  - The next hop of the static route is reachable.
  - The configured static route is valid.
- If the track entry is in Negative state, the following conditions exist:
  - The next hop of the static route is not reachable.

- The configured static route is invalid.

- If the track entry is in NotReady state, the following conditions exist:
  - The accessibility of the next hop of the static route is unknown.
  - The static route is valid.

Restrictions and guidelines

If a static route needs route recursion, the associated track entry must monitor the next hop of the recursive route. The next hop of the static route cannot be monitored. Otherwise, a valid route might be considered invalid.

Procedure

1. Enter system view.

   system-view

2. Associate a static route with a track entry to check the accessibility of the next hop.

   ip route-static { *dest-address* { *mask-length* | *mask* } | **group** *group-name* } { *interface-type interface-number* [*next-hop-address*] [**backup-interface** *interface-type interface-number* [**backup-nexthop** *backup-nexthop-address*] [**permanent**] | **bfd** { **control-packet** | **echo-packet** } | **permanent** | **track** *track-entry-number*] | *next-hop-address* [**recursive-lookup host-route**] [**bfd control-packet bfd-source** *ip-address* | **permanent** | **track** *track-entry-number*] } [**preference** *preference*] [**tag** *tag-value*] [**description** *text*]

   By default, Track is not associated with static routing.

Associating Track with PBR

About Track association with PBR

PBR uses user-defined policies to route packets. You can specify parameters in a PBR policy to guide the forwarding of the packets that match specific criteria. For more information about PBR, see *Layer 3—IP Routing Configuration Guide*.

PBR cannot detect the availability of any action taken on packets. When an action is not available, packets processed by the action might be discarded. For example, if the output interface specified for PBR fails, PBR cannot detect the failure, and continues to forward matching packets out of the interface.

To enable PBR to detect topology changes and improve the flexibility of the PBR application, configure Track-PBR-detection module collaboration.

After you associate a track entry with an apply clause, the detection module associated with the track entry sends Track the detection result of the availability of the tracked object.

- The Positive state of the track entry indicates that the object is available, and the apply clause is valid.
- The Negative state of the track entry indicates that the object is not available, and the apply clause is invalid.
- The NotReady state of the track entry indicates that the apply clause is valid.

You can associate a track entry with only next hops.

Prerequisites for Track association with PBR

Before you associate Track with PBR, create a policy node, and set the match criteria.

Associating Track with PBR

1. Enter system view.

system-view

2. Create a policy node and enter its view.
   policy-based-route *policy-name* [**deny** | **permit**] **node** *node-number*
3. Set an ACL match criterion.
   if-match acl { *acl-number* | **name** *acl-name* }

   By default, no ACL match criterion is set.

   The ACL match criterion cannot match Layer 2 information.

   When using the ACL to match packets, PBR ignores the action (**permit** or **deny**) and time range settings in the ACL.
4. Set next hops and associate the next hops with a track entry.
   apply next-hop { *ip-address* [**direct**] [**track** *track-entry-number*] }&<1-n>

   By default, no next hops are set.

Associating Track with IPv6 PBR

1. Enter system view.
   system-view
2. Create an IPv6 policy node and enter its view.
   ipv6 policy-based-route *policy-name* [**deny** | **permit**] **node** *node-number*
3. Set an ACL match criterion.
   if-match acl { *ipv6-acl-number* | **name** *ipv6-acl-name* }

   By default, no ACL match criterion is set.

   The ACL match criterion cannot match Layer 2 information.

   When using the ACL to match packets, IPv6 PBR ignores the action (**permit** or **deny**) and time range settings in the ACL.
4. Set next hops and associate the next hops with a track entry.
   apply next-hop { *ipv6-address* [**direct**] [**track** *track-entry-number*] } &<1-n>

   By default, no next hops are set.

Associating Track with Smart Link

About Track association with Smart Link

Smart Link cannot detect unidirectional links, misconnected fibers, or packet loss on intermediate devices or network paths of the uplink. It also cannot detect when faults are cleared. To check the link status, Smart Link ports must use link detection protocols. When a fault is detected or cleared, the link detection protocols inform Smart Link to switch over the links.

You can configure the collaboration between Smart Link and Track on a smart link group member port. Smart Link collaborates with the CC feature of CFD through the track entry to detect the link status on the port.

- When the track entry is in Positive state, the link is in normal state. Smart Link does not perform link switchover for the smart link group.
- When the track entry is in Negative state, the link has failed. Smart Link determines whether to perform link switchover according to the link preemption mode and port role configured in the smart link group.
- When the track entry is in NotReady state, the port state does not change.

For more information about Smart Link, see "Configuring Smart Link."

Hardware and feature compatibility

The S5110V2-SI, S5000V3-EI, S5000V5-EI, S5000E-X, S5000X-EI, and WAS6000 switch series do not support this feature.

Restrictions and guidelines

The track entry to be used for collaboration with Smart Link must have been associated with the CC feature of CFD.

Procedure

1. Enter system view.
   system-view
2. Enter Layer 2 Ethernet interface view or Layer 2 aggregate interface view.
   interface *interface-type interface-number*
3. Configure collaboration between Smart Link and Track on the port.
   port smart-link group *group-id* **track** *track-entry-number*
   By default, the collaboration between Smart Link and Track is not configured.

Associating Track with EAA

About Track association with EAA

You can configure EAA track event monitor policies to monitor the positive-to-negative or negative-to-positive state changes of track entries.

- If you specify only one track entry for a policy, EAA triggers the policy when it detects the specified state change on the track entry.
- If you specify multiple track entries for a policy, EAA triggers the policy when it detects the specified state change on the last monitored track entry. For example, if you configure a policy to monitor the positive-to-negative state change of multiple track entries, EAA triggers the policy when the last positive track entry monitored by the policy is changed to the Negative state.

You can set a suppression time for a track event monitor policy. The timer starts when the policy is triggered. The system does not process messages that report the monitored track event until the timer times out.

For more information about EAA, see *Network Management and Monitoring Configuration Guide*.

Procedure

1. Enter system view.
   system-view
2. Create a CLI-defined monitor policy and enter its view, or enter the view of an existing CLI-defined monitor policy.
   rtm cli-policy *policy-name*
3. Configure a track event.
   event track *track-entry-number-list* **state** { **negative** | **positive** } [**suppress-time** *suppress-time*]
   By default, a monitor policy does not monitor any track event.

Associating Track with ERPS

About Track association with ERPS

To detect and clear link faults typically for a fiber link, use ERPS with CFD and Track. You can associate ERPS ring member ports with the continuity check function of CFD through track entries.

CFD reports link events only when the monitored VLAN is the control VLAN of the ERPS instance for the port.

Track changes the track entry state based on the monitoring result of CFD, and notifies the track entry state change to the associated EPRS ring.

- When the track entry is in Positive state, the link of the monitored ERPS ring member port is in normal state. The ERPS ring does not switch traffic to other links.
- When the track entry is in Negative state, the link of the monitored ERPS ring member port is faulty. The ERPS ring switches traffic to other links.
- When the track entry is in NotReady state, the state of the ERPS ring member port does not change.

For more information about ERPS, see "Configuring ERPS."

Restrictions and guidelines

Before you associate a port with a track entry, make sure the port has joined an ERPS instance.

Procedure

1. Enter system view.
   system-view
2. Enter Layer 2 Ethernet interface view or Layer 2 aggregate interface view.
   interface *interface-type interface-number*
3. Associate an ERPS ring member port with a track entry.
   port erps ring *ring-id* **instance** *instance-id* **track** *track-entry-index*
   By default, an ERPS ring member port is not associated with any track entries.

Display and maintenance commands for Track

Execute **display** commands in any view.

Task	Command
Display information about track entries.	**display track** { *track-entry-number* | **all** [**negative** | **positive**] } [**brief**]

Track configuration examples

Example: Configuring VRRP-Track-NQA collaboration

Network configuration

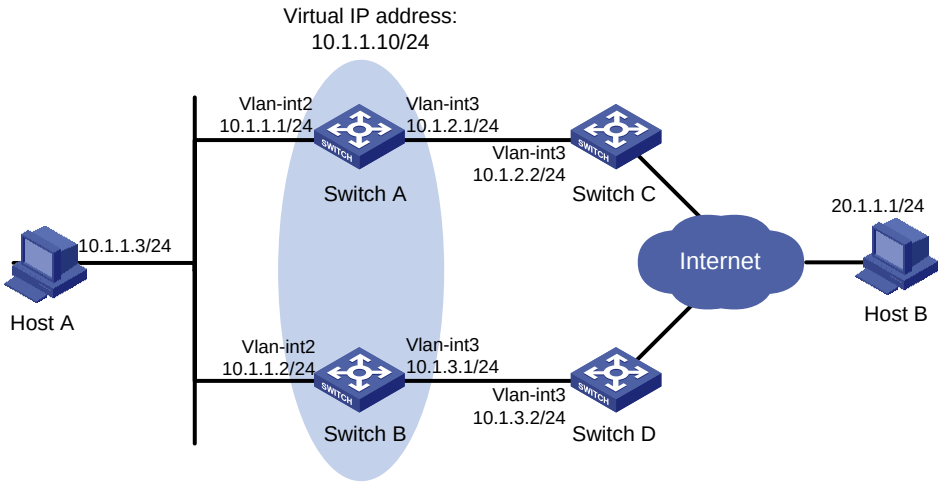
As shown in Figure 2:

- Host A requires access to Host B. The default gateway of Host A is 10.1.1.10/24.
- Switch A and Switch B belong to VRRP group 1. The virtual IP address of VRRP group 1 is 10.1.1.10.

Configure VRRP-Track-NQA collaboration to monitor the uplink on the master and meet the following requirements:

- When Switch A operates correctly, Switch A forwards packets from Host A to Host B.
- When NQA detects a fault on the uplink of Switch A, Switch B forwards packets from Host A to Host B.

Figure 2 Network diagram



Procedure

1. Create VLANs and assign ports to them. Configure the IP address of each VLAN interface, as shown in Figure 2. (Details not shown.)
2. Configure an NQA operation on Switch A:

   # Create an NQA operation with administrator name **admin** and operation tag **test**.

   ```
   <SwitchA> system-view
   [SwitchA] nqa entry admin test
   ```

   # Specify the **ICMP echo** operation type.

   ```
   [SwitchA-nqa-admin-test] type icmp-echo
   ```

   # Specify 10.1.2.2 as the destination address of ICMP echo requests.

   ```
   [SwitchA-nqa-admin-test-icmp-echo] destination ip 10.1.2.2
   ```

   # Configure the ICMP echo operation to repeat every 100 milliseconds.

   ```
   [SwitchA-nqa-admin-test-icmp-echo] frequency 100
   ```

   # Configure reaction entry 1, specifying that five consecutive probe failures trigger the Track module.

   ```
   [SwitchA-nqa-admin-test-icmp-echo] reaction 1 checked-element probe-fail
   threshold-type consecutive 5 action-type trigger-only
   [SwitchA-nqa-admin-test-icmp-echo] quit
   ```

   # Start the NQA operation.

   ```
   [SwitchA] nqa schedule admin test start-time now lifetime forever
   ```

3. On Switch A, configure track entry 1, and associate it with reaction entry 1 of the NQA operation.

   ```
   [SwitchA] track 1 nqa entry admin test reaction 1
   [SwitchA-track-1] quit
   ```

4. Configure VRRP on Switch A:

   # Specify VRRPv2 to run on VLAN-interface 2.

   ```
   [SwitchA] interface vlan-interface 2
   [SwitchA-Vlan-interface2] vrrp version 2
   ```

   # Create VRRP group 1, and configure virtual IP address 10.1.1.10 for the group.

   ```
   [SwitchA-Vlan-interface2] vrrp vrid 1 virtual-ip 10.1.1.10
   ```

   # Set the priority of Switch A to 110 in VRRP group 1.

   ```
   [SwitchA-Vlan-interface2] vrrp vrid 1 priority 110
   ```

Set the authentication mode of VRRP group 1 to **simple**, and the authentication key to **hello**.

```
[SwitchA-Vlan-interface2] vrrp vrid 1 authentication-mode simple hello
```

Configure the master to send VRRP packets every 500 centiseconds.

```
[SwitchA-Vlan-interface2] vrrp vrid 1 timer advertise 500
```

Configure Switch A to operate in preemptive mode and set the preemption delay to 5000 centiseconds.

```
[SwitchA-Vlan-interface2] vrrp vrid 1 preempt-mode timer delay 5000
```

Associate VRRP group 1 with track entry 1 and decrease the router priority by 30 when the state of track entry 1 changes to Negative.

```
[SwitchA-Vlan-interface2] vrrp vrid 1 track 1 priority reduced 30
```

5. Configure VRRP on Switch B:

Specify VRRPv2 to run on VLAN-interface 2.

```
<SwitchB> system-view
[SwitchB] interface vlan-interface 2
[SwitchB-Vlan-interface2] vrrp version 2
```

Create VRRP group 1, and configure virtual IP address 10.1.1.10 for the group.

```
[SwitchB-Vlan-interface2] vrrp vrid 1 virtual-ip 10.1.1.10
```

Set the authentication mode of VRRP group 1 to **simple**, and the authentication key to **hello**.

```
[SwitchB-Vlan-interface2] vrrp vrid 1 authentication-mode simple hello
```

Configure the master to send VRRP packets every 500 centiseconds.

```
[SwitchB-Vlan-interface2] vrrp vrid 1 timer advertise 500
```

Configure Switch B to operate in preemptive mode and set the preemption delay to 5000 centiseconds.

```
[SwitchB-Vlan-interface2] vrrp vrid 1 preempt-mode timer delay 5000
```

Verifying the configuration

Ping Host B from Host A to verify that Host B is reachable. (Details not shown.)

Display detailed information about VRRP group 1 on Switch A.

```
[SwitchA-Vlan-interface2] display vrrp verbose
IPv4 Virtual Router Information:
 Running Mode      : Standard
 Total number of virtual routers : 1
   Interface Vlan-interface2
     VRID             : 1              Adver Timer  : 500
     Admin Status     : Up             State        : Master
     Config Pri       : 110            Running Pri  : 110
     Preempt Mode     : Yes            Delay Time   : 5000
     Auth Type        : Simple         Key          : ******
     Virtual IP       : 10.1.1.10
     Virtual MAC      : 0000-5e00-0101
     Master IP        : 10.1.1.1
   VRRP Track Information:
     Track Object   : 1              State : Positive          Pri Reduced : 30
```

Display detailed information about VRRP group 1 on Switch B.

```
[SwitchB-Vlan-interface2] display vrrp verbose
IPv4 Virtual Router Information:
 Running Mode      : Standard
 Total number of virtual routers : 1
```

```
  Interface Vlan-interface2
    VRID             : 1               Adver Timer  : 500
    Admin Status     : Up              State        : Backup
    Config Pri       : 100             Running Pri  : 100
    Preempt Mode     : Yes             Delay Time   : 5000
    Become Master    : 2200ms left
    Auth Type        : Simple          Key          : ******
    Virtual IP       : 10.1.1.10
    Master IP        : 10.1.1.1
```

The output shows that in VRRP group 1, Switch A is the master, and Switch B is a backup. Switch A forwards packets from Host A to Host B.

Disconnect the link between Switch A and Switch C, and verify that Host A can still ping Host B. (Details not shown.)

Display detailed information about VRRP group 1 on Switch A.

```
[SwitchA-Vlan-interface2] display vrrp verbose
IPv4 Virtual Router Information:
 Running Mode      : Standard
 Total number of virtual routers : 1
   Interface Vlan-interface2
     VRID             : 1               Adver Timer  : 500
     Admin Status     : Up              State        : Backup
     Config Pri       : 110             Running Pri  : 80
     Preempt Mode     : Yes             Delay Time   : 5000
     Become Master    : 2200ms left
     Auth Type        : Simple          Key          : ******
     Virtual IP       : 10.1.1.10
     Master IP        : 10.1.1.2
   VRRP Track Information:
     Track Object   : 1              State : Negative          Pri Reduced : 30
```

Display detailed information about VRRP group 1 on Switch B.

```
[SwitchB-Vlan-interface2] display vrrp verbose
IPv4 Virtual Router Information:
 Running Mode      : Standard
 Total number of virtual routers : 1
   Interface Vlan-interface2
     VRID             : 1               Adver Timer  : 500
     Admin Status     : Up              State        : Master
     Config Pri       : 100             Running Pri  : 100
     Preempt Mode     : Yes             Delay Time   : 5000
     Auth Type        : Simple          Key          : ******
     Virtual IP       : 10.1.1.10
     Virtual MAC      : 0000-5e00-0101
     Master IP        : 10.1.1.2
```

The output shows that Switch A becomes the backup, and Switch B becomes the master. Switch B forwards packets from Host A to Host B.

Example: Configuring an echo-mode BFD session for a VRRP backup to monitor the master

Network configuration

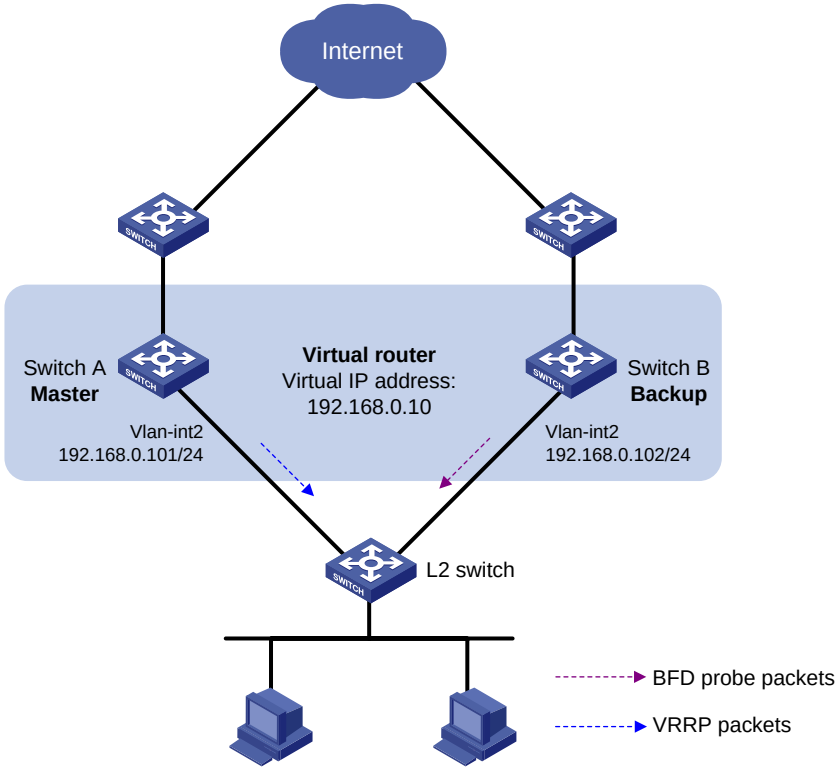
As shown in Figure 3:

- Switch A and Switch B belong to VRRP group 1. The virtual IP address of VRRP group 1 is 192.168.0.10.
- The default gateway of the hosts in the LAN is 192.168.0.10.

Configure VRRP-Track-BFD (echo mode) collaboration to monitor the master on the backup and meet the following requirements:

- When Switch A operates correctly, the hosts in the LAN access the Internet through Switch A.
- When Switch A fails, the backup (Switch B) can detect the state change of the master through the echo-mode BFD session and become the new master. The hosts in the LAN access the Internet through Switch B.

Figure 3 Network diagram



Procedure

1. Create VLANs and assign ports to them. Configure the IP address of each VLAN interface, as shown in Figure 3. (Details not shown.)
2. Configure Switch A:

   # Create VRRP group 1, and configure virtual IP address 192.168.0.10 for the group.

   ```
   <SwitchA> system-view
   [SwitchA] interface vlan-interface 2
   [SwitchA-Vlan-interface2] vrrp vrid 1 virtual-ip 192.168.0.10
   ```

   # Set the priority of Switch A to 110 in VRRP group 1.

```
[SwitchA-Vlan-interface2] vrrp vrid 1 priority 110
[SwitchA-Vlan-interface2] return
```

3. Configure Switch B:

Specify 10.10.10.10 as the source address of BFD echo packets.

```
<SwitchB> system-view
[SwitchB] bfd echo-source-ip 10.10.10.10
```

Create track entry 1, and associate it with the echo-mode BFD session to verify the reachability of Switch A.

```
[SwitchB] track 1 bfd echo interface vlan-interface 2 remote ip 192.168.0.101 local
ip 192.168.0.102
[SwitchB-track-1] quit
```

Create VRRP group 1, and configure virtual IP address 192.168.0.10 for the group.

```
[SwitchB] interface vlan-interface 2
[SwitchB-Vlan-interface2] vrrp vrid 1 virtual-ip 192.168.0.10
```

Configure VRRP group 1 to monitor the status of track entry 1.

```
[SwitchB-Vlan-interface2] vrrp vrid 1 track 1 switchover
[SwitchB-Vlan-interface2] return
```

Verifying the configuration

Display detailed information about VRRP group 1 on Switch A.

```
<SwitchA> display vrrp verbose
IPv4 Virtual Router Information:
 Running Mode      : Standard
 Total number of virtual routers : 1
   Interface Vlan-interface2
     VRID             : 1              Adver Timer  : 100
     Admin Status     : Up             State        : Master
     Config Pri       : 110            Running Pri  : 110
     Preempt Mode     : Yes            Delay Time   : 0
     Auth Type        : None
     Virtual IP       : 192.168.0.10
     Virtual MAC      : 0000-5e00-0101
     Master IP        : 192.168.0.101
```

Display detailed information about VRRP group 1 on Switch B.

```
<SwitchB> display vrrp verbose
IPv4 Virtual Router Information:
 Running Mode      : Standard
 Total number of virtual routers : 1
   Interface Vlan-interface2
     VRID             : 1              Adver Timer  : 100
     Admin Status     : Up             State        : Backup
     Config Pri       : 100            Running Pri  : 100
     Preempt Mode     : Yes            Delay Time   : 0
     Become Master    : 2200ms left
     Auth Type        : None
     Virtual IP       : 192.168.0.10
     Master IP        : 192.168.0.101
   VRRP Track Information:
```

```
    Track Object   : 1             State : Positive         Switchover
```

Display information about track entry 1 on Switch B.

```
<SwitchB> display track 1
Track ID: 1
  State: Positive
  Duration: 0 days 0 hours 0 minutes 32 seconds
  Tracked object type: BFD echo
  Notification delay: Positive 0, Negative 0 (in seconds)
  Tracked object:
    BFD session mode: Echo
    Outgoing interface: Vlan-interface2
    VPN instance name: --
    Remote IP: 192.168.0.101
    Local IP: 192.168.0.102
```

The output shows that when the status of the track entry becomes Positive, Switch A is the master and Switch B is the backup.

Enable VRRP state debugging and BFD event notification debugging on Switch B.

```
<SwitchB> terminal debugging
<SwitchB> terminal monitor
<SwitchB> debugging vrrp fsm
<SwitchB> debugging bfd ntfy
```

When Switch A fails, the following output is displayed on Switch B.

```
*Dec 17 14:44:34:142 2008 SwitchB BFD/7/DEBUG: Notify application:TRACK State:DOWN
*Dec 17 14:44:34:144 2008 SwitchB VRRP4/7/FSM:
 IPv4 Vlan-interface2 | Virtual Router 1 : Backup --> Master   reason: The status of the
tracked object changed
```

Display detailed information about the VRRP group on Switch B.

```
<SwitchB> display vrrp verbose
IPv4 Virtual Router Information:
 Running Mode      : Standard
 Total number of virtual routers : 1
   Interface Vlan-interface2
     VRID             : 1              Adver Timer  : 100
     Admin Status     : Up             State        : Master
     Config Pri       : 100            Running Pri  : 100
     Preempt Mode     : Yes            Delay Time   : 0
     Auth Type        : None
     Virtual IP       : 192.168.0.10
     Virtual MAC      : 0000-5e00-0101
     Master IP        : 192.168.0.102
   VRRP Track Information:
     Track Object   : 1             State : Negative         Switchover
```

The output shows that when the echo-mode BFD session detects that Switch A fails, the Track module notifies VRRP to change the status of Switch B to master. The backup can quickly preempt as the master without waiting for a period three times the advertisement interval plus the Skew_Time.

Example: Configuring a control-mode BFD session for a VRRP backup to monitor the master

Network configuration

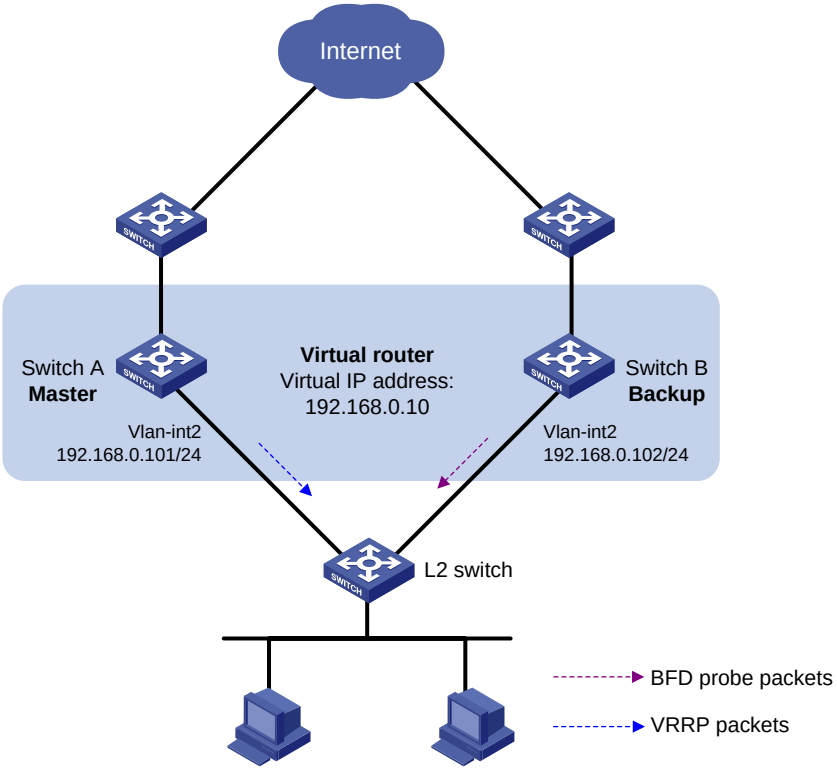
As shown in Figure 4:

- Switch A and Switch B belong to VRRP group 1. The virtual IP address of VRRP group 1 is 192.168.0.10.
- The default gateway of the hosts in the LAN is 192.168.0.10.

Configure VRRP-Track-BFD (control mode) collaboration to monitor the master on the backup and meet the following requirements:

- When Switch A operates correctly, the hosts in the LAN access the Internet through Switch A.
- When Switch A fails, the backup (Switch B) can detect the state change of the master through the control-mode BFD session and become the new master. The hosts in the LAN access the Internet through Switch B.

Figure 4 Network diagram



Procedure

1. Create VLANs and assign ports to them. Configure the IP address of each VLAN interface, as shown in Figure 4. (Details not shown.)
2. Configure Switch A:

   # Create VRRP group 1, and configure virtual IP address 192.168.0.10 for the group.

   ```
   <SwitchA> system-view
   [SwitchA] interface vlan-interface 2
   [SwitchA-Vlan-interface2] vrrp vrid 1 virtual-ip 192.168.0.10
   ```

   # Set the priority of Switch A to 110 in VRRP group 1.

```
[SwitchA-Vlan-interface2] vrrp vrid 1 priority 110
[SwitchA-Vlan-interface2] return
```

Create track entry 1, and associate it with the control-mode BFD session to verify the reachability of Switch B.

```
[SwitchA] track 1 bfd ctrl interface vlan-interface 2 remote ip 192.168.0.102 local ip 192.168.0.101
[SwitchA-track-1] quit
```

3. Configure Switch B:

Create VRRP group 1, and configure virtual IP address 192.168.0.10 for the group.

```
<SwitchB> system-view
[SwitchB] interface vlan-interface 2
[SwitchB-Vlan-interface2] vrrp vrid 1 virtual-ip 192.168.0.10
```

Configure VRRP group 1 to monitor track entry 1 so Switch B can take over as the master once the track entry changes to the Negative state.

```
[SwitchB-Vlan-interface2] vrrp vrid 1 track 1 switchover
[SwitchB-Vlan-interface2] return
```

Create track entry 1, and associate it with the control-mode BFD session to verify the reachability of Switch A.

```
[SwitchB] track 1 bfd ctrl interface vlan-interface 2 remote ip 192.168.0.101 local ip 192.168.0.102
[SwitchB-track-1] quit
```

Verifying the configuration

Display detailed information about VRRP group 1 on Switch A.

```
<SwitchA> display vrrp verbose
IPv4 Virtual Router Information:
 Running Mode      : Standard
 Total number of virtual routers : 1
   Interface Vlan-interface2
     VRID             : 1              Adver Timer  : 100
     Admin Status     : Up             State        : Master
     Config Pri       : 110            Running Pri  : 110
     Preempt Mode     : Yes            Delay Time   : 0
     Auth Type        : None
     Virtual IP       : 192.168.0.10
     Virtual MAC      : 0000-5e00-0101
     Master IP        : 192.168.0.101
```

Display detailed information about VRRP group 1 on Switch B.

```
<SwitchB> display vrrp verbose
IPv4 Virtual Router Information:
 Running Mode      : Standard
 Total number of virtual routers : 1
   Interface Vlan-interface2
     VRID             : 1              Adver Timer  : 100
     Admin Status     : Up             State        : Backup
     Config Pri       : 100            Running Pri  : 100
     Preempt Mode     : Yes            Delay Time   : 0
     Become Master    : 2200ms left
     Auth Type        : None
```

```
    Virtual IP       : 192.168.0.10
    Master IP        : 192.168.0.101
  VRRP Track Information:
    Track Object   : 1              State : Positive          Switchover
```

Display information about track entry 1 on Switch B.

```
<SwitchB> display track 1
Track ID: 1
  State: Positive
  Duration: 0 days 0 hours 0 minutes 32 seconds
  Tracked object type: BFD ctrl
  Notification delay: Positive 0, Negative 0 (in seconds)
  Tracked object:
    BFD session mode: Ctrl
    Outgoing interface: Vlan-interface2
    VPN instance name: --
    Remote IP: 192.168.0.101
    Local IP: 192.168.0.102
```

The output shows that when the status of the track entry becomes Positive, Switch A is the master and Switch B is the backup.

Enable VRRP state debugging and BFD event notification debugging on Switch B.

```
<SwitchB> terminal debugging
<SwitchB> terminal monitor
<SwitchB> debugging vrrp fsm
<SwitchB> debugging bfd ntfy
```

When Switch A fails, the following output is displayed on Switch B.

```
*Dec 17 14:44:34:142 2008 SwitchB BFD/7/DEBUG: Notify application:TRACK State:DOWN
*Dec 17 14:44:34:144 2008 SwitchB VRRP4/7/FSM:
 IPv4 Vlan-interface2 | Virtual Router 1 : Backup --> Master   reason: The status of the
tracked object changed
```

Display detailed information about the VRRP group on Switch B.

```
<SwitchB> display vrrp verbose
IPv4 Virtual Router Information:
 Running Mode      : Standard
 Total number of virtual routers : 1
   Interface Vlan-interface2
     VRID             : 1              Adver Timer  : 100
     Admin Status     : Up             State        : Master
     Config Pri       : 100            Running Pri  : 100
     Preempt Mode     : Yes            Delay Time   : 0
     Auth Type        : None
     Virtual IP       : 192.168.0.10
     Virtual MAC      : 0000-5e00-0101
     Master IP        : 192.168.0.102
   VRRP Track Information:
     Track Object   : 1              State : Negative          Switchover
```

The output shows that when the control-mode BFD session detects that Switch A fails, the Track module notifies VRRP to change the status of Switch B to master. The backup can quickly preempt

as the master without waiting for a period three times the advertisement interval plus the Skew_Time.

Example: Configuring an echo-mode BFD session for the VRRP master to monitor the uplink

Network configuration

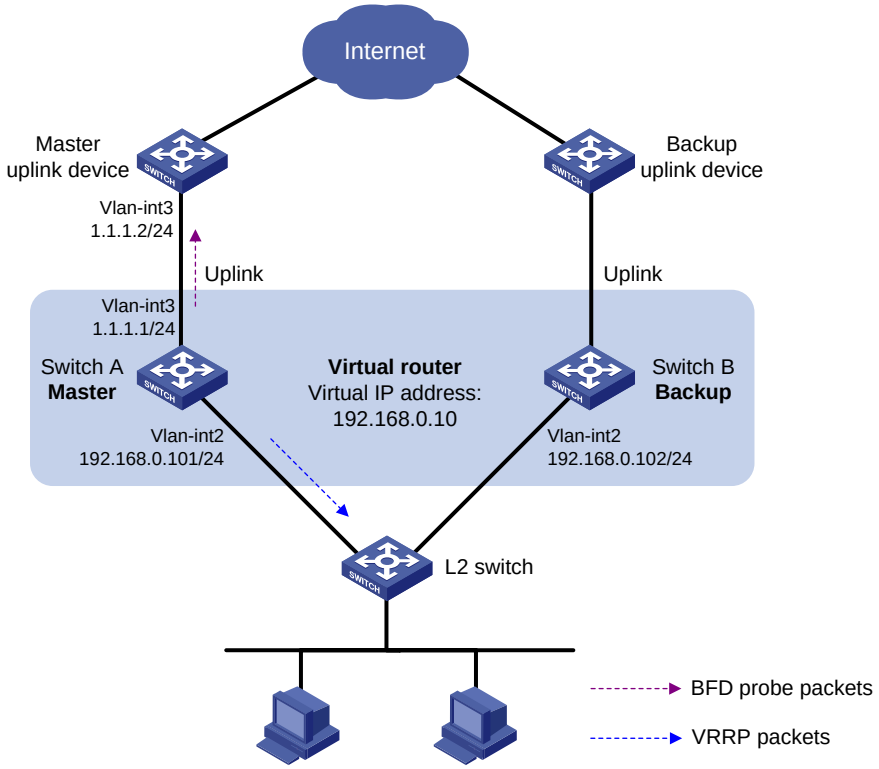
As shown in Figure 5:

- Switch A and Switch B belong to VRRP group 1. The virtual IP address of VRRP group 1 is 192.168.0.10.
- The default gateway of the hosts in the LAN is 192.168.0.10.

Configure VRRP-Track-BFD (echo mode) collaboration to monitor the uplink on the master and meet the following requirements:

- When Switch A operates correctly, the hosts in the LAN access the Internet through Switch A.
- When Switch A detects that the uplink is down through the echo-mode BFD session, Switch B can preempt as the master. The hosts in the LAN can access the Internet through Switch B.

Figure 5 Network diagram



Procedure

1. Create VLANs and assign ports to them. Configure the IP address of each VLAN interface, as shown in Figure 5. (Details not shown.)
2. Configure Switch A:

   # Specify 10.10.10.10 as the source address of BFD echo packets.

   ```
   <SwitchA> system-view
   [SwitchA] bfd echo-source-ip 10.10.10.10
   ```

Create track entry 1 for the echo-mode BFD session to verify the reachability of the uplink device (1.1.1.2).

```
[SwitchA] track 1 bfd echo interface vlan-interface 3 remote ip 1.1.1.2 local ip 1.1.1.1
[SwitchA-track-1] quit
```

Create VRRP group 1, and specify 192.168.0.10 as the virtual IP address of the group.

```
[SwitchA] interface vlan-interface 2
[SwitchA-Vlan-interface2] vrrp vrid 1 virtual-ip 192.168.0.10
```

Set the priority of Switch A to 110 in VRRP group 1.

```
[SwitchA-Vlan-interface2] vrrp vrid 1 priority 110
```

Associate VRRP group 1 with track entry 1 and decrease the router priority by 20 when the state of track entry 1 changes to Negative.

```
[SwitchA-Vlan-interface2] vrrp vrid 1 track 1 priority reduced 20
[SwitchA-Vlan-interface2] return
```

3. On Switch B, create VRRP group 1, and specify 192.168.0.10 as the virtual IP address of the group.

```
<SwitchB> system-view
[SwitchB] interface vlan-interface 2
[SwitchB-Vlan-interface2] vrrp vrid 1 virtual-ip 192.168.0.10
[SwitchB-Vlan-interface2] return
```

Verifying the configuration

Display detailed information about the VRRP group on Switch A.

```
<SwitchA> display vrrp verbose
IPv4 Virtual Router Information:
 Running Mode      : Standard
 Total number of virtual routers : 1
   Interface Vlan-interface2
     VRID             : 1               Adver Timer  : 100
     Admin Status     : Up              State        : Master
     Config Pri       : 110             Running Pri  : 110
     Preempt Mode     : Yes             Delay Time   : 0
     Auth Type        : None
     Virtual IP       : 192.168.0.10
     Virtual MAC      : 0000-5e00-0101
     Master IP        : 192.168.0.101
   VRRP Track Information:
     Track Object   : 1              State : Positive          Pri Reduced : 20
```

Display information about track entry 1 on Switch A.

```
<SwitchA> display track 1
Track ID: 1
  State: Positive
  Duration: 0 days 0 hours 0 minutes 32 seconds
  Tracked object type: BFD echo
  Notification delay: Positive 0, Negative 0 (in seconds)
  Tracked object:
    BFD session mode: Echo
    Outgoing interface: Vlan-interface2
    VPN instance name: --
```

```
    Remote IP: 1.1.1.2
    Local IP: 1.1.1.1
```

Display detailed information about the VRRP group on Switch B.

```
<SwitchB> display vrrp verbose
IPv4 Virtual Router Information:
 Running Mode      : Standard
 Total number of virtual routers : 1
   Interface Vlan-interface2
     VRID             : 1              Adver Timer  : 100
     Admin Status     : Up             State        : Backup
     Config Pri       : 100            Running Pri  : 100
     Preempt Mode     : Yes            Delay Time   : 0
     Become Master    : 2200ms left
     Auth Type        : None
     Virtual IP       : 192.168.0.10
     Master IP        : 192.168.0.101
```

The output shows that when the status of track entry 1 becomes Positive, Switch A is the master and Switch B is the backup.

Display information about track entry 1 when the uplink of Switch A goes down.

```
<SwitchA> display track 1
Track ID: 1
  State: Negative
  Duration: 0 days 0 hours 0 minutes 32 seconds
  Tracked object type: BFD echo
  Notification delay: Positive 0, Negative 0 (in seconds)
  Tracked object:
    BFD session mode: Echo
    Outgoing interface: Vlan-interface2
    VPN instance name: --
    Remote IP: 1.1.1.2
    Local IP: 1.1.1.1
```

Display detailed information about VRRP group 1 on Switch A.

```
<SwitchA> display vrrp verbose
IPv4 Virtual Router Information:
 Running Mode      : Standard
 Total number of virtual routers : 1
   Interface Vlan-interface2
     VRID             : 1              Adver Timer  : 100
     Admin Status     : Up             State        : Backup
     Config Pri       : 110            Running Pri  : 90
     Preempt Mode     : Yes            Delay Time   : 0
     Become Master    : 2200ms left
     Auth Type        : None
     Virtual IP       : 192.168.0.10
     Master IP        : 192.168.0.102
   VRRP Track Information:
     Track Object   : 1              State : Negative          Pri Reduced : 20
```

Display detailed information about VRRP group 1 on Switch B.

```
<SwitchB> display vrrp verbose
IPv4 Virtual Router Information:
 Running Mode      : Standard
 Total number of virtual routers : 1
   Interface Vlan-interface2
     VRID             : 1                Adver Timer   : 100
     Admin Status     : Up               State         : Master
     Config Pri       : 100              Running Pri   : 100
     Preempt Mode     : Yes              Delay Time    : 0
     Auth Type        : None
     Virtual IP       : 192.168.0.10
     Virtual MAC      : 0000-5e00-0101
     Master IP        : 192.168.0.102
```

The output shows that when Switch A detects that the uplink fails through the echo-mode BFD session, it decreases its priority by 20. Switch B then preempts as the master.

Example: Configuring a control-mode BFD session for the VRRP master to monitor the uplink

Network configuration

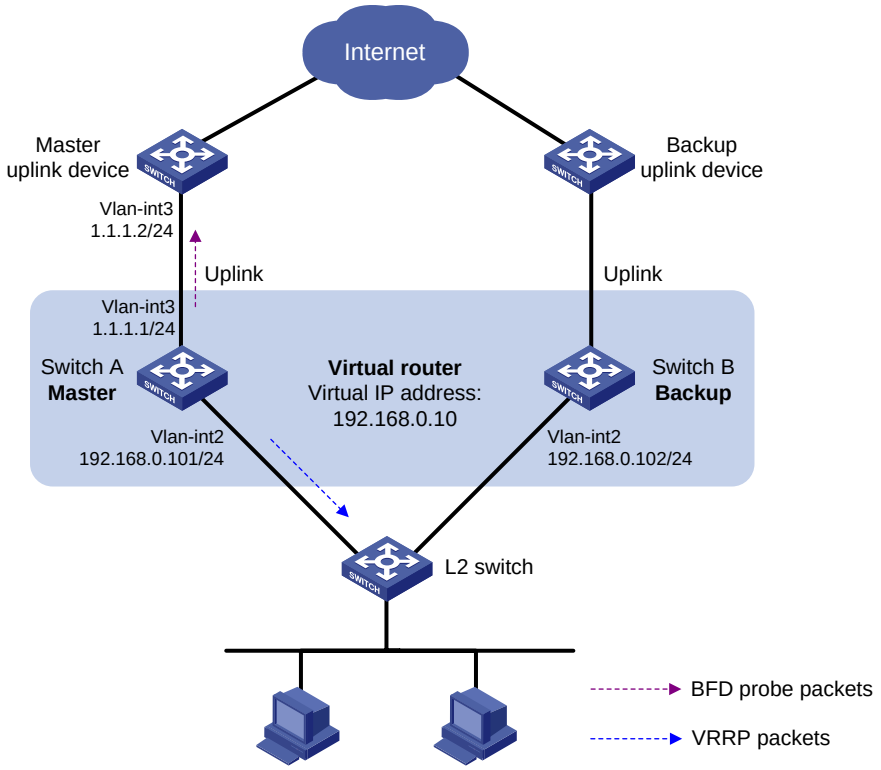
As shown in Figure 6:

- Switch A and Switch B belong to VRRP group 1. The virtual IP address of VRRP group 1 is 192.168.0.10.
- The default gateway of the hosts in the LAN is 192.168.0.10.

Configure VRRP-Track-BFD (control mode) collaboration to monitor the uplink on the master and meet the following requirements:

- When Switch A operates correctly, the hosts in the LAN access the Internet through Switch A.
- When Switch A detects that the uplink is down through the control-mode BFD session, Switch B can preempt as the master. The hosts in the LAN can access the Internet through Switch B.

Figure 6 Network diagram



Procedure

1. Create VLANs and assign ports to them. Configure the IP address of each VLAN interface, as shown in Figure 6. (Details not shown.)
2. Configure Switch A:

   # Create VRRP group 1, and specify 192.168.0.10 as the virtual IP address of the group.

   ```
   <SwitchA> system-view
   [SwitchA] interface vlan-interface 2
   [SwitchA-Vlan-interface2] vrrp vrid 1 virtual-ip 192.168.0.10
   ```

   # Set the priority of Switch A to 110 in VRRP group 1.

   ```
   [SwitchA-Vlan-interface2] vrrp vrid 1 priority 110
   ```

   # Associate VRRP group 1 with track entry 1 and decrease the router priority by 20 when the state of track entry 1 changes to Negative.

   ```
   [SwitchA-Vlan-interface2] vrrp vrid 1 track 1 priority reduced 20
   [SwitchA-Vlan-interface2] quit
   ```

   # Create track entry 1 for the control-mode BFD session to monitor the reachability of the uplink device (1.1.1.2).

   ```
   [SwitchA] track 1 bfd ctrl interface vlan-interface 3 remote ip 1.1.1.2 local ip
   1.1.1.1
   [SwitchA-track-1] quit
   ```
3. On the uplink device of Switch A, create track entry 1 and associate it with the control-mode BFD session to verify the reachability of the Switch A.

   ```
   <Master> system-view
   [Master] track 1 bfd ctrl interface vlan-interface 3 remote ip 1.1.1.1 local ip 1.1.1.2
   [Master-track-1] quit
   ```

4. On Switch B, create VRRP group 1, and specify 192.168.0.10 as the virtual IP address of the group.

```
<SwitchB> system-view
[SwitchB] interface vlan-interface 2
[SwitchB-Vlan-interface2] vrrp vrid 1 virtual-ip 192.168.0.10
[SwitchB-Vlan-interface2] return
```

Verifying the configuration

Display detailed information about the VRRP group on Switch A.

```
<SwitchA> display vrrp verbose
IPv4 Virtual Router Information:
 Running Mode      : Standard
 Total number of virtual routers : 1
   Interface Vlan-interface2
     VRID             : 1               Adver Timer  : 100
     Admin Status     : Up              State        : Master
     Config Pri       : 110             Running Pri  : 110
     Preempt Mode     : Yes             Delay Time   : 0
     Auth Type        : None
     Virtual IP       : 192.168.0.10
     Virtual MAC      : 0000-5e00-0101
     Master IP        : 192.168.0.101
   VRRP Track Information:
     Track Object   : 1             State : Positive          Pri Reduced : 20
```

Display information about track entry 1 on Switch A.

```
<SwitchA> display track 1
Track ID: 1
  State: Positive
  Duration: 0 days 0 hours 0 minutes 32 seconds
  Tracked object type: BFD ctrl
  Notification delay: Positive 0, Negative 0 (in seconds)
  Tracked object:
    BFD session mode: Ctrl
    Outgoing interface: Vlan-interface2
    VPN instance name: --
    Remote IP: 1.1.1.2
    Local IP: 1.1.1.1
```

Display detailed information about the VRRP group on Switch B.

```
<SwitchB> display vrrp verbose
IPv4 Virtual Router Information:
 Running Mode      : Standard
 Total number of virtual routers : 1
   Interface Vlan-interface2
     VRID             : 1               Adver Timer  : 100
     Admin Status     : Up              State        : Backup
     Config Pri       : 100             Running Pri  : 100
     Preempt Mode     : Yes             Delay Time   : 0
     Become Master    : 2200ms left
     Auth Type        : None
```

```
    Virtual IP       : 192.168.0.10
    Master IP        : 192.168.0.101
```

The output shows that when the status of track entry 1 becomes Positive, Switch A is the master and Switch B is the backup.

Display information about track entry 1 when the uplink of Switch A goes down.

```
<SwitchA> display track 1
Track ID: 1
  State: Negative
  Duration: 0 days 0 hours 0 minutes 32 seconds
  Tracked object type: BFD ctrl
  Notification delay: Positive 0, Negative 0 (in seconds)
  Tracked object:
    BFD session mode: Ctrl
    Outgoing interface: Vlan-interface2
    VPN instance name: --
    Remote IP: 1.1.1.2
    Local IP: 1.1.1.1
```

Display detailed information about VRRP group 1 on Switch A.

```
<SwitchA> display vrrp verbose
IPv4 Virtual Router Information:
 Running Mode      : Standard
 Total number of virtual routers : 1
   Interface Vlan-interface2
     VRID             : 1              Adver Timer  : 100
     Admin Status     : Up             State        : Backup
     Config Pri       : 110            Running Pri  : 90
     Preempt Mode     : Yes            Delay Time   : 0
     Become Master    : 2200ms left
     Auth Type        : None
     Virtual IP       : 192.168.0.10
     Master IP        : 192.168.0.102
   VRRP Track Information:
     Track Object   : 1              State : Negative          Pri Reduced : 20
```

Display detailed information about VRRP group 1 on Switch B.

```
<SwitchB> display vrrp verbose
IPv4 Virtual Router Information:
 Running Mode      : Standard
 Total number of virtual routers : 1
   Interface Vlan-interface2
     VRID             : 1              Adver Timer  : 100
     Admin Status     : Up             State        : Master
     Config Pri       : 100            Running Pri  : 100
     Preempt Mode     : Yes            Delay Time   : 0
     Auth Type        : None
     Virtual IP       : 192.168.0.10
     Virtual MAC      : 0000-5e00-0101
     Master IP        : 192.168.0.102
```

The output shows that when Switch A detects that the uplink fails through the control-mode BFD session, it decreases its priority by 20. Switch B then preempts as the master.

Example: Configuring static routing-Track-NQA collaboration

Network configuration

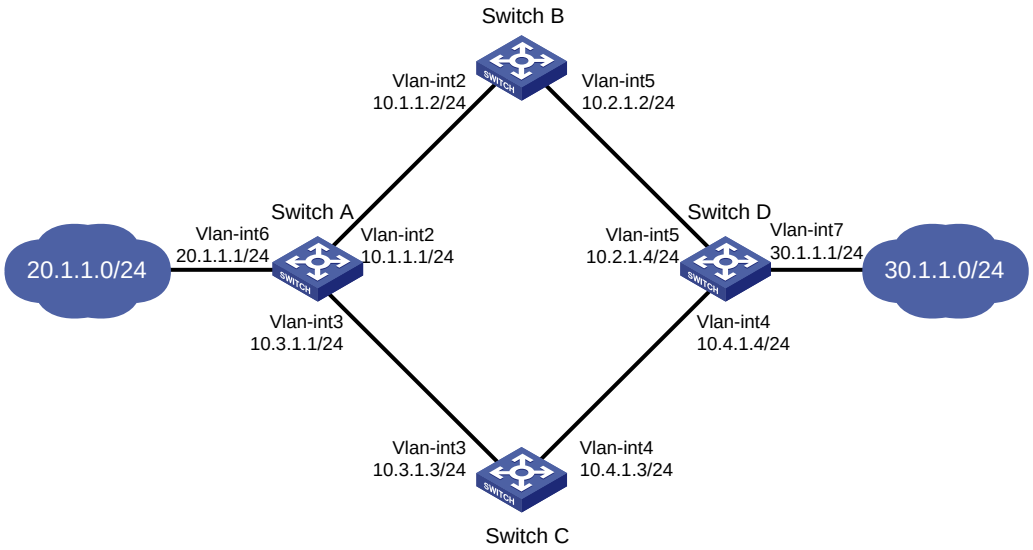
As shown in Figure 7:

- Switch A is the default gateway of the hosts in network 20.1.1.0/24.
- Switch D is the default gateway of the hosts in network 30.1.1.0/24.
- Hosts in the two networks communicate with each other through static routes.

To ensure network availability, configure route backup and static routing-Track-NQA collaboration on Switch A and Switch D as follows:

- On Switch A, assign a higher priority to the static route to 30.1.1.0/24 with next hop Switch B. This route is the master route. The static route to 30.1.1.0/24 with next hop Switch C acts as the backup route. When the master route is unavailable, the backup route takes effect. Switch A forwards packets to 30.1.1.0/24 through Switch C.
- On Switch D, assign a higher priority to the static route to 20.1.1.0/24 with next hop Switch B. This route is the master route. The static route to 20.1.1.0/24 with next hop Switch C acts as the backup route. When the master route is unavailable, the backup route takes effect. Switch D forwards packets to 20.1.1.0/24 through Switch C.

Figure 7 Network diagram



Procedure

1. Create VLANs and assign ports to them. Configure the IP address of each VLAN interface, as shown in Figure 7. (Details not shown.)
2. Configure Switch A:

   # Configure a static route to 30.1.1.0/24 with next hop 10.1.1.2 and the default priority (60). Associate this static route with track entry 1.

   ```
   <SwitchA> system-view
   [SwitchA] ip route-static 30.1.1.0 24 10.1.1.2 track 1
   ```

   # Configure a static route to 30.1.1.0/24 with next hop 10.3.1.3 and priority 80.

   ```
   [SwitchA] ip route-static 30.1.1.0 24 10.3.1.3 preference 80
   ```

Configure a static route to 10.2.1.4 with next hop 10.1.1.2.

```
[SwitchA] ip route-static 10.2.1.4 24 10.1.1.2
```

Create an NQA operation with administrator name **admin** and operation tag **test**.

```
[SwitchA] nqa entry admin test
```

Specify the **ICMP echo** operation type.

```
[SwitchA-nqa-admin-test] type icmp-echo
```

Specify 10.2.1.4 as the destination address of the operation.

```
[SwitchA-nqa-admin-test-icmp-echo] destination ip 10.2.1.4
```

Specify 10.1.1.2 as the next hop of the operation.

```
[SwitchA-nqa-admin-test-icmp-echo] next-hop ip 10.1.1.2
```

Configure the ICMP echo operation to repeat every 100 milliseconds.

```
[SwitchA-nqa-admin-test-icmp-echo] frequency 100
```

Configure reaction entry 1, specifying that five consecutive probe failures trigger the Track module.

```
[SwitchA-nqa-admin-test-icmp-echo] reaction 1 checked-element probe-fail
threshold-type consecutive 5 action-type trigger-only
[SwitchA-nqa-admin-test-icmp-echo] quit
```

Start the NQA operation.

```
[SwitchA] nqa schedule admin test start-time now lifetime forever
```

Configure track entry 1, and associate it with reaction entry 1 of the NQA operation.

```
[SwitchA] track 1 nqa entry admin test reaction 1
[SwitchA-track-1] quit
```

3. Configure Switch B:

Configure a static route to 30.1.1.0/24 with next hop 10.2.1.4.

```
<SwitchB> system-view
[SwitchB] ip route-static 30.1.1.0 24 10.2.1.4
```

Configure a static route to 20.1.1.0/24 with next hop 10.1.1.1.

```
[SwitchB] ip route-static 20.1.1.0 24 10.1.1.1
```

4. Configure Switch C:

Configure a static route to 30.1.1.0/24 with next hop 10.4.1.4.

```
<SwitchC> system-view
[SwitchC] ip route-static 30.1.1.0 24 10.4.1.4
```

Configure a static route to 20.1.1.0/24 with next hop 10.3.1.1.

```
[SwitchC] ip route-static 20.1.1.0 24 10.3.1.1
```

5. Configure Switch D:

Configure a static route to 20.1.1.0/24 with next hop 10.2.1.2 and the default priority (60). Associate this static route with track entry 1.

```
<SwitchD> system-view
[SwitchD] ip route-static 20.1.1.0 24 10.2.1.2 track 1
```

Configure a static route to 20.1.1.0/24 with next hop 10.4.1.3 and priority 80.

```
[SwitchD] ip route-static 20.1.1.0 24 10.4.1.3 preference 80
```

Configure a static route to 10.1.1.1 with next hop 10.2.1.2.

```
[SwitchD] ip route-static 10.1.1.1 24 10.2.1.2
```

Create an NQA operation with administrator name **admin** and operation tag **test**.

```
[SwitchD] nqa entry admin test
```

Specify the **ICMP echo** operation type.

```
[SwitchD-nqa-admin-test] type icmp-echo
```

Specify 10.1.1.1 as the destination address of the operation.

```
[SwitchD-nqa-admin-test-icmp-echo] destination ip 10.1.1.1
```

Specify 10.2.1.2 as the next hop of the operation.

```
[SwitchD-nqa-admin-test-icmp-echo] next-hop ip 10.2.1.2
```

Configure the ICMP echo operation to repeat every 100 milliseconds.

```
[SwitchD-nqa-admin-test-icmp-echo] frequency 100
```

Configure reaction entry 1, specifying that five consecutive probe failures trigger the Track module.

```
[SwitchD-nqa-admin-test-icmp-echo] reaction 1 checked-element probe-fail
threshold-type consecutive 5 action-type trigger-only
[SwitchD-nqa-admin-test-icmp-echo] quit
```

Start the NQA operation.

```
[SwitchD] nqa schedule admin test start-time now lifetime forever
```

Configure track entry 1, and associate it with reaction entry 1 of the NQA operation.

```
[SwitchD] track 1 nqa entry admin test reaction 1
[SwitchD-track-1] quit
```

Verifying the configuration

Display information about the track entry on Switch A.

```
[SwitchA] display track all
Track ID: 1
  State: Positive
  Duration: 0 days 0 hours 0 minutes 32 seconds
  Tracked object type: NQA
  Notification delay: Positive 0, Negative 0 (in seconds)
  Tracked object:
    NQA entry: admin test
    Reaction: 1
    Remote IP/URL:--
    Local IP:--
    Interface:--
```

The output shows that the status of the track entry is Positive, indicating that the NQA operation has succeeded and the master route is available.

Display the routing table of Switch A.

```
[SwitchA] display ip routing-table

Destinations : 10       Routes : 10

Destination/Mask    Proto  Pre  Cost         NextHop         Interface
10.1.1.0/24         Direct 0    0            10.1.1.1        Vlan2
10.1.1.1/32         Direct 0    0            127.0.0.1       InLoop0
10.2.1.0/24         Static 60   0            10.1.1.2        Vlan2
10.3.1.0/24         Direct 0    0            10.3.1.1        Vlan3
10.3.1.1/32         Direct 0    0            127.0.0.1       InLoop0
20.1.1.0/24         Direct 0    0            20.1.1.1        Vlan6
20.1.1.1/32         Direct 0    0            127.0.0.1       InLoop0
30.1.1.0/24         Static 60   0            10.1.1.2        Vlan2
127.0.0.0/8         Direct 0    0            127.0.0.1       InLoop0
```

```
127.0.0.1/32        Direct 0    0           127.0.0.1       InLoop0
```

The output shows that Switch A forwards packets to 30.1.1.0/24 through Switch B.

Remove the IP address of interface VLAN-interface 2 on Switch B.

```
<SwitchB> system-view
[SwitchB] interface vlan-interface 2
[SwitchB-Vlan-interface2] undo ip address
```

Display information about the track entry on Switch A.

```
[SwitchA] display track all
Track ID: 1
  State: Negative
  Duration: 0 days 0 hours 0 minutes 32 seconds
  Tracked object type: NQA
  Notification delay: Positive 0, Negative 0 (in seconds)
  Tracked object:
    NQA entry: admin test
    Reaction: 1
    Remote IP/URL:--
    Local IP:--
    Interface:--
```

The output shows that the status of the track entry is Negative, indicating that the NQA operation has failed and the master route is unavailable.

Display the routing table of Switch A.

```
[SwitchA] display ip routing-table

Destinations : 10       Routes : 10

Destination/Mask    Proto  Pre  Cost         NextHop         Interface
10.1.1.0/24         Direct 0    0            10.1.1.1        Vlan2
10.1.1.1/32         Direct 0    0            127.0.0.1       InLoop0
10.2.1.0/24         Static 60   0            10.1.1.2        Vlan2
10.3.1.0/24         Direct 0    0            10.3.1.1        Vlan3
10.3.1.1/32         Direct 0    0            127.0.0.1       InLoop0
20.1.1.0/24         Direct 0    0            20.1.1.1        Vlan6
20.1.1.1/32         Direct 0    0            127.0.0.1       InLoop0
30.1.1.0/24         Static 80   0            10.3.1.3        Vlan3
127.0.0.0/8         Direct 0    0            127.0.0.1       InLoop0
127.0.0.1/32        Direct 0    0            127.0.0.1       InLoop0
```

The output shows that Switch A forwards packets to 30.1.1.0/24 through Switch C. The backup static route has taken effect.

Verify that hosts in 20.1.1.0/24 can communicate with the hosts in 30.1.1.0/24 when the master route fails.

```
[SwitchA] ping -a 20.1.1.1 30.1.1.1
Ping 30.1.1.1: 56  data bytes, press CTRL_C to break
Reply from 30.1.1.1: bytes=56 Sequence=1 ttl=254 time=2 ms
Reply from 30.1.1.1: bytes=56 Sequence=2 ttl=254 time=1 ms
Reply from 30.1.1.1: bytes=56 Sequence=3 ttl=254 time=1 ms
Reply from 30.1.1.1: bytes=56 Sequence=4 ttl=254 time=2 ms
```

```
Reply from 30.1.1.1: bytes=56 Sequence=5 ttl=254 time=1 ms

--- Ping statistics for 30.1.1.1 ---
5 packet(s) transmitted, 5 packet(s) received, 0.00% packet loss
round-trip min/avg/max/std-dev = 1/1/2/1 ms
```

Verify that the hosts in 30.1.1.0/24 can communicate with the hosts in 20.1.1.0/24 when the master route fails.

```
[SwitchB] ping -a 30.1.1.1 20.1.1.1
Ping 20.1.1.1: 56  data bytes, press CTRL_C to break
Reply from 20.1.1.1: bytes=56 Sequence=1 ttl=254 time=2 ms
Reply from 20.1.1.1: bytes=56 Sequence=2 ttl=254 time=1 ms
Reply from 20.1.1.1: bytes=56 Sequence=3 ttl=254 time=1 ms
Reply from 20.1.1.1: bytes=56 Sequence=4 ttl=254 time=1 ms
Reply from 20.1.1.1: bytes=56 Sequence=5 ttl=254 time=1 ms

--- Ping statistics for 20.1.1.1 ---
5 packet(s) transmitted, 5 packet(s) received, 0.00% packet loss
round-trip min/avg/max/std-dev = 1/1/2/1 ms
```

Example: Configuring static routing-Track-BFD (echo mode) collaboration

Network configuration

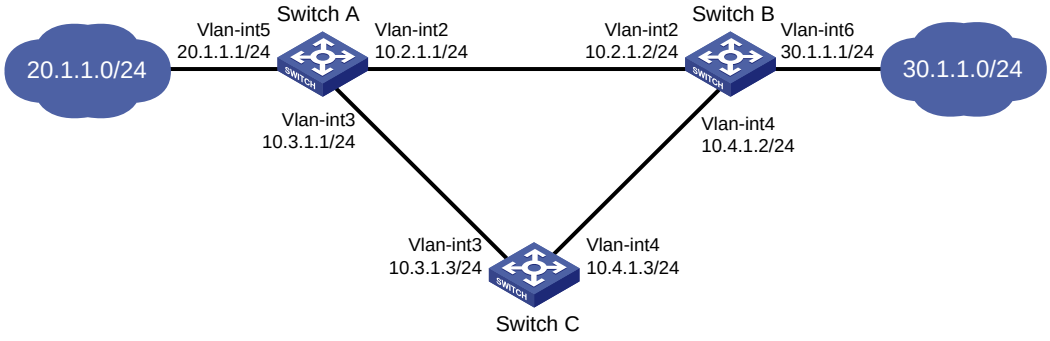
As shown in Figure 8:

- Switch A is the default gateway of the hosts in network 20.1.1.0/24.
- Switch B is the default gateway of the hosts in network 30.1.1.0/24.
- Hosts in the two networks communicate with each other through static routes.

To ensure network availability, configure route backup and static routing-Track-BFD (echo mode) collaboration on Switch A and Switch B as follows:

- On Switch A, assign a higher priority to the static route to 30.1.1.0/24 with next hop Switch B. This route is the master route. The static route to 30.1.1.0/24 with next hop Switch C acts as the backup route. When the master route is unavailable, the echo-mode BFD session can quickly detect the route failure to make the backup route take effect.
- On Switch B, assign a higher priority to the static route to 20.1.1.0/24 with next hop Switch A. This route is the master route. The static route to 20.1.1.0/24 with next hop Switch C acts as the backup route. When the master route is unavailable, the echo-mode BFD session can quickly detect the route failure to make the backup route take effect.

Figure 8 Network diagram



Procedure

1. Create VLANs and assign ports to them. Configure the IP address of each VLAN interface, as shown in Figure 8. (Details not shown.)
2. Configure Switch A:

   # Configure a static route to 30.1.1.0/24 with next hop 10.2.1.2 and the default priority (60). Associate this static route with track entry 1.

   ```
   <SwitchA> system-view
   [SwitchA] ip route-static 30.1.1.0 24 10.2.1.2 track 1
   ```

   # Configure a static route to 30.1.1.0/24 with next hop 10.3.1.3 and priority 80.

   ```
   [SwitchA] ip route-static 30.1.1.0 24 10.3.1.3 preference 80
   ```

   # Specify 10.10.10.10 as the source address of BFD echo packets.

   ```
   [SwitchA] bfd echo-source-ip 10.10.10.10
   ```

   # Configure track entry 1, and associate it with the echo-mode BFD session to verify the connectivity between Switch A and Switch B.

   ```
   [SwitchA] track 1 bfd echo interface vlan-interface 2 remote ip 10.2.1.2 local ip
   10.2.1.1
   [SwitchA-track-1] quit
   ```

3. Configure Switch B:

   # Configure a static route to 20.1.1.0/24 with next hop 10.2.1.1 and the default priority (60). Associate this static route with track entry 1.

   ```
   <SwitchB> system-view
   [SwitchB] ip route-static 20.1.1.0 24 10.2.1.1 track 1
   ```

   # Configure a static route to 20.1.1.0/24 with next hop 10.4.1.3 and priority 80.

   ```
   [SwitchB] ip route-static 20.1.1.0 24 10.4.1.3 preference 80
   ```

   # Specify 1.1.1.1 as the source address of BFD echo packets.

   ```
   [SwitchB] bfd echo-source-ip 1.1.1.1
   ```

   # Configure track entry 1, and associate it with the echo-mode BFD session to verify the connectivity between Switch B and Switch A.

   ```
   [SwitchB] track 1 bfd echo interface vlan-interface 2 remote ip 10.2.1.1 local ip
   10.2.1.2
   [SwitchB-track-1] quit
   ```

4. Configure Switch C:

   # Configure a static route to 30.1.1.0/24 with next hop 10.4.1.2.

   ```
   <SwitchC> system-view
   [SwitchC] ip route-static 30.1.1.0 24 10.4.1.2
   ```

   # Configure a static route to 20.1.1.0/24 with next hop 10.3.1.1.

```
[SwitchC] ip route-static 20.1.1.0 24 10.3.1.1
```

Verifying the configuration

Display information about the track entry on Switch A.

```
[SwitchA] display track all
Track ID: 1
  State: Positive
  Duration: 0 days 0 hours 0 minutes 32 seconds
  Tracked object type: BFD echo
  Notification delay: Positive 0, Negative 0 (in seconds)
  Tracked object:
    BFD session mode: Echo
    Outgoing interface: Vlan-interface2
    VPN instance name: --
    Remote IP: 10.2.1.2
    Local IP: 10.2.1.1
```

The output shows that the status of the track entry is Positive, indicating that next hop 10.2.1.2 is reachable.

Display the routing table of Switch A.

```
[SwitchA] display ip routing-table

Destinations : 9        Routes : 9

Destination/Mask    Proto  Pre  Cost         NextHop         Interface
10.2.1.0/24         Direct 0    0            10.2.1.1        Vlan2
10.2.1.1/32         Direct 0    0            127.0.0.1       InLoop0
10.3.1.0/24         Direct 0    0            10.3.1.1        Vlan3
10.3.1.1/32         Direct 0    0            127.0.0.1       InLoop0
20.1.1.0/24         Direct 0    0            20.1.1.1        Vlan5
20.1.1.1/32         Direct 0    0            127.0.0.1       InLoop0
30.1.1.0/24         Static 60   0            10.2.1.2        Vlan2
127.0.0.0/8         Direct 0    0            127.0.0.1       InLoop0
127.0.0.1/32        Direct 0    0            127.0.0.1       InLoop0
```

The output shows that Switch A forwards packets to 30.1.1.0/24 through Switch B. The master static route has taken effect.

Remove the IP address of VLAN-interface 2 on Switch B.

```
<SwitchB> system-view
[SwitchB] interface vlan-interface 2
[SwitchB-Vlan-interface2] undo ip address
```

Display information about the track entry on Switch A.

```
[SwitchA] display track all
Track ID: 1
  State: Negative
  Duration: 0 days 0 hours 0 minutes 32 seconds
  Tracked object type: BFD echo
  Notification delay: Positive 0, Negative 0 (in seconds)
  Tracked object:
    BFD session mode: Echo
```

```
    Outgoing interface: Vlan-interface2
    VPN instance name: --
    Remote IP: 10.2.1.2
    Local IP: 10.2.1.1
```

The output shows that the status of the track entry is Negative, indicating that next hop 10.2.1.2 is unreachable.

Display the routing table of Switch A.

```
[SwitchA] display ip routing-table

Destinations : 9        Routes : 9

Destination/Mask    Proto  Pre  Cost         NextHop         Interface
10.2.1.0/24         Direct 0    0            10.2.1.1        Vlan2
10.2.1.1/32         Direct 0    0            127.0.0.1       InLoop0
10.3.1.0/24         Direct 0    0            10.3.1.1        Vlan3
10.3.1.1/32         Direct 0    0            127.0.0.1       InLoop0
20.1.1.0/24         Direct 0    0            20.1.1.1        Vlan5
20.1.1.1/32         Direct 0    0            127.0.0.1       InLoop0
30.1.1.0/24         Static 80   0            10.3.1.3        Vlan3
127.0.0.0/8         Direct 0    0            127.0.0.1       InLoop0
127.0.0.1/32        Direct 0    0            127.0.0.1       InLoop0
```

The output shows that Switch A forwards packets to 30.1.1.0/24 through Switch C. The backup static route has taken effect.

Verify that the hosts in 20.1.1.0/24 can communicate with the hosts in 30.1.1.0/24 when the master route fails.

```
[SwitchA] ping -a 20.1.1.1 30.1.1.1
Ping 30.1.1.1: 56  data bytes, press CTRL_C to break
Reply from 30.1.1.1: bytes=56 Sequence=1 ttl=254 time=2 ms
Reply from 30.1.1.1: bytes=56 Sequence=2 ttl=254 time=1 ms
Reply from 30.1.1.1: bytes=56 Sequence=3 ttl=254 time=1 ms
Reply from 30.1.1.1: bytes=56 Sequence=4 ttl=254 time=2 ms
Reply from 30.1.1.1: bytes=56 Sequence=5 ttl=254 time=1 ms

--- Ping statistics for 30.1.1.1 ---
5 packet(s) transmitted, 5 packet(s) received, 0.00% packet loss
round-trip min/avg/max/std-dev = 1/1/2/1 ms
```

Verify that the hosts in 30.1.1.0/24 can still communicate with the hosts in 20.1.1.0/24 when the master route fails.

```
[SwitchB] ping -a 30.1.1.1 20.1.1.1
Ping 20.1.1.1: 56  data bytes, press CTRL_C to break
Reply from 20.1.1.1: bytes=56 Sequence=1 ttl=254 time=2 ms
Reply from 20.1.1.1: bytes=56 Sequence=2 ttl=254 time=1 ms
Reply from 20.1.1.1: bytes=56 Sequence=3 ttl=254 time=1 ms
Reply from 20.1.1.1: bytes=56 Sequence=4 ttl=254 time=1 ms
Reply from 20.1.1.1: bytes=56 Sequence=5 ttl=254 time=1 ms

--- Ping statistics for 20.1.1.1 ---
5 packet(s) transmitted, 5 packet(s) received, 0.00% packet loss
```

```
round-trip min/avg/max/std-dev = 1/1/2/1 ms
```

Example: Configuring static routing-Track-BFD (control mode) collaboration

Network configuration

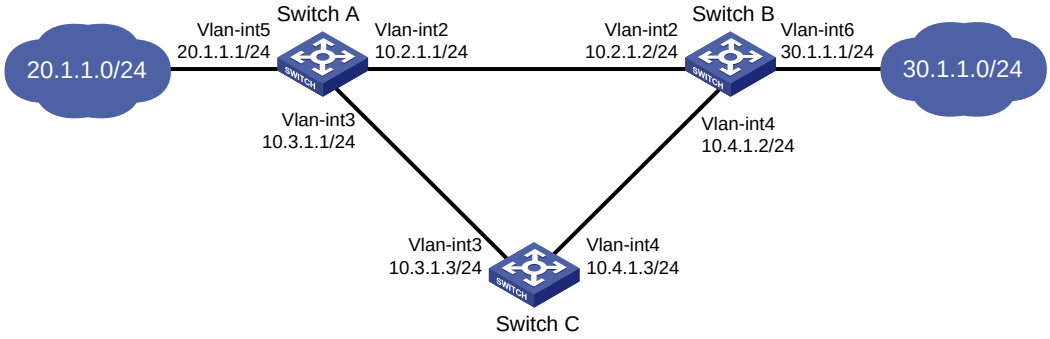
As shown in Figure 9:

- Switch A is the default gateway of the hosts in network 20.1.1.0/24.
- Switch B is the default gateway of the hosts in network 30.1.1.0/24.
- Hosts in the two networks communicate with each other through static routes.

To ensure network availability, configure route backup and static routing-Track-BFD (control mode) collaboration on Switch A and Switch B as follows:

- On Switch A, assign a higher priority to the static route to 30.1.1.0/24 with next hop Switch B. This route is the master route. The static route to 30.1.1.0/24 with next hop Switch C acts as the backup route. When the master route is unavailable, the control-mode BFD session can quickly detect the route failure to make the backup route take effect.
- On Switch B, assign a higher priority to the static route to 20.1.1.0/24 with next hop Switch A. This route is the master route. The static route to 20.1.1.0/24 with next hop Switch C acts as the backup route. When the master route is unavailable, the control-mode BFD session can quickly detect the route failure to make the backup route take effect.

Figure 9 Network diagram



Procedure

1. Create VLANs and assign ports to them. Configure the IP address of each VLAN interface, as shown in Figure 9. (Details not shown.)
2. Configure Switch A:

   # Configure a static route to 30.1.1.0/24 with next hop 10.2.1.2 and the default priority (60). Associate this static route with track entry 1.

   ```
   <SwitchA> system-view
   [SwitchA] ip route-static 30.1.1.0 24 10.2.1.2 track 1
   ```

   # Configure a static route to 30.1.1.0/24 with next hop 10.3.1.3 and priority 80.

   ```
   [SwitchA] ip route-static 30.1.1.0 24 10.3.1.3 preference 80
   ```

   # Configure track entry 1, and associate it with the control-mode BFD session to verify the connectivity between Switch A and Switch B.

   ```
   [SwitchA] track 1 bfd ctrl interface vlan-interface 2 remote ip 10.2.1.2 local ip
   10.2.1.1
   [SwitchA-track-1] quit
   ```
3. Configure Switch B:

Configure a static route to 20.1.1.0/24 with next hop 10.2.1.1 and the default priority (60). Associate this static route with track entry 1.

```
<SwitchB> system-view
[SwitchB] ip route-static 20.1.1.0 24 10.2.1.1 track 1
```

Configure a static route to 20.1.1.0/24 with next hop 10.4.1.3 and priority 80.

```
[SwitchB] ip route-static 20.1.1.0 24 10.4.1.3 preference 80
```

Configure track entry 1, and associate it with the control-mode BFD session to verify the connectivity between Switch B and Switch A.

```
[SwitchB] track 1 bfd ctrl interface vlan-interface 2 remote ip 10.2.1.1 local ip
10.2.1.2
[SwitchB-track-1] quit
```

4. Configure Switch C:

Configure a static route to 30.1.1.0/24 with next hop 10.4.1.2.

```
<SwitchC> system-view
[SwitchC] ip route-static 30.1.1.0 24 10.4.1.2
```

Configure a static route to 20.1.1.0/24 with next hop 10.3.1.1.

```
[SwitchC] ip route-static 20.1.1.0 24 10.3.1.1
```

Verifying the configuration

Display information about the track entry on Switch A.

```
[SwitchA] display track all
Track ID: 1
  State: Positive
  Duration: 0 days 0 hours 0 minutes 32 seconds
  Tracked object type: BFD ctrl
  Notification delay: Positive 0, Negative 0 (in seconds)
  Tracked object:
    BFD session mode: Echo
    Outgoing interface: Vlan-interface2
    VPN instance name: --
    Remote IP: 10.2.1.2
    Local IP: 10.2.1.1
```

The output shows that the status of the track entry is Positive, indicating that next hop 10.2.1.2 is reachable.

Display the routing table of Switch A.

```
[SwitchA] display ip routing-table

Destinations : 9        Routes : 9

Destination/Mask    Proto  Pre  Cost         NextHop         Interface
10.2.1.0/24         Direct 0    0            10.2.1.1        Vlan2
10.2.1.1/32         Direct 0    0            127.0.0.1       InLoop0
10.3.1.0/24         Direct 0    0            10.3.1.1        Vlan3
10.3.1.1/32         Direct 0    0            127.0.0.1       InLoop0
20.1.1.0/24         Direct 0    0            20.1.1.1        Vlan5
20.1.1.1/32         Direct 0    0            127.0.0.1       InLoop0
30.1.1.0/24         Static 60   0            10.2.1.2        Vlan2
127.0.0.0/8         Direct 0    0            127.0.0.1       InLoop0
127.0.0.1/32        Direct 0    0            127.0.0.1       InLoop0
```

The output shows that Switch A forwards packets to 30.1.1.0/24 through Switch B. The master static route has taken effect.

Remove the IP address of VLAN-interface 2 on Switch B.

```
<SwitchB> system-view
[SwitchB] interface vlan-interface 2
[SwitchB-Vlan-interface2] undo ip address
```

Display information about the track entry on Switch A.

```
[SwitchA] display track all
Track ID: 1
  State: Negative
  Duration: 0 days 0 hours 0 minutes 32 seconds
  Tracked object type: BFD ctrl
  Notification delay: Positive 0, Negative 0 (in seconds)
  Tracked object:
    BFD session mode: Echo
    Outgoing interface: Vlan-interface2
    VPN instance name: --
    Remote IP: 10.2.1.2
    Local IP: 10.2.1.1
```

The output shows that the status of the track entry is Negative, indicating that next hop 10.2.1.2 is unreachable.

Display the routing table of Switch A.

```
[SwitchA] display ip routing-table

Destinations : 9        Routes : 9

Destination/Mask    Proto  Pre  Cost         NextHop         Interface
10.2.1.0/24         Direct 0    0            10.2.1.1        Vlan2
10.2.1.1/32         Direct 0    0            127.0.0.1       InLoop0
10.3.1.0/24         Direct 0    0            10.3.1.1        Vlan3
10.3.1.1/32         Direct 0    0            127.0.0.1       InLoop0
20.1.1.0/24         Direct 0    0            20.1.1.1        Vlan5
20.1.1.1/32         Direct 0    0            127.0.0.1       InLoop0
30.1.1.0/24         Static 80   0            10.3.1.3        Vlan3
127.0.0.0/8         Direct 0    0            127.0.0.1       InLoop0
127.0.0.1/32        Direct 0    0            127.0.0.1       InLoop0
```

The output shows that Switch A forwards packets to 30.1.1.0/24 through Switch C. The backup static route has taken effect.

Verify that the hosts in 20.1.1.0/24 can communicate with the hosts in 30.1.1.0/24 when the master route fails.

```
[SwitchA] ping -a 20.1.1.1 30.1.1.1
Ping 30.1.1.1: 56  data bytes, press CTRL_C to break
Reply from 30.1.1.1: bytes=56 Sequence=1 ttl=254 time=2 ms
Reply from 30.1.1.1: bytes=56 Sequence=2 ttl=254 time=1 ms
Reply from 30.1.1.1: bytes=56 Sequence=3 ttl=254 time=1 ms
Reply from 30.1.1.1: bytes=56 Sequence=4 ttl=254 time=2 ms
Reply from 30.1.1.1: bytes=56 Sequence=5 ttl=254 time=1 ms
```

```
--- Ping statistics for 30.1.1.1 ---
5 packet(s) transmitted, 5 packet(s) received, 0.00% packet loss
round-trip min/avg/max/std-dev = 1/1/2/1 ms
```

Verify that the hosts in 30.1.1.0/24 can still communicate with the hosts in 20.1.1.0/24 when the master route fails.

```
[SwitchB] ping -a 30.1.1.1 20.1.1.1
Ping 20.1.1.1: 56  data bytes, press CTRL_C to break
Reply from 20.1.1.1: bytes=56 Sequence=1 ttl=254 time=2 ms
Reply from 20.1.1.1: bytes=56 Sequence=2 ttl=254 time=1 ms
Reply from 20.1.1.1: bytes=56 Sequence=3 ttl=254 time=1 ms
Reply from 20.1.1.1: bytes=56 Sequence=4 ttl=254 time=1 ms
Reply from 20.1.1.1: bytes=56 Sequence=5 ttl=254 time=1 ms

--- Ping statistics for 20.1.1.1 ---
5 packet(s) transmitted, 5 packet(s) received, 0.00% packet loss
round-trip min/avg/max/std-dev = 1/1/2/1 ms
```

Example: Configuring VRRP-Track-interface management collaboration

Network configuration

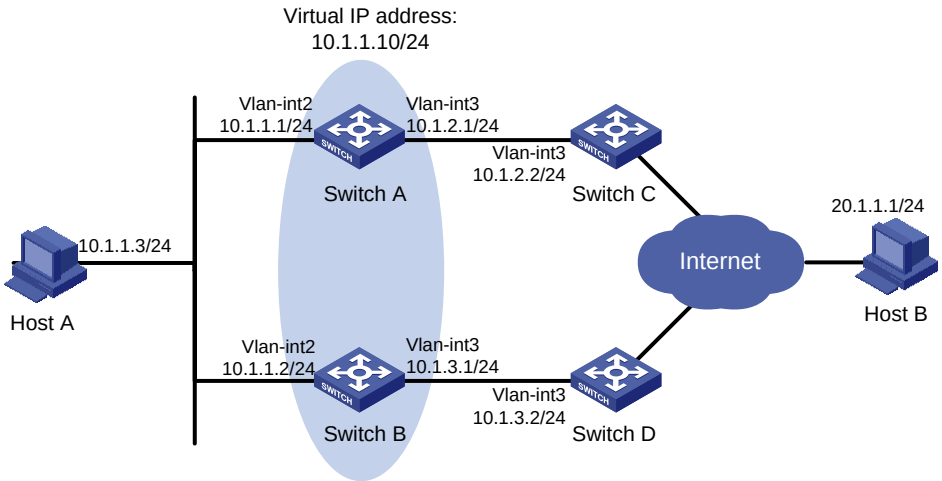
As shown in Figure 10:

- Host A requires access to Host B. The default gateway of Host A is 10.1.1.10/24.
- Switch A and Switch B belong to VRRP group 1. The virtual IP address of VRRP group 1 is 10.1.1.10.

Configure VRRP-Track-interface management collaboration to monitor the uplink interface on the master and meet the following requirements:

- When Switch A operates correctly, Switch A forwards packets from Host A to Host B.
- When VRRP detects a fault on the uplink interface of Switch A through the interface management module, Switch B forwards packets from Host A to Host B.

Figure 10 Network diagram



Procedure

1. Create VLANs and assign ports to them. Configure the IP address of each VLAN interface, as shown in Figure 10. (Details not shown.)
2. Configure Switch A:

   # Configure track entry 1 and associate it with the link status of the uplink interface VLAN-interface 3.

   ```
   [SwitchA] track 1 interface vlan-interface 3
   [SwitchA-track-1] quit
   ```

   # Create VRRP group 1 and configure virtual IP address 10.1.1.10 for the group.

   ```
   [SwitchA] interface vlan-interface 2
   [SwitchA-Vlan-interface2] vrrp vrid 1 virtual-ip 10.1.1.10
   ```

   # Set the priority of Switch A to 110 in VRRP group 1.

   ```
   [SwitchA-Vlan-interface2] vrrp vrid 1 priority 110
   ```

   # Associate VRRP group 1 with track entry 1 and decrease the router priority by 30 when the state of track entry 1 changes to Negative.

   ```
   [SwitchA-Vlan-interface2] vrrp vrid 1 track 1 priority reduced 30
   ```

3. On Switch B, create VRRP group 1, and configure virtual IP address 10.1.1.10 for the group.

   ```
   <SwitchB> system-view
   [SwitchB] interface vlan-interface 2
   [SwitchB-Vlan-interface2] vrrp vrid 1 virtual-ip 10.1.1.10
   ```

Verifying the configuration

Ping Host B from Host A to verify that Host B is reachable. (Details not shown.)

Display detailed information about VRRP group 1 on Switch A.

```
[SwitchA-Vlan-interface2] display vrrp verbose
IPv4 Virtual Router Information:
 Running Mode      : Standard
 Total number of virtual routers : 1
   Interface Vlan-interface2
     VRID             : 1              Adver Timer  : 100
     Admin Status     : Up             State        : Master
     Config Pri       : 110            Running Pri  : 110
     Preempt Mode     : Yes            Delay Time   : 0
     Auth Type        : None
     Virtual IP       : 10.1.1.10
     Virtual MAC      : 0000-5e00-0101
     Master IP        : 10.1.1.1
   VRRP Track Information:
     Track Object   : 1              State : Positive          Pri Reduced : 30
```

Display detailed information about VRRP group 1 on Switch B.

```
[SwitchB-Vlan-interface2] display vrrp verbose
IPv4 Virtual Router Information:
 Running Mode       : Standard
 Total number of virtual routers : 1
   Interface Vlan-interface2
     VRID             : 1              Adver Timer  : 100
     Admin Status     : Up             State        : Backup
     Config Pri       : 100            Running Pri  : 100
```

```
    Preempt Mode     : Yes             Delay Time   : 0
    Become Master    : 2200ms left
    Auth Type        : None
    Virtual IP       : 10.1.1.10
    Master IP        : 10.1.1.1
```

The output shows that in VRRP group 1, Switch A is the master, and Switch B is a backup. Switch A forwards packets from Host A to Host B.

Shut down the uplink interface VLAN-interface 3 on Switch A.

```
[SwitchA-Vlan-interface2] interface vlan-interface 3
[SwitchA-Vlan-interface3] shutdown
```

Ping Host B from Host A to verify that Host B is reachable. (Details not shown.)

Display detailed information about VRRP group 1 on Switch A.

```
[SwitchA-Vlan-interface3] display vrrp verbose
IPv4 Virtual Router Information:
 Running Mode      : Standard
 Total number of virtual routers : 1
   Interface Vlan-interface2
     VRID             : 1               Adver Timer  : 100
     Admin Status     : Up              State        : Backup
     Config Pri       : 110             Running Pri  : 80
     Preempt Mode     : Yes             Delay Time   : 0
     Become Master    : 2200ms left
     Auth Type        : None
     Virtual IP       : 10.1.1.10
     Master IP        : 10.1.1.2
   VRRP Track Information:
     Track Object   : 1              State : Negative          Pri Reduced : 30
```

Display detailed information about VRRP group 1 on Switch B.

```
[SwitchB-Vlan-interface2] display vrrp verbose
IPv4 Virtual Router Information:
 Running Mode      : Standard
 Total number of virtual routers : 1
   Interface Vlan-interface2
     VRID             : 1               Adver Timer  : 100
     Admin Status     : Up              State        : Master
     Config Pri       : 100             Running Pri  : 100
     Preempt Mode     : Yes             Delay Time   : 0
     Auth Type        : None
     Virtual IP       : 10.1.1.10
     Virtual MAC      : 0000-5e00-0101
     Master IP        : 10.1.1.2
```

The output shows that Switch A becomes the backup, and Switch B becomes the master. Switch B forwards packets from Host A to Host B.

Example: Configuring static routing-Track-LLDP collaboration

Network requirements

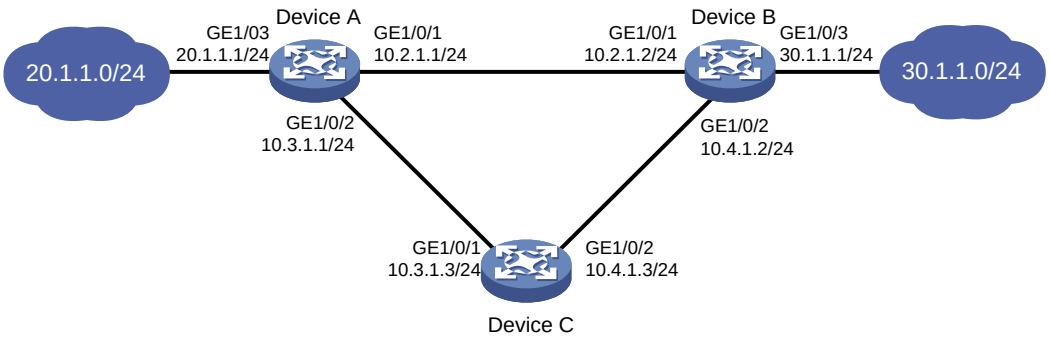
As shown in Figure 11:

- Device A is the default gateway of the hosts in network 20.1.1.0/24.
- Device B is the default gateway of the hosts in network 30.1.1.0/24.
- Hosts in the two networks communicate with each other through static routes.

To ensure network availability, configure route backup and static routing-Track-LLDP collaboration on Device A and Device B as follows:

- On Device A, assign a higher priority to the static route to 30.1.1.0/24 with next hop Device B. This route is the master route. The static route to 30.1.1.0/24 with next hop Device C acts as the backup route. When the master route is unavailable, the backup route takes effect. Device A forwards packets destined for 30.1.1.0/24 to Device C.
- On Device B, assign a higher priority to the static route to 20.1.1.0/24 with next hop Device A. This route is the master route. The static route to 20.1.1.0/24 with next hop Device C acts as the backup route. When the master route is unavailable, the backup route takes effect. Device B forwards packets destined for 20.1.1.0/24 to Device C.

Figure 11 Network diagram



Procedure

1. Configure the IP address of each interface, as shown in Figure 11. (Details not shown.)
2. Configure Device A:

   # Configure a static route to 30.1.1.0/24 with next hop 10.1.1.2 and the default priority (60). Associate this static route with track entry 1.

   ```
   <DeviceA> system-view
   [DeviceA] ip route-static 30.1.1.0 24 10.2.1.2 track 1
   ```

   # Configure a static route to 30.1.1.0/24 with next hop 10.3.1.3 and priority 80.

   ```
   [DeviceA] ip route-static 30.1.1.0 24 10.3.1.3 preference 80
   ```

   # Enable LLDP globally.

   ```
   [DeviceA] lldp global enable
   ```

   # Enable LLDP on GigabitEthernet 1/0/1. (This step is optional because LLDP is enabled on the port by default.)

   ```
   [DeviceA] interface gigabitethernet 1/0/1
   [DeviceA-GigabitEthernet1/0/1] lldp enable
   ```

   # Configure track entry 1 and associate it with the availability of the neighbor for LLDP interface GigabitEthernet 1/0/1.

```
[DeviceA] track 1 lldp neighbor interface gigabitethernet 1/0/1
[DeviceA-track-1] quit
```

3. Configure Device B:

Configure a static route to 20.1.1.0/24 with next hop 10.2.1.1 and the default priority (60). Associate this static route with track entry 1.

```
<DeviceB> system-view
[DeviceB] ip route-static 20.1.1.0 24 10.2.1.1 track 1
```

Configure a static route to 20.1.1.0/24 with next hop 10.4.1.3 and priority 80.

```
[DeviceB] ip route-static 20.1.1.0 24 10.4.1.3 preference 80
```

Enable LLDP globally.

```
[DeviceB] lldp global enable
```

Enable LLDP on GigabitEthernet 1/0/1. (This step is optional because LLDP is enabled on the port by default.)

```
[DeviceB] interface gigabitethernet 1/0/1
[DeviceB-GigabitEthernet1/0/1] lldp enable
```

Configure track entry 1 and associate it with the availability of the neighbor for LLDP interface GigabitEthernet 1/0/1.

```
[DeviceB] track 1 lldp neighbor interface gigabitethernet 1/0/1
[DeviceB-track-1] quit
```

4. Configure Device C:

Configure a static route to 30.1.1.0/24 with next hop 10.4.1.2.

```
<DeviceC> system-view
[DeviceC] ip route-static 30.1.1.0 24 10.4.1.2
```

Configure a static route to 20.1.1.0/24 with next hop 10.3.1.1.

```
[DeviceC] ip route-static 20.1.1.0 24 10.3.1.1
```

Verifying the configuration

Display track entry information on Device A.

```
[DeviceA] display track all
Track ID: 1
  State: Positive
  Duration: 0 days 0 hours 0 minutes 32 seconds
  Tracked object type: LLDP
  Notification delay: Positive 0, Negative 0 (in seconds)
  Tracked object:
    LLDP interface: GigabitEthernet1/0/1
```

The output shows that the status of track entry 1 is Positive, indicating that the neighbor of LLDP interface GigabitEthernet 1/0/1 is available. The master route takes effect.

Display the routing table of Device A.

```
[DeviceA] display ip routing-table

Destinations : 9        Routes : 9

Destination/Mask    Proto  Pre  Cost         NextHop         Interface
10.2.1.0/24         Direct 0    0            10.2.1.1        GE1/0/1
10.2.1.1/32         Direct 0    0            127.0.0.1       InLoop0
10.3.1.0/24         Direct 0    0            10.3.1.1        GE1/0/2
10.3.1.1/32         Direct 0    0            127.0.0.1       InLoop0
```

```
20.1.1.0/24         Direct 0    0           20.1.1.1        GE1/0/3
20.1.1.1/32         Direct 0    0           127.0.0.1       InLoop0
30.1.1.0/24         Static 60   0           10.2.1.2        GE1/0/1
127.0.0.0/8         Direct 0    0           127.0.0.1       InLoop0
127.0.0.1/32        Direct 0    0           127.0.0.1       InLoop0
```

The output shows that Device A forwards packets to 30.1.1.0/24 through Device B.

On Device B, disable LLDP on GigabitEthernet 1/0/1.

```
<DeviceB> system-view
[DeviceB] interface gigabitethernet 1/0/1
[DeviceB-GigabitEthernet1/0/1] undo lldp enable
```

Display track entry information on Device A.

```
[DeviceA] display track all
Track ID: 1
  State: Negative
  Duration: 0 days 0 hours 0 minutes 32 seconds
  Tracked object type: LLDP
  Notification delay: Positive 0, Negative 0 (in seconds)
  Tracked object:
    LLDP interface: GigabitEthernet1/0/1
```

The output shows that the status of track entry 1 is Negative, indicating that the neighbor of LLDP interface GigabitEthernet 1/0/1 is unavailable. The master route fails.

Display the routing table of Device A.

```
[DeviceA] display ip routing-table

Destinations : 9        Routes : 9

Destination/Mask    Proto  Pre  Cost         NextHop         Interface
10.2.1.0/24         Direct 0    0           10.2.1.1        GE1/0/1
10.2.1.1/32         Direct 0    0           127.0.0.1       InLoop0
10.3.1.0/24         Direct 0    0           10.3.1.1        GE1/0/2
10.3.1.1/32         Direct 0    0           127.0.0.1       InLoop0
20.1.1.0/24         Direct 0    0           20.1.1.1        GE1/0/3
20.1.1.1/32         Direct 0    0           127.0.0.1       InLoop0
30.1.1.0/24         Static 80   0           10.3.1.3        GE1/0/2
127.0.0.0/8         Direct 0    0           127.0.0.1       InLoop0
127.0.0.1/32        Direct 0    0           127.0.0.1       InLoop0
```

The output shows that Device A forwards packets destined for 30.1.1.0/24 to Device C. The backup static route has taken effect.

Verify that hosts in 20.1.1.0/24 can communicate with the hosts in 30.1.1.0/24 when the master route fails.

```
[DeviceA] ping -a 20.1.1.1 30.1.1.1
Ping 30.1.1.1: 56  data bytes, press CTRL_C to break
Reply from 30.1.1.1: bytes=56 Sequence=1 ttl=254 time=2 ms
Reply from 30.1.1.1: bytes=56 Sequence=2 ttl=254 time=1 ms
Reply from 30.1.1.1: bytes=56 Sequence=3 ttl=254 time=1 ms
Reply from 30.1.1.1: bytes=56 Sequence=4 ttl=254 time=2 ms
Reply from 30.1.1.1: bytes=56 Sequence=5 ttl=254 time=1 ms
```

```
--- Ping statistics for 30.1.1.1 ---
5 packet(s) transmitted, 5 packet(s) received, 0.00% packet loss
round-trip min/avg/max/std-dev = 1/1/2/1 ms
```

Verify that the hosts in 30.1.1.0/24 can communicate with the hosts in 20.1.1.0/24 when the master route fails.

```
[DeviceB] ping -a 30.1.1.1 20.1.1.1
Ping 20.1.1.1: 56  data bytes, press CTRL_C to break
Reply from 20.1.1.1: bytes=56 Sequence=1 ttl=254 time=2 ms
Reply from 20.1.1.1: bytes=56 Sequence=2 ttl=254 time=1 ms
Reply from 20.1.1.1: bytes=56 Sequence=3 ttl=254 time=1 ms
Reply from 20.1.1.1: bytes=56 Sequence=4 ttl=254 time=1 ms
Reply from 20.1.1.1: bytes=56 Sequence=5 ttl=254 time=1 ms

--- Ping statistics for 20.1.1.1 ---
5 packet(s) transmitted, 5 packet(s) received, 0.00% packet loss
round-trip min/avg/max/std-dev = 1/1/2/1 ms
```

Example: Configuring Smart Link-Track-CFD collaboration

For information about the Smart Link-Track-CFD collaboration configuration example, see "Configuring Smart Link."

Contents

Configuring loopback MAC swap

About loopback MAC swap

Loopback MAC swap is a technique that tests the Layer 2 network performance. It is typically used to measure Ethernet connectivity and network performance.

Loopback MAC swap enables a tester to send test packets (matching the specified parameters) to an interface of the tested device. Upon receiving the test packets, the interface swaps the source and destination MAC addresses of the test packets, and then loops back the test packets to the tester. In this way, the tester obtains the network connectivity and analyzes the network performance.

Loopback MAC swap supports only Ethernet frames with IP packets as the payload.

Loopback MAC swap has the following two types:

- Local loopback MAC swap
- Remote loopback MAC swap

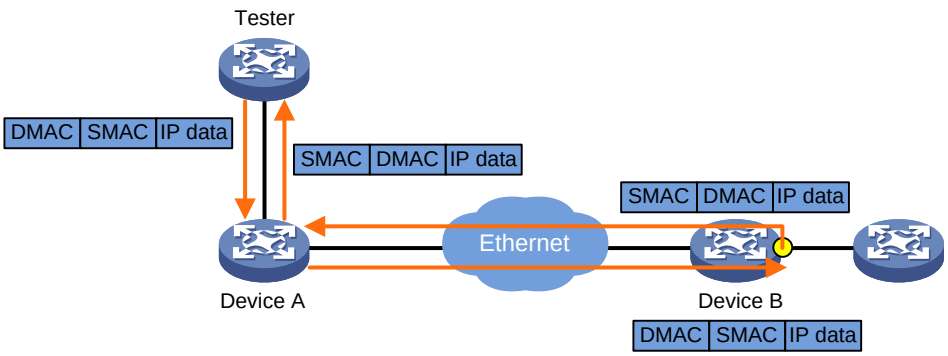
Operating mechanism of loopback MAC swap

Local loopback MAC swap

The test scope for local loopback MAC swap is the network from the tester to the downlink interface on the tested device (including the tested device).

As shown in Figure 1, the tester sends test packets to the downlink interface on Device B. Upon receiving the packets, the tested device swaps the source and destination MAC addresses in the test packets on the downlink interface, and then loops back the test packets to the tester through the specified interface.

Figure 1 Local loopback MAC swap

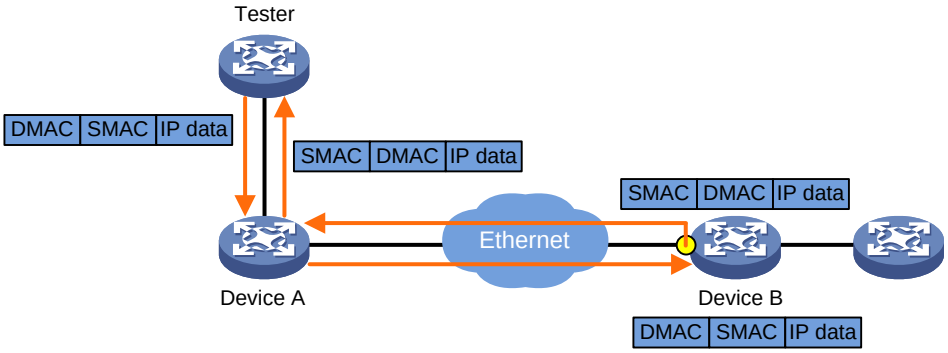


Remote loopback MAC swap

The test scope for local loopback MAC swap is the network from the tester to the uplink interface on the tested device (excluding the tested device).

As shown in Figure 2, the tester sends test packets to the uplink interface on Device B. Upon receiving the packets, the tested device swaps the source and destination MAC addresses in the test packets on the uplink interface, and then loops back the test packets to the tester through the uplink interface.

Figure 2 Remote loopback MAC swap



Restrictions: Software version compatibility with loopback MAC swap

Loopback MAC swap is supported only in Release R6348P01 and later.

Restrictions and guidelines: loopback MAC swap configuration

Loopback MAC swap will interrupt services on the tested interface, but it will not affect services on other interfaces.

Loopback MAC swap tasks at a glance

To configure loopback MAC swap, perform the following tasks:

1. Configuring local loopback MAC swap
2. Configuring remote loopback MAC swap

Configuring local loopback MAC swap

About this task

The test scope for local loopback MAC swap is the network from the tester to the downlink interface on the tested device (including the tested device).

After starting the local loopback MAC swap test, the tester sends test packets to the downlink interface on the tested device. The tested device swaps the source and destination MAC addresses in the test packets on the downlink interface, and then loops back the test packets to the tester through the specified interface. In this way, the network connectivity and quality information are obtained.

Restrictions and guidelines

After configuring local loopback MAC swap parameters, you need to execute the **`loopback swap-mac start`** command to start the test.

Execute the **loopback swap-mac start** command again to start a new test if the previous test automatically stops upon expiration of the timeout timer or is manually stopped with the **loopback swap-mac stop** command.

Local loopback MAC swap tests will affect normal operation of the network. As a best practice to minimize impact on the network, execute the **loopback swap-mac stop** command immediately to stop the test after it is completed.

Procedure

1. Enter system view.

   system-view

2. Enter interface view.

   interface *interface-type interface-number*

3. Configure local loopback MAC swap parameters.

   loopback local swap-mac source-mac *source-mac-address* **dest-mac** *dest-mac-address* **vlan** *vlan-id* [**inner-vlan** *inner-vlan-id*] **interface** *interface-type interface-number* [**timeout** { *time-value* | **none** }]

4. Start the loopback MAC swap test.

   loopback swap-mac start

5. (Optional.) Stop the loopback MAC swap test.

   loopback swap-mac start

Configuring remote loopback MAC swap

About this task

The test scope for local loopback MAC swap is the network from the tester to the uplink interface on the tested device (excluding the tested device).

After starting the remote loopback MAC swap test, the tester sends test packets to the uplink interface on the tested device. The tested device swaps the source and destination MAC addresses in the test packets on the uplink interface, and then loops back the test packets to the tester through the uplink interface. In this way, the network connectivity and quality information are obtained.

Restrictions and guidelines

After configuring remote loopback MAC swap parameters, you need to execute the **loopback swap-mac start** command to start the test.

Execute the **loopback swap-mac start** command again to start a new test if the previous test automatically stops upon expiration of the timeout timer or is manually stopped with the **loopback swap-mac stop** command.

Remote loopback MAC swap tests will affect normal operation of the network. As a best practice to minimize impact on the network, execute the **loopback swap-mac stop** command immediately to stop the test after it is completed.

Procedure

1. Enter system view.

   system-view

2. Enter interface view.

   interface *interface-type interface-number*

3. Configure remote loopback MAC swap parameters.

loopback remote swap-mac source-mac *source-mac-address* **dest-mac** *dest-mac-address* **vlan** *vlan-id* [**inner-vlan** *inner-vlan-id*] [**timeout** { *time-value* | **none** }]

4. Start the loopback MAC swap test.

   loopback swap-mac start

5. (Optional.) Stop the loopback MAC swap test.

   loopback swap-mac start

Display and maintenance commands for loopback MAC swap

Execute the **display** command in any view.

Task	Command
Display loopback MAC swap test information.	**display loopback swap-mac information**

Loopback MAC swap configuration examples

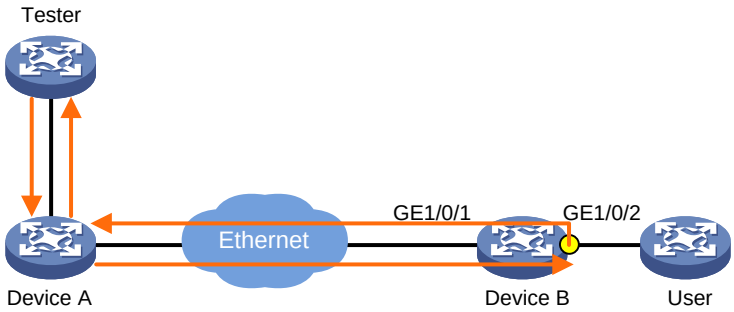
Example: Configuring local loopback MAC swap

Network configuration

As shown in Figure 3, Device B is connected to the Ethernet network through GE 1/0/1, and is connected to the user through GE 1/0/2.

Configure local loopback MAC swap to test the Ethernet connectivity and network performance. The test scope includes Device B.

Figure 3 Network diagram



Procedure

1. Create VLAN 100 on Device B. Configure GigabitEthernet 1/0/1 as a trunk port, and assign the port to VLAN 100. Configure GigabitEthernet 1/0/2 as a hybrid port, set its PVID to VLAN 100, and assign it to VLAN 100 as an untagged member.

```
<Device B> system-view
[Device B] vlan 100
[Device B] interface gigabitethernet 1/0/1
[Device B-GigabitEthernet1/0/1] port link-type trunk
```

```
[Device B-GigabitEthernet1/0/1] port trunk permit vlan 100
[Device B-GigabitEthernet1/0/1] quit
[Device B] interface gigabitethernet 1/0/2
[Device B-GigabitEthernet1/0/2] port link-type hybrid
[Device B-GigabitEthernet1/0/2] port hybrid pvid vlan 100
[Device B-GigabitEthernet1/0/2] port hybrid vlan 100 untagged
```

2. Configure local loopback MAC swap on GigabitEthernet 1/0/2, and specify GigabitEthernet 1/0/1 for looping back the test packets.

```
[Device B-GigabitEthernet1/0/2] loopback local swap-mac source-mac 0001-0001-0001
dest-mac 0002-0002-0002 vlan 100 interface gigabitethernet 1/0/1 timeout 80
```

3. Start the loopback MAC swap test.

```
[Device B-GigabitEthernet1/0/2] loopback swap-mac start
[Device B-GigabitEthernet1/0/2] quit
[Device B] quit
```

Verifying the configuration

Use the **`display loopback swap-mac information`** command to view loopback MAC swap test information.

```
<Device B > display loopback swap-mac information
  Loopback type             : local
  Loopback state            : running
  Loopback test times(s)    : 80
  Loopback interface        : GigabitEthernet1/0/1
  Loopback output interface : GigabitEthernet1/0/2
  Loopback source MAC       : 0001-0001-0001
  Loopback destination MAC  : 0002-0002-0002
  Loopback vlan             : 100
  Loopback inner vlan       : 0
  Loopback packets          : 0
  Drop packets              : 0
```

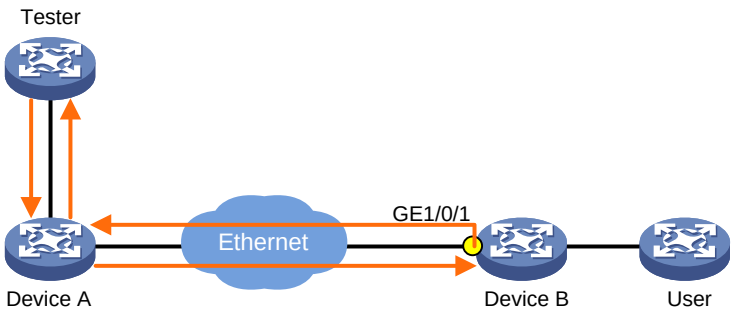
Example: Configuring remote loopback MAC swap

Network configuration

As shown in Figure 3, Device B is connected to the Ethernet network through GE 1/0/1.

Configure remote loopback MAC swap to test the Ethernet connectivity and network performance. The test scope does not include Device B.

Figure 4 Network diagram



Procedure

1. Create VLAN 100 on Device B. Configure GigabitEthernet 1/0/1 as a trunk port, and assign the port to VLAN 100.

```
<Device B> system-view
[Device B] vlan 100
[Device B] interface gigabitethernet 1/0/1
[Device B-GigabitEthernet1/0/1] port link-type trunk
[Device B-GigabitEthernet1/0/1] port trunk permit vlan 100
```

2. Configure remote loopback MAC swap on GigabitEthernet 1/0/1.

```
[Device B-GigabitEthernet1/0/1]  loopback remote swap-mac source-mac 0001-0001-0001
dest-mac 0002-0002-0002 vlan 100 timeout 80
```

3. Start the loopback MAC swap test.

```
[Device B-GigabitEthernet1/0/1] loopback swap-mac start
[Device B-GigabitEthernet1/0/1] quit
[Device B] quit
```

Verifying the configuration

Use the **`display loopback swap-mac information`** command to view loopback MAC swap test information.

```
<Device B> display loopback swap-mac information
  Loopback type             : remote
  Loopback state            : running
  Loopback test time(s)     : 80
  Loopback interface        : GigabitEthernet1/0/1
  Loopback source MAC       : 0001-0001-0001
  Loopback destination MAC  : 0002-0002-0002
  Loopback vlan             : 100
  Loopback inner vlan       : 0
  Loopback packets          : 0
```

Network Management and Monitoring Configuration Guide

This command reference is applicable to the following switches and software versions:

H3C S5120V2-LI switch series (Release 6308P01 and later)
H3C S3100V3-SI switch series (Release 6309P01 and later)
H3C S5110V2 switch series (Release 6310 and later)
H3C S5110V2-SI switch series (Release 6310 and later)
H3C S5000V3-EI switch series (Release 6310 and later)
H3C S5000V5-EI switch series (Release 6319P01 and later)
H3C S5000E-X switch series (Release 6310 and later)
H3C S5130S-LI switch series (Release 6310 and later)
H3C MS4320V2 switch series (Release 6308P01 and later)
H3C MS4320 switch series (Release 6308P01 and later)
H3C MS4300V2 switch series (Release 6308P01 and later)
H3C MS4200 switch series (Release 6310 and later)
H3C WS5810-WiNet switch series (Release 6308P01 and later)
H3C WS5820-WiNet switch series (Release 6308P01 and later)
H3C WAS6000 switch series (Release 6308P01 and later)
H3C S5000X-EI switch series (Release 6329 and later)
H3C MS4320V3 switch series (Release 6329 and later)
H3C S5120V3-SI switch series (Release 6329 and later)
H3C S5120V3-LI switch series (Release 6329 and later)

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http://www.h3c.com

Software version: Release 63xx
Document version: 6W105-20230524

Preface

This configuration guide describes the network management and monitoring fundamentals and configuration procedures. It describes how to view system information, collect traffic statistics, assess the network performance, synchronize time for all devices with clocks in your network, and use the ping, tracert, and debug commands to check and debug the current network connectivity.

This preface includes the following topics about the documentation:

Audience

This documentation is intended for:

- Network planners.
- Field technical support and servicing engineers.
- Network administrators.

Conventions

The following information describes the conventions used in the documentation.

Command conventions

Convention	Description
Boldface	**Bold** text represents commands and keywords that you enter literally as shown.
Italic	*Italic* text represents arguments that you replace with actual values.
[ ]	Square brackets enclose syntax choices (keywords or arguments) that are optional.
{ x | y | ... }	Braces enclose a set of required syntax choices separated by vertical bars, from which you select one.
[x | y | ...]	Square brackets enclose a set of optional syntax choices separated by vertical bars, from which you select one or none.
{ x | y | ... } *	Asterisk marked braces enclose a set of required syntax choices separated by vertical bars, from which you select a minimum of one.
[x | y | ...] *	Asterisk marked square brackets enclose optional syntax choices separated by vertical bars, from which you select one choice, multiple choices, or none.
&<1-n>	The argument or keyword and argument combination before the ampersand (&) sign can be entered 1 to n times.
#	A line that starts with a pound (#) sign is comments.

GUI conventions

Convention	Description
Boldface	Window names, button names, field names, and menu items are in Boldface. For example, the **New User** window opens; click **OK**.

Convention	Description
>	Multi-level menus are separated by angle brackets. For example, **File** > **Create** > **Folder**.

Symbols

Convention	Description
WARNING!	An alert that calls attention to important information that if not understood or followed can result in personal injury.
CAUTION:	An alert that calls attention to important information that if not understood or followed can result in data loss, data corruption, or damage to hardware or software.
IMPORTANT:	An alert that calls attention to essential information.
NOTE:	An alert that contains additional or supplementary information.
TIP:	An alert that provides helpful information.

Network topology icons

Convention	Description
	Represents a generic network device, such as a router, switch, or firewall.
	Represents a routing-capable device, such as a router or Layer 3 switch.
	Represents a generic switch, such as a Layer 2 or Layer 3 switch, or a router that supports Layer 2 forwarding and other Layer 2 features.
	Represents an access controller, a unified wired-WLAN module, or the access controller engine on a unified wired-WLAN switch.
	Represents an access point.
	Represents a wireless terminator unit.
	Represents a wireless terminator.
	Represents a mesh access point.
	Represents omnidirectional signals.
	Represents directional signals.
	Represents a security product, such as a firewall, UTM, multiservice security gateway, or load balancing device.
	Represents a security module, such as a firewall, load balancing, NetStream, SSL VPN, IPS, or ACG module.

Examples provided in this document

Examples in this document might use devices that differ from your device in hardware model, configuration, or software version. It is normal that the port numbers, sample output, screenshots, and other information in the examples differ from what you have on your device.

Documentation feedback

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We appreciate your comments.

Contents

Using ping, tracert, and system debugging

This chapter covers ping, tracert, and information about debugging the system.

Ping

About ping

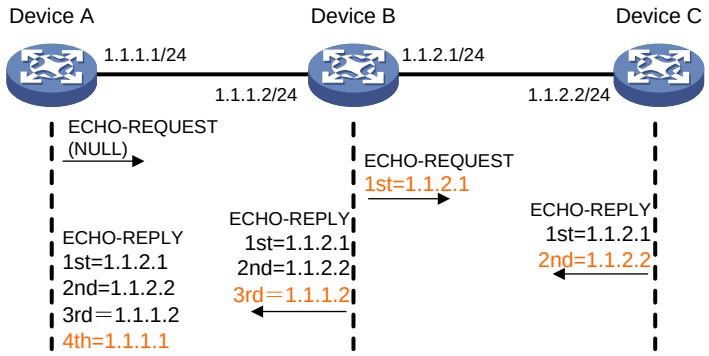
Use the ping utility to determine if an address is reachable.

Ping sends ICMP echo requests (ECHO-REQUEST) to the destination device. Upon receiving the requests, the destination device responds with ICMP echo replies (ECHO-REPLY) to the source device. The source device outputs statistics about the ping operation, including the number of packets sent, number of echo replies received, and the round-trip time. You can measure the network performance by analyzing these statistics.

You can use the **`ping -r`** command to display the routers through which ICMP echo requests have passed. The test procedure of **`ping -r`** is as shown in Figure 1:

1. The source device (Device A) sends an ICMP echo request to the destination device (Device C) with the RR option empty.
2. The intermediate device (Device B) adds the IP address of its outbound interface (1.1.2.1) to the RR option of the ICMP echo request, and forwards the packet.
3. Upon receiving the request, the destination device copies the RR option in the request and adds the IP address of its outbound interface (1.1.2.2) to the RR option. Then the destination device sends an ICMP echo reply.
4. The intermediate device adds the IP address of its outbound interface (1.1.1.2) to the RR option in the ICMP echo reply, and then forwards the reply.
5. Upon receiving the reply, the source device adds the IP address of its inbound interface (1.1.1.1) to the RR option. The detailed information of routes from Device A to Device C is formatted as: 1.1.1.1 <-> {1.1.1.2; 1.1.2.1} <-> 1.1.2.2.

Figure 1 Ping operation



Using a ping command to test network connectivity

Perform the following tasks in any view:

- Determine if an IPv4 address is reachable.

ping [**ip**] [**-a** *source-ip* | **-c** *count* | **-f** | **-h** *ttl* | **-i** *interface-type interface-number* | **-m** *interval* | **-n** | **-p** *pad* | **-q** | **-r** | **-s** *packet-size* | **-t** *timeout* | **-tos** *tos* | **-v**] * *host*

Increase the timeout time (indicated by the **-t** keyword) on a low-speed network.

- Determine if an IPv6 address is reachable.

  ping ipv6 [**-a** *source-ipv6* | **-c** *count* | **-i** *interface-type interface-number* | **-m** *interval* | **-q** | **-s** *packet-size* | **-t** *timeout* | **-tc** *traffic-class* | **-v**] * *host*

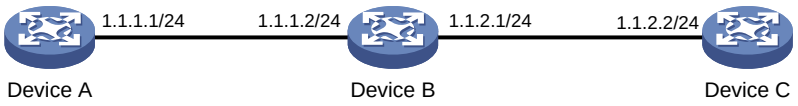
  Increase the timeout time (indicated by the **-t** keyword) on a low-speed network.

Example: Using the ping utility

Network configuration

As shown in Figure 2, determine if Device A and Device C can reach each other.

Figure 2 Network diagram



Procedure

Test the connectivity between Device A and Device C.

```
<DeviceA> ping 1.1.2.2
Ping 1.1.2.2 (1.1.2.2): 56 data bytes, press CTRL_C to break
56 bytes from 1.1.2.2: icmp_seq=0 ttl=254 time=2.137 ms
56 bytes from 1.1.2.2: icmp_seq=1 ttl=254 time=2.051 ms
56 bytes from 1.1.2.2: icmp_seq=2 ttl=254 time=1.996 ms
56 bytes from 1.1.2.2: icmp_seq=3 ttl=254 time=1.963 ms
56 bytes from 1.1.2.2: icmp_seq=4 ttl=254 time=1.991 ms

--- Ping statistics for 1.1.2.2 ---
5 packet(s) transmitted, 5 packet(s) received, 0.0% packet loss
round-trip min/avg/max/std-dev = 1.963/2.028/2.137/0.062 ms
```

The output shows the following information:

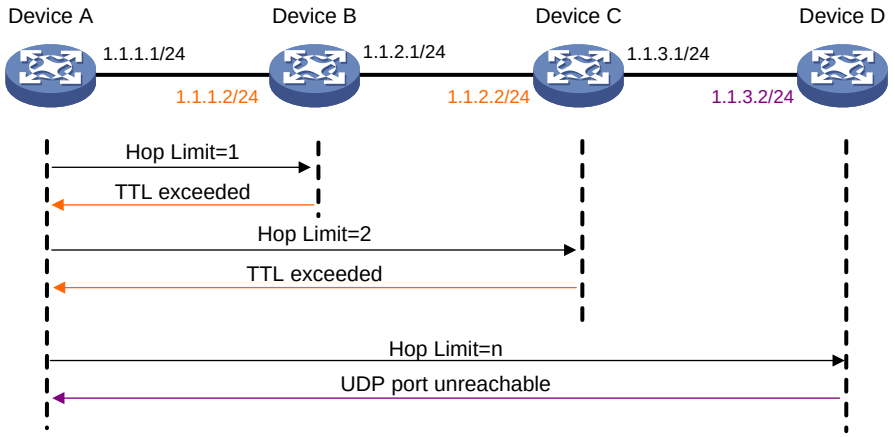
- Device A sends five ICMP packets to Device C and Device A receives five ICMP packets.
- No ICMP packet is lost.
- The route is reachable.

Tracert

About tracert

Tracert (also called Traceroute) enables retrieval of the IP addresses of Layer 3 devices in the path to a destination. In the event of network failure, use tracert to test network connectivity and identify failed nodes.

Figure 3 Tracert operation



Tracert uses received ICMP error messages to get the IP addresses of devices. Tracert works as shown in Figure 3:

1. The source device sends a UDP packet with a TTL value of 1 to the destination device. The destination UDP port is not used by any application on the destination device.
2. The first hop (Device B, the first Layer 3 device that receives the packet) responds by sending a TTL-expired ICMP error message to the source, with its IP address (1.1.1.2) encapsulated. This way, the source device can get the address of the first Layer 3 device (1.1.1.2).
3. The source device sends a packet with a TTL value of 2 to the destination device.
4. The second hop (Device C) responds with a TTL-expired ICMP error message, which gives the source device the address of the second Layer 3 device (1.1.2.2).
5. This process continues until a packet sent by the source device reaches the ultimate destination device. Because no application uses the destination port specified in the packet, the destination device responds with a port-unreachable ICMP message to the source device, with its IP address encapsulated. This way, the source device gets the IP address of the destination device (1.1.3.2).
6. The source device determines that:
   - The packet has reached the destination device after receiving the port-unreachable ICMP message.
   - The path to the destination device is 1.1.1.2 to 1.1.2.2 to 1.1.3.2.

Prerequisites

Before you use a tracert command, perform the tasks in this section.

For an IPv4 network:

- Enable sending of ICMP timeout packets on the intermediate devices (devices between the source and destination devices). If the intermediate devices are H3C devices, execute the **ip ttl-expires enable** command on the devices. For more information about this command, see *Layer 3—IP Services Command Reference*.
- Enable sending of ICMP destination unreachable packets on the destination device. If the destination device is an H3C device, execute the **ip unreachables enable** command. For more information about this command, see *Layer 3—IP Services Command Reference*.

For an IPv6 network:

- Enable sending of ICMPv6 timeout packets on the intermediate devices (devices between the source and destination devices). If the intermediate devices are H3C devices, execute the

ipv6 hoplimit-expires enable command on the devices. For more information about this command, see *Layer 3—IP Services Command Reference*.

- Enable sending of ICMPv6 destination unreachable packets on the destination device. If the destination device is an H3C device, execute the **ipv6 unreachables enable** command. For more information about this command, see *Layer 3—IP Services Command Reference*.

Using a tracert command to identify failed or all nodes in a path

Perform the following tasks in any view:

- Trace the route to an IPv4 destination.

  tracert [**-a** *source-ip* | **-f** *first-ttl* | **-m** *max-ttl* | **-p** *port* | **-q** *packet-number* | **-t** *tos* | **-w** *timeout*] * *host*

- Trace the route to an IPv6 destination.

  tracert ipv6 [**-f** *first-hop* | **-m** *max-hops* | **-p** *port* | **-q** *packet-number* | **-t** *traffic-class* | **-w** *timeout*] * *host*

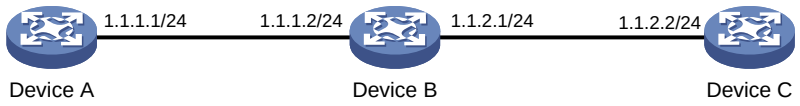
Example: Using the tracert utility

Network configuration

As shown in Figure 4, Device A failed to Telnet to Device C.

Test the network connectivity between Device A and Device C. If they cannot reach each other, locate the failed nodes in the network.

Figure 4 Network diagram



Procedure

1. Configure IP addresses for the devices as shown in Figure 4.
2. Configure a static route on Device A.

   ```
   <DeviceA> system-view
   [DeviceA] ip route-static 0.0.0.0 0.0.0.0 1.1.1.2
   ```

3. Test connectivity between Device A and Device C.

   ```
   [DeviceA] ping 1.1.2.2
   Ping 1.1.2.2(1.1.2.2): 56 -data bytes, press CTRL_C to break
   Request time out
   Request time out
   Request time out
   Request time out
   Request time out

   --- Ping statistics for 1.1.2.2 ---
   5 packet(s) transmitted,0 packet(s) received,100.0% packet loss
   ```

   The output shows that Device A and Device C cannot reach each other.

4. Identify failed nodes:

Enable sending of ICMP timeout packets on Device B.

```
<DeviceB> system-view
[DeviceB] ip ttl-expires enable
```

Enable sending of ICMP destination unreachable packets on Device C.

```
<DeviceC> system-view
[DeviceC] ip unreachables enable
```

Identify failed nodes.

```
[DeviceA] tracert 1.1.2.2
traceroute to 1.1.2.2 (1.1.2.2) 30 hops at most,40 bytes each packet, press CTRL_C
to break
 1  1.1.1.2 (1.1.1.2) 1 ms 2 ms 1 ms
 2  * * *
 3  * * *
 4  * * *
 5
[DeviceA]
```

The output shows that Device A can reach Device B but cannot reach Device C. An error has occurred on the connection between Device B and Device C.

5. To identify the cause of the issue, execute the following commands on Device A and Device C:
   - Execute the **`debugging ip icmp`** command and verify that Device A and Device C can send and receive the correct ICMP packets.
   - Execute the **`display ip routing-table`** command to verify that Device A and Device C have a route to each other.

System debugging

About system debugging

The device supports debugging for the majority of protocols and features, and provides debugging information to help users diagnose errors.

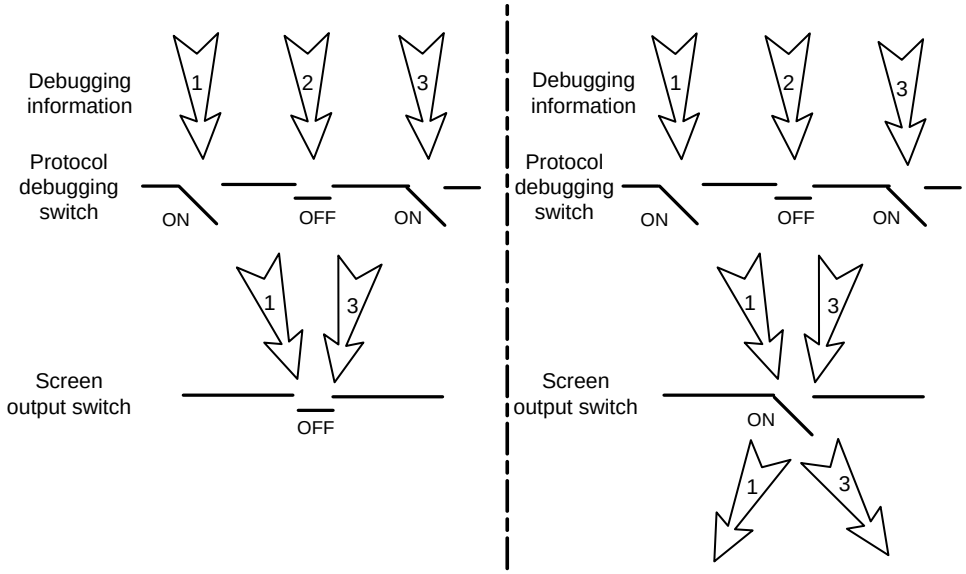
The following switches control the display of debugging information:

- **Module debugging switch**—Controls whether to generate the module-specific debugging information.
- **Screen output switch**—Controls whether to display the debugging information on a certain screen. Use **`terminal monitor`** and **`terminal logging level`** commands to turn on the screen output switch. For more information about these two commands, see *Network Management and Monitoring Command Reference*.

As shown in Figure 5, the device can provide debugging for the three modules 1, 2, and 3. The debugging information can be output on a terminal only when both the module debugging switch and the screen output switch are turned on.

Debugging information is typically displayed on a console. You can also send debugging information to other destinations. For more information, see "Configuring the information center."

Figure 5 Relationship between the module and screen output switch



Debugging a feature module

Restrictions and guidelines

CAUTION:

Output of excessive debugging messages increases the CPU usage and downgrades the system performance. To guarantee system performance, enable debugging only for modules that are in an exceptional condition.

Enable debugging for modules for troubleshooting purposes. When debugging is complete, use the **undo debugging all** command to disable all the debugging functions.

Procedure

1. Enable debugging for a module.

   debugging *module-name* [*option*]

   By default, debugging is disabled for all modules.

   This command is available in user view.

2. (Optional.) Display the enabled debugging features.

   display debugging [*module-name*]

   This command is available in any view.

Contents

Configuring NQA

About NQA

Network quality analyzer (NQA) allows you to measure network performance, verify the service levels for IP services and applications, and troubleshoot network problems.

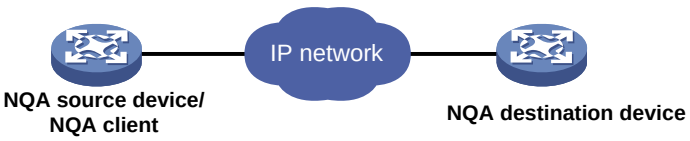
NQA operating mechanism

An NQA operation contains a set of parameters such as the operation type, destination IP address, and port number to define how the operation is performed. Each NQA operation is identified by the combination of the administrator name and the operation tag. You can configure the NQA client to run the operations at scheduled time periods.

As shown in Figure 1, the NQA source device (NQA client) sends data to the NQA destination device by simulating IP services and applications to measure network performance.

All types of NQA operations require the NQA client, but only the TCP, UDP echo, UDP jitter, and voice operations require the NQA server. The NQA operations for services that are already provided by the destination device such as FTP do not need the NQA server. You can configure the NQA server to listen and respond to specific IP addresses and ports to meet various test needs.

Figure 1 Network diagram



After starting an NQA operation, the NQA client periodically performs the operation at the interval specified by using the **`frequency`** command.

You can set the number of probes the NQA client performs in an operation by using the **`probe count`** command. For the voice and path jitter operations, the NQA client performs only one probe per operation and the **`probe count`** command is not available.

Collaboration with Track

NQA can collaborate with the Track module to notify application modules of state or performance changes so that the application modules can take predefined actions.

The NQA + Track collaboration is available for the following application modules:

- VRRP.
- Static routing.
- Policy-based routing.
- Traffic redirecting.
- Smart Link

The following describes how a static route destined for 192.168.0.88 is monitored through collaboration:

1. NQA monitors the reachability to 192.168.0.88.
2. When 192.168.0.88 becomes unreachable, NQA notifies the Track module of the change.

3. The Track module notifies the static routing module of the state change.
4. The static routing module sets the static route to invalid according to a predefined action.

For more information about collaboration, see *High Availability Configuration Guide*.

Threshold monitoring

Threshold monitoring enables the NQA client to take a predefined action when the NQA operation performance metrics violate the specified thresholds.

Table 1 describes the relationships between performance metrics and NQA operation types.

Table 1 Performance metrics and NQA operation types

Performance metric	NQA operation types that can gather the metric
Probe duration	All NQA operation types except UDP jitter, UDP tracert, path jitter, and voice
Number of probe failures	All NQA operation types except UDP jitter, UDP tracert, path jitter, and voice
Round-trip time	ICMP jitter, UDP jitter, and voice
Number of discarded packets	ICMP jitter, UDP jitter, and voice
One-way jitter (source-to-destination or destination-to-source)	ICMP jitter, UDP jitter, and voice
One-way delay (source-to-destination or destination-to-source)	ICMP jitter, UDP jitter, and voice
Calculated Planning Impairment Factor (ICPIF) (see "Configuring the voice operation")	Voice
Mean Opinion Scores (MOS) (see "Configuring the voice operation")	Voice

NQA templates

An NQA template is a set of parameters (such as destination address and port number) that defines how an NQA operation is performed. Features can use the NQA template to collect statistics.

You can create multiple NQA templates on the NQA client. Each template must be identified by a unique template name.

NQA tasks at a glance

To configure NQA, perform the following tasks:

1. Configuring the NQA server

   Perform this task on the destination device before you configure the TCP, UDP echo, UDP jitter, and voice operations.
2. Enabling the NQA client
3. Configuring NQA operations or NQA templates

   Choose the following tasks as needed:
   - Configuring NQA operations on the NQA client
   - Configuring NQA templates on the NQA client

After you configure an NQA operation, you can schedule the NQA client to run the NQA operation.

An NQA template does not run immediately after it is configured. The template creates and run the NQA operation only when it is required by the feature (such as load balancing) to which the template is applied.

Configuring the NQA server

Restrictions and guidelines

To perform TCP, UDP echo, UDP jitter, and voice operations, you must configure the NQA server on the destination device. The NQA server listens and responds to requests on the specified IP addresses and ports.

You can configure multiple TCP or UDP listening services on an NQA server, where each corresponds to a specific IP address and port number.

The IP address and port number for a listening service must be unique on the NQA server and match the configuration on the NQA client.

Procedure

1. Enter system view.
   `system-view`
2. Enable the NQA server.
   `nqa server enable`
   By default, the NQA server is disabled.
3. Configure a TCP listening service.
   `nqa server tcp-connect` *`ip-address port-number`* [**`tos`** *`tos`*]
   This task is required for only TCP operations.
4. Configure a UDP listening service.
   `nqa server udp-echo` *`ip-address port-number`* [**`tos`** *`tos`*]
   This task is required for only UDP echo, UDP jitter, and voice operations.

Enabling the NQA client

1. Enter system view.
   `system-view`
2. Enable the NQA client.
   `nqa agent enable`
   By default, the NQA client is enabled.
   The NQA client configuration takes effect after you enable the NQA client.

Configuring NQA operations on the NQA client

NQA operations tasks at a glance

To configure NQA operations, perform the following tasks:

1. Configuring an NQA operation
   - Configuring the ICMP echo operation

- Configuring the ICMP jitter operation
- Configuring the DHCP operation
- Configuring the DNS operation
- Configuring the FTP operation
- Configuring the HTTP operation
- Configuring the UDP jitter operation
- Configuring the SNMP operation
- Configuring the TCP operation
- Configuring the UDP echo operation
- Configuring the UDP tracert operation
- Configuring the voice operation
- Configuring the DLSw operation
- Configuring the path jitter operation

2. (Optional.) Configuring optional parameters for the NQA operation
3. (Optional.) Configuring the collaboration feature
4. (Optional.) Configuring threshold monitoring
5. (Optional.) Configuring the NQA statistics collection feature
6. (Optional.) Configuring the saving of NQA history records
7. Scheduling the NQA operation on the NQA client

Configuring the ICMP echo operation

About the ICMP echo operation

The ICMP echo operation measures the reachability of a destination device. It has the same function as the **ping** command, but provides more output information. In addition, if multiple paths exist between the source and destination devices, you can specify the next hop for the ICMP echo operation.

The ICMP echo operation sends an ICMP echo request to the destination device per probe.

Procedure

1. Enter system view.
   system-view
2. Create an NQA operation and enter NQA operation view.
   nqa entry *admin-name operation-tag*
3. Specify the ICMP echo type and enter its view.
   type icmp-echo
4. Specify the destination IP address for ICMP echo requests.
   IPv4:
   destination ip *ip-address*
   IPv6:
   destination ipv6 *ipv6-address*
   By default, no destination IP address is specified.
5. Specify the source IP address for ICMP echo requests. Choose one of the following tasks:
   - Use the IP address of the specified interface as the source IP address.
     source interface *interface-type interface-number*

By default, the source IP address of ICMP echo requests is the primary IP address of their output interface.

The specified source interface must be up.

- Specify the source IPv4 address.

  source ip *ip-address*

  By default, the source IPv4 address of ICMP echo requests is the primary IPv4 address of their output interface.

  The specified source IPv4 address must be the IPv4 address of a local interface, and the interface must be up. Otherwise, no probe packets can be sent out.

- Specify the source IPv6 address.

  source ipv6 *ipv6-address*

  By default, the source IPv6 address of ICMP echo requests is the primary IPv6 address of their output interface.

  The specified source IPv6 address must be the IPv6 address of a local interface, and the interface must be up. Otherwise, no probe packets can be sent out.

6. Specify the output interface or the next hop IP address for ICMP echo requests. Choose one of the following tasks:
   - Specify the output interface for ICMP echo requests.

     out interface *interface-type interface-number*

     By default, the output interface for ICMP echo requests is not specified. The NQA client determines the output interface based on the routing table lookup.

   - Specify the next hop IPv4 address.

     next-hop ip *ip-address*

     By default, no next hop IPv4 address is specified.

   - Specify the next hop IPv6 address.

     next-hop ipv6 *ipv6-address*

     By default, no next hop IPv6 address is specified.
7. (Optional.) Set the payload size for each ICMP echo request.

   data-size *size*

   The default payload size is 100 bytes.
8. (Optional.) Specify the payload fill string for ICMP echo requests.

   data-fill *string*

   The default payload fill string is the hexadecimal string 00010203040506070809.

Configuring the ICMP jitter operation

About the ICMP jitter operation

The ICMP jitter operation measures unidirectional and bidirectional jitters. The operation result helps you to determine whether the network can carry jitter-sensitive services such as real-time voice and video services.

The ICMP jitter operation works as follows:

1. The NQA client sends ICMP packets to the destination device.
2. The destination device time stamps each packet it receives, and then sends the packet back to the NQA client.
3. Upon receiving the responses, the NQA client calculates the jitter according to the timestamps.

The ICMP jitter operation sends a number of ICMP packets to the destination device per probe. The number of packets to send is determined by using the **probe packet-number** command.

Restrictions and guidelines

The **display nqa history** command does not display the results or statistics of the ICMP jitter operation. To view the results or statistics of the operation, use the **display nqa result** or **display nqa statistics** command.

Before starting the operation, make sure the network devices are time synchronized by using NTP. For more information about NTP, see "Configuring NTP."

Procedure

1. Enter system view.
   system-view
2. Create an NQA operation and enter NQA operation view.
   nqa entry *admin-name operation-tag*
3. Specify the ICMP jitter type and enter its view.
   type icmp-jitter
4. Specify the destination IP address for ICMP packets.
   destination ip *ip-address*

   By default, no destination IP address is specified.
5. Set the number of ICMP packets sent per probe.
   probe packet-number *packet-number*

   The default setting is 10.
6. Set the interval for sending ICMP packets.
   probe packet-interval *interval*

   The default setting is 20 milliseconds.
7. Specify how long the NQA client waits for a response from the server before it regards the response times out.
   probe packet-timeout *timeout*

   The default setting is 3000 milliseconds.
8. Specify the source IP address for ICMP packets.
   source ip *ip-address*

   By default, the source IP address of ICMP packets is the primary IP address of their output interface.

   The source IP address must be the IP address of a local interface, and the interface must be up. Otherwise, no ICMP packets can be sent out.

Configuring the DHCP operation

About the DHCP operation

The DHCP operation measures whether or not the DHCP server can respond to client requests. DHCP also measures the amount of time it takes the NQA client to obtain an IP address from a DHCP server.

The NQA client simulates the DHCP relay agent to forward DHCP requests for IP address acquisition from the DHCP server. The interface that performs the DHCP operation does not change its IP address. When the DHCP operation completes, the NQA client sends a packet to release the obtained IP address.

The DHCP operation acquires an IP address from the DHCP server per probe.

Procedure

1. Enter system view.
   system-view
2. Create an NQA operation and enter NQA operation view.
   nqa entry *admin-name operation-tag*
3. Specify the DHCP type and enter its view.
   type dhcp
4. Specify the IP address of the DHCP server as the destination IP address of DHCP packets.
   destination ip *ip-address*
   By default, no destination IP address is specified.
5. Specify the output interface for DHCP request packets.
   out interface *interface-type interface-number*
   By default, the NQA client determines the output interface based on the routing table lookup.
6. Specify the source IP address of DHCP request packets.
   source ip *ip-address*
   By default, the source IP address of DHCP request packets is the primary IP address of their output interface.
   The specified source IP address must be the IP address of a local interface, and the local interface must be up. Otherwise, no probe packets can be sent out.

Configuring the DNS operation

About the DNS operation

The DNS operation simulates domain name resolution, and it measures the time for the NQA client to resolve a domain name into an IP address through a DNS server. The obtained DNS entry is not saved.

The DNS operation resolves a domain name into an IP address per probe.

Procedure

1. Enter system view.
   system-view
2. Create an NQA operation and enter NQA operation view.
   nqa entry *admin-name operation-tag*
3. Specify the DNS type and enter its view.
   type dns
4. Specify the IP address of the DNS server as the destination IP address of DNS packets.
   destination ip *ip-address*
   By default, no destination IP address is specified.
5. Specify the domain name to be translated.
   resolve-target *domain-name*
   By default, no domain name is specified.

Configuring the FTP operation

About the FTP operation

The FTP operation measures the time for the NQA client to transfer a file to or download a file from an FTP server.

The FTP operation uploads or downloads a file from an FTP server per probe.

Restrictions and guidelines

To upload (**put**) a file to the FTP server, use the **filename** command to specify the name of the file you want to upload. The file must exist on the NQA client.

To download (**get**) a file from the FTP server, include the name of the file you want to download in the **url** command. The file must exist on the FTP server. The NQA client does not save the file obtained from the FTP server.

Use a small file for the FTP operation. A big file might result in transfer failure because of timeout, or might affect other services because of the amount of network bandwidth it occupies.

Procedure

1. Enter system view.
   system-view
2. Create an NQA operation and enter NQA operation view.
   nqa entry *admin-name operation-tag*
3. Specify the FTP type and enter its view.
   type ftp
4. Specify an FTP login username.
   username *username*

   By default, no FTP login username is specified.
5. Specify an FTP login password.
   password { **cipher** | **simple** } *string*

   By default, no FTP login password is specified.
6. Specify the source IP address for FTP request packets.
   source ip *ip-address*

   By default, the source IP address of FTP request packets is the primary IP address of their output interface.

   The source IP address must be the IP address of a local interface, and the interface must be up. Otherwise, no FTP requests can be sent out.
7. Set the data transmission mode.
   mode { **active** | **passive** }

   The default mode is **active**.
8. Specify the FTP operation type.
   operation { **get** | **put** }

   The default FTP operation type is **get**.
9. Specify the destination URL for the FTP operation.
   url *url*

   By default, no destination URL is specified for an FTP operation.

   Enter the URL in one of the following formats:

   - ftp://*host*/*filename*.

- ftp://*host:port*/*filename*.

The *filename* argument is required only for the **get** operation.

10. Specify the name of the file to be uploaded.

filename *file-name*

By default, no file is specified.

This task is required only for the **put** operation.

The configuration does not take effect for the **get** operation.

Configuring the HTTP operation

About the HTTP operation

The HTTP operation measures the time for the NQA client to obtain responses from an HTTP server.

The HTTP operation supports the following operation types:

- **Get**—Retrieves data such as a Web page from the HTTP server.
- **Post**—Sends data to the HTTP server for processing.
- **Raw**—Sends a user-defined HTTP request to the HTTP server. You must manually configure the content of the HTTP request to be sent.

The HTTP operation completes the operation of the specified type per probe.

Procedure

1. Enter system view.

system-view

2. Create an NQA operation and enter NQA operation view.

nqa entry *admin-name operation-tag*

3. Specify the HTTP type and enter its view.

type http

4. Specify the destination URL for the HTTP operation.

url *url*

By default, no destination URL is specified for an HTTP operation.

Enter the URL in one of the following formats:

- http://*host*/*resource*
- http://*host:port/resource*

5. Specify an HTTP login username.

username *username*

By default, no HTTP login username is specified.

6. Specify an HTTP login password.

password { **cipher** | **simple** } *string*

By default, no HTTP login password is specified.

7. Specify the HTTP version.

version { **v1.0** | **v1.1** }

By default, HTTP 1.0 is used.

8. Specify the HTTP operation type.

operation { **get** | **post** | **raw** }

The default HTTP operation type is **get**.

If you set the operation type to **raw**, the client pads the content configured in raw request view to the HTTP request to send to the HTTP server.

9. Configure the HTTP raw request.
   a. Enter raw request view.

      raw-request

      Every time you enter raw request view, the previously configured raw request content is cleared.

   b. Enter or paste the request content.

      By default, no request content is configured.

      To ensure successful operations, make sure the request content does not contain command aliases configured by using the **alias** command. For more information about the **alias** command, see CLI commands in *Fundamentals Command Reference*.

   c. Save the input and return to HTTP operation view:

      quit

   This step is required only when the operation type is set to **raw**.
10. Specify the source IP address for the HTTP packets.

    source ip *ip-address*

    By default, the source IP address of HTTP packets is the primary IP address of their output interface.

    The source IP address must be the IP address of a local interface, and the interface must be up. Otherwise, no request packets can be sent out.

Configuring the UDP jitter operation

About the UDP jitter operation

The UDP jitter operation measures unidirectional and bidirectional jitters. The operation result helps you determine whether the network can carry jitter-sensitive services such as real-time voice and video services.

The UDP jitter operation works as follows:

1. The NQA client sends UDP packets to the destination port.
2. The destination device time stamps each packet it receives, and then sends the packet back to the NQA client.
3. Upon receiving the responses, the NQA client calculates the jitter according to the timestamps.

The UDP jitter operation sends a number of UDP packets to the destination device per probe. The number of packets to send is determined by using the **probe packet-number** command.

The UDP jitter operation requires both the NQA server and the NQA client. Before you perform the UDP jitter operation, configure the UDP listening service on the NQA server. For more information about UDP listening service configuration, see "Configuring the NQA server."

Restrictions and guidelines

To ensure successful UDP jitter operations and avoid affecting existing services, do not perform the operations on well-known ports from 1 to 1023.

The **display nqa history** command does not display the results or statistics of the UDP jitter operation. To view the results or statistics of the UDP jitter operation, use the **display nqa result** or **display nqa statistics** command.

Before starting the operation, make sure the network devices are time synchronized by using NTP. For more information about NTP, see "Configuring NTP."

Procedure

1. Enter system view.
   system-view
2. Create an NQA operation and enter NQA operation view.
   nqa entry *admin-name operation-tag*
3. Specify the UDP jitter type and enter its view.
   type udp-jitter
4. Specify the destination IP address for UDP packets.
   destination ip *ip-address*

   By default, no destination IP address is specified.

   The destination IP address must be the same as the IP address of the UDP listening service configured on the NQA server. To configure a UDP listening service on the server, use the **nqa server udp-echo** command.
5. Specify the destination port number for UDP packets.
   destination port *port-number*

   By default, no destination port number is specified.

   The destination port number must be the same as the port number of the UDP listening service configured on the NQA server. To configure a UDP listening service on the server, use the **nqa server udp-echo** command.
6. Specify the source IP address for UDP packets.
   source ip *ip-address*

   By default, the source IP address of UDP packets is the primary IP address of their output interface.

   The source IP address must be the IP address of a local interface, and the interface must be up. Otherwise, no UDP packets can be sent out.
7. Specify the source port number for UDP packets.
   source port *port-number*

   By default, the NQA client randomly picks an unused port as the source port when the operation starts.
8. Set the number of UDP packets sent per probe.
   probe packet-number *packet-number*

   The default setting is 10.
9. Set the interval for sending UDP packets.
   probe packet-interval *interval*

   The default setting is 20 milliseconds.
10. Specify how long the NQA client waits for a response from the server before it regards the response times out.
    probe packet-timeout *timeout*

    The default setting is 3000 milliseconds.
11. (Optional.) Set the payload size for each UDP packet.
    data-size *size*

    The default payload size is 100 bytes.
12. (Optional.) Specify the payload fill string for UDP packets.
    data-fill *string*

    The default payload fill string is the hexadecimal string 00010203040506070809.

Configuring the SNMP operation

About the SNMP operation

The SNMP operation tests whether the SNMP service is available on an SNMP agent.

The SNMP operation sends one SNMPv1 packet, one SNMPv2c packet, and one SNMPv3 packet to the SNMP agent per probe.

Procedure

1. Enter system view.

   system-view
2. Create an NQA operation and enter NQA operation view.

   nqa entry *admin-name operation-tag*
3. Specify the SNMP type and enter its view.

   type snmp
4. Specify the destination address for SNMP packets.

   destination ip *ip-address*

   By default, no destination IP address is specified.
5. Specify the source IP address for SNMP packets.

   source ip *ip-address*

   By default, the source IP address of SNMP packets is the primary IP address of their output interface.

   The source IP address must be the IP address of a local interface, and the interface must be up. Otherwise, no SNMP packets can be sent out.
6. Specify the source port number for SNMP packets.

   source port *port-number*

   By default, the NQA client randomly picks an unused port as the source port when the operation starts.
7. Specify the community name carried in the SNMPv1 and SNMPv2c packets.

   community read { **cipher** | **simple** } *community-name*

   By default, the SNMPv1 and SNMPv2c packets carry community name **public**.

   Make sure the specified community name is the same as the community name configured on the SNMP agent.

Configuring the TCP operation

About the TCP operation

The TCP operation measures the time for the NQA client to establish a TCP connection to a port on the NQA server.

The TCP operation requires both the NQA server and the NQA client. Before you perform a TCP operation, configure a TCP listening service on the NQA server. For more information about the TCP listening service configuration, see "Configuring the NQA server."

The TCP operation sets up a TCP connection per probe.

Procedure

1. Enter system view.

   system-view
2. Create an NQA operation and enter NQA operation view.

nqa entry *admin-name operation-tag*

3. Specify the TCP type and enter its view.

   type tcp

4. Specify the destination address for TCP packets.

   destination ip *ip-address*

   By default, no destination IP address is specified.

   The destination address must be the same as the IP address of the TCP listening service configured on the NQA server. To configure a TCP listening service on the server, use the **nqa server tcp-connect** command.

5. Specify the destination port for TCP packets.

   destination port *port-number*

   By default, no destination port number is configured.

   The destination port number must be the same as the port number of the TCP listening service configured on the NQA server. To configure a TCP listening service on the server, use the **nqa server tcp-connect** command.

6. Specify the source IP address for TCP packets.

   source ip *ip-address*

   By default, the source IP address of TCP packets is the primary IP address of their output interface.

   The source IP address must be the IP address of a local interface, and the interface must be up. Otherwise, no TCP packets can be sent out.

Configuring the UDP echo operation

About the UDP echo operation

The UDP echo operation measures the round-trip time between the client and a UDP port on the NQA server.

The UDP echo operation requires both the NQA server and the NQA client. Before you perform a UDP echo operation, configure a UDP listening service on the NQA server. For more information about the UDP listening service configuration, see "Configuring the NQA server."

The UDP echo operation sends a UDP packet to the destination device per probe.

Procedure

1. Enter system view.

   system-view

2. Create an NQA operation and enter NQA operation view.

   nqa entry *admin-name operation-tag*

3. Specify the UDP echo type and enter its view.

   type udp-echo

4. Specify the destination address for UDP packets.

   destination ip *ip-address*

   By default, no destination IP address is specified.

   The destination address must be the same as the IP address of the UDP listening service configured on the NQA server. To configure a UDP listening service on the server, use the **nqa server udp-echo** command.

5. Specify the destination port number for UDP packets.

   destination port *port-number*

By default, no destination port number is specified.

The destination port number must be the same as the port number of the UDP listening service configured on the NQA server. To configure a UDP listening service on the server, use the **nqa server udp-echo** command.

6. Specify the source IP address for UDP packets.

   source ip *ip-address*

   By default, the source IP address of UDP packets is the primary IP address of their output interface.

   The source IP address must be the IP address of a local interface, and the interface must be up. Otherwise, no UDP packets can be sent out.

7. Specify the source port number for UDP packets.

   source port *port-number*

   By default, the NQA client randomly picks an unused port as the source port when the operation starts.

8. (Optional.) Set the payload size for each UDP packet.

   data-size *size*

   The default setting is 100 bytes.

9. (Optional.) Specify the payload fill string for UDP packets.

   data-fill *string*

   The default payload fill string is the hexadecimal string 00010203040506070809.

Configuring the UDP tracert operation

About the UDP tracert operation

The UDP tracert operation determines the routing path from the source device to the destination device.

The UDP tracert operation sends a UDP packet to a hop along the path per probe.

Restrictions and guidelines

The UDP tracert operation is not supported on IPv6 networks. To determine the routing path that the IPv6 packets traverse from the source to the destination, use the **tracert ipv6** command. For more information about the command, see *Network Management and Monitoring Command Reference.*

Prerequisites

Before you configure the UDP tracert operation, you must perform the following tasks:

- Enable sending ICMP time exceeded messages on the intermediate devices between the source and destination devices. If the intermediate devices are H3C devices, use the **ip ttl-expires enable** command.
- Enable sending ICMP destination unreachable messages on the destination device. If the destination device is an H3C device, use the **ip unreachables enable** command.

  For more information about the **ip ttl-expires enable** and **ip unreachables enable** commands, see *Layer 3—IP Services Command Reference*.

Procedure

1. Enter system view.

   system-view

2. Create an NQA operation and enter NQA operation view.

nqa entry *admin-name operation-tag*

3. Specify the UDP tracert operation type and enter its view.

   type udp-tracert

4. Specify the destination device for the operation. Choose one of the following tasks:
   - Specify the destination device by its host name.

     destination host *host-name*

     By default, no destination host name is specified.
   - Specify the destination device by its IP address.

     destination ip *ip-address*

     By default, no destination IP address is specified.

5. Specify the destination port number for UDP packets.

   destination port *port-number*

   By default, the destination port number is 33434.

   This port number must be an unused number on the destination device, so that the destination device can reply with ICMP port unreachable messages.

6. Specify an output interface for UDP packets.

   out interface *interface-type interface-number*

   By default, the NQA client determines the output interface based on the routing table lookup.

7. Specify the source IP address for UDP packets.
   - Specify the IP address of the specified interface as the source IP address.

     source interface *interface-type interface-number*

     By default, the source IP address of UDP packets is the primary IP address of their output interface.
   - Specify the source IP address.

     source ip *ip-address*

     The specified source interface must be up. The source IP address must be the IP address of a local interface, and the local interface must be up. Otherwise, no probe packets can be sent out.

8. Specify the source port number for UDP packets.

   source port *port-number*

   By default, the NQA client randomly picks an unused port as the source port when the operation starts.

9. Set the maximum number of consecutive probe failures.

   max-failure *times*

   The default setting is 5.

10. Set the initial TTL value for UDP packets.

    init-ttl *value*

    The default setting is 1.

11. (Optional.) Set the payload size for each UDP packet.

    data-size *size*

    The default setting is 100 bytes.

12. (Optional.) Enable the no-fragmentation feature.

    no-fragment enable

    By default, the no-fragmentation feature is disabled.

Configuring the voice operation

About the voice operation

The voice operation measures VoIP network performance.

The voice operation works as follows:

1. The NQA client sends voice packets at sending intervals to the destination device (NQA server).

   The voice packets are of one of the following codec types:

   - G.711 A-law.
   - G.711 μ-law.
   - G.729 A-law.

2. The destination device time stamps each voice packet it receives and sends it back to the source.
3. Upon receiving the packet, the source device calculates the jitter and one-way delay based on the timestamp.

The voice operation sends a number of voice packets to the destination device per probe. The number of packets to send per probe is determined by using the **probe packet-number** command.

The following parameters that reflect VoIP network performance can be calculated by using the metrics gathered by the voice operation:

- **Calculated Planning Impairment Factor (ICPIF)**—Measures impairment to voice quality on a VoIP network. It is decided by packet loss and delay. A higher value represents a lower service quality.
- **Mean Opinion Scores (MOS)**—A MOS value can be evaluated by using the ICPIF value, in the range of 1 to 5. A higher value represents a higher service quality.

The evaluation of voice quality depends on users' tolerance for voice quality. For users with higher tolerance for voice quality, use the **advantage-factor** command to set an advantage factor. When the system calculates the ICPIF value, it subtracts the advantage factor to modify ICPIF and MOS values for voice quality evaluation.

The voice operation requires both the NQA server and the NQA client. Before you perform a voice operation, configure a UDP listening service on the NQA server. For more information about UDP listening service configuration, see "Configuring the NQA server."

Restrictions and guidelines

To ensure successful voice operations and avoid affecting existing services, do not perform the operations on well-known ports from 1 to 1023.

The **display nqa history** command does not display the results or statistics of the voice operation. To view the results or statistics of the voice operation, use the **display nqa result** or **display nqa statistics** command.

Before starting the operation, make sure the network devices are time synchronized by using NTP. For more information about NTP, see "Configuring NTP."

Procedure

1. Enter system view.

   system-view

2. Create an NQA operation and enter NQA operation view.

   nqa entry *admin-name operation-tag*

3. Specify the voice type and enter its view.

type voice

4. Specify the destination IP address for voice packets.

   destination ip *ip-address*

   By default, no destination IP address is configured.

   The destination IP address must be the same as the IP address of the UDP listening service configured on the NQA server. To configure a UDP listening service on the server, use the **nqa server udp-echo** command.

5. Specify the destination port number for voice packets.

   destination port *port-number*

   By default, no destination port number is configured.

   The destination port number must be the same as the port number of the UDP listening service configured on the NQA server. To configure a UDP listening service on the server, use the **nqa server udp-echo** command.

6. Specify the source IP address for voice packets.

   source ip *ip-address*

   By default, the source IP address of voice packets is the primary IP address of their output interface.

   The source IP address must be the IP address of a local interface, and the interface must be up. Otherwise, no voice packets can be sent out.

7. Specify the source port number for voice packets.

   source port *port-number*

   By default, the NQA client randomly picks an unused port as the source port when the operation starts.

8. Configure the basic voice operation parameters.
   - Specify the codec type.

     codec-type { **g711a** | **g711u** | **g729a** }

     By default, the codec type is G.711 A-law.
   - Set the advantage factor for calculating MOS and ICPIF values.

     advantage-factor *factor*

     By default, the advantage factor is 0.

9. Configure the probe parameters for the voice operation.
   - Set the number of voice packets to be sent per probe.

     probe packet-number *packet-number*

     The default setting is 1000.
   - Set the interval for sending voice packets.

     probe packet-interval *interval*

     The default setting is 20 milliseconds.
   - Specify how long the NQA client waits for a response from the server before it regards the response times out.

     probe packet-timeout *timeout*

     The default setting is 5000 milliseconds.

10. Configure the payload parameters.

    a. Set the payload size for voice packets.

    data-size *size*

    By default, the voice packet size varies by codec type. The default packet size is 172 bytes for G.711A-law and G.711 μ-law codec type, and 32 bytes for G.729 A-law codec type.

b. (Optional.) Specify the payload fill string for voice packets.

data-fill *string*

The default payload fill string is the hexadecimal string 00010203040506070809.

Configuring the DLSw operation

About the DLSw operation

The DLSw operation measures the response time of a DLSw device.

It sets up a DLSw connection to the DLSw device per probe.

Procedure

1. Enter system view.

   system-view

2. Create an NQA operation and enter NQA operation view.

   nqa entry *admin-name operation-tag*

3. Specify the DLSw type and enter its view.

   type dlsw

4. Specify the destination IP address for the probe packets.

   destination ip *ip-address*

   By default, no destination IP address is specified.

5. Specify the source IP address for the probe packets.

   source ip *ip-address*

   By default, the source IP address of the probe packets is the primary IP address of their output interface.

   The source IP address must be the IP address of a local interface, and the interface must be up. Otherwise, no probe packets can be sent out.

Configuring the path jitter operation

About the path jitter operation

The path jitter operation measures the jitter, negative jitters, and positive jitters from the NQA client to each hop on the path to the destination.

The path jitter operation performs the following steps per probe:

1. Obtains the path from the NQA client to the destination through tracert. A maximum of 64 hops can be detected.
2. Sends a number of ICMP echo requests to each hop along the path. The number of ICMP echo requests to send is set by using the **probe packet-number** command.

Prerequisites

Before you configure the path jitter operation, you must perform the following tasks:

- Enable sending ICMP time exceeded messages on the intermediate devices between the source and destination devices. If the intermediate devices are H3C devices, use the **ip ttl-expires enable** command.
- Enable sending ICMP destination unreachable messages on the destination device. If the destination device is an H3C device, use the **ip unreachables enable** command.

  For more information about the **ip ttl-expires enable** and **ip unreachables enable** commands, see *Layer 3—IP Services Command Reference*.

Procedure

1. Enter system view.
   system-view
2. Create an NQA operation and enter NQA operation view.
   nqa entry *admin-name operation-tag*
3. Specify the path jitter type and enter its view.
   type path-jitter
4. Specify the destination IP address for ICMP echo requests.
   destination ip *ip-address*
   By default, no destination IP address is specified.
5. Specify the source IP address for ICMP echo requests.
   source ip *ip-address*
   By default, the source IP address of ICMP echo requests is the primary IP address of their output interface.
   The source IP address must be the IP address of a local interface, and the interface must be up. Otherwise, no ICMP echo requests can be sent out.
6. Configure the probe parameters for the path jitter operation.
   a. Set the number of ICMP echo requests to be sent per probe.
      probe packet-number *packet-number*
      The default setting is 10.
   b. Set the interval for sending ICMP echo requests.
      probe packet-interval *interval*
      The default setting is 20 milliseconds.
   c. Specify how long the NQA client waits for a response from the server before it regards the response times out.
      probe packet-timeout *timeout*
      The default setting is 3000 milliseconds.
7. (Optional.) Specify an LSR path.
   lsr-path *ip-address*&<1-8>
   By default, no LSR path is specified.
   The path jitter operation uses tracert to detect the LSR path to the destination, and sends ICMP echo requests to each hop on the LSR path.
8. Perform the path jitter operation only on the destination address.
   target-only
   By default, the path jitter operation is performed on each hop on the path to the destination.
9. (Optional.) Set the payload size for each ICMP echo request.
   data-size *size*
   The default setting is 100 bytes.
10. (Optional.) Specify the payload fill string for ICMP echo requests.
    data-fill *string*
    The default payload fill string is the hexadecimal string 00010203040506070809.

Configuring optional parameters for the NQA operation

Restrictions and guidelines

Unless otherwise specified, the following optional parameters apply to all types of NQA operations.

The parameter settings take effect only on the current operation.

Procedure

1. Enter system view.

   system-view

2. Enter the view of an existing NQA operation.

   nqa entry *admin-name operation-tag*

3. Configure a description for the operation.

   description *text*

   By default, no description is configured.

4. Set the interval at which the NQA operation repeats.

   frequency *interval*

   For a voice or path jitter operation, the default setting is 60000 milliseconds.

   For other types of operations, the default setting is 0 milliseconds, and only one operation is performed.

   When the interval expires, but the operation is not completed or is not timed out, the next operation does not start.

5. Specify the probe times.

   probe count *times*

   In an UDP tracert operation, the NQA client performs three probes to each hop to the destination by default.

   In other types of operations, the NQA client performs one probe to the destination per operation by default.

   This command is not available for the voice and path jitter operations. Each of these operations performs only one probe.

6. Set the probe timeout time.

   probe timeout *timeout*

   The default setting is 3000 milliseconds.

   This command is not available for the ICMP jitter, UDP jitter, voice, or path jitter operations.

7. Set the maximum number of hops that the probe packets can traverse.

   ttl *value*

   The default setting is 30 for probe packets of the UDP tracert operation, and is 20 for probe packets of other types of operations.

   This command is not available for the DHCP or path jitter operations.

8. Set the ToS value in the IP header of the probe packets.

   tos *value*

   The default setting is 0.

9. Enable the routing table bypass feature.

   route-option bypass-route

   By default, the routing table bypass feature is disabled.

   This command is not available for the DHCP or path jitter operations.

This command does not take effect if the destination address of the NQA operation is an IPv6 address.

Configuring the collaboration feature

About the collaboration feature

Collaboration is implemented by associating a reaction entry of an NQA operation with a track entry. The reaction entry monitors the NQA operation. If the number of operation failures reaches the specified threshold, the configured action is triggered.

Restrictions and guidelines

The collaboration feature is not available for the following types of operations:

- ICMP jitter operation.
- UDP jitter operation.
- UDP tracert operation.
- Voice operation.
- Path jitter operation.

Procedure

1. Enter system view.

   system-view
2. Enter the view of an existing NQA operation.

   nqa entry *admin-name operation-tag*
3. Configure a reaction entry.

   reaction *item-number* **checked-element probe-fail threshold-type consecutive** *consecutive-occurrences* **action-type trigger-only**

   You cannot modify the content of an existing reaction entry.
4. Return to system view.

   quit
5. Associate Track with NQA.

   For information about the configuration, see *High Availability Configuration Guide*.
6. Associate Track with an application module.

   For information about the configuration, see *High Availability Configuration Guide*.

Configuring threshold monitoring

About threshold monitoring

This feature allows you to monitor the NQA operation running status.

An NQA operation supports the following threshold types:

- **average**—If the average value for the monitored performance metric either exceeds the upper threshold or goes below the lower threshold, a threshold violation occurs.
- **accumulate**—If the total number of times that the monitored performance metric is out of the specified value range reaches or exceeds the specified threshold, a threshold violation occurs.
- **consecutive**—If the number of consecutive times that the monitored performance metric is out of the specified value range reaches or exceeds the specified threshold, a threshold violation occurs.

Threshold violations for the average or accumulate threshold type are determined on a per NQA operation basis. The threshold violations for the consecutive type are determined from the time the NQA operation starts.

The following actions might be triggered:

- **none**—NQA displays results only on the terminal screen. It does not send traps to the NMS.
- **trap-only**—NQA displays results on the terminal screen, and meanwhile it sends traps to the NMS.

  To send traps to the NMS, the NMS address must be specified by using the **snmp-agent target-host** command. For more information about the command, see *Network Management and Monitoring Command Reference*.
- **trigger-only**—NQA displays results on the terminal screen, and meanwhile triggers other modules for collaboration.

In a reaction entry, configure a monitored element, a threshold type, and an action to be triggered to implement threshold monitoring.

The state of a reaction entry can be invalid, over-threshold, or below-threshold.

- Before an NQA operation starts, the reaction entry is in invalid state.
- If the threshold is violated, the state of the entry is set to over-threshold. Otherwise, the state of the entry is set to below-threshold.

Restrictions and guidelines

The threshold monitoring feature is not available for the path jitter operations.

Procedure

1. Enter system view.

   system-view
2. Enter the view of an existing NQA operation.

   nqa entry *admin-name operation-tag*
3. Enable sending traps to the NMS when specific conditions are met.

   reaction trap { **path-change** | **probe-failure** *consecutive-probe-failures* | **test-complete** | **test-failure** [*accumulate-probe-failures*] }

   By default, no traps are sent to the NMS.

   The ICMP jitter, UDP jitter, and voice operations support only the **test-complete** keyword.

   The following parameters are not available for the UDP tracert operation:

   - The **probe-failure** *consecutive-probe-failures* option.
   - The *accumulate-probe-failures* argument.
4. Configure threshold monitoring. Choose the options to configure as needed:

   - Monitor the operation duration.

     reaction *item-number* **checked-element probe-duration threshold-type** { **accumulate** *accumulate-occurrences* | **average** | **consecutive** *consecutive-occurrences* } **threshold-value** *upper-threshold lower-threshold* [**action-type** { **none** | **trap-only** }]

     This reaction entry is not supported in the ICMP jitter, UDP jitter, UDP tracert, or voice operations
   - Monitor failure times.

     reaction *item-number* **checked-element probe-fail threshold-type** { **accumulate** *accumulate-occurrences* | **consecutive** *consecutive-occurrences* } [**action-type** { **none** | **trap-only** }]

This reaction entry is not supported in the ICMP jitter, UDP jitter, UDP tracert, or voice operations.

- Monitor the round-trip time.

  reaction *item-number* **checked-element rtt threshold-type** { **accumulate** *accumulate-occurrences* | **average** } **threshold-value** *upper-threshold lower-threshold* [**action-type** { **none** | **trap-only** }]

  Only the ICMP jitter, UDP jitter, and voice operations support this reaction entry.

- Monitor packet loss.

  reaction *item-number* **checked-element packet-loss threshold-type accumulate** *accumulate-occurrences* [**action-type** { **none** | **trap-only** }]

  Only the ICMP jitter, UDP jitter, and voice operations support this reaction entry.

- Monitor the one-way jitter.

  reaction *item-number* **checked-element** { **jitter-ds** | **jitter-sd** } **threshold-type** { **accumulate** *accumulate-occurrences* | **average** } **threshold-value** *upper-threshold lower-threshold* [**action-type** { **none** | **trap-only** }]

  Only the ICMP jitter, UDP jitter, and voice operations support this reaction entry.

- Monitor the one-way delay.

  reaction *item-number* **checked-element** { **owd-ds** | **owd-sd** } **threshold-value** *upper-threshold lower-threshold*

  Only the ICMP jitter, UDP jitter, and voice operations support this reaction entry.

- Monitor the ICPIF value.

  reaction *item-number* **checked-element icpif threshold-value** *upper-threshold lower-threshold* [**action-type** { **none** | **trap-only** }]

  Only the voice operation supports this reaction entry.

- Monitor the MOS value.

  reaction *item-number* **checked-element mos threshold-value** *upper-threshold lower-threshold* [**action-type** { **none** | **trap-only** }]

  Only the voice operation supports this reaction entry.

The DNS operation does not support the action of sending trap messages. For the DNS operation, the action type can only be **none**.

Configuring the NQA statistics collection feature

About NQA statistics collection

NQA forms statistics within the same collection interval as a statistics group. To display information about the statistics groups, use the **display nqa statistics** command.

When the maximum number of statistics groups is reached, the NQA client deletes the oldest statistics group to save a new one.

A statistics group is automatically deleted when its hold time expires.

Restrictions and guidelines

The NQA statistics collection feature is not available for the UDP tracert operations.

If you use the **frequency** command to set the interval to 0 milliseconds for an NQA operation, NQA does not generate any statistics group for the operation.

Procedure

1. Enter system view.
   system-view
2. Enter the view of an existing NQA operation.
   nqa entry *admin-name operation-tag*
3. Set the statistics collection interval.
   statistics interval *interval*
   The default setting is 60 minutes.
4. Set the maximum number of statistics groups that can be saved.
   statistics max-group *number*
   By default, the NQA client can save a maximum of two statistics groups for an operation.
   To disable the NQA statistics collection feature, set the *number* argument to 0.
5. Set the hold time of statistics groups.
   statistics hold-time *hold-time*
   The default setting is 120 minutes.

Configuring the saving of NQA history records

About NQA history record saving

This task enables the NQA client to save NQA history records. You can use the **display nqa history** command to display the NQA history records.

Restrictions and guidelines

The NQA history record saving feature is not available for the following types of operations:

- ICMP jitter operation.
- UDP jitter operation.
- Voice operation.
- Path jitter operation.

Procedure

1. Enter system view.
   system-view
2. Enter the view of an existing NQA operation.
   nqa entry *admin-name operation-tag*
3. Enable the saving of history records for the NQA operation.
   history-record enable
   By default, this feature is enabled only for the UDP tracert operation.
4. Set the lifetime of history records.
   history-record keep-time *keep-time*
   The default setting is 120 minutes.
   A record is deleted when its lifetime is reached.
5. Set the maximum number of history records that can be saved.
   history-record number *number*
   The default setting is 50.

When the maximum number of history records is reached, the system will delete the oldest record to save a new one.

Scheduling the NQA operation on the NQA client

About NQA operation scheduling

The NQA operation runs between the specified start time and end time (the start time plus operation duration). If the specified start time is ahead of the system time, the operation starts immediately. If both the specified start and end time are ahead of the system time, the operation does not start. To display the current system time, use the **`display clock`** command.

Restrictions and guidelines

You cannot enter the operation type view or the operation view of a scheduled NQA operation.

A system time adjustment does not affect started or completed NQA operations. It affects only the NQA operations that have not started.

Procedure

1. Enter system view.

   `system-view`

2. Specify the scheduling parameters for an NQA operation.

   `nqa schedule` *`admin-name operation-tag`* **`start-time`** { *`hh:mm:ss`* [*`yyyy/mm/dd | mm/dd/yyyy`*] | **`now`** } **`lifetime`** { *`lifetime`* | **`forever`** } [**`recurring`**]

Configuring NQA templates on the NQA client

Restrictions and guidelines

Some operation parameters for an NQA template can be specified by the template configuration or the feature that uses the template. When both are specified, the parameters in the template configuration take effect.

NQA template tasks at a glance

To configure NQA templates, perform the following tasks:

1. Perform at least one of the following tasks:
   - Configuring the ICMP template
   - Configuring the DNS template
   - Configuring the TCP template
   - Configuring the TCP half open template
   - Configuring the UDP template
   - Configuring the HTTP template
   - Configuring the HTTPS template
   - Configuring the FTP template
   - Configuring the RADIUS template
   - Configuring the SSL template
2. (Optional.) Configuring optional parameters for the NQA template

Configuring the ICMP template

About the ICMP template

A feature that uses the ICMP template performs the ICMP operation to measure the reachability of a destination device. The ICMP template is supported on both IPv4 and IPv6 networks.

Procedure

1. Enter system view.

   system-view

2. Create an ICMP template and enter its view.

   nqa template icmp *name*

3. Specify the destination IP address for the operation.

   IPv4:

   destination ip *ip-address*

   IPv6:

   destination ipv6 *ipv6-address*

   By default, no destination IP address is configured.

4. Specify the source IP address for ICMP echo requests. Choose one of the following tasks:

   - Use the IP address of the specified interface as the source IP address.

     source interface *interface-type interface-number*

     By default, the primary IP address of the output interface is used as the source IP address of ICMP echo requests.

     The specified source interface must be up.

   - Specify the source IPv4 address.

     source ip *ip-address*

     By default, the primary IPv4 address of the output interface is used as the source IPv4 address of ICMP echo requests.

     The specified source IPv4 address must be the IPv4 address of a local interface, and the interface must be up. Otherwise, no probe packets can be sent out.

   - Specify the source IPv6 address.

     source ipv6 *ipv6-address*

     By default, the primary IPv6 address of the output interface is used as the source IPv6 address of ICMP echo requests.

     The specified source IPv6 address must be the IPv6 address of a local interface, and the interface must be up. Otherwise, no probe packets can be sent out.

5. Specify the next hop IP address for ICMP echo requests.

   IPv4:

   next-hop ip *ip-address*

   IPv6:

   next-hop ipv6 *ipv6-address*

   By default, no IP address of the next hop is configured.

6. Configure the probe result sending on a per-probe basis.

   reaction trigger per-probe

   By default, the probe result is sent to the feature that uses the template after three consecutive failed or successful probes.

If you execute the **reaction trigger per-probe** and **reaction trigger probe-pass** commands multiple times, the most recent configuration takes effect.

If you execute the **reaction trigger per-probe** and **reaction trigger probe-fail** commands multiple times, the most recent configuration takes effect.

7. (Optional.) Set the payload size for each ICMP request.

   data-size *size*

   The default setting is 100 bytes.

8. (Optional.) Specify the payload fill string for ICMP echo requests.

   data-fill *string*

   The default payload fill string is the hexadecimal string 00010203040506070809.

Configuring the DNS template

About the DNS template

A feature that uses the DNS template performs the DNS operation to determine the status of the server. The DNS template is supported on both IPv4 and IPv6 networks.

In DNS template view, you can specify the address expected to be returned. If the returned IP addresses include the expected address, the DNS server is valid and the operation succeeds. Otherwise, the operation fails.

Prerequisites

Create a mapping between the domain name and an address before you perform the DNS operation. For information about configuring the DNS server, see documents about the DNS server configuration.

Procedure

1. Enter system view.

   system-view

2. Create a DNS template and enter DNS template view.

   nqa template dns *name*

3. Specify the destination IP address for the probe packets.

   IPv4:

   destination ip *ip-address*

   IPv6:

   destination ipv6 *ipv6-address*

   By default, no destination address is specified.

4. Specify the destination port number for the probe packets.

   destination port *port-number*

   By default, the destination port number is 53.

5. Specify the source IP address for the probe packets.

   IPv4:

   source ip *ip-address*

   By default, the source IPv4 address of the probe packets is the primary IPv4 address of their output interface.

   The source IPv4 address must be the IPv4 address of a local interface, and the interface must be up. Otherwise, no probe packets can be sent out.

   IPv6:

source ipv6 *ipv6-address*

By default, the source IPv6 address of the probe packets is the primary IPv6 address of their output interface.

The source IPv6 address must be the IPv6 address of a local interface, and the interface must be up. Otherwise, no probe packets can be sent out.

6. Specify the source port number for the probe packets.

   source port *port-number*

   By default, no source port number is specified.

7. Specify the domain name to be translated.

   resolve-target *domain-name*

   By default, no domain name is specified.

8. Specify the domain name resolution type.

   resolve-type { **A** | **AAAA** }

   By default, the type is type A.

   A type A query resolves a domain name to a mapped IPv4 address, and a type AAAA query to a mapped IPv6 address.

9. (Optional.) Specify the IP address that is expected to be returned.

   IPv4:

   expect ip *ip-address*

   IPv6:

   expect ipv6 *ipv6-address*

   By default, no expected IP address is specified.

Configuring the TCP template

About the TCP template

A feature that uses the TCP template performs the TCP operation to test whether the NQA client can establish a TCP connection to a specific port on the server.

In TCP template view, you can specify the expected data to be returned. If you do not specify the expected data, the TCP operation tests only whether the client can establish a TCP connection to the server.

The TCP operation requires both the NQA server and the NQA client. Before you perform a TCP operation, configure a TCP listening service on the NQA server. For more information about the TCP listening service configuration, see "Configuring the NQA server."

Procedure

1. Enter system view.

   system-view

2. Create a TCP template and enter its view.

   nqa template tcp *name*

3. Specify the destination IP address for the probe packets.

   IPv4:

   destination ip *ip-address*

   IPv6:

   destination ipv6 *ipv6-address*

   By default, no destination IP address is specified.

The destination address must be the same as the IP address of the TCP listening service configured on the NQA server. To configure a TCP listening service on the server, use the **nqa server tcp-connect** command.

4. Specify the destination port number for the operation.

   destination port *port-number*

   By default, no destination port number is specified.

   The destination port number must be the same as the port number of the TCP listening service configured on the NQA server. To configure a TCP listening service on the server, use the **nqa server tcp-connect** command.

5. Specify the source IP address for the probe packets.

   IPv4:

   source ip *ip-address*

   By default, the primary IPv4 address of the output interface is used as the source IPv4 address of the probe packets.

   The source IP address must be the IPv4 address of a local interface, and the interface must be up. Otherwise, no probe packets can be sent out.

   IPv6:

   source ipv6 *ipv6-address*

   By default, the primary IPv6 address of the output interface is used as the source IPv6 address of the probe packets.

   The source IPv6 address must be the IPv6 address of a local interface, and the interface must be up. Otherwise, no probe packets can be sent out.

6. (Optional.) Specify the payload fill string for the probe packets.

   data-fill *string*

   The default payload fill string is the hexadecimal string 00010203040506070809.

7. (Optional.) Configure the expected data.

   expect data *expression* [**offset** *number*]

   By default, no expected data is configured.

   The NQA client performs expect data check only when you configure both the **data-fill** and **expect-data** commands.

Configuring the TCP half open template

About the TCP half open template

A feature that uses the TCP half open template performs the TCP half open operation to test whether the TCP service is available on the server. The TCP half open operation is used when the feature cannot get a response from the TCP server through an existing TCP connection.

In the TCP half open operation, the NQA client sends a TCP ACK packet to the server. If the client receives an RST packet, it considers that the TCP service is available on the server.

Procedure

1. Enter system view.

   system-view

2. Create a TCP half open template and enter its view.

   nqa template tcphalfopen *name*

3. Specify the destination IP address of the operation.

   IPv4:

destination ip *ip-address*

IPv6:

destination ipv6 *ipv6-address*

By default, no destination IP address is specified.

The destination address must be the same as the IP address of the TCP listening service configured on the NQA server. To configure a TCP listening service on the server, use the **nqa server tcp-connect** command.

4. Specify the source IP address for the probe packets.

   IPv4:

   source ip *ip-address*

   By default, the primary IPv4 address of the output interface is used as the source IPv4 address of the probe packets.

   The source IPv4 address must be the IPv4 address of a local interface, and the interface must be up. Otherwise, no probe packets can be sent out.

   IPv6:

   source ipv6 *ipv6-address*

   By default, the primary IPv6 address of the output interface is used as the source IPv6 address of the probe packets.

   The source IPv6 address must be the IPv6 address of a local interface, and the interface must be up. Otherwise, no probe packets can be sent out.

5. Specify the next hop IP address for the probe packets.

   IPv4:

   next-hop ip *ip-address*

   IPv6:

   next-hop ipv6 *ipv6-address*

   By default, the IP address of the next hop is configured.

6. Configure the probe result sending on a per-probe basis.

   reaction trigger per-probe

   By default, the probe result is sent to the feature that uses the template after three consecutive failed or successful probes.

   If you execute the **reaction trigger per-probe** and **reaction trigger probe-pass** commands multiple times, the most recent configuration takes effect.

   If you execute the **reaction trigger per-probe** and **reaction trigger probe-fail** commands multiple times, the most recent configuration takes effect.

Configuring the UDP template

About the UDP template

A feature that uses the UDP template performs the UDP operation to test the following items:

- Reachability of a specific port on the NQA server.
- Availability of the requested service on the NQA server.

In UDP template view, you can specify the expected data to be returned. If you do not specify the expected data, the UDP operation tests only whether the client can receive the response packet from the server.

The UDP operation requires both the NQA server and the NQA client. Before you perform a UDP operation, configure a UDP listening service on the NQA server. For more information about the UDP listening service configuration, see "Configuring the NQA server."

Procedure

1. Enter system view.

   system-view

2. Create a UDP template and enter its view.

   nqa template udp *name*

3. Specify the destination IP address of the operation.

   IPv4:

   destination ip *ip-address*

   IPv6:

   destination ipv6 *ipv6-address*

   By default, no destination IP address is specified.

   The destination address must be the same as the IP address of the UDP listening service configured on the NQA server. To configure a UDP listening service on the server, use the **nqa server udp-echo** command.

4. Specify the destination port number for the operation.

   destination port *port-number*

   By default, no destination port number is specified.

   The destination port number must be the same as the port number of the UDP listening service configured on the NQA server. To configure a UDP listening service on the server, use the **nqa server udp-echo** command.

5. Specify the source IP address for the probe packets.

   IPv4:

   source ip *ip-address*

   By default, the primary IPv4 address of the output interface is used as the source IPv4 address of the probe packets.

   The source IP address must be the IPv4 address of a local interface, and the interface must be up. Otherwise, no probe packets can be sent out.

   IPv6:

   source ipv6 *ipv6-address*

   By default, the primary IPv6 address of the output interface is used as the source IPv6 address of the probe packets.

   The source IPv6 address must be the IPv6 address of a local interface, and the interface must be up. Otherwise, no probe packets can be sent out.

6. Specify the payload fill string for the probe packets.

   data-fill *string*

   The default payload fill string is the hexadecimal string 00010203040506070809.

7. (Optional.) Set the payload size for the probe packets.

   data-size *size*

   The default setting is 100 bytes.

8. (Optional.) Configure the expected data.

   expect data *expression* [**offset** *number*]

   By default, no expected data is configured.

Expected data check is performed only when both the **data-fill** command and the **expect data** command are configured.

Configuring the HTTP template

About the HTTP template

A feature that uses the HTTP template performs the HTTP operation to measure the time it takes the NQA client to obtain data from an HTTP server.

The expected data is checked only when the data is configured and the HTTP response contains the Content-Length field in the HTTP header.

The status code of the HTTP packet is a three-digit field in decimal notation, and it includes the status information for the HTTP server. The first digit defines the class of response.

Prerequisites

Before you perform the HTTP operation, you must configure the HTTP server.

Procedure

1. Enter system view.
   system-view
2. Create an HTTP template and enter its view.
   nqa template http *name*
3. Specify the destination URL for the HTTP template.
   url *url*
   By default, no destination URL is specified for an HTTP template.
   Enter the URL in one of the following formats:
   - http://*host*/*resource*
   - http://*host*:*port*/*resource*
4. Specify an HTTP login username.
   username *username*
   By default, no HTTP login username is specified.
5. Specify an HTTP login password.
   password { **cipher** | **simple** } *string*
   By default, no HTTP login password is specified.
6. Specify the HTTP version.
   version { **v1.0** | **v1.1** }
   By default, HTTP 1.0 is used.
7. Specify the HTTP operation type.
   operation { **get** | **post** | **raw** }
   By default, the HTTP operation type is **get**.
   If you set the operation type to raw, the client pads the content configured in raw request view to the HTTP request to send to the HTTP server.
8. Configure the content of the HTTP raw request.
   a. Enter raw request view.
      raw-request
      Every time you enter raw request view, the previously configured raw request content is cleared.

b. Enter or paste the request content.

By default, no request content is configured.

To ensure successful operations, make sure the request content does not contain command aliases configured by using the **alias** command. For more information about the **alias** command, see CLI commands in *Fundamentals Command Reference*.

c. Return to HTTP template view.

quit

The system automatically saves the configuration in raw request view before it returns to HTTP template view.

This step is required only when the operation type is set to **raw**.

9. Specify the source IP address for the probe packets.

IPv4:

source ip *ip-address*

By default, the primary IPv4 address of the output interface is used as the source IPv4 address of the probe packets.

The source IPv4 address must be the IPv4 address of a local interface, and the interface must be up. Otherwise, no probe packets can be sent out.

IPv6:

source ipv6 *ipv6-address*

By default, the primary IPv6 address of the output interface is used as the source IPv6 address of the probe packets.

The source IPv6 address must be the IPv6 address of a local interface, and the interface must be up. Otherwise, no probe packets can be sent out.

10. (Optional.) Configure the expected status codes.

expect status *status-list*

By default, no expected status code is configured.

11. (Optional.) Configure the expected data.

expect data *expression* [**offset** *number*]

By default, no expected data is configured.

Configuring the HTTPS template

About the HTTPS template

A feature that uses the HTTPS template performs the HTTPS operation to measure the time it takes for the NQA client to obtain data from an HTTPS server.

The expected data is checked only when the expected data is configured and the HTTPS response contains the Content-Length field in the HTTPS header.

The status code of the HTTPS packet is a three-digit field in decimal notation, and it includes the status information for the HTTPS server. The first digit defines the class of response.

Prerequisites

Before you perform the HTTPS operation, configure the HTTPS server and the SSL client policy for the SSL client. For information about configuring SSL client policies, see *Security Configuration Guide*.

Procedure

1. Enter system view.

system-view

2. Create an HTTPS template and enter its view.

   nqa template https *name*

3. Specify the destination URL for the HTTPS template.

   url *url*

   By default, no destination URL is specified for an HTTPS template.

   Enter the URL in one of the following formats:

   - https://*host*/*resource*
   - https://*host*:*port*/*resource*

4. Specify an HTTPS login username.

   username *username*

   By default, no HTTPS login username is specified.

5. Specify an HTTPS login password.

   password { **cipher** | **simple** } *string*

   By default, no HTTPS login password is specified.

6. Specify an SSL client policy.

   ssl-client-policy *policy-name*

   By default, no SSL client policy is specified.

7. Specify the HTTPS version.

   version { **v1.0** | **v1.1** }

   By default, HTTPS 1.0 is used.

8. Specify the HTTPS operation type.

   operation { **get** | **post** | **raw** }

   By default, the HTTPS operation type is **get**.

   If you set the operation type to raw, the client pads the content configured in raw request view to the HTTPS request to send to the HTTPS server.

9. Configure the content of the HTTPS raw request.

   a. Enter raw request view.

      raw-request

      Every time you enter raw request view, the previously configured raw request content is cleared.

   b. Enter or paste the request content.

      By default, no request content is configured.

      To ensure successful operations, make sure the request content does not contain command aliases configured by using the **alias** command. For more information about the **alias** command, see CLI commands in *Fundamentals Command Reference*.

   c. Return to HTTPS template view.

      quit

      The system automatically saves the configuration in raw request view before it returns to HTTPS template view.

   This step is required only when the operation type is set to **raw**.

10. Specify the source IP address for the probe packets.

    IPv4:

    source ip *ip-address*

    By default, the primary IPv4 address of the output interface is used as the source IPv4 address of the probe packets.

The source IP address must be the IPv4 address of a local interface, and the interface must be up. Otherwise, no probe packets can be sent out.

IPv6:

source ipv6 *ipv6-address*

By default, the primary IPv6 address of the output interface is used as the source IPv6 address of the probe packets.

The source IPv6 address must be the IPv6 address of a local interface, and the interface must be up. Otherwise, no probe packets can be sent out.

11. (Optional.) Configure the expected data.

expect data *expression* [**offset** *number*]

By default, no expected data is configured.

12. (Optional.) Configure the expected status codes.

expect status *status-list*

By default, no expected status code is configured.

Configuring the FTP template

About the FTP template

A feature that uses the FTP template performs the FTP operation. The operation measures the time it takes the NQA client to transfer a file to or download a file from an FTP server.

Configure the username and password for the FTP client to log in to the FTP server before you perform an FTP operation. For information about configuring the FTP server, see *Fundamentals Configuration Guide*.

Procedure

1. Enter system view.

system-view

2. Create an FTP template and enter its view.

nqa template ftp *name*

3. Specify an FTP login username.

username *username*

By default, no FTP login username is specified.

4. Specify an FTP login password.

password { **cipher** | **simple** } *sting*

By default, no FTP login password is specified.

5. Specify the source IP address for the probe packets.

IPv4:

source ip *ip-address*

By default, the primary IPv4 address of the output interface is used as the source IPv4 address of the probe packets.

The source IP address must be the IPv4 address of a local interface, and the interface must be up. Otherwise, no probe packets can be sent out.

IPv6:

source ipv6 *ipv6-address*

By default, the primary IPv6 address of the output interface is used as the source IPv6 address of the probe packets.

The source IPv6 address must be the IPv6 address of a local interface, and the interface must be up. Otherwise, no probe packets can be sent out.

6. Set the data transmission mode.

   mode { **active** | **passive** }

   The default mode is **active**.

7. Specify the FTP operation type.

   operation { **get** | **put** }

   By default, the FTP operation type is **get**, which means obtaining files from the FTP server.

8. Specify the destination URL for the FTP template.

   url *url*

   By default, no destination URL is specified for an FTP template.

   Enter the URL in one of the following formats:

   - ftp://*host*/*filename*.
   - ftp://*host*:*port*/*filename*.

   When you perform the **get** operation, the file name is required.

   When you perform the **put** operation, the *filename* argument does not take effect, even if it is specified. The file name for the **put** operation is determined by using the **filename** command.

9. Specify the name of a file to be transferred.

   filename *filename*

   By default, no file is specified.

   This task is required only for the **put** operation.

   The configuration does not take effect for the **get** operation.

Configuring the RADIUS template

About template-based RADIUS authentication operation

A feature that uses the RADIUS template performs the RADIUS authentication operation to check the availability of the authentication service on the RADIUS server.

The RADIUS authentication operation workflow is as follows:

1. The NQA client sends an authentication request (Access-Request) to the RADIUS server. The request includes the username and the password. The password is encrypted by using the MD5 algorithm and the shared key.
2. The RADIUS server authenticates the username and password.
   - If the authentication succeeds, the server sends an Access-Accept packet to the NQA client.
   - If the authentication fails, the server sends an Access-Reject packet to the NQA client.
3. The NQA client determines the availability of the authentication service on the RADIUS server based on the response packet it received:
   - If an Access-Accept packet is received, the authentication service is available on the RADIUS server.
   - If an Access-Reject packet is received, the authentication service is not available on the RADIUS server.

Prerequisites

Before you configure the RADIUS template, specify a username, password, and shared key on the RADIUS server. For more information about configuring the RADIUS server, see AAA in *Security Configuration Guide*.

Procedure

1. Enter system view.
   system-view
2. Create a RADIUS template and enter its view.
   nqa template radius *name*
3. Specify the destination IP address of the operation.
   IPv4:
   destination ip *ip-address*
   IPv6:
   destination ipv6 *ipv6-address*
   By default, no destination IP address is specified.
4. Specify the destination port number for the operation.
   destination port *port-number*
   By default, the destination port number is 1812.
5. Specify a username.
   username *username*
   By default, no username is specified.
6. Specify a password.
   password { **cipher** | **simple** } *string*
   By default, no password is specified.
7. Specify a shared key for secure RADIUS authentication.
   key { **cipher** | **simple** } *string*
   By default, no shared key is specified for RADIUS authentication.
8. Specify the source IP address for the probe packets.
   IPv4:
   source ip *ip-address*
   By default, the primary IPv4 address of the output interface is used as the source IPv4 address of the probe packets.
   The source IP address must be the IPv4 address of a local interface, and the interface must be up. Otherwise, no probe packets can be sent out.
   IPv6:
   source ipv6 *ipv6-address*
   By default, the primary IPv6 address of the output interface is used as the source IPv6 address of the probe packets.
   The source IPv6 address must be the IPv6 address of a local interface, and the interface must be up. Otherwise, no probe packets can be sent out.

Configuring the SSL template

About the SSL template

A feature that uses the SSL template performs the SSL operation to measure the time required to establish an SSL connection to an SSL server.

Prerequisites

Before you configure the SSL template, you must configure the SSL client policy. For information about configuring SSL client policies, see *Security Configuration Guide*.

Procedure

1. Enter system view.
   system-view
2. Create an SSL template and enter its view.
   nqa template ssl *name*
3. Specify the destination IP address of the operation.
   IPv4:
   destination ip *ip-address*
   IPv6:
   destination ipv6 *ipv6-address*
   By default, no destination IP address is specified.
4. Specify the destination port number for the operation.
   destination port *port-number*
   By default, the destination port number is not specified.
5. Specify an SSL client policy.
   ssl-client-policy *policy-name*
   By default, no SSL client policy is specified.
6. Specify the source IP address for the probe packets.
   IPv4:
   source ip *ip-address*
   By default, the primary IPv4 address of the output interface is used as the source IPv4 address of the probe packets.
   The source IP address must be the IPv4 address of a local interface, and the interface must be up. Otherwise, no probe packets can be sent out.
   IPv6:
   source ipv6 *ipv6-address*
   By default, the primary IPv6 address of the output interface is used as the source IPv6 address of the probe packets.
   The source IPv6 address must be the IPv6 address of a local interface, and the interface must be up. Otherwise, no probe packets can be sent out.

Configuring optional parameters for the NQA template

Restrictions and guidelines

Unless otherwise specified, the following optional parameters apply to all types of NQA templates.

The parameter settings take effect only on the current NQA template.

Procedure

1. Enter system view.
   system-view
2. Enter the view of an existing NQA template.
   nqa template { **dns** | **ftp** | **http** | **https** | **icmp** | **radius** | **ssl** | **tcp** | **tcphalfopen** | **udp** } *name*
3. Configure a description.
   description *text*

By default, no description is configured.

4. Set the interval at which the NQA operation repeats.

   frequency *interval*

   The default setting is 5000 milliseconds.

   When the interval expires, but the operation is not completed or is not timed out, the next operation does not start.

5. Set the probe timeout time.

   probe timeout *timeout*

   The default setting is 3000 milliseconds.

6. Set the TTL for the probe packets.

   ttl *value*

   The default setting is 20.

   This command is not available for the ARP template.

7. Set the ToS value in the IP header of the probe packets.

   tos *value*

   The default setting is 0.

   This command is not available for the ARP template.

8. Set the number of consecutive successful probes to determine a successful operation event.

   reaction trigger probe-pass *count*

   The default setting is 3.

   If the number of consecutive successful probes for an NQA operation is reached, the NQA client notifies the feature that uses the template of the successful operation event.

9. Set the number of consecutive probe failures to determine an operation failure.

   reaction trigger probe-fail *count*

   The default setting is 3.

   If the number of consecutive probe failures for an NQA operation is reached, the NQA client notifies the feature that uses the NQA template of the operation failure.

Display and maintenance commands for NQA

Execute **display** commands in any view.

Task	Command
Display history records of NQA operations.	**display nqa history** [*admin-name operation-tag*]
Display the current monitoring results of reaction entries.	**display nqa reaction counters** [*admin-name operation-tag* [*item-number*]]
Display the most recent result of the NQA operation.	**display nqa result** [*admin-name operation-tag*]
Display NQA server status.	**display nqa server status**
Display NQA statistics.	**display nqa statistics** [*admin-name operation-tag*]

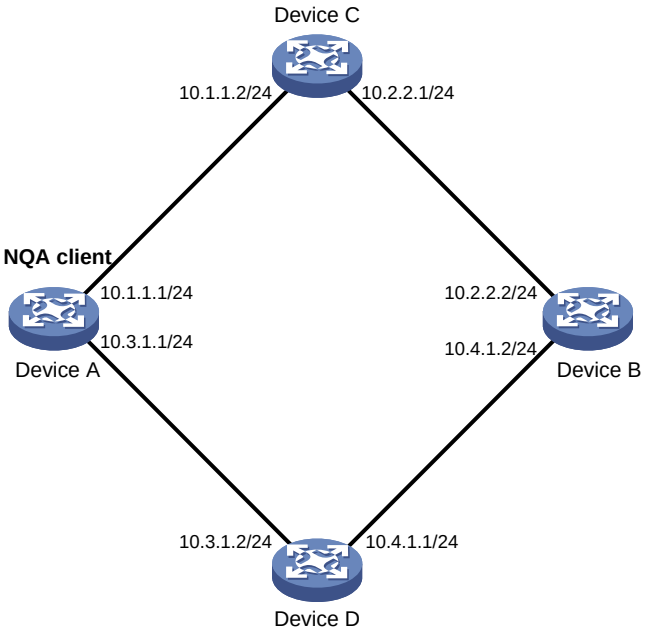
NQA configuration examples

Example: Configuring the ICMP echo operation

Network configuration

As shown in Figure 2, configure an ICMP echo operation on the NQA client (Device A) to test the round-trip time to Device B. The next hop of Device A is Device C.

Figure 2 Network diagram



Procedure

Assign IP addresses to interfaces, as shown in Figure 2. (Details not shown.)

Configure static routes or a routing protocol to make sure the devices can reach each other. (Details not shown.)

Create an ICMP echo operation.

```
<DeviceA> system-view
[DeviceA] nqa entry admin test1
[DeviceA-nqa-admin-test1] type icmp-echo
```

Specify 10.2.2.2 as the destination IP address of ICMP echo requests.

```
[DeviceA-nqa-admin-test1-icmp-echo] destination ip 10.2.2.2
```

Specify 10.1.1.2 as the next hop. The ICMP echo requests are sent through Device C to Device B.

```
[DeviceA-nqa-admin-test1-icmp-echo] next-hop ip 10.1.1.2
```

Configure the ICMP echo operation to perform 10 probes.

```
[DeviceA-nqa-admin-test1-icmp-echo] probe count 10
```

Set the probe timeout time to 500 milliseconds for the ICMP echo operation.

```
[DeviceA-nqa-admin-test1-icmp-echo] probe timeout 500
```

Configure the ICMP echo operation to repeat every 5000 milliseconds.

```
[DeviceA-nqa-admin-test1-icmp-echo] frequency 5000
```

Enable saving history records.

```
[DeviceA-nqa-admin-test1-icmp-echo] history-record enable
```

Set the maximum number of history records to 10.

```
[DeviceA-nqa-admin-test1-icmp-echo] history-record number 10
[DeviceA-nqa-admin-test1-icmp-echo] quit
```

Start the ICMP echo operation.

```
[DeviceA] nqa schedule admin test1 start-time now lifetime forever
```

After the ICMP echo operation runs for a period of time, stop the operation.

```
[DeviceA] undo nqa schedule admin test1
```

Verifying the configuration

Display the most recent result of the ICMP echo operation.

```
[DeviceA] display nqa result admin test1
NQA entry (admin admin, tag test1) test results:
    Send operation times: 10             Receive response times: 10
    Min/Max/Average round trip time: 2/5/3
    Square-Sum of round trip time: 96
    Last succeeded probe time: 2011-08-23 15:00:01.2
  Extended results:
    Packet loss ratio: 0%
    Failures due to timeout: 0
    Failures due to internal error: 0
    Failures due to other errors: 0
```

Display the history records of the ICMP echo operation.

```
[DeviceA] display nqa history admin test1
NQA entry (admin admin, tag test) history records:
  Index      Response     Status           Time
  370        3            Succeeded        2007-08-23 15:00:01.2
  369        3            Succeeded        2007-08-23 15:00:01.2
  368        3            Succeeded        2007-08-23 15:00:01.2
  367        5            Succeeded        2007-08-23 15:00:01.2
  366        3            Succeeded        2007-08-23 15:00:01.2
  365        3            Succeeded        2007-08-23 15:00:01.2
  364        3            Succeeded        2007-08-23 15:00:01.1
  363        2            Succeeded        2007-08-23 15:00:01.1
  362        3            Succeeded        2007-08-23 15:00:01.1
  361        2            Succeeded        2007-08-23 15:00:01.1
```

The output shows that the packets sent by Device A can reach Device B through Device C. No packet loss occurs during the operation. The minimum, maximum, and average round-trip times are 2, 5, and 3 milliseconds, respectively.

Example: Configuring the ICMP jitter operation

Network configuration

As shown in Figure 3, configure an ICMP jitter operation to test the jitter between Device A and Device B.

Figure 3 Network diagram

Procedure

1. Assign IP addresses to interfaces, as shown in Figure 3. (Details not shown.)
2. Configure static routes or a routing protocol to make sure the devices can reach each other. (Details not shown.)
3. Configure Device A:

   # Create an ICMP jitter operation.

```
<DeviceA> system-view
[DeviceA] nqa entry admin test1
[DeviceA-nqa-admin-test1] type icmp-jitter
```

   # Specify 10.2.2.2 as the destination address for the operation.

```
[DeviceA-nqa-admin-test1-icmp-jitter] destination ip 10.2.2.2
```

   # Configure the operation to repeat every 1000 milliseconds.

```
[DeviceA-nqa-admin-test1-icmp-jitter] frequency 1000
[DeviceA-nqa-admin-test1-icmp-jitter] quit
```

   # Start the ICMP jitter operation.

```
[DeviceA] nqa schedule admin test1 start-time now lifetime forever
```

   # After the ICMP jitter operation runs for a period of time, stop the operation.

```
[DeviceA] undo nqa schedule admin test1
```

Verifying the configuration

Display the most recent result of the ICMP jitter operation.

```
[DeviceA] display nqa result admin test1
NQA entry (admin admin, tag test1) test results:
    Send operation times: 10              Receive response times: 10
    Min/Max/Average round trip time: 1/2/1
    Square-Sum of round trip time: 13
    Last packet received time: 2015-03-09 17:40:29.8
  Extended results:
    Packet loss ratio: 0%
    Failures due to timeout: 0
    Failures due to internal error: 0
    Failures due to other errors: 0
    Packets out of sequence: 0
    Packets arrived late: 0
  ICMP-jitter results:
   RTT number: 10
    Min positive SD: 0                    Min positive DS: 0
    Max positive SD: 0                    Max positive DS: 0
    Positive SD number: 0                 Positive DS number: 0
    Positive SD sum: 0                    Positive DS sum: 0
    Positive SD average: 0                Positive DS average: 0
    Positive SD square-sum: 0             Positive DS square-sum: 0
```

```
    Min negative SD: 1                  Min negative DS: 2
    Max negative SD: 1                  Max negative DS: 2
    Negative SD number: 1               Negative DS number: 1
    Negative SD sum: 1                  Negative DS sum: 2
    Negative SD average: 1              Negative DS average: 2
    Negative SD square-sum: 1           Negative DS square-sum: 4
    SD average: 1                       DS average: 2
  One way results:
    Max SD delay: 1                     Max DS delay: 2
    Min SD delay: 1                     Min DS delay: 2
    Number of SD delay: 1               Number of DS delay: 1
    Sum of SD delay: 1                  Sum of DS delay: 2
    Square-Sum of SD delay: 1           Square-Sum of DS delay: 4
    Lost packets for unknown reason: 0
```

Display the statistics of the ICMP jitter operation.

```
[DeviceA] display nqa statistics admin test1
NQA entry (admin admin, tag test1) test statistics:
  NO. : 1
    Start time: 2015-03-09 17:42:10.7
    Life time: 156 seconds
    Send operation times: 1560          Receive response times: 1560
    Min/Max/Average round trip time: 1/2/1
    Square-Sum of round trip time: 1563
  Extended results:
    Packet loss ratio: 0%
    Failures due to timeout: 0
    Failures due to internal error: 0
    Failures due to other errors: 0
    Packets out of sequence: 0
    Packets arrived late: 0
  ICMP-jitter results:
   RTT number: 1560
    Min positive SD: 1                  Min positive DS: 1
    Max positive SD: 1                  Max positive DS: 2
    Positive SD number: 18              Positive DS number: 46
    Positive SD sum: 18                 Positive DS sum: 49
    Positive SD average: 1              Positive DS average: 1
    Positive SD square-sum: 18          Positive DS square-sum: 55
    Min negative SD: 1                  Min negative DS: 1
    Max negative SD: 1                  Max negative DS: 2
    Negative SD number: 24              Negative DS number: 57
    Negative SD sum: 24                 Negative DS sum: 58
    Negative SD average: 1              Negative DS average: 1
    Negative SD square-sum: 24          Negative DS square-sum: 60
    SD average: 16                      DS average: 2
  One way results:
    Max SD delay: 1                     Max DS delay: 2
    Min SD delay: 1                     Min DS delay: 1
```

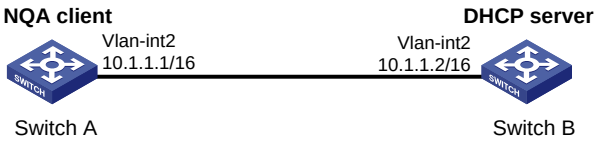
```
Number of SD delay: 4                Number of DS delay: 4
Sum of SD delay: 4                   Sum of DS delay: 5
Square-Sum of SD delay: 4            Square-Sum of DS delay: 7
Lost packets for unknown reason: 0
```

Example: Configuring the DHCP operation

Network configuration

As shown in Figure 4, configure a DHCP operation to test the time required for Switch A to obtain an IP address from the DHCP server (Switch B).

Figure 4 Network diagram



Procedure

Create a DHCP operation.

```
<SwitchA> system-view
[SwitchA] nqa entry admin test1
[SwitchA-nqa-admin-test1] type dhcp
```

Specify the DHCP server address (10.1.1.2) as the destination address.

```
[SwitchA-nqa-admin-test1-dhcp] destination ip 10.1.1.2
```

Enable the saving of history records.

```
[SwitchA-nqa-admin-test1-dhcp] history-record enable
[SwitchA-nqa-admin-test1-dhcp] quit
```

Start the DHCP operation.

```
[SwitchA] nqa schedule admin test1 start-time now lifetime forever
```

After the DHCP operation runs for a period of time, stop the operation.

```
[SwitchA] undo nqa schedule admin test1
```

Verifying the configuration

Display the most recent result of the DHCP operation.

```
[SwitchA] display nqa result admin test1
NQA entry (admin admin, tag test1) test results:
    Send operation times: 1              Receive response times: 1
    Min/Max/Average round trip time: 512/512/512
    Square-Sum of round trip time: 262144
    Last succeeded probe time: 2011-11-22 09:56:03.2
  Extended results:
    Packet loss ratio: 0%
    Failures due to timeout: 0
    Failures due to internal error: 0
    Failures due to other errors: 0
```

Display the history records of the DHCP operation.

```
[SwitchA] display nqa history admin test1
```

```
NQA entry (admin admin, tag test1) history records:
  Index      Response     Status           Time
  1          512          Succeeded        2011-11-22 09:56:03.2
```

The output shows that it took Switch A 512 milliseconds to obtain an IP address from the DHCP server.

Example: Configuring the DNS operation

Network configuration

As shown in Figure 5, configure a DNS operation to test whether Device A can perform address resolution through the DNS server and test the resolution time.

Figure 5 Network diagram

Procedure

Assign IP addresses to interfaces, as shown in Figure 5. (Details not shown.)

Configure static routes or a routing protocol to make sure the devices can reach each other. (Details not shown.)

Create a DNS operation.

```
<DeviceA> system-view
[DeviceA] nqa entry admin test1
[DeviceA-nqa-admin-test1] type dns
```

Specify the IP address of the DNS server (10.2.2.2) as the destination address.

```
[DeviceA-nqa-admin-test1-dns] destination ip 10.2.2.2
```

Specify **host.com** as the domain name to be translated.

```
[DeviceA-nqa-admin-test1-dns] resolve-target host.com
```

Enable the saving of history records.

```
[DeviceA-nqa-admin-test1-dns] history-record enable
[DeviceA-nqa-admin-test1-dns] quit
```

Start the DNS operation.

```
[DeviceA] nqa schedule admin test1 start-time now lifetime forever
```

After the DNS operation runs for a period of time, stop the operation.

```
[DeviceA] undo nqa schedule admin test1
```

Verifying the configuration

Display the most recent result of the DNS operation.

```
[DeviceA] display nqa result admin test1
NQA entry (admin admin, tag test1) test results:
    Send operation times: 1              Receive response times: 1
    Min/Max/Average round trip time: 62/62/62
    Square-Sum of round trip time: 3844
    Last succeeded probe time: 2011-11-10 10:49:37.3
  Extended results:
```

```
    Packet loss ratio: 0%
    Failures due to timeout: 0
    Failures due to internal error: 0
    Failures due to other errors: 0
```

Display the history records of the DNS operation.

```
[DeviceA] display nqa history admin test1
NQA entry (admin admin, tag test) history records:
  Index      Response     Status           Time
  1          62           Succeeded        2011-11-10 10:49:37.3
```

The output shows that it took Device A 62 milliseconds to translate domain name **host.com** into an IP address.

Example: Configuring the FTP operation

Network configuration

As shown in Figure 6, configure an FTP operation to test the time required for Device A to upload a file to the FTP server. The login username and password are **admin** and **systemtest**, respectively. The file to be transferred to the FTP server is **config.txt**.

Figure 6 Network diagram

Procedure

Assign IP addresses to interfaces, as shown in Figure 6. (Details not shown.)

Configure static routes or a routing protocol to make sure the devices can reach each other. (Details not shown.)

Create an FTP operation.

```
<DeviceA> system-view
[DeviceA] nqa entry admin test1
[DeviceA-nqa-admin-test1] type ftp
```

Specify the URL of the FTP server.

```
[DeviceA-nqa-admin-test-ftp] url ftp://10.2.2.2
```

Specify 10.1.1.1 as the source IP address.

```
[DeviceA-nqa-admin-test1-ftp] source ip 10.1.1.1
```

Configure the device to upload file **config.txt** to the FTP server.

```
[DeviceA-nqa-admin-test1-ftp] operation put
[DeviceA-nqa-admin-test1-ftp] filename config.txt
```

Set the username to **admin** for the FTP operation.

```
[DeviceA-nqa-admin-test1-ftp] username admin
```

Set the password to **systemtest** for the FTP operation.

```
[DeviceA-nqa-admin-test1-ftp] password simple systemtest
```

Enable the saving of history records.

```
[DeviceA-nqa-admin-test1-ftp] history-record enable
```

```
[DeviceA-nqa-admin-test1-ftp] quit
```

Start the FTP operation.

```
[DeviceA] nqa schedule admin test1 start-time now lifetime forever
```

After the FTP operation runs for a period of time, stop the operation.

```
[DeviceA] undo nqa schedule admin test1
```

Verifying the configuration

Display the most recent result of the FTP operation.

```
[DeviceA] display nqa result admin test1
NQA entry (admin admin, tag test1) test results:
    Send operation times: 1              Receive response times: 1
    Min/Max/Average round trip time: 173/173/173
    Square-Sum of round trip time: 29929
    Last succeeded probe time: 2011-11-22 10:07:28.6
  Extended results:
    Packet loss ratio: 0%
    Failures due to timeout: 0
    Failures due to disconnect: 0
    Failures due to no connection: 0
    Failures due to internal error: 0
    Failures due to other errors: 0
```

Display the history records of the FTP operation.

```
[DeviceA] display nqa history admin test1
NQA entry (admin admin, tag test1) history records:
  Index      Response     Status           Time
  1          173          Succeeded        2011-11-22 10:07:28.6
```

The output shows that it took Device A 173 milliseconds to upload a file to the FTP server.

Example: Configuring the HTTP operation

Network configuration

As shown in Figure 7, configure an HTTP operation on the NQA client to test the time required to obtain data from the HTTP server.

Figure 7 Network diagram

Procedure

Assign IP addresses to interfaces, as shown in Figure 7. (Details not shown.)

Configure static routes or a routing protocol to make sure the devices can reach each other. (Details not shown.)

Create an HTTP operation.

```
<DeviceA> system-view
[DeviceA] nqa entry admin test1
```

```
[DeviceA-nqa-admin-test1] type http
```

Specify the URL of the HTTP server.

```
[DeviceA-nqa-admin-test1-http] url http://10.2.2.2/index.htm
```

Configure the HTTP operation to get data from the HTTP server.

```
[DeviceA-nqa-admin-test1-http] operation get
```

Configure the operation to use HTTP version 1.0.

```
[DeviceA-nqa-admin-test1-http] version v1.0
```

Enable the saving of history records.

```
[DeviceA-nqa-admin-test1-http] history-record enable
[DeviceA-nqa-admin-test1-http] quit
```

Start the HTTP operation.

```
[DeviceA] nqa schedule admin test1 start-time now lifetime forever
```

After the HTTP operation runs for a period of time, stop the operation.

```
[DeviceA] undo nqa schedule admin test1
```

Verifying the configuration

Display the most recent result of the HTTP operation.

```
[DeviceA] display nqa result admin test1
NQA entry (admin admin, tag test1) test results:
    Send operation times: 1              Receive response times: 1
    Min/Max/Average round trip time: 64/64/64
    Square-Sum of round trip time: 4096
    Last succeeded probe time: 2011-11-22 10:12:47.9
  Extended results:
    Packet loss ratio: 0%
    Failures due to timeout: 0
    Failures due to disconnect: 0
    Failures due to no connection: 0
    Failures due to internal error: 0
    Failures due to other errors: 0
```

Display the history records of the HTTP operation.

```
[DeviceA] display nqa history admin test1
NQA entry (admin admin, tag test1) history records:
  Index      Response     Status           Time
  1          64           Succeeded        2011-11-22 10:12:47.9
```

The output shows that it took Device A 64 milliseconds to obtain data from the HTTP server.

Example: Configuring the UDP jitter operation

Network configuration

As shown in Figure 8, configure a UDP jitter operation to test the jitter, delay, and round-trip time between Device A and Device B.

Figure 8 Network diagram

Procedure

1. Assign IP addresses to interfaces, as shown in Figure 8. (Details not shown.)
2. Configure static routes or a routing protocol to make sure the devices can reach each other. (Details not shown.)
3. Configure Device B:

   # Enable the NQA server.

   ```
   <DeviceB> system-view
   [DeviceB] nqa server enable
   ```

   # Configure a listening service to listen to UDP port 9000 on IP address 10.2.2.2.

   ```
   [DeviceB] nqa server udp-echo 10.2.2.2 9000
   ```

4. Configure Device A:

   # Create a UDP jitter operation.

   ```
   <DeviceA> system-view
   [DeviceA] nqa entry admin test1
   [DeviceA-nqa-admin-test1] type udp-jitter
   ```

   # Specify 10.2.2.2 as the destination address of the operation.

   ```
   [DeviceA-nqa-admin-test1-udp-jitter] destination ip 10.2.2.2
   ```

   # Set the destination port number to 9000.

   ```
   [DeviceA-nqa-admin-test1-udp-jitter] destination port 9000
   ```

   # Configure the operation to repeat every 1000 milliseconds.

   ```
   [DeviceA-nqa-admin-test1-udp-jitter] frequency 1000
   [DeviceA-nqa-admin-test1-udp-jitter] quit
   ```

   # Start the UDP jitter operation.

   ```
   [DeviceA] nqa schedule admin test1 start-time now lifetime forever
   ```

   # After the UDP jitter operation runs for a period of time, stop the operation.

   ```
   [DeviceA] undo nqa schedule admin test1
   ```

Verifying the configuration

Display the most recent result of the UDP jitter operation.

```
[DeviceA] display nqa result admin test1
NQA entry (admin admin, tag test1) test results:
    Send operation times: 10             Receive response times: 10
    Min/Max/Average round trip time: 15/32/17
    Square-Sum of round trip time: 3235
    Last packet received time: 2011-05-29 13:56:17.6
  Extended results:
    Packet loss ratio: 0%
    Failures due to timeout: 0
    Failures due to internal error: 0
    Failures due to other errors: 0
    Packets out of sequence: 0
```

```
    Packets arrived late: 0
  UDP-jitter results:
   RTT number: 10
    Min positive SD: 4                    Min positive DS: 1
    Max positive SD: 21                   Max positive DS: 28
    Positive SD number: 5                 Positive DS number: 4
    Positive SD sum: 52                   Positive DS sum: 38
    Positive SD average: 10               Positive DS average: 10
    Positive SD square-sum: 754           Positive DS square-sum: 460
    Min negative SD: 1                    Min negative DS: 6
    Max negative SD: 13                   Max negative DS: 22
    Negative SD number: 4                 Negative DS number: 5
    Negative SD sum: 38                   Negative DS sum: 52
    Negative SD average: 10               Negative DS average: 10
    Negative SD square-sum: 460           Negative DS square-sum: 754
    SD average: 10                        DS average: 10
  One way results:
    Max SD delay: 15                      Max DS delay: 16
    Min SD delay: 7                       Min DS delay: 7
    Number of SD delay: 10                Number of DS delay: 10
    Sum of SD delay: 78                   Sum of DS delay: 85
    Square-Sum of SD delay: 666           Square-Sum of DS delay: 787
    SD lost packets: 0                  DS lost packets: 0
    Lost packets for unknown reason: 0
```

Display the statistics of the UDP jitter operation.

```
[DeviceA] display nqa statistics admin test1
NQA entry (admin admin, tag test1) test statistics:
  NO. : 1
    Start time: 2011-05-29 13:56:14.0
    Life time: 47 seconds
    Send operation times: 410           Receive response times: 410
    Min/Max/Average round trip time: 1/93/19
    Square-Sum of round trip time: 206176
  Extended results:
    Packet loss ratio: 0%
    Failures due to timeout: 0
    Failures due to internal error: 0
    Failures due to other errors: 0
    Packets out of sequence: 0
    Packets arrived late: 0
  UDP-jitter results:
   RTT number: 410
    Min positive SD: 3                    Min positive DS: 1
    Max positive SD: 30                   Max positive DS: 79
    Positive SD number: 186               Positive DS number: 158
    Positive SD sum: 2602                 Positive DS sum: 1928
    Positive SD average: 13               Positive DS average: 12
    Positive SD square-sum: 45304         Positive DS square-sum: 31682
```

```
  Min negative SD: 1                    Min negative DS: 1
  Max negative SD: 30                   Max negative DS: 78
  Negative SD number: 181               Negative DS number: 209
  Negative SD sum: 181                  Negative DS sum: 209
  Negative SD average: 13               Negative DS average: 14
  Negative SD square-sum: 46994         Negative DS square-sum: 3030
  SD average: 9                         DS average: 1
One way results:
  Max SD delay: 46                      Max DS delay: 46
  Min SD delay: 7                       Min DS delay: 7
  Number of SD delay: 410               Number of DS delay: 410
  Sum of SD delay: 3705                 Sum of DS delay: 3891
  Square-Sum of SD delay: 45987         Square-Sum of DS delay: 49393
  SD lost packets: 0                  DS lost packets: 0
  Lost packets for unknown reason: 0
```

Example: Configuring the SNMP operation

Network configuration

As shown in Figure 9, configure an SNMP operation to test the time the NQA client uses to get a response from the SNMP agent.

Figure 9 Network diagram

Procedure

1. Assign IP addresses to interfaces, as shown in Figure 9. (Details not shown.)
2. Configure static routes or a routing protocol to make sure the devices can reach each other. (Details not shown.)
3. Configure the SNMP agent (Device B):

   # Set the SNMP version to **all**.

   ```
   <DeviceB> system-view
   [DeviceB] snmp-agent sys-info version all
   ```

   # Set the read community to **public**.

   ```
   [DeviceB] snmp-agent community read public
   ```

   # Set the write community to **private**.

   ```
   [DeviceB] snmp-agent community write private
   ```

4. Configure Device A:

   # Create an SNMP operation.

   ```
   <DeviceA> system-view
   [DeviceA] nqa entry admin test1
   [DeviceA-nqa-admin-test1] type snmp
   ```

   # Specify 10.2.2.2 as the destination IP address of the SNMP operation.

   ```
   [DeviceA-nqa-admin-test1-snmp] destination ip 10.2.2.2
   ```

   # Enable the saving of history records.

```
[DeviceA-nqa-admin-test1-snmp] history-record enable
[DeviceA-nqa-admin-test1-snmp] quit
```

Start the SNMP operation.

```
[DeviceA] nqa schedule admin test1 start-time now lifetime forever
```

After the SNMP operation runs for a period of time, stop the operation.

```
[DeviceA] undo nqa schedule admin test1
```

Verifying the configuration

Display the most recent result of the SNMP operation.

```
[DeviceA] display nqa result admin test1
NQA entry (admin admin, tag test1) test results:
    Send operation times: 1              Receive response times: 1
    Min/Max/Average round trip time: 50/50/50
    Square-Sum of round trip time: 2500
    Last succeeded probe time: 2011-11-22 10:24:41.1
  Extended results:
    Packet loss ratio: 0%
    Failures due to timeout: 0
    Failures due to internal error: 0
    Failures due to other errors: 0
```

Display the history records of the SNMP operation.

```
[DeviceA] display nqa history admin test1
NQA entry (admin admin, tag test1) history records:
  Index      Response     Status           Time
  1          50           Succeeded        2011-11-22 10:24:41.1
```

The output shows that it took Device A 50 milliseconds to receive a response from the SNMP agent.

Example: Configuring the TCP operation

Network configuration

As shown in Figure 10, configure a TCP operation to test the time required for Device A to establish a TCP connection with Device B.

Figure 10 Network diagram

Procedure

1. Assign IP addresses to interfaces, as shown in Figure 10. (Details not shown.)
2. Configure static routes or a routing protocol to make sure the devices can reach each other. (Details not shown.)
3. Configure Device B:

   # Enable the NQA server.

   ```
   <DeviceB> system-view
   [DeviceB] nqa server enable
   ```

Configure a listening service to listen to TCP port 9000 on IP address 10.2.2.2.

```
[DeviceB] nqa server tcp-connect 10.2.2.2 9000
```

4. Configure Device A:

Create a TCP operation.

```
<DeviceA> system-view
[DeviceA] nqa entry admin test1
[DeviceA-nqa-admin-test1] type tcp
```

Specify 10.2.2.2 as the destination IP address.

```
[DeviceA-nqa-admin-test1-tcp] destination ip 10.2.2.2
```

Set the destination port number to 9000.

```
[DeviceA-nqa-admin-test1-tcp] destination port 9000
```

Enable the saving of history records.

```
[DeviceA-nqa-admin-test1-tcp] history-record enable
[DeviceA-nqa-admin-test1-tcp] quit
```

Start the TCP operation.

```
[DeviceA] nqa schedule admin test1 start-time now lifetime forever
```

After the TCP operation runs for a period of time, stop the operation.

```
[DeviceA] undo nqa schedule admin test1
```

Verifying the configuration

Display the most recent result of the TCP operation.

```
[DeviceA] display nqa result admin test1
NQA entry (admin admin, tag test1) test results:
    Send operation times: 1              Receive response times: 1
    Min/Max/Average round trip time: 13/13/13
    Square-Sum of round trip time: 169
    Last succeeded probe time: 2011-11-22 10:27:25.1
  Extended results:
    Packet loss ratio: 0%
    Failures due to timeout: 0
    Failures due to disconnect: 0
    Failures due to no connection: 0
    Failures due to internal error: 0
    Failures due to other errors: 0
```

Display the history records of the TCP operation.

```
[DeviceA] display nqa history admin test1
NQA entry (admin admin, tag test1) history records:
  Index      Response     Status           Time
  1          13           Succeeded        2011-11-22 10:27:25.1
```

The output shows that it took Device A 13 milliseconds to establish a TCP connection to port 9000 on the NQA server.

Example: Configuring the UDP echo operation

Network configuration

As shown in Figure 11, configure a UDP echo operation on the NQA client to test the round-trip time to Device B. The destination port number is 8000.

Figure 11 Network diagram

Procedure

1. Assign IP addresses to interfaces, as shown in Figure 11. (Details not shown.)
2. Configure static routes or a routing protocol to make sure the devices can reach each other. (Details not shown.)
3. Configure Device B:

   # Enable the NQA server.

   ```
   <DeviceB> system-view
   [DeviceB] nqa server enable
   ```

   # Configure a listening service to listen to UDP port 8000 on IP address 10.2.2.2.

   ```
   [DeviceB] nqa server udp-echo 10.2.2.2 8000
   ```

4. Configure Device A:

   # Create a UDP echo operation.

   ```
   <DeviceA> system-view
   [DeviceA] nqa entry admin test1
   [DeviceA-nqa-admin-test1] type udp-echo
   ```

   # Specify 10.2.2.2 as the destination IP address.

   ```
   [DeviceA-nqa-admin-test1-udp-echo] destination ip 10.2.2.2
   ```

   # Set the destination port number to 8000.

   ```
   [DeviceA-nqa-admin-test1-udp-echo] destination port 8000
   ```

   # Enable the saving of history records.

   ```
   [DeviceA-nqa-admin-test1-udp-echo] history-record enable
   [DeviceA-nqa-admin-test1-udp-echo] quit
   ```

   # Start the UDP echo operation.

   ```
   [DeviceA] nqa schedule admin test1 start-time now lifetime forever
   ```

   # After the UDP echo operation runs for a period of time, stop the operation.

   ```
   [DeviceA] undo nqa schedule admin test1
   ```

Verifying the configuration

Display the most recent result of the UDP echo operation.

```
[DeviceA] display nqa result admin test1
NQA entry (admin admin, tag test1) test results:
    Send operation times: 1              Receive response times: 1
    Min/Max/Average round trip time: 25/25/25
    Square-Sum of round trip time: 625
    Last succeeded probe time: 2011-11-22 10:36:17.9
  Extended results:
    Packet loss ratio: 0%
    Failures due to timeout: 0
    Failures due to internal error: 0
    Failures due to other errors: 0
```

Display the history records of the UDP echo operation.

```
[DeviceA] display nqa history admin test1
NQA entry (admin admin, tag test1) history records:
  Index      Response     Status           Time
  1          25           Succeeded        2011-11-22 10:36:17.9
```

The output shows that the round-trip time between Device A and port 8000 on Device B is 25 milliseconds.

Example: Configuring the UDP tracert operation

Network configuration

As shown in Figure 12, configure a UDP tracert operation to determine the routing path from Device A to Device B.

Figure 12 Network diagram

Procedure

1. Assign IP addresses to interfaces, as shown in Figure 12. (Details not shown.)
2. Configure static routes or a routing protocol to make sure the devices can reach each other. (Details not shown.)
3. Execute the **ip ttl-expires enable** command on the intermediate devices and execute the **ip unreachables enable** command on Device B.
4. Configure Device A:

   # Create a UDP tracert operation.

   ```
   <DeviceA> system-view
   [DeviceA] nqa entry admin test1
   [DeviceA-nqa-admin-test1] type udp-tracert
   ```

   # Specify 10.2.2.2 as the destination IP address.

   ```
   [DeviceA-nqa-admin-test1-udp-tracert] destination ip 10.2.2.2
   ```

   # Set the destination port number to 33434.

   ```
   [DeviceA-nqa-admin-test1-udp-tracert] destination port 33434
   ```

   # Configure Device A to perform three probes to each hop.

   ```
   [DeviceA-nqa-admin-test1-udp-tracert] probe count 3
   ```

   # Set the probe timeout time to 500 milliseconds.

   ```
   [DeviceA-nqa-admin-test1-udp-tracert] probe timeout 500
   ```

   # Configure the UDP tracert operation to repeat every 5000 milliseconds.

   ```
   [DeviceA-nqa-admin-test1-udp-tracert] frequency 5000
   ```

   # Specify GigabitEthernet 1/0/1 as the output interface for UDP packets.

   ```
   [DeviceA-nqa-admin-test1-udp-tracert] out interface gigabitethernet 1/0/1
   ```

   # Enable the no-fragmentation feature.

   ```
   [DeviceA-nqa-admin-test1-udp-tracert] no-fragment enable
   ```

   # Set the maximum number of consecutive probe failures to 6.

   ```
   [DeviceA-nqa-admin-test1-udp-tracert] max-failure 6
   ```

   # Set the TTL value to 1 for UDP packets in the start round of the UDP tracert operation.

```
[DeviceA-nqa-admin-test1-udp-tracert] init-ttl 1
```

Start the UDP tracert operation.

```
[DeviceA] nqa schedule admin test1 start-time now lifetime forever
```

After the UDP tracert operation runs for a period of time, stop the operation.

```
[DeviceA] undo nqa schedule admin test1
```

Verifying the configuration

Display the most recent result of the UDP tracert operation.

```
[DeviceA] display nqa result admin test1
NQA entry (admin admin, tag test1) test results:
    Send operation times: 6              Receive response times: 6
    Min/Max/Average round trip time: 1/1/1
    Square-Sum of round trip time: 1
    Last succeeded probe time: 2013-09-09 14:46:06.2
  Extended results:
    Packet loss in test: 0%
    Failures due to timeout: 0
    Failures due to internal error: 0
Failures due to other errors: 0
  UDP-tracert results:
    TTL     Hop IP              Time
    1       3.1.1.1             2013-09-09 14:46:03.2
    2       10.2.2.2            2013-09-09 14:46:06.2
```

Display the history records of the UDP tracert operation.

```
[DeviceA] display nqa history admin test1
NQA entry (admin admin, tag test1) history records:
Index      TTL  Response  Hop IP          Status          Time
1          2    2         10.2.2.2        Succeeded       2013-09-09 14:46:06.2
1          2    1         10.2.2.2        Succeeded       2013-09-09 14:46:05.2
1          2    2         10.2.2.2        Succeeded       2013-09-09 14:46:04.2
1          1    1         3.1.1.1         Succeeded       2013-09-09 14:46:03.2
1          1    2         3.1.1.1         Succeeded       2013-09-09 14:46:02.2
1          1    1         3.1.1.1         Succeeded       2013-09-09 14:46:01.2
```

Example: Configuring the voice operation

Network configuration

As shown in Figure 13, configure a voice operation to test jitters, delay, MOS, and ICPIF between Device A and Device B.

Figure 13 Network diagram

Procedure

1. Assign IP addresses to interfaces, as shown in Figure 13. (Details not shown.)

2. Configure static routes or a routing protocol to make sure the devices can reach each other. (Details not shown.)
3. Configure Device B:

   # Enable the NQA server.

   ```
   <DeviceB> system-view
   [DeviceB] nqa server enable
   ```

   # Configure a listening service to listen to UDP port 9000 on IP address 10.2.2.2.

   ```
   [DeviceB] nqa server udp-echo 10.2.2.2 9000
   ```

4. Configure Device A:

   # Create a voice operation.

   ```
   <DeviceA> system-view
   [DeviceA] nqa entry admin test1
   [DeviceA-nqa-admin-test1] type voice
   ```

   # Specify 10.2.2.2 as the destination IP address.

   ```
   [DeviceA-nqa-admin-test1-voice] destination ip 10.2.2.2
   ```

   # Set the destination port number to 9000.

   ```
   [DeviceA-nqa-admin-test1-voice] destination port 9000
   [DeviceA-nqa-admin-test1-voice] quit
   ```

   # Start the voice operation.

   ```
   [DeviceA] nqa schedule admin test1 start-time now lifetime forever
   ```

   # After the voice operation runs for a period of time, stop the operation.

   ```
   [DeviceA] undo nqa schedule admin test1
   ```

Verifying the configuration

Display the most recent result of the voice operation.

```
[DeviceA] display nqa result admin test1
NQA entry (admin admin, tag test1) test results:
    Send operation times: 1000          Receive response times: 1000
    Min/Max/Average round trip time: 31/1328/33
    Square-Sum of round trip time: 2844813
    Last packet received time: 2011-06-13 09:49:31.1
  Extended results:
    Packet loss ratio: 0%
    Failures due to timeout: 0
    Failures due to internal error: 0
    Failures due to other errors: 0
Packets out of sequence: 0
    Packets arrived late: 0
  Voice results:
   RTT number: 1000
    Min positive SD: 1                  Min positive DS: 1
    Max positive SD: 204                Max positive DS: 1297
    Positive SD number: 257             Positive DS number: 259
    Positive SD sum: 759                Positive DS sum: 1797
    Positive SD average: 2              Positive DS average: 6
    Positive SD square-sum: 54127       Positive DS square-sum: 1691967
    Min negative SD: 1                  Min negative DS: 1
    Max negative SD: 203                Max negative DS: 1297
```

```
    Negative SD number: 255                Negative DS number: 259
    Negative SD sum: 759                   Negative DS sum: 1796
    Negative SD average: 2                 Negative DS average: 6
    Negative SD square-sum: 53655          Negative DS square-sum: 1691776
    SD average: 2                          DS average: 6
  One way results:
    Max SD delay: 343                      Max DS delay: 985
    Min SD delay: 343                      Min DS delay: 985
    Number of SD delay: 1                  Number of DS delay: 1
    Sum of SD delay: 343                   Sum of DS delay: 985
    Square-Sum of SD delay: 117649         Square-Sum of DS delay: 970225
    SD lost packets: 0                    DS lost packets: 0
    Lost packets for unknown reason: 0
  Voice scores:
    MOS value: 4.38                        ICPIF value: 0
```

Display the statistics of the voice operation.

```
[DeviceA] display nqa statistics admin test1
NQA entry (admin admin, tag test1) test statistics:
  NO. : 1

    Start time: 2011-06-13 09:45:37.8
    Life time: 331 seconds
    Send operation times: 4000           Receive response times: 4000
    Min/Max/Average round trip time: 15/1328/32
    Square-Sum of round trip time: 7160528
  Extended results:
    Packet loss ratio: 0%
    Failures due to timeout: 0
    Failures due to internal error: 0
    Failures due to other errors: 0
Packets out of sequence: 0
    Packets arrived late: 0
  Voice results:
   RTT number: 4000
    Min positive SD: 1                     Min positive DS: 1
    Max positive SD: 360                   Max positive DS: 1297
    Positive SD number: 1030               Positive DS number: 1024
    Positive SD sum: 4363                  Positive DS sum: 5423
    Positive SD average: 4                 Positive DS average: 5
    Positive SD square-sum: 497725         Positive DS square-sum: 2254957
    Min negative SD: 1                     Min negative DS: 1
    Max negative SD: 360                   Max negative DS: 1297
    Negative SD number: 1028               Negative DS number: 1022
    Negative SD sum: 1028                  Negative DS sum: 1022
    Negative SD average: 4                 Negative DS average: 5
    Negative SD square-sum: 495901         Negative DS square-sum: 5419
    SD average: 16                         DS average: 2
  One way results:
```

```
  Max SD delay: 359                    Max DS delay: 985
  Min SD delay: 0                      Min DS delay: 0
  Number of SD delay: 4                Number of DS delay: 4
  Sum of SD delay: 1390                Sum of DS delay: 1079
  Square-Sum of SD delay: 483202       Square-Sum of DS delay: 973651
  SD lost packets: 0                  DS lost packets: 0
  Lost packets for unknown reason: 0
Voice scores:
  Max MOS value: 4.38                  Min MOS value: 4.38
  Max ICPIF value: 0                   Min ICPIF value: 0
```

Example: Configuring the DLSw operation

Network configuration

As shown in Figure 14, configure a DLSw operation to test the response time of the DLSw device.

Figure 14 Network diagram

Procedure

Assign IP addresses to interfaces, as shown in Figure 14. (Details not shown.)

Configure static routes or a routing protocol to make sure the devices can reach each other. (Details not shown.)

Create a DLSw operation.

```
<DeviceA> system-view
[DeviceA] nqa entry admin test1
[DeviceA-nqa-admin-test1] type dlsw
```

Specify 10.2.2.2 as the destination IP address.

```
[DeviceA-nqa-admin-test1-dlsw] destination ip 10.2.2.2
```

Enable the saving of history records.

```
[DeviceA-nqa-admin-test1-dlsw] history-record enable
[DeviceA-nqa-admin-test1-dlsw] quit
```

Start the DLSw operation.

```
[DeviceA] nqa schedule admin test1 start-time now lifetime forever
```

After the DLSw operation runs for a period of time, stop the operation.

```
[DeviceA] undo nqa schedule admin test1
```

Verifying the configuration

Display the most recent result of the DLSw operation.

```
[DeviceA] display nqa result admin test1
NQA entry (admin admin, tag test1) test results:
    Send operation times: 1              Receive response times: 1
    Min/Max/Average round trip time: 19/19/19
    Square-Sum of round trip time: 361
```

```
    Last succeeded probe time: 2011-11-22 10:40:27.7
  Extended results:
    Packet loss ratio: 0%
    Failures due to timeout: 0
    Failures due to disconnect: 0
    Failures due to no connection: 0
    Failures due to internal error: 0
    Failures due to other errors: 0
```

Display the history records of the DLSw operation.

```
[DeviceA] display nqa history admin test1
NQA entry (admin admin, tag test1) history records:
  Index      Response     Status           Time
  1          19           Succeeded        2011-11-22 10:40:27.7
```

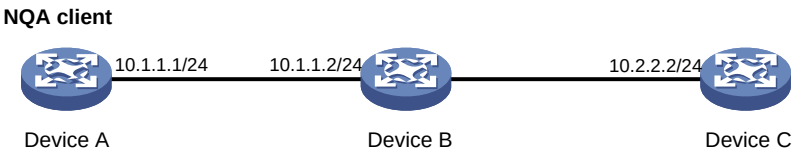
The output shows that the response time of the DLSw device is 19 milliseconds.

Example: Configuring the path jitter operation

Network configuration

As shown in Figure 15, configure a path jitter operation to test the round trip time and jitters from Device A to Device B and Device C.

Figure 15 Network diagram



Procedure

Assign IP addresses to interfaces, as shown in Figure 15. (Details not shown.)

Configure static routes or a routing protocol to make sure the devices can reach each other. (Details not shown.)

Execute the **ip ttl-expires enable** command on Device B and execute the **ip unreachables enable** command on Device C.

Create a path jitter operation.

```
<DeviceA> system-view
[DeviceA] nqa entry admin test1
[DeviceA-nqa-admin-test1] type path-jitter
```

Specify 10.2.2.2 as the destination IP address of ICMP echo requests.

```
[DeviceA-nqa-admin-test1-path-jitter] destination ip 10.2.2.2
```

Configure the path jitter operation to repeat every 10000 milliseconds.

```
[DeviceA-nqa-admin-test1-path-jitter] frequency 10000
[DeviceA-nqa-admin-test1-path-jitter] quit
```

Start the path jitter operation.

```
[DeviceA] nqa schedule admin test1 start-time now lifetime forever
```

After the path jitter operation runs for a period of time, stop the operation.

```
[DeviceA] undo nqa schedule admin test1
```

Verifying the configuration

Display the most recent result of the path jitter operation.

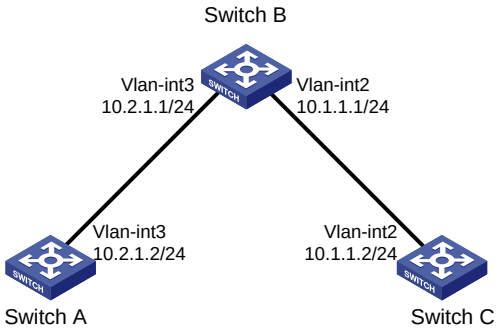
```
[DeviceA] display nqa result admin test1
NQA entry (admin admin, tag test1) test results:
  Hop IP 10.1.1.2
    Basic Results
      Send operation times: 10             Receive response times: 10
      Min/Max/Average round trip time: 9/21/14
      Square-Sum of round trip time: 2419
    Extended Results
      Failures due to timeout: 0
      Failures due to internal error: 0
      Failures due to other errors: 0
      Packets out of sequence: 0
      Packets arrived late: 0
    Path-Jitter Results
      Jitter number: 9
        Min/Max/Average jitter: 1/10/4
      Positive jitter number: 6
        Min/Max/Average positive jitter: 1/9/4
        Sum/Square-Sum positive jitter: 25/173
      Negative jitter number: 3
        Min/Max/Average negative jitter: 2/10/6
        Sum/Square-Sum positive jitter: 19/153

  Hop IP 10.2.2.2
    Basic Results
      Send operation times: 10             Receive response times: 10
      Min/Max/Average round trip time: 15/40/28
      Square-Sum of round trip time: 4493
    Extended Results
      Failures due to timeout: 0
      Failures due to internal error: 0
      Failures due to other errors: 0
      Packets out of sequence: 0
      Packets arrived late: 0
    Path-Jitter Results
      Jitter number: 9
        Min/Max/Average jitter: 1/10/4
      Positive jitter number: 6
        Min/Max/Average positive jitter: 1/9/4
        Sum/Square-Sum positive jitter: 25/173
      Negative jitter number: 3
        Min/Max/Average negative jitter: 2/10/6
        Sum/Square-Sum positive jitter: 19/153
```

Example: Configuring NQA collaboration

Network configuration

As shown in Figure 16, configure a static route to Switch C with Switch B as the next hop on Switch A. Associate the static route, a track entry, and an ICMP echo operation to monitor the state of the static route.

Figure 16 Network diagram



Procedure

1. Assign IP addresses to interfaces, as shown in Figure 16. (Details not shown.)
2. On Switch A, configure a static route, and associate the static route with track entry 1.

```
<SwitchA> system-view
[SwitchA] ip route-static 10.1.1.2 24 10.2.1.1 track 1
```

3. On Switch A, configure an ICMP echo operation:

   # Create an NQA operation with administrator name **admin** and operation tag **test1**.

```
[SwitchA] nqa entry admin test1
```

   # Configure the NQA operation type as ICMP echo.

```
[SwitchA-nqa-admin-test1] type icmp-echo
```

   # Specify 10.2.1.1 as the destination IP address.

```
[SwitchA-nqa-admin-test1-icmp-echo] destination ip 10.2.1.1
```

   # Configure the operation to repeat every 100 milliseconds.

```
[SwitchA-nqa-admin-test1-icmp-echo] frequency 100
```

   # Create reaction entry 1. If the number of consecutive probe failures reaches 5, collaboration is triggered.

```
[SwitchA-nqa-admin-test1-icmp-echo] reaction 1 checked-element probe-fail
threshold-type consecutive 5 action-type trigger-only
[SwitchA-nqa-admin-test1-icmp-echo] quit
```

   # Start the ICMP operation.

```
[SwitchA] nqa schedule admin test1 start-time now lifetime forever
```

4. On Switch A, create track entry 1, and associate it with reaction entry 1 of the NQA operation.

```
[SwitchA] track 1 nqa entry admin test1 reaction 1
```

Verifying the configuration

Display information about all the track entries on Switch A.

```
[SwitchA] display track all
Track ID: 1
  State: Positive
  Duration: 0 days 0 hours 0 minutes 0 seconds
```

```
  Notification delay: Positive 0, Negative 0 (in seconds)
  Tracked object:
    NQA entry: admin test1
    Reaction: 1
```

Display brief information about active routes in the routing table on Switch A.

```
[SwitchA] display ip routing-table

Destinations : 13        Routes : 13

Destination/Mask    Proto  Pre  Cost         NextHop         Interface
0.0.0.0/32          Direct 0    0            127.0.0.1       InLoop0
10.1.1.0/24         Static 60   0            10.2.1.1        Vlan3
10.2.1.0/24         Direct 0    0            10.2.1.2        Vlan3
10.2.1.0/32         Direct 0    0            10.2.1.2        Vlan3
10.2.1.2/32         Direct 0    0            127.0.0.1       InLoop0
10.2.1.255/32       Direct 0    0            10.2.1.2        Vlan3
127.0.0.0/8         Direct 0    0            127.0.0.1       InLoop0
127.0.0.0/32        Direct 0    0            127.0.0.1       InLoop0
127.0.0.1/32        Direct 0    0            127.0.0.1       InLoop0
127.255.255.255/32  Direct 0    0            127.0.0.1       InLoop0
224.0.0.0/4         Direct 0    0            0.0.0.0         NULL0
224.0.0.0/24        Direct 0    0            0.0.0.0         NULL0
255.255.255.255/32  Direct 0    0            127.0.0.1       InLoop0
```

The output shows that the static route with the next hop 10.2.1.1 is active, and the status of the track entry is positive.

Remove the IP address of VLAN-interface 3 on Switch B.

```
<SwitchB> system-view
[SwitchB] interface vlan-interface 3
[SwitchB-Vlan-interface3] undo ip address
```

Display information about all the track entries on Switch A.

```
[SwitchA] display track all
Track ID: 1
  State: Negative
  Duration: 0 days 0 hours 0 minutes 0 seconds
  Notification delay: Positive 0, Negative 0 (in seconds)
  Tracked object:
    NQA entry: admin test1
    Reaction: 1
```

Display brief information about active routes in the routing table on Switch A.

```
[SwitchA] display ip routing-table

Destinations : 12        Routes : 12

Destination/Mask    Proto  Pre  Cost         NextHop         Interface
0.0.0.0/32          Direct 0    0            127.0.0.1       InLoop0
10.2.1.0/24         Direct 0    0            10.2.1.2        Vlan3
10.2.1.0/32         Direct 0    0            10.2.1.2        Vlan3
```

```
10.2.1.2/32         Direct 0    0           127.0.0.1       InLoop0
10.2.1.255/32       Direct 0    0           10.2.1.2        Vlan3
127.0.0.0/8         Direct 0    0           127.0.0.1       InLoop0
127.0.0.0/32        Direct 0    0           127.0.0.1       InLoop0
127.0.0.1/32        Direct 0    0           127.0.0.1       InLoop0
127.255.255.255/32  Direct 0    0           127.0.0.1       InLoop0
224.0.0.0/4         Direct 0    0           0.0.0.0         NULL0
224.0.0.0/24        Direct 0    0           0.0.0.0         NULL0
255.255.255.255/32  Direct 0    0           127.0.0.1       InLoop0
```

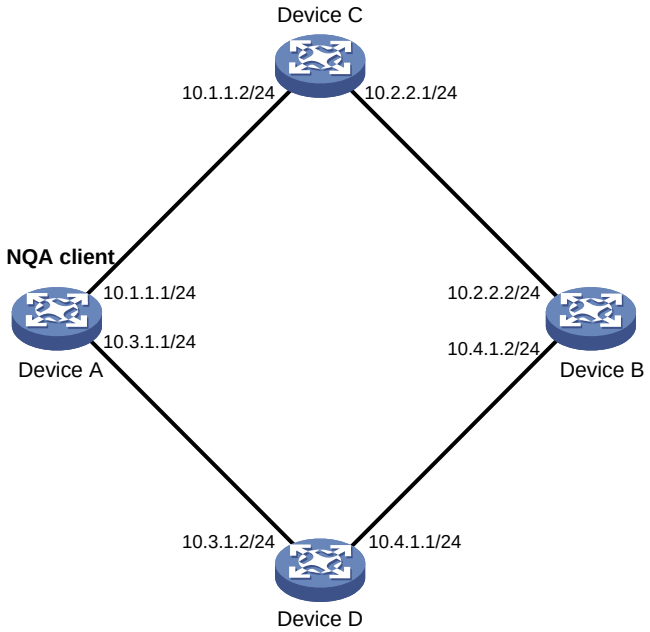
The output shows that the static route does not exist, and the status of the track entry is negative.

Example: Configuring the ICMP template

Network configuration

As shown in Figure 17, configure an ICMP template for a feature to perform the ICMP echo operation from Device A to Device B.

Figure 17 Network diagram



Procedure

Assign IP addresses to interfaces, as shown in Figure 17. (Details not shown.)

Configure static routes or a routing protocol to make sure the devices can reach each other. (Details not shown.)

Create ICMP template **icmp**.

```
<DeviceA> system-view
[DeviceA] nqa template icmp icmp
```

Specify 10.2.2.2 as the destination IP address of ICMP echo requests.

```
[DeviceA-nqatplt-icmp-icmp] destination ip 10.2.2.2
```

Set the probe timeout time to 500 milliseconds for the ICMP echo operation.

```
[DeviceA-nqatplt-icmp-icmp] probe timeout 500
```

Configure the ICMP echo operation to repeat every 3000 milliseconds.

```
[DeviceA-nqatplt-icmp-icmp] frequency 3000
```

Configure the NQA client to notify the feature of the successful operation event if the number of consecutive successful probes reaches 2.

```
[DeviceA-nqatplt-icmp-icmp] reaction trigger probe-pass 2
```

Configure the NQA client to notify the feature of the operation failure if the number of consecutive failed probes reaches 2.

```
[DeviceA-nqatplt-icmp-icmp] reaction trigger probe-fail 2
```

Example: Configuring the DNS template

Network configuration

As shown in Figure 18, configure a DNS template for a feature to perform the DNS operation. The operation tests whether Device A can perform the address resolution through the DNS server.

Figure 18 Network diagram

Procedure

Assign IP addresses to interfaces, as shown in Figure 18. (Details not shown.)

Configure static routes or a routing protocol to make sure the devices can reach each other. (Details not shown.)

Create DNS template **dns**.

```
<DeviceA> system-view
[DeviceA] nqa template dns dns
```

Specify the IP address of the DNS server (10.2.2.2) as the destination IP address.

```
[DeviceA-nqatplt-dns-dns] destination ip 10.2.2.2
```

Specify **host.com** as the domain name to be translated.

```
[DeviceA-nqatplt-dns-dns] resolve-target host.com
```

Set the domain name resolution type to type A.

```
[DeviceA-nqatplt-dns-dns] resolve-type A
```

Specify 3.3.3.3 as the expected IP address.

```
[DeviceA-nqatplt-dns-dns] expect ip 3.3.3.3
```

Configure the NQA client to notify the feature of the successful operation event if the number of consecutive successful probes reaches 2.

```
[DeviceA-nqatplt-dns-dns] reaction trigger probe-pass 2
```

Configure the NQA client to notify the feature of the operation failure if the number of consecutive failed probes reaches 2.

```
[DeviceA-nqatplt-dns-dns] reaction trigger probe-fail 2
```

Example: Configuring the TCP template

Network configuration

As shown in Figure 19, configure a TCP template for a feature to perform the TCP operation. The operation tests whether Device A can establish a TCP connection to Device B.

Figure 19 Network diagram

Procedure

1. Assign IP addresses to interfaces, as shown in Figure 19. (Details not shown.)
2. Configure static routes or a routing protocol to make sure the devices can reach each other. (Details not shown.)
3. Configure Device B:

   # Enable the NQA server.

   ```
   <DeviceB> system-view
   [DeviceB] nqa server enable
   ```

   # Configure a listening service to listen to TCP port 9000 on IP address 10.2.2.2.

   ```
   [DeviceB] nqa server tcp-connect 10.2.2.2 9000
   ```

4. Configure Device A:

   # Create TCP template **tcp**.

   ```
   <DeviceA> system-view
   [DeviceA] nqa template tcp tcp
   ```

   # Specify 10.2.2.2 as the destination IP address.

   ```
   [DeviceA-nqatplt-tcp-tcp] destination ip 10.2.2.2
   ```

   # Set the destination port number to 9000.

   ```
   [DeviceA-nqatplt-tcp-tcp] destination port 9000
   ```

   # Configure the NQA client to notify the feature of the successful operation event if the number of consecutive successful probes reaches 2.

   ```
   [DeviceA-nqatplt-tcp-tcp] reaction trigger probe-pass 2
   ```

   # Configure the NQA client to notify the feature of the operation failure if the number of consecutive failed probes reaches 2.

   ```
   [DeviceA-nqatplt-tcp-tcp] reaction trigger probe-fail 2
   ```

Example: Configuring the TCP half open template

Network configuration

As shown in Figure 20, configure a TCP half open template for a feature to test whether Device B can provide the TCP service for Device A.

Figure 20 Network diagram

Procedure

1. Assign IP addresses to interfaces, as shown in Figure 20. (Details not shown.)
2. Configure static routes or a routing protocol to make sure the devices can reach each other. (Details not shown.)
3. Configure Device A:

   # Create TCP half open template **test**.

   ```
   <DeviceA> system-view
   [DeviceA] nqa template tcphalfopen test
   ```

   # Specify 10.2.2.2 as the destination IP address.

   ```
   [DeviceA-nqatplt-tcphalfopen-test] destination ip 10.2.2.2
   ```

   # Configure the NQA client to notify the feature of the successful operation event if the number of consecutive successful probes reaches 2.

   ```
   [DeviceA-nqatplt-tcphalfopen-test] reaction trigger probe-pass 2
   ```

   # Configure the NQA client to notify the feature of the operation failure if the number of consecutive failed probes reaches 2.

   ```
   [DeviceA-nqatplt-tcphalfopen-test] reaction trigger probe-fail 2
   ```

Example: Configuring the UDP template

Network configuration

As shown in Figure 21, configure a UDP template for a feature to perform the UDP operation. The operation tests whether Device A can receive a response from Device B.

Figure 21 Network diagram

Procedure

1. Assign IP addresses to interfaces, as shown in Figure 21. (Details not shown.)
2. Configure static routes or a routing protocol to make sure the devices can reach each other. (Details not shown.)
3. Configure Device B:

   # Enable the NQA server.

   ```
   <DeviceB> system-view
   [DeviceB] nqa server enable
   ```

   # Configure a listening service to listen to UDP port 9000 on IP address 10.2.2.2.

   ```
   [DeviceB] nqa server udp-echo 10.2.2.2 9000
   ```

4. Configure Device A:

   # Create UDP template **udp**.

```
<DeviceA> system-view
[DeviceA] nqa template udp udp
```

Specify 10.2.2.2 as the destination IP address.

```
[DeviceA-nqatplt-udp-udp] destination ip 10.2.2.2
```

Set the destination port number to 9000.

```
[DeviceA-nqatplt-udp-udp] destination port 9000
```

Configure the NQA client to notify the feature of the successful operation event if the number of consecutive successful probes reaches 2.

```
[DeviceA-nqatplt-udp-udp] reaction trigger probe-pass 2
```

Configure the NQA client to notify the feature of the operation failure if the number of consecutive failed probes reaches 2.

```
[DeviceA-nqatplt-udp-udp] reaction trigger probe-fail 2
```

Example: Configuring the HTTP template

Network configuration

As shown in Figure 22, configure an HTTP template for a feature to perform the HTTP operation. The operation tests whether the NQA client can get data from the HTTP server.

Figure 22 Network diagram

Procedure

Assign IP addresses to interfaces, as shown in Figure 22. (Details not shown.)

Configure static routes or a routing protocol to make sure the devices can reach each other. (Details not shown.)

Create HTTP template **http**.

```
<DeviceA> system-view
[DeviceA] nqa template http http
```

Specify **http://10.2.2.2/index.htm** as the URL of the HTTP server.

```
[DeviceA-nqatplt-http-http] url http://10.2.2.2/index.htm
```

Set the HTTP operation type to **get**.

```
[DeviceA-nqatplt-http-http] operation get
```

Configure the NQA client to notify the feature of the successful operation event if the number of consecutive successful probes reaches 2.

```
[DeviceA-nqatplt-http-http] reaction trigger probe-pass 2
```

Configure the NQA client to notify the feature of the operation failure if the number of consecutive failed probes reaches 2.

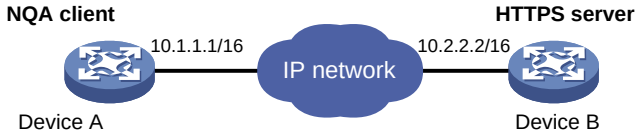
```
[DeviceA-nqatplt-http-http] reaction trigger probe-fail 2
```

Example: Configuring the HTTPS template

Network configuration

As shown in Figure 23, configure an HTTPS template for a feature to test whether the NQA client can get data from the HTTPS server (Device B).

Figure 23 Network diagram



Procedure

Assign IP addresses to interfaces, as shown in Figure 23. (Details not shown.)

Configure static routes or a routing protocol to make sure the devices can reach each other. (Details not shown.)

Configure an SSL client policy named **abc** on Device A, and make sure Device A can use the policy to connect to the HTTPS server. (Details not shown.)

Create HTTPS template **test**.

```
<DeviceA> system-view
[DeviceA] nqa template https https
```

Specify **http://10.2.2.2/index.htm** as the URL of the HTTPS server.

```
[DeviceA-nqatplt-https-https] url https://10.2.2.2/index.htm
```

Specify SSL client policy **abc** for the HTTPS template.

```
[DeviceA-nqatplt-https- https] ssl-client-policy abc
```

Set the HTTPS operation type to **get** (the default HTTPS operation type).

```
[DeviceA-nqatplt-https-https] operation get
```

Set the HTTPS version to 1.0 (the default HTTPS version).

```
 [DeviceA-nqatplt-https-https] version v1.0
```

Configure the NQA client to notify the feature of the successful operation event if the number of consecutive successful probes reaches 2.

```
[DeviceA-nqatplt-https-https] reaction trigger probe-pass 2
```

Configure the NQA client to notify the feature of the operation failure if the number of consecutive failed probes reaches 2.

```
[DeviceA-nqatplt-https-https] reaction trigger probe-fail 2
```

Example: Configuring the FTP template

Network configuration

As shown in Figure 24, configure an FTP template for a feature to perform the FTP operation. The operation tests whether Device A can upload a file to the FTP server. The login username and password are **admin** and **systemtest**, respectively. The file to be transferred to the FTP server is **config.txt**.

Figure 24 Network diagram

Procedure

Assign IP addresses to interfaces, as shown in Figure 24. (Details not shown.)

Configure static routes or a routing protocol to make sure the devices can reach each other. (Details not shown.)

Create FTP template **ftp**.

```
<DeviceA> system-view
[DeviceA] nqa template ftp ftp
```

Specify the URL of the FTP server.

```
[DeviceA-nqatplt-ftp-ftp] url ftp://10.2.2.2
```

Specify 10.1.1.1 as the source IP address.

```
[DeviceA-nqatplt-ftp-ftp] source ip 10.1.1.1
```

Configure the device to upload file **config.txt** to the FTP server.

```
[DeviceA-nqatplt-ftp-ftp] operation put
[DeviceA-nqatplt-ftp-ftp] filename config.txt
```

Set the username to **admin** for the FTP server login.

```
[DeviceA-nqatplt-ftp-ftp] username admin
```

Set the password to **systemtest** for the FTP server login.

```
[DeviceA-nqatplt-ftp-ftp] password simple systemtest
```

Configure the NQA client to notify the feature of the successful operation event if the number of consecutive successful probes reaches 2.

```
[DeviceA-nqatplt-ftp-ftp] reaction trigger probe-pass 2
```

Configure the NQA client to notify the feature of the operation failure if the number of consecutive failed probes reaches 2.

```
[DeviceA-nqatplt-ftp-ftp] reaction trigger probe-fail 2
```

Example: Configuring the RADIUS template

Network configuration

As shown in Figure 25, configure a RADIUS template for a feature to test whether the RADIUS server (Device B) can provide authentication service for Device A. The username and password are **admin** and **systemtest**, respectively. The shared key is **123456** for secure RADIUS authentication.

Figure 25 Network diagram

Procedure

Assign IP addresses to interfaces, as shown in Figure 25. (Details not shown.)

Configure static routes or a routing protocol to make sure the devices can reach each other. (Details not shown.)

Configure the RADIUS server. (Details not shown.)

Create RADIUS template **radius**.

```
<DeviceA> system-view
[DeviceA] nqa template radius radius
```

Specify 10.2.2.2 as the destination IP address of the operation.

```
[DeviceA-nqatplt-radius-radius] destination ip 10.2.2.2
```

Set the username to **admin**.

```
[DeviceA-nqatplt-radius-radius] username admin
```

Set the password to **systemtest**.

```
[DeviceA-nqatplt-radius-radius] password simple systemtest
```

Set the shared key to **123456** in plain text for secure RADIUS authentication.

```
[DeviceA-nqatplt-radius-radius] key simple 123456
```

Configure the NQA client to notify the feature of the successful operation event if the number of consecutive successful probes reaches 2.

```
[DeviceA-nqatplt-radius-radius] reaction trigger probe-pass 2
```

Configure the NQA client to notify the feature of the operation failure if the number of consecutive failed probes reaches 2.

```
[DeviceA-nqatplt-radius-radius] reaction trigger probe-fail 2
```

Example: Configuring the SSL template

Network configuration

As shown in Figure 26, configure an SSL template for a feature to test whether Device A can establish an SSL connection to the SSL server on Device B.

Figure 26 Network diagram

Procedure

Assign IP addresses to interfaces, as shown in Figure 26. (Details not shown.)

Configure static routes or a routing protocol to make sure the devices can reach each other. (Details not shown.)

Configure an SSL client policy named **abc** on Device A, and make sure Device A can use the policy to connect to the SSL server on Device B. (Details not shown.)

Create SSL template **ssl**.

```
<DeviceA> system-view
[DeviceA] nqa template ssl ssl
```

Set the destination IP address and port number to **10.2.2.2** and **9000**, respectively.

```
[DeviceA-nqatplt-ssl-ssl] destination ip 10.2.2.2
[DeviceA-nqatplt-ssl-ssl] destination port 9000
```

Specify SSL client policy **abc** for the SSL template.

```
[DeviceA-nqatplt-ssl-ssl] ssl-client-policy abc
```

Configure the NQA client to notify the feature of the successful operation event if the number of consecutive successful probes reaches 2.

```
[DeviceA-nqatplt-ssl-ssl] reaction trigger probe-pass 2
```

Configure the NQA client to notify the feature of the operation failure if the number of consecutive failed probes reaches 2.

```
[DeviceA-nqatplt-ssl-ssl] reaction trigger probe-fail 2
```

Contents

Configuring NTP

About NTP

NTP is used to synchronize system clocks among distributed time servers and clients on a network. NTP runs over UDP and uses UDP port 123.

NTP application scenarios

Various tasks, including network management, charging, auditing, and distributed computing depend on accurate and synchronized system time setting on the network devices. NTP is typically used in large networks to dynamically synchronize time among network devices.

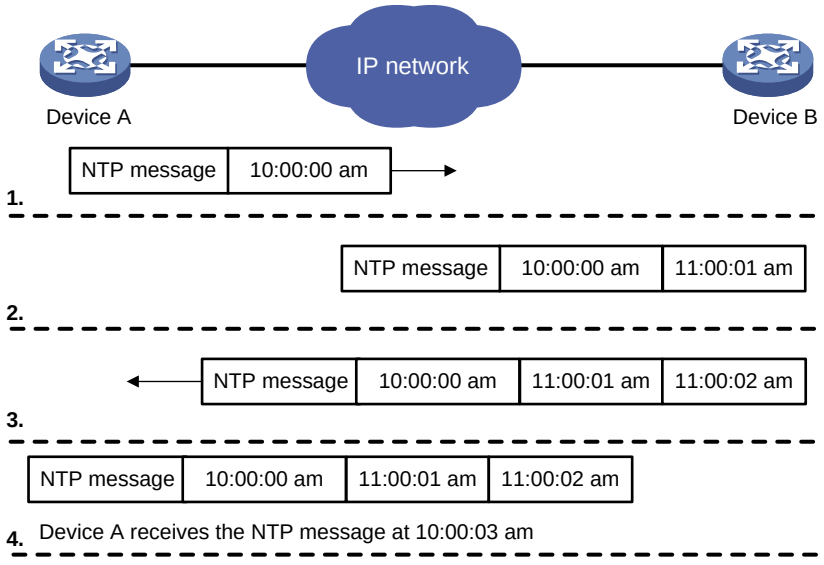
NTP guarantees higher clock accuracy than manual system clock setting. In a small network that does not require high clock accuracy, you can keep time synchronized among devices by changing their system clocks one by one.

NTP working mechanism

Figure 1 shows how NTP synchronizes the system time between two devices (Device A and Device B, in this example). Assume that:

- Prior to the time synchronization, the time is set to 10:00:00 am for Device A and 11:00:00 am for Device B.
- Device B is used as the NTP server. Device A is to be synchronized to Device B.
- It takes 1 second for an NTP message to travel from Device A to Device B, and from Device B to Device A.
- It takes 1 second for Device B to process the NTP message.

Figure 1 Basic work flow



The synchronization process is as follows:

1. Device A sends Device B an NTP message, which is timestamped when it leaves Device A. The time stamp is 10:00:00 am (T1).

2. When this NTP message arrives at Device B, Device B adds a timestamp showing the time when the message arrived at Device B. The timestamp is 11:00:01 am (T2).
3. When the NTP message leaves Device B, Device B adds a timestamp showing the time when the message left Device B. The timestamp is 11:00:02 am (T3).
4. When Device A receives the NTP message, the local time of Device A is 10:00:03 am (T4).

Up to now, Device A can calculate the following parameters based on the timestamps:

- The roundtrip delay of the NTP message: Delay = (T4 – T1) – (T3 – T2) = 2 seconds.
- Time difference between Device A and Device B: Offset = [(T2 – T1) + (T3 – T4)] /2 = 1 hour.

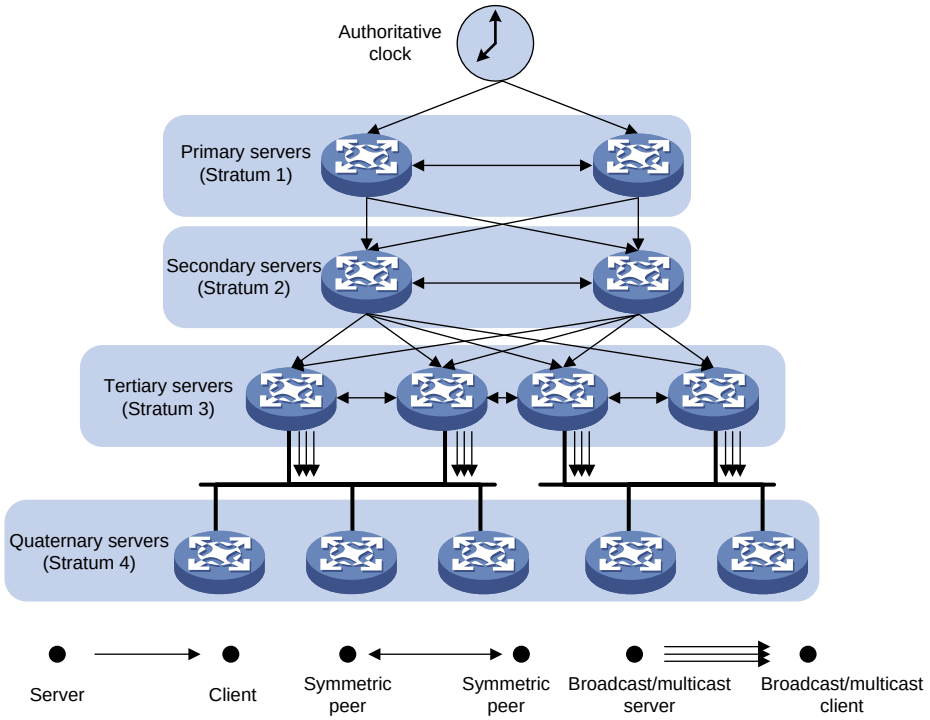
Based on these parameters, Device A can be synchronized to Device B.

This is only a rough description of the work mechanism of NTP. For more information, see the related protocols and standards.

NTP architecture

NTP uses stratums 1 to 16 to define clock accuracy, as shown in Figure 2. A lower stratum value represents higher accuracy. Clocks at stratums 1 through 15 are in synchronized state, and clocks at stratum 16 are not synchronized.

Figure 2 NTP architecture



A stratum 1 NTP server gets its time from an authoritative time source, such as an atomic clock. It provides time for other devices as the primary NTP server. A stratum 2 time server receives its time from a stratum 1 time server, and so on.

To ensure time accuracy and availability, you can specify multiple NTP servers for a device. The device selects an optimal NTP server as the clock source based on parameters such as stratum. The clock that the device selects is called the reference source. For more information about clock selection, see the related protocols and standards.

If the devices in a network cannot synchronize to an authoritative time source, you can perform the following tasks:

- Select a device that has a relatively accurate clock from the network.
- Use the local clock of the device as the reference clock to synchronize other devices in the network.

NTP association modes

NTP supports the following association modes:

- Client/server mode
- Symmetric active/passive mode
- Broadcast mode
- Multicast mode

You can select one or more association modes for time synchronization. Table 1 provides detailed description for the four association modes.

In this document, an "NTP server" or a "server" refers to a device that operates as an NTP server in client/server mode. Time servers refer to all the devices that can provide time synchronization, including NTP servers, NTP symmetric peers, broadcast servers, and multicast servers.

Table 1 NTP association modes

Mode	Working process	Principle	Application scenario
Client/server	On the client, specify the IP address of the NTP server. A client sends a clock synchronization message to the NTP servers. Upon receiving the message, the servers automatically operate in server mode and send a reply. If the client can be synchronized to multiple time servers, it selects an optimal clock and synchronizes its local clock to the optimal reference source after receiving the replies from the servers.	A client can synchronize to a server, but a server cannot synchronize to a client.	As Figure 2 shows, this mode is intended for configurations where devices of a higher stratum synchronize to devices with a lower stratum.
Symmetric active/passive	On the symmetric active peer, specify the IP address of the symmetric passive peer. A symmetric active peer periodically sends clock synchronization messages to a symmetric passive peer. The symmetric passive peer automatically operates in symmetric passive mode and sends a reply. If the symmetric active peer can be synchronized to multiple time servers, it selects an optimal clock and synchronizes its local clock to the optimal reference source after receiving the replies from the servers.	A symmetric active peer and a symmetric passive peer can be synchronized to each other. If both of them are synchronized, the peer with a higher stratum is synchronized to the peer with a lower stratum.	As Figure 2 shows, this mode is most often used between servers with the same stratum to operate as a backup for one another. If a server fails to communicate with all the servers of a lower stratum, the server can still synchronize to the servers of the same stratum.
Broadcast	A server periodically sends clock synchronization messages to the broadcast address	A broadcast client can synchronize to a broadcast server, but a	A broadcast server sends clock synchronization messages to synchronize

Mode	Working process	Principle	Application scenario
	255.255.255.255. Clients listen to the broadcast messages from the servers to synchronize to the server according to the broadcast messages. When a client receives the first broadcast message, the client and the server start to exchange messages to calculate the network delay between them. Then, only the broadcast server sends clock synchronization messages.	broadcast server cannot synchronize to a broadcast client.	clients in the same subnet. As Figure 2 shows, broadcast mode is intended for configurations involving one or a few servers and a potentially large client population. The broadcast mode has lower time accuracy than the client/server and symmetric active/passive modes because only the broadcast servers send clock synchronization messages.
Multicast	A multicast server periodically sends clock synchronization messages to the user-configured multicast address. Clients listen to the multicast messages from servers and synchronize to the server according to the received messages.	A multicast client can synchronize to a multicast server, but a multicast server cannot synchronize to a multicast client.	A multicast server can provide time synchronization for clients in the same subnet or in different subnets. The multicast mode has lower time accuracy than the client/server and symmetric active/passive modes.

NTP security

To improve time synchronization security, NTP provides the access control and authentication functions.

NTP access control

You can control NTP access by using an ACL. The access rights are in the following order, from the least restrictive to the most restrictive:

- **Peer**—Allows time requests and NTP control queries (such as alarms, authentication status, and time server information) and allows the local device to synchronize itself to a peer device.
- **Server**—Allows time requests and NTP control queries, but does not allow the local device to synchronize itself to a peer device.
- **Synchronization**—Allows only time requests from a system whose address passes the access list criteria.
- **Query**—Allows only NTP control queries from a peer device to the local device.

When the device receives an NTP request, it matches the request against the access rights in order from the least restrictive to the most restrictive: **peer**, **server**, **synchronization**, and **query**.

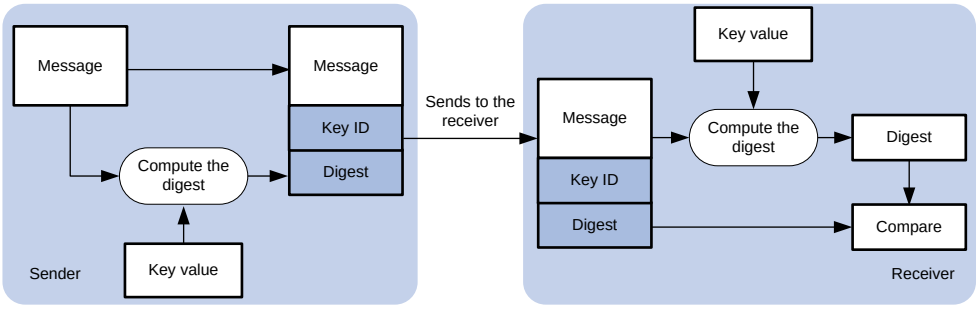
- If no NTP access control is configured, the **peer** access right applies.
- If the IP address of the peer device matches a **permit** statement in an ACL, the access right is granted to the peer device. If a **deny** statement or no ACL is matched, no access right is granted.
- If no ACL is specified for an access right or the ACL specified for the access right is not created, the access right is not granted.
- If none of the ACLs specified for the access rights is created, the **peer** access right applies.
- If none of the ACLs specified for the access rights contains rules, no access right is granted.

This feature provides minimal security for a system running NTP. A more secure method is NTP authentication.

NTP authentication

Use this feature to authenticate the NTP messages for security purposes. If an NTP message passes authentication, the device can receive it and get time synchronization information. If not, the device discards the message. This function makes sure the device does not synchronize to an unauthorized time server.

Figure 3 NTP authentication



As shown in Figure 3, NTP authentication is performed as follows:

1. The sender uses the key identified by the key ID to calculate a digest for the NTP message through the MD5/HMAC authentication algorithm. Then it sends the calculated digest together with the NTP message and key ID to the receiver.
2. Upon receiving the message, the receiver performs the following actions:
   a. Finds the key according to the key ID in the message.
   b. Uses the key and the MD5/HMAC authentication algorithm to calculate the digest for the message.
   c. Compares the digest with the digest contained in the NTP message.
      - If they are different, the receiver discards the message.
      - If they are the same and an NTP association is not required to be established, the receiver provides a response packet. For information about NTP associations, see "Configuring the maximum number of dynamic associations."
      - If they are the same and an NTP association is required to be established or has existed, the local device determines whether the sender is allowed to use the authentication ID. If the sender is allowed to use the authentication ID, the receiver accepts the message. If the sender is not allowed to use the authentication ID, the receiver discards the message.

Protocols and standards

- RFC 1305, *Network Time Protocol (Version 3) Specification, Implementation and Analysis*
- RFC 5905, *Network Time Protocol Version 4: Protocol and Algorithms Specification*

Restrictions and guidelines: NTP configuration

- You cannot configure both NTP and SNTP on the same device.
- NTP is supported only on Layer 3 interfaces.
- Do not configure NTP on an aggregate member port.

- The NTP service and SNTP service are mutually exclusive. You can only enable either NTP service or SNTP service at a time.
- To avoid frequent time changes or even synchronization failures, do not specify more than one reference source on a network.
- To use NTP for time synchronization, you must use the **`clock protocol`** command to specify NTP for obtaining the time. For more information about the **`clock protocol`** command, see device management commands in *Fundamentals Command Reference*.

NTP tasks at a glance

To configure NTP, perform the following tasks:

1. Enabling the NTP service
2. Configuring NTP association mode
   - Configuring NTP in client/server mode
   - Configuring NTP in symmetric active/passive mode
   - Configuring NTP in broadcast mode
   - Configuring NTP in multicast mode
3. (Optional.) Configuring the local clock as the reference source
4. (Optional.) Configuring access control rights
5. (Optional.) Configuring NTP authentication
   - Configuring NTP authentication in client/server mode
   - Configuring NTP authentication in symmetric active/passive mode
   - Configuring NTP authentication in broadcast mode
   - Configuring NTP authentication in multicast mode
6. (Optional.) Controlling NTP packet sending and receiving
   - Specifying a source address for NTP messages
   - Disabling an interface from receiving NTP messages
   - Configuring the maximum number of dynamic associations
   - Setting a DSCP value for NTP packets
7. (Optional.) Specifying the NTP time-offset thresholds for log and trap outputs

Enabling the NTP service

Restrictions and guidelines

NTP and SNTP are mutually exclusive. Before you enable NTP, make sure SNTP is disabled.

Procedure

1. Enter system view.
   `system-view`
2. Enable the NTP service.
   `ntp-service enable`
   By default, the NTP service is disabled.

Configuring NTP association mode

Configuring NTP in client/server mode

Restrictions and guidelines

To configure NTP in client/server mode, specify an NTP server for the client.

For a client to synchronize to an NTP server, make sure the server is synchronized by other devices or uses its local clock as the reference source.

If the stratum level of a server is higher than or equal to a client, the client will not synchronize to that server.

You can specify multiple servers for a client by executing the **ntp-service unicast-server** or **ntp-service ipv6 unicast-server** command multiple times.

Procedure

1. Enter system view.

   system-view

2. Specify an NTP server for the device.

   IPv4:

   ntp-service unicast-server { *server-name* | *ip-address* } [**authentication-keyid** *keyid* | **maxpoll** *maxpoll-interval* | **minpoll** *minpoll-interval* | **priority** | **source** *interface-type interface-number* | **version** *number*] *

   IPv6:

   ntp-service ipv6 unicast-server { *server-name* | *ipv6-address* } [**authentication-keyid** *keyid* | **maxpoll** *maxpoll-interval* | **minpoll** *minpoll-interval* | **priority** | **source** *interface-type interface-number*] *

   By default, no NTP server is specified.

Configuring NTP in symmetric active/passive mode

Restrictions and guidelines

To configure NTP in symmetric active/passive mode, specify a symmetric passive peer for the active peer.

For a symmetric passive peer to process NTP messages from a symmetric active peer, execute the **ntp-service enable** command on the symmetric passive peer to enable NTP.

For time synchronization between the symmetric active peer and the symmetric passive peer, make sure either or both of them are in synchronized state.

You can specify multiple symmetric passive peers by executing the **ntp-service unicast-peer** or **ntp-service ipv6 unicast-peer** command multiple times.

Procedure

1. Enter system view.

   system-view

2. Specify a symmetric passive peer for the device.

   IPv4:

ntp-service unicast-peer { *peer-name* | *ip-address* }
[**authentication-keyid** *keyid* | **maxpoll** *maxpoll-interval* | **minpoll** *minpoll-interval* | **priority** | **source** *interface-type interface-number* | **version** *number*] *

IPv6:

ntp-service ipv6 unicast-peer { *peer-name* | *ipv6-address* }
[**authentication-keyid** *keyid* | **maxpoll** *maxpoll-interval* | **minpoll** *minpoll-interval* | **priority** | **source** *interface-type interface-number*] *

By default, no symmetric passive peer is specified.

Configuring NTP in broadcast mode

Restrictions and guidelines

To configure NTP in broadcast mode, you must configure an NTP broadcast client and an NTP broadcast server.

For a broadcast client to synchronize to a broadcast server, make sure the broadcast server is synchronized by other devices or uses its local clock as the reference source.

Configuring the broadcast client

1. Enter system view.

   system-view

2. Enter interface view.

   interface *interface-type interface-number*

3. Configure the device to operate in broadcast client mode.

   ntp-service broadcast-client

   By default, the device does not operate in any NTP association mode.

   After you execute the command, the device receives NTP broadcast messages from the specified interface.

Configuring the broadcast server

1. Enter system view.

   system-view

2. Enter interface view.

   interface *interface-type interface-number*

3. Configure the device to operate in NTP broadcast server mode.

   ntp-service broadcast-server [**authentication-keyid** *keyid* | **version** *number*] *

   By default, the device does not operate in any NTP association mode.

   After you execute the command, the device sends NTP broadcast messages from the specified interface.

Configuring NTP in multicast mode

Restrictions and guidelines

To configure NTP in multicast mode, you must configure an NTP multicast client and an NTP multicast server.

For a multicast client to synchronize to a multicast server, make sure the multicast server is synchronized by other devices or uses its local clock as the reference source.

Configuring a multicast client

1. Enter system view.

   system-view

2. Enter interface view.

   interface *interface-type interface-number*

3. Configure the device to operate in multicast client mode.

   IPv4:

   ntp-service multicast-client [*ip-address*]

   IPv6:

   ntp-service ipv6 multicast-client *ipv6-address*

   By default, the device does not operate in any NTP association mode.

   After you execute the command, the device receives NTP multicast messages from the specified interface.

Configuring the multicast server

1. Enter system view.

   system-view

2. Enter interface view.

   interface *interface-type interface-number*

3. Configure the device to operate in multicast server mode.

   IPv4:

   ntp-service multicast-server [*ip-address*][**authentication-keyid** *keyid* | **ttl** *ttl-number* | **version** *number*]*

   IPv6:

   ntp-service ipv6 multicast-server *ipv6-address* [**authentication-keyid** *keyid* | **ttl** *ttl-number*] *

   By default, the device does not operate in any NTP association mode.

   After you execute the command, the device sends NTP multicast messages from the specified interface.

Configuring the local clock as the reference source

About configuring the local clock as the reference source

This task enables the device to use the local clock as the reference so that the device is synchronized.

Restrictions and guidelines

Make sure the local clock can provide the time accuracy required for the network. After you configure the local clock as the reference source, the local clock is synchronized, and can operate as a time server to synchronize other devices in the network. If the local clock is incorrect, timing errors occur.

The system time reverts to the initial BIOS default after a cold reboot. As a best practice, do not configure the local clock as the reference source or configure the device as a time server.

Devices differ in clock precision. As a best practice to avoid network flapping and clock synchronization failure, configure only one reference clock on the same network segment and make sure the clock has high precision.

Prerequisites

Before you configure this feature, adjust the local system time to ensure that it is accurate.

Procedure

1. Enter system view.

   system-view

2. Configure the local clock as the reference source.

   ntp-service refclock-master [*ip-address*] [*stratum*]

   By default, the device does not use the local clock as the reference source.

Configuring access control rights

Prerequisites

Before you configure the right for peer devices to access the NTP services on the local device, create and configure ACLs associated with the access right. For information about configuring an ACL, see *ACL and QoS Configuration Guide*.

Procedure

1. Enter system view.

   system-view

2. Configure the right for peer devices to access the NTP services on the local device.

   IPv4:

   ntp-service access { **peer** | **query** | **server** | **synchronization** } **acl** *ipv4-acl-number*

   IPv6:

   ntp-service ipv6 { **peer** | **query** | **server** | **synchronization** } **acl** *ipv6-acl-number*

   By default, the right for peer devices to access the NTP services on the local device is **peer**.

Configuring NTP authentication

Configuring NTP authentication in client/server mode

Restrictions and guidelines

To ensure a successful NTP authentication in client/server mode, configure the same authentication key ID, algorithm, and key on the server and client. Make sure the peer device is allowed to use the key ID for authentication on the local device.

NTP authentication results differ when different configurations are performed on client and server. For more information, see Table 2. (N/A in the table means that whether the configuration is performed or not does not make any difference.)

Table 2 NTP authentication results

Client			Server	
Enable NTP authentication	**Specify the server and key**	**Trusted key**	**Enable NTP authentication**	**Trusted key**
Successful authentication				
Yes	Yes	Yes	Yes	Yes
Failed authentication				
Yes	Yes	Yes	Yes	No
Yes	Yes	Yes	No	N/A
Yes	Yes	No	N/A	N/A
Authentication not performed				
Yes	No	N/A	N/A	N/A
No	N/A	N/A	N/A	N/A

Configuring NTP authentication for a client

1. Enter system view.

   system-view

2. Enable NTP authentication.

   ntp-service authentication enable

   By default, NTP authentication is disabled.

3. Configure an NTP authentication key.

   ntp-service authentication-keyid *keyid* **authentication-mode** { **hmac-sha-1** | **hmac-sha-256** | **hmac-sha-384** | **hmac-sha-512** | **md5** } { **cipher** | **simple** } *string* [**acl** *ipv4-acl-number* | **ipv6 acl** *ipv6-acl-number*] *

   By default, no NTP authentication key exists.

4. Configure the key as a trusted key.

   ntp-service reliable authentication-keyid *keyid*

   By default, no authentication key is configured as a trusted key.

5. Associate the specified key with an NTP server.

   IPv4:

   ntp-service unicast-server { *server-name* | *ip-address* } **authentication-keyid** *keyid*

   IPv6:

   ntp-service ipv6 unicast-server { *server-name* | *ipv6-address* } **authentication-keyid** *keyid*

Configuring NTP authentication for a server

1. Enter system view.

   system-view

2. Enable NTP authentication.

   ntp-service authentication enable

   By default, NTP authentication is disabled.

3. Configure an NTP authentication key.

ntp-service authentication-keyid *keyid* **authentication-mode** { **hmac-sha-1** | **hmac-sha-256** | **hmac-sha-384** | **hmac-sha-512** | **md5** } { **cipher** | **simple** } *string* [**acl** *ipv4-acl-number* | **ipv6 acl** *ipv6-acl-number*] *

By default, no NTP authentication key exists.

4. Configure the key as a trusted key.

ntp-service reliable authentication-keyid *keyid*

By default, no authentication key is configured as a trusted key.

Configuring NTP authentication in symmetric active/passive mode

Restrictions and guidelines

To ensure a successful NTP authentication in symmetric active/passive mode, configure the same authentication key ID, algorithm, and key on the active peer and passive peer. Make sure the peer device is allowed to use the key ID for authentication on the local device.

NTP authentication results differ when different configurations are performed on active peer and passive peer. For more information, see Table 3. (N/A in the table means that whether the configuration is performed or not does not make any difference.)

Table 3 NTP authentication results

Active peer				Passive peer	
Enable NTP authentication	**Specify the peer and key**	**Trusted key**	**Stratum level**	**Enable NTP authentication**	**Trusted key**
Successful authentication					
Yes	Yes	Yes	N/A	Yes	Yes
Failed authentication					
Yes	Yes	Yes	N/A	Yes	No
Yes	Yes	Yes	N/A	No	N/A
Yes	No	N/A	N/A	Yes	N/A
No	N/A	N/A	N/A	Yes	N/A
Yes	Yes	No	Larger than the passive peer	N/A	N/A
Yes	Yes	No	Smaller than the passive peer	Yes	N/A
Authentication not performed					
Yes	No	N/A	N/A	No	N/A
No	N/A	N/A	N/A	No	N/A
Yes	Yes	No	Smaller than the passive peer	No	N/A

Configuring NTP authentication for an active peer

1. Enter system view.

system-view

2. Enable NTP authentication.

ntp-service authentication enable

By default, NTP authentication is disabled.

3. Configure an NTP authentication key.

ntp-service authentication-keyid *keyid* **authentication-mode** { **hmac-sha-1** | **hmac-sha-256** | **hmac-sha-384** | **hmac-sha-512** | **md5** } { **cipher** | **simple** } *string* [**acl** *ipv4-acl-number* | **ipv6 acl** *ipv6-acl-number*] *

By default, no NTP authentication key exists.

4. Configure the key as a trusted key.

ntp-service reliable authentication-keyid *keyid*

By default, no authentication key is configured as a trusted key.

5. Associate the specified key with a passive peer.

IPv4:

ntp-service unicast-peer { *ip-address* | *peer-name* } **authentication-keyid** *keyid*

IPv6:

ntp-service ipv6 unicast-peer { *ipv6-address* | *peer-name* } **authentication-keyid** *keyid*

Configuring NTP authentication for a passive peer

1. Enter system view.

system-view

2. Enable NTP authentication.

ntp-service authentication enable

By default, NTP authentication is disabled.

3. Configure an NTP authentication key.

ntp-service authentication-keyid *keyid* **authentication-mode** { **hmac-sha-1** | **hmac-sha-256** | **hmac-sha-384** | **hmac-sha-512** | **md5** } { **cipher** | **simple** } *string* [**acl** *ipv4-acl-number* | **ipv6 acl** *ipv6-acl-number*] *

By default, no NTP authentication key exists.

4. Configure the key as a trusted key.

ntp-service reliable authentication-keyid *keyid*

By default, no authentication key is configured as a trusted key.

Configuring NTP authentication in broadcast mode

Restrictions and guidelines

To ensure a successful NTP authentication in broadcast mode, configure the same authentication key ID, algorithm, and key on the broadcast server and client. Make sure the peer device is allowed to use the key ID for authentication on the local device.

NTP authentication results differ when different configurations are performed on broadcast client and server. For more information, see Table 4. (N/A in the table means that whether the configuration is performed or not does not make any difference.)

Table 4 NTP authentication results

Broadcast server			Broadcast client	
Enable NTP authentication	**Specify the server and key**	**Trusted key**	**Enable NTP authentication**	**Trusted key**
Successful authentication				
Yes	Yes	Yes	Yes	Yes
Failed authentication				
Yes	Yes	Yes	Yes	No
Yes	Yes	Yes	No	N/A
Yes	Yes	No	Yes	N/A
Yes	No	N/A	Yes	N/A
No	N/A	N/A	Yes	N/A
Authentication not performed				
Yes	Yes	No	No	N/A
Yes	No	N/A	No	N/A
No	N/A	N/A	No	N/A

Configuring NTP authentication for a broadcast client

1. Enter system view.

   system-view
2. Enable NTP authentication.

   ntp-service authentication enable

   By default, NTP authentication is disabled.
3. Configure an NTP authentication key.

   ntp-service authentication-keyid *keyid* **authentication-mode** { **hmac-sha-1** | **hmac-sha-256** | **hmac-sha-384** | **hmac-sha-512** | **md5** } { **cipher** | **simple** } *string* [**acl** *ipv4-acl-number* | **ipv6 acl** *ipv6-acl-number*] *

   By default, no NTP authentication key exists.
4. Configure the key as a trusted key.

   ntp-service reliable authentication-keyid *keyid*

   By default, no authentication key is configured as a trusted key.

Configuring NTP authentication for a broadcast server

1. Enter system view.

   system-view
2. Enable NTP authentication.

   ntp-service authentication enable

   By default, NTP authentication is disabled.
3. Configure an NTP authentication key.

   ntp-service authentication-keyid *keyid* **authentication-mode** { **hmac-sha-1** | **hmac-sha-256** | **hmac-sha-384** | **hmac-sha-512** | **md5** } { **cipher** | **simple** } *string* [**acl** *ipv4-acl-number* | **ipv6 acl** *ipv6-acl-number*] *

By default, no NTP authentication key exists.

4. Configure the key as a trusted key.
   ntp-service reliable authentication-keyid *keyid*
   By default, no authentication key is configured as a trusted key.
5. Enter interface view.
   interface *interface-type interface-number*
6. Associate the specified key with the broadcast server.
   ntp-service broadcast-server authentication-keyid *keyid*
   By default, the broadcast server is not associated with a key.

Configuring NTP authentication in multicast mode

Restrictions and guidelines

To ensure a successful NTP authentication in multicast mode, configure the same authentication key ID, algorithm, and key on the multicast server and client. Make sure the peer device is allowed to use the key ID for authentication on the local device.

NTP authentication results differ when different configurations are performed on broadcast client and server. For more information, see Table 5. (N/A in the table means that whether the configuration is performed or not does not make any difference.)

Table 5 NTP authentication results

Multicast server			Multicast client	
Enable NTP authentication	**Specify the server and key**	**Trusted key**	**Enable NTP authentication**	**Trusted key**
Successful authentication				
Yes	Yes	Yes	Yes	Yes
Failed authentication				
Yes	Yes	Yes	Yes	No
Yes	Yes	Yes	No	N/A
Yes	Yes	No	Yes	N/A
Yes	No	N/A	Yes	N/A
No	N/A	N/A	Yes	N/A
Authentication not performed				
Yes	Yes	No	No	N/A
Yes	No	N/A	No	N/A
No	N/A	N/A	No	N/A

Configuring NTP authentication for a multicast client

1. Enter system view.
   system-view
2. Enable NTP authentication.
   ntp-service authentication enable
   By default, NTP authentication is disabled.
3. Configure an NTP authentication key.

ntp-service authentication-keyid *keyid* **authentication-mode** { **hmac-sha-1** | **hmac-sha-256** | **hmac-sha-384** | **hmac-sha-512** | **md5** } { **cipher** | **simple** } *string* [**acl** *ipv4-acl-number* | **ipv6 acl** *ipv6-acl-number*] *

By default, no NTP authentication key exists.

4. Configure the key as a trusted key.

ntp-service reliable authentication-keyid *keyid*

By default, no authentication key is configured as a trusted key.

Configuring NTP authentication for a multicast server

1. Enter system view.

system-view

2. Enable NTP authentication.

ntp-service authentication enable

By default, NTP authentication is disabled.

3. Configure an NTP authentication key.

ntp-service authentication-keyid *keyid* **authentication-mode** { **hmac-sha-1** | **hmac-sha-256** | **hmac-sha-384** | **hmac-sha-512** | **md5** } { **cipher** | **simple** } *string* [**acl** *ipv4-acl-number* | **ipv6 acl** *ipv6-acl-number*] *

By default, no NTP authentication key exists.

4. Configure the key as a trusted key.

ntp-service reliable authentication-keyid *keyid*

By default, no authentication key is configured as a trusted key.

5. Enter interface view.

interface *interface-type interface-number*

6. Associate the specified key with a multicast server.

IPv4:

ntp-service multicast-server [*ip-address*] **authentication-keyid** *keyid*

IPv6:

ntp-service ipv6 multicast-server *ipv6-multicast-address* **authentication-keyid** *keyid*

By default, no multicast server is associated with the specified key.

Controlling NTP packet sending and receiving

Specifying a source address for NTP messages

About specifying a source address for NTP messages

You can specify a source address or a source interface for NTP messages. If you specify a source interface for NTP messages, the device uses the IP address of the specified interface as the source address to send NTP messages.

Restrictions and guidelines

To prevent interface status changes from causing NTP communication failures, specify an interface that is always up as the source interface, a loopback interface for example.

When the device responds to an NTP request, the source IP address of the NTP response is always the IP address of the interface that has received the NTP request.

If you have specified the source interface for NTP messages in the **ntp-service unicast-server/ntp-service ipv6 unicast-server** or **ntp-service unicast-peer/ntp-service ipv6 unicast-peer** command, the IP address of the specified interface is used as the source IP address for NTP messages.

If you have configured the **ntp-service broadcast-server** or **ntp-service multicast-server/ntp-service ipv6 multicast-server** command in an interface view, the IP address of the interface is used as the source IP address for broadcast or multicast NTP messages.

Procedure

1. Enter system view.

   system-view
2. Specify the source address for NTP messages.

   IPv4:

   ntp-service source { *interface-type interface-number* | *ip-address* }

   IPv6:

   ntp-service ipv6 source *interface-type interface-number*

   By default, no source address is specified for NTP messages.

Disabling an interface from receiving NTP messages

About disabling an interface from receiving NTP messages

When NTP is enabled, all interfaces by default can receive NTP messages. For security purposes, you can disable some of the interfaces from receiving NTP messages.

Procedure

1. Enter system view.

   system-view
2. Enter interface view.

   interface *interface-type interface-number*
3. Disable the interface from receiving NTP packets.

   IPv4:

   undo ntp-service inbound enable

   IPv6:

   undo ntp-service ipv6 inbound enable

   By default, an interface receives NTP messages.

Configuring the maximum number of dynamic associations

About configuring the maximum number of dynamic associations

Perform this task to restrict the number of dynamic associations to prevent dynamic associations from occupying too many system resources.

NTP has the following types of associations:

- **Static association**—A manually created association.
- **Dynamic association**—Temporary association created by the system during NTP operation. A dynamic association is removed if no messages are exchanged within about 12 minutes.

The following describes how an association is established in different association modes:

- **Client/server mode**—After you specify an NTP server, the system creates a static association on the client. The server simply responds passively upon the receipt of a message, rather than creating an association (static or dynamic).
- **Symmetric active/passive mode**—After you specify a symmetric passive peer on a symmetric active peer, static associations are created on the symmetric active peer, and dynamic associations are created on the symmetric passive peer.
- **Broadcast or multicast mode**—Static associations are created on the server, and dynamic associations are created on the client.

Restrictions and guidelines

A single device can have a maximum of 128 concurrent associations, including static associations and dynamic associations.

Procedure

1. Enter system view.
   system-view
2. Configure the maximum number of dynamic sessions.
   ntp-service max-dynamic-sessions *number*
   By default, the maximum number of dynamic sessions is 100.

Setting a DSCP value for NTP packets

About DSCP values for NTP packets

The DSCP value determines the sending precedence of an NTP packet.

Procedure

1. Enter system view.
   system-view
2. Set a DSCP value for NTP packets.
   IPv4:
   ntp-service dscp *dscp-value*
   IPv6:
   ntp-service ipv6 dscp *dscp-value*
   The default DSCP value is 48 for IPv4 packets and 56 for IPv6 packets.

Specifying the NTP time-offset thresholds for log and trap outputs

About NTP time-offset thresholds for log and trap outputs

By default, the system synchronizes the NTP client's time to the server and outputs a log and a trap when the time offset exceeds 128 ms for multiple times.

After you set the NTP time-offset thresholds for log and trap outputs, the system synchronizes the client's time to the server when the time offset exceeds 128 ms for multiple times, but outputs logs and traps only when the time offset exceeds the specified thresholds, respectively.

Procedure

1. Enter system view.

system-view

2. Specify the NTP time-offset thresholds for log and trap outputs.
   ntp-service time-offset-threshold { **log** *log-threshold* | **trap** *trap-threshold* } *
   By default, no NTP time-offset thresholds are set for log and trap outputs.

Display and maintenance commands for NTP

Execute **display** commands in any view.

Task	Command
Display information about IPv6 NTP associations.	**display ntp-service ipv6 sessions** [**verbose**]
Display information about IPv4 NTP associations.	**display ntp-service sessions** [**verbose**]
Display information about NTP service status.	**display ntp-service status**
Display brief information about the NTP servers from the local device back to the primary NTP server.	**display ntp-service trace** [**source** *interface-type interface-number*]

NTP configuration examples

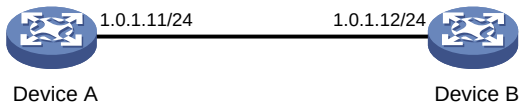
Example: Configuring NTP client/server association mode

Network configuration

As shown in Figure 4, perform the following tasks:

- Configure Device A's local clock as its reference source, with stratum level 2.
- Configure Device B to operate in client mode and specify Device A as the NTP server of Device B.

Figure 4 Network diagram



Procedure

1. Assign an IP address to each interface, and make sure Device A and Device B can reach each other, as shown in Figure 4. (Details not shown.)
2. Configure Device A:
   # Enable the NTP service.
   ```
   <DeviceA> system-view
   [DeviceA] ntp-service enable
   ```
   # Specify the local clock as the reference source, with stratum level 2.
   ```
   [DeviceA] ntp-service refclock-master 2
   ```
3. Configure Device B:
   # Enable the NTP service.

```
<DeviceB> system-view
[DeviceB] ntp-service enable
```

Specify NTP for obtaining the time.

```
[DeviceB] clock protocol ntp
```

Specify Device A as the NTP server of Device B.

```
[DeviceB] ntp-service unicast-server 1.0.1.11
```

Verifying the configuration

Verify that Device B has synchronized its time with Device A, and the clock stratum level of Device B is 3.

```
[DeviceB] display ntp-service status
 Clock status: synchronized
 Clock stratum: 3
 System peer: 1.0.1.11
 Local mode: client
 Reference clock ID: 1.0.1.11
 Leap indicator: 00
 Clock jitter: 0.000977 s
 Stability: 0.000 pps
 Clock precision: 2^-19
 Root delay: 0.00383 ms
 Root dispersion: 16.26572 ms
 Reference time: d0c6033f.b9923965  Wed, Dec 29 2010 18:58:07.724
 System poll interval: 64 s
```

Verify that an IPv4 NTP association has been established between Device B and Device A.

```
[DeviceB] display ntp-service sessions
      source          reference       stra reach poll  now offset  delay disper
**************************************************************************
[12345]1.0.1.11        127.127.1.0        2     1   64   15   -4.0 0.0038 16.262
Notes: 1 source(master), 2 source(peer), 3 selected, 4 candidate, 5 configured.
 Total sessions: 1
```

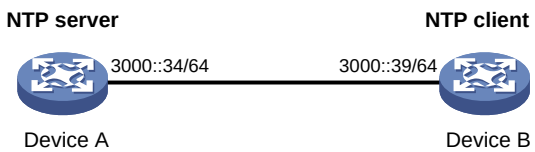
Example: Configuring IPv6 NTP client/server association mode

Network configuration

As shown in Figure 5, perform the following tasks:

- Configure Device A's local clock as its reference source, with stratum level 2.
- Configure Device B to operate in client mode and specify Device A as the IPv6 NTP server of Device B.

Figure 5 Network diagram



Procedure

1. Assign an IP address to each interface, and make sure Device A and Device B can reach each other, as shown in Figure 5. (Details not shown.)
2. Configure Device A:

   # Enable the NTP service.

   ```
   <DeviceA> system-view
   [DeviceA] ntp-service enable
   ```

   # Specify the local clock as the reference source, with stratum level 2.

   ```
   [DeviceA] ntp-service refclock-master 2
   ```

3. Configure Device B:

   # Enable the NTP service.

   ```
   <DeviceB> system-view
   [DeviceB] ntp-service enable
   ```

   # Specify NTP for obtaining the time.

   ```
   [DeviceB] clock protocol ntp
   ```

   # Specify Device A as the IPv6 NTP server of Device B.

   ```
   [DeviceB] ntp-service ipv6 unicast-server 3000::34
   ```

Verifying the configuration

Verify that Device B has synchronized its time with Device A, and the clock stratum level of Device B is 3.

```
[DeviceB] display ntp-service status
 Clock status: synchronized
 Clock stratum: 3
 System peer: 3000::34
 Local mode: client
 Reference clock ID: 163.29.247.19
 Leap indicator: 00
 Clock jitter: 0.000977 s
 Stability: 0.000 pps
 Clock precision: 2^-19
 Root delay: 0.02649 ms
 Root dispersion: 12.24641 ms
 Reference time: d0c60419.9952fb3e  Wed, Dec 29 2010 19:01:45.598
 System poll interval: 64 s
```

Verify that an IPv6 NTP association has been established between Device B and Device A.

```
[DeviceB] display ntp-service ipv6 sessions
Notes: 1 source(master), 2 source(peer), 3 selected, 4 candidate, 5 configured.

 Source: [12345]3000::34
 Reference: 127.127.1.0          Clock stratum: 2
 Reachabilities: 15              Poll interval: 64
 Last receive time: 19           Offset: 0.0
 Roundtrip delay: 0.0            Dispersion: 0.0

 Total sessions: 1
```

Example: Configuring NTP symmetric active/passive association mode

Network configuration

As shown in Figure 6, perform the following tasks:

- Configure Device A's local clock as its reference source, with stratum level 2.
- Configure Device A to operate in symmetric active mode and specify Device B as the passive peer of Device A.

Figure 6 Network diagram

Procedure

1. Assign an IP address to each interface, and make sure Device A and Device B can reach each other, as shown in Figure 6. (Details not shown.)
2. Configure Device B:

   # Enable the NTP service.

   ```
   <DeviceB> system-view
   [DeviceB] ntp-service enable
   ```

   # Specify NTP for obtaining the time.

   ```
   [DeviceB] clock protocol ntp
   ```

3. Configure Device A:

   # Enable the NTP service.

   ```
   <DeviceA> system-view
   [DeviceA] ntp-service enable
   ```

   # Specify NTP for obtaining the time.

   ```
   [DeviceA] clock protocol ntp
   ```

   # Specify the local clock as the reference source, with stratum level 2.

   ```
   [DeviceA] ntp-service refclock-master 2
   ```

   # Configure Device B as the symmetric passive peer.

   ```
   [DeviceA] ntp-service unicast-peer 3.0.1.32
   ```

Verifying the configuration

Verify that Device B has synchronized its time with Device A.

```
[DeviceB] display ntp-service status
 Clock status: synchronized
 Clock stratum: 3
 System peer: 3.0.1.31
 Local mode: sym_passive
 Reference clock ID: 3.0.1.31
 Leap indicator: 00
 Clock jitter: 0.000916 s
 Stability: 0.000 pps
```

```
 Clock precision: 2^-19
 Root delay: 0.00609 ms
 Root dispersion: 1.95859 ms
 Reference time: 83aec681.deb6d3e5  Wed, Jan  8 2014 14:33:11.081
 System poll interval: 64 s
```

Verify that an IPv4 NTP association has been established between Device B and Device A.

```
[DeviceB] display ntp-service sessions
       source          reference       stra reach poll  now offset  delay disper
**********************************************************************************
   [12]3.0.1.31        127.127.1.0        2    62   64   34 0.4251 6.0882 1392.1
Notes: 1 source(master), 2 source(peer), 3 selected, 4 candidate, 5 configured.
 Total sessions: 1
```

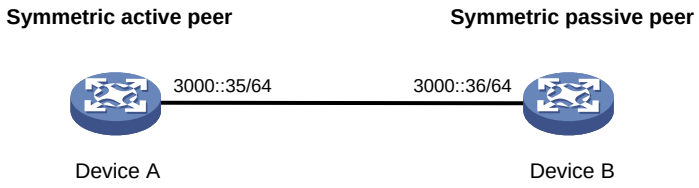
Example: Configuring IPv6 NTP symmetric active/passive association mode

Network configuration

As shown in Figure 7, perform the following tasks:

- Configure Device A's local clock as its reference source, with stratum level 2.
- Configure Device A to operate in symmetric active mode and specify Device B as the IPv6 passive peer of Device A.

Figure 7 Network diagram



Procedure

1. Assign an IP address to each interface, and make sure Device A and Device B can reach each other, as shown in Figure 7. (Details not shown.)
2. Configure Device B:

   # Enable the NTP service.

   ```
   <DeviceB> system-view
   [DeviceB] ntp-service enable
   ```

   # Specify NTP for obtaining the time.

   ```
   [DeviceB] clock protocol ntp
   ```

3. Configure Device A:

   # Enable the NTP service.

   ```
   <DeviceA> system-view
   [DeviceA] ntp-service enable
   ```

   # Specify NTP for obtaining the time.

   ```
   [DeviceA] clock protocol ntp
   ```

   # Specify the local clock as the reference source, with stratum level 2.

   ```
   [DeviceA] ntp-service refclock-master 2
   ```

Configure Device B as the IPv6 symmetric passive peer.

```
[DeviceA] ntp-service ipv6 unicast-peer 3000::36
```

Verifying the configuration

Verify that Device B has synchronized its time with Device A.

```
[DeviceB] display ntp-service status
 Clock status: synchronized
 Clock stratum: 3
 System peer: 3000::35
 Local mode: sym_passive
 Reference clock ID: 251.73.79.32
 Leap indicator: 11
 Clock jitter: 0.000977 s
 Stability: 0.000 pps
 Clock precision: 2^-19
 Root delay: 0.01855 ms
 Root dispersion: 9.23483 ms
 Reference time: d0c6047c.97199f9f  Wed, Dec 29 2010 19:03:24.590
 System poll interval: 64 s
```

Verify that an IPv6 NTP association has been established between Device B and Device A.

```
[DeviceB] display ntp-service ipv6 sessions
Notes: 1 source(master), 2 source(peer), 3 selected, 4 candidate, 5 configured.

 Source:  [1234]3000::35
 Reference: 127.127.1.0          Clock stratum: 2
 Reachabilities: 15              Poll interval: 64
 Last receive time: 19           Offset: 0.0
 Roundtrip delay: 0.0            Dispersion: 0.0

 Total sessions: 1
```

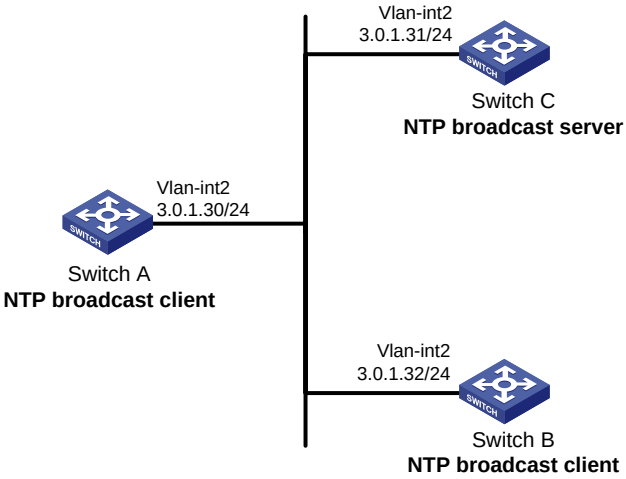
Example: Configuring NTP broadcast association mode

Network configuration

As shown in Figure 8, configure Switch C as the NTP server for multiple devices on a network segment to synchronize the time of the devices.

- Configure Switch C's local clock as its reference source, with stratum level 2.
- Configure Switch C to operate in broadcast server mode and send broadcast messages from VLAN-interface 2.
- Configure Switch A and Switch B to operate in broadcast client mode, and listen to broadcast messages on VLAN-interface 2.

Figure 8 Network diagram



Procedure

1. Assign an IP address to each interface, and make sure Switch A, Switch B, and Switch C can reach each other, as shown in Figure 8. (Details not shown.)
2. Configure Switch C:

   # Enable the NTP service.

   ```
   <SwitchC> system-view
   [SwitchC] ntp-service enable
   ```

   # Specify NTP for obtaining the time.

   ```
   [SwitchC] clock protocol ntp
   ```

   # Specify the local clock as the reference source, with stratum level 2.

   ```
   [SwitchC] ntp-service refclock-master 2
   ```

   # Configure Switch C to operate in broadcast server mode and send broadcast messages from VLAN-interface 2.

   ```
   [SwitchC] interface vlan-interface 2
   [SwitchC-Vlan-interface2] ntp-service broadcast-server
   ```

3. Configure Switch A:

   # Enable the NTP service.

   ```
   <SwitchA> system-view
   [SwitchA] ntp-service enable
   ```

   # Specify NTP for obtaining the time.

   ```
   [SwitchA] clock protocol ntp
   ```

   # Configure Switch A to operate in broadcast client mode and receive broadcast messages on VLAN-interface 2.

   ```
   [SwitchA] interface vlan-interface 2
   [SwitchA-Vlan-interface2] ntp-service broadcast-client
   ```

4. Configure Switch B:

   # Enable the NTP service.

   ```
   <SwitchB> system-view
   [SwitchB] ntp-service enable
   ```

   # Specify NTP for obtaining the time.

   ```
   [SwitchB] clock protocol ntp
   ```

Configure Switch B to operate in broadcast client mode and receive broadcast messages on VLAN-interface 2.

```
[SwitchB] interface vlan-interface 2
[SwitchB-Vlan-interface2] ntp-service broadcast-client
```

Verifying the configuration

The following procedure uses Switch A as an example to verify the configuration.

Verify that Switch A has synchronized to Switch C, and the clock stratum level is 3 on Switch A and 2 on Switch C.

```
[SwitchA-Vlan-interface2] display ntp-service status
 Clock status: synchronized
 Clock stratum: 3
 System peer: 3.0.1.31
 Local mode: bclient
 Reference clock ID: 3.0.1.31
 Leap indicator: 00
 Clock jitter: 0.044281 s
 Stability: 0.000 pps
 Clock precision: 2^-19
 Root delay: 0.00229 ms
 Root dispersion: 4.12572 ms
 Reference time: d0d289fe.ec43c720  Sat, Jan  8 2011  7:00:14.922
 System poll interval: 64 s
```

Verify that an IPv4 NTP association has been established between Switch A and Switch C.

```
[SwitchA-Vlan-interface2] display ntp-service sessions
       source          reference       stra reach poll  now offset  delay disper
**********************************************************************************
 [1245]3.0.1.31        127.127.1.0        2     1   64  519   -0.0 0.0022 4.1257
Notes: 1 source(master),2 source(peer),3 selected,4 candidate,5 configured.
 Total sessions: 1
```

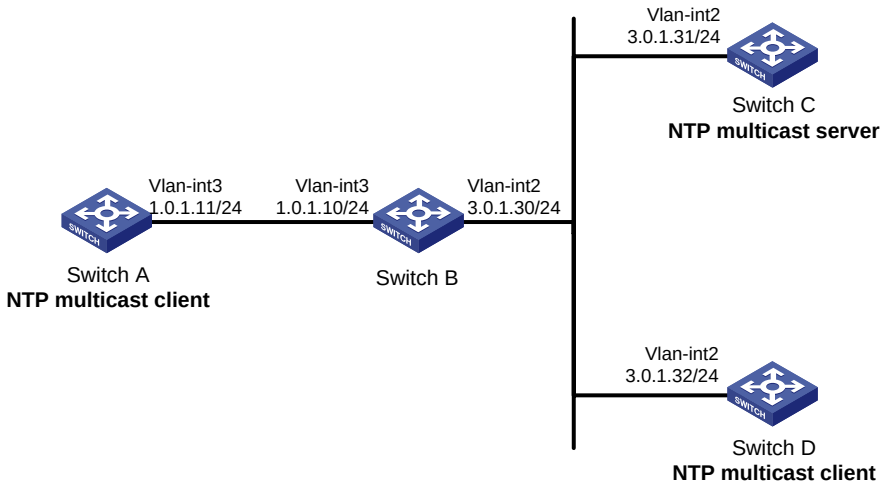
Example: Configuring NTP multicast association mode

Network configuration

As shown in Figure 9, configure Switch C as the NTP server for multiple devices on different network segments to synchronize the time of the devices.

- Configure Switch C's local clock as its reference source, with stratum level 2.
- Configure Switch C to operate in multicast server mode and send multicast messages from VLAN-interface 2.
- Configure Switch A and Switch D to operate in multicast client mode and receive multicast messages on VLAN-interface 3 and VLAN-interface 2, respectively.

Figure 9 Network diagram



Procedure

1. Assign an IP address to each interface, and make sure the switches can reach each other, as shown in Figure 9. (Details not shown.)
2. Configure Switch C:

   # Enable the NTP service.

   ```
   <SwitchC> system-view
   [SwitchC] ntp-service enable
   ```

   # Specify NTP for obtaining the time.

   ```
   [SwitchC] clock protocol ntp
   ```

   # Specify the local clock as the reference source, with stratum level 2.

   ```
   [SwitchC] ntp-service refclock-master 2
   ```

   # Configure Switch C to operate in multicast server mode and send multicast messages from VLAN-interface 2.

   ```
   [SwitchC] interface vlan-interface 2
   [SwitchC-Vlan-interface2] ntp-service multicast-server
   ```

3. Configure Switch D:

   # Enable the NTP service.

   ```
   <SwitchD> system-view
   [SwitchD] ntp-service enable
   ```

   # Specify NTP for obtaining the time.

   ```
   [SwitchD] clock protocol ntp
   ```

   # Configure Switch D to operate in multicast client mode and receive multicast messages on VLAN-interface 2.

   ```
   [SwitchD] interface vlan-interface 2
   [SwitchD-Vlan-interface2] ntp-service multicast-client
   ```

4. Verify the configuration:

   # Verify that Switch D has synchronized to Switch C, and the clock stratum level is 3 on Switch D and 2 on Switch C.

   Switch D and Switch C are on the same subnet, so Switch D can receive the multicast messages from Switch C without being enabled with the multicast functions.

   ```
   [SwitchD-Vlan-interface2] display ntp-service status
    Clock status: synchronized
   ```

```
 Clock stratum: 3
 System peer: 3.0.1.31
 Local mode: bclient
 Reference clock ID: 3.0.1.31
 Leap indicator: 00
 Clock jitter: 0.044281 s
 Stability: 0.000 pps
 Clock precision: 2^-19
 Root delay: 0.00229 ms
 Root dispersion: 4.12572 ms
 Reference time: d0d289fe.ec43c720  Sat, Jan  8 2011  7:00:14.922
 System poll interval: 64 s
```

Verify that an IPv4 NTP association has been established between Switch D and Switch C.

```
[SwitchD-Vlan-interface2] display ntp-service sessions
      source          reference       stra reach poll  now offset  delay disper
********************************************************************************
 [1245]3.0.1.31        127.127.1.0        2     1   64  519   -0.0 0.0022 4.1257
Notes: 1 source(master),2 source(peer),3 selected,4 candidate,5 configured.
 Total sessions: 1
```

5. Configure Switch B:

Because Switch A and Switch C are on different subnets, you must enable the multicast functions on Switch B before Switch A can receive multicast messages from Switch C.

Enable IP multicast functions.

```
<SwitchB> system-view
[SwitchB] multicast routing
[SwitchB-mrib] quit
[SwitchB] interface vlan-interface 2
[SwitchB-Vlan-interface2] pim dm
[SwitchB-Vlan-interface2] quit
[SwitchB] vlan 3
[SwitchB-vlan3] port gigabitethernet 1/0/1
[SwitchB-vlan3] quit
[SwitchB] interface vlan-interface 3
[SwitchB-Vlan-interface3] igmp enable
[SwitchB-Vlan-interface3] igmp static-group 224.0.1.1
[SwitchB-Vlan-interface3] quit
[SwitchB] igmp-snooping
[SwitchB-igmp-snooping] quit
[SwitchB] interface gigabitethernet 1/0/1
[SwitchB-GigabitEthernet1/0/1] igmp-snooping static-group 224.0.1.1 vlan 3
```

6. Configure Switch A:

Enable the NTP service.

```
<SwitchA> system-view
[SwitchA] ntp-service enable
```

Specify NTP for obtaining the time.

```
[SwitchA] clock protocol ntp
```

Configure Switch A to operate in multicast client mode and receive multicast messages on VLAN-interface 3.

```
[SwitchA] interface vlan-interface 3
[SwitchA-Vlan-interface3] ntp-service multicast-client
```

Verifying the configuration

Verify that Switch A has synchronized its time with Switch C, and the clock stratum level of Switch A is 3.

```
[SwitchA-Vlan-interface3] display ntp-service status
 Clock status: synchronized
 Clock stratum: 3
 System peer: 3.0.1.31
 Local mode: bclient
 Reference clock ID: 3.0.1.31
 Leap indicator: 00
 Clock jitter: 0.165741 s
 Stability: 0.000 pps
 Clock precision: 2^-19
 Root delay: 0.00534 ms
 Root dispersion: 4.51282 ms
 Reference time: d0c61289.10b1193f  Wed, Dec 29 2010 20:03:21.065
 System poll interval: 64 s
```

Verify that an IPv4 NTP association has been established between Switch A and Switch C.

```
[SwitchA-Vlan-interface3] display ntp-service sessions
       source          reference       stra reach poll  now offset  delay disper
**********************************************************************************
 [1234]3.0.1.31        127.127.1.0        2   247   64  381   -0.0 0.0053 4.5128
Notes: 1 source(master),2 source(peer),3 selected,4 candidate,5 configured.
 Total sessions: 1
```

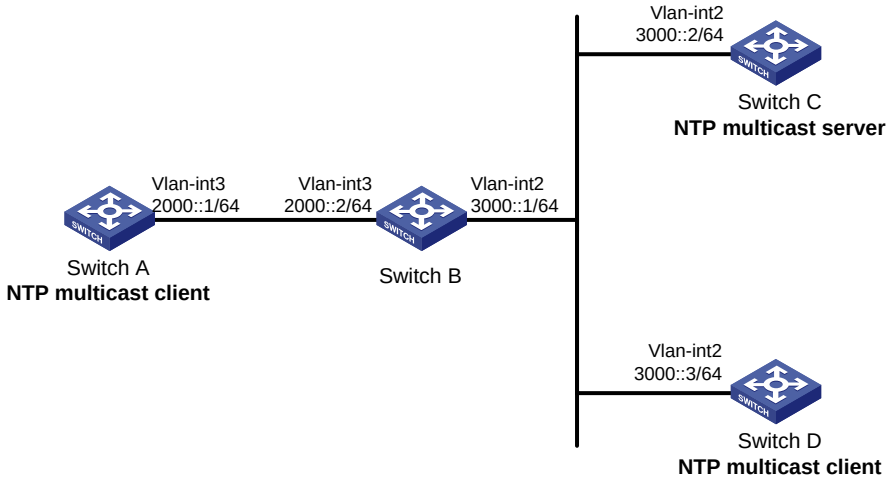
Example: Configuring IPv6 NTP multicast association mode

Network configuration

As shown in Figure 10, configure Switch C as the NTP server for multiple devices on different network segments to synchronize the time of the devices.

- Configure Switch C's local clock as its reference source, with stratum level 2.
- Configure Switch C to operate in IPv6 multicast server mode and send IPv6 multicast messages from VLAN-interface 2.
- Configure Switch A and Switch D to operate in IPv6 multicast client mode and receive IPv6 multicast messages on VLAN-interface 3 and VLAN-interface 2, respectively.

Figure 10 Network diagram



Procedure

1. Assign an IP address to each interface, and make sure the switches can reach each other, as shown in Figure 10. (Details not shown.)
2. Configure Switch C:

   # Enable the NTP service.

   ```
   <SwitchC> system-view
   [SwitchC] ntp-service enable
   ```

   # Specify NTP for obtaining the time.

   ```
   [SwitchC] clock protocol ntp
   ```

   # Specify the local clock as the reference source, with stratum level 2.

   ```
   [SwitchC] ntp-service refclock-master 2
   ```

   # Configure Switch C to operate in IPv6 multicast server mode and send multicast messages from VLAN-interface 2.

   ```
   [SwitchC] interface vlan-interface 2
   [SwitchC-Vlan-interface2] ntp-service ipv6 multicast-server ff24::1
   ```

3. Configure Switch D:

   # Enable the NTP service.

   ```
   <SwitchD> system-view
   [SwitchD] ntp-service enable
   ```

   # Specify NTP for obtaining the time.

   ```
   [SwitchD] clock protocol ntp
   ```

   # Configure Switch D to operate in IPv6 multicast client mode and receive multicast messages on VLAN-interface 2.

   ```
   [SwitchD] interface vlan-interface 2
   [SwitchD-Vlan-interface2] ntp-service ipv6 multicast-client ff24::1
   ```

4. Verify the configuration:

   # Verify that Switch D has synchronized its time with Switch C, and the clock stratum level of Switch D is 3.

   Switch D and Switch C are on the same subnet, so Switch D can Receive the IPv6 multicast messages from Switch C without being enabled with the IPv6 multicast functions.

   ```
   [SwitchD-Vlan-interface2] display ntp-service status
    Clock status: synchronized
   ```

```
Clock stratum: 3
System peer: 3000::2
Local mode: bclient
Reference clock ID: 165.84.121.65
Leap indicator: 00
Clock jitter: 0.000977 s
Stability: 0.000 pps
Clock precision: 2^-19
Root delay: 0.00000 ms
Root dispersion: 8.00578 ms
Reference time: d0c60680.9754fb17  Wed, Dec 29 2010 19:12:00.591
System poll interval: 64 s
```

Verify that an IPv6 NTP association has been established between Switch D and Switch C.

```
[SwitchD-Vlan-interface2] display ntp-service ipv6 sessions
Notes: 1 source(master), 2 source(peer), 3 selected, 4 candidate, 5 configured.

Source:  [1234]3000::2
Reference: 127.127.1.0          Clock stratum: 2
Reachabilities: 111             Poll interval: 64
Last receive time: 23           Offset: -0.0
Roundtrip delay: 0.0            Dispersion: 0.0

Total sessions: 1
```

5. Configure Switch B:

Because Switch A and Switch C are on different subnets, you must enable the IPv6 multicast functions on Switch B before Switch A can receive IPv6 multicast messages from Switch C.

Enable IPv6 multicast functions.

```
<SwitchB> system-view
[SwitchB] ipv6 multicast routing
[SwitchB-mrib6] quit
[SwitchB] interface vlan-interface 2
[SwitchB-Vlan-interface2] ipv6 pim dm
[SwitchB-Vlan-interface2] quit
[SwitchB] vlan 3
[SwitchB-vlan3] port gigabitethernet 1/0/1
[SwitchB-vlan3] quit
[SwitchB] interface vlan-interface 3
[SwitchB-Vlan-interface3] mld enable
[SwitchB-Vlan-interface3] mld static-group ff24::1
[SwitchB-Vlan-interface3] quit
[SwitchB] mld-snooping
[SwitchB-mld-snooping] quit
[SwitchB] interface gigabitethernet 1/0/1
[SwitchB-GigabitEthernet1/0/1] mld-snooping static-group ff24::1 vlan 3
```

6. Configure Switch A:

Enable the NTP service.

```
<SwitchA> system-view
[SwitchA] ntp-service enable
```

Specify NTP for obtaining the time.

```
[SwitchA] clock protocol ntp
```

Configure Switch A to operate in IPv6 multicast client mode and receive IPv6 multicast messages on VLAN-interface 3.

```
[SwitchA] interface vlan-interface 3
[SwitchA-Vlan-interface3] ntp-service ipv6 multicast-client ff24::1
```

Verifying the configuration

Verify that Switch A has synchronized to Switch C, and the clock stratum level is 3 on Switch A and 2 on Switch C.

```
[SwitchA-Vlan-interface3] display ntp-service status
 Clock status: synchronized
 Clock stratum: 3
 System peer: 3000::2
 Local mode: bclient
 Reference clock ID: 165.84.121.65
 Leap indicator: 00
 Clock jitter: 0.165741 s
 Stability: 0.000 pps
 Clock precision: 2^-19
 Root delay: 0.00534 ms
 Root dispersion: 4.51282 ms
 Reference time: d0c61289.10b1193f  Wed, Dec 29 2010 20:03:21.065
 System poll interval: 64 s
```

Verify that an IPv6 NTP association has been established between Switch A and Switch C.

```
[SwitchA-Vlan-interface3] display ntp-service ipv6 sessions
Notes: 1 source(master), 2 source(peer), 3 selected, 4 candidate, 5 configured.

 Source:   [124]3000::2
 Reference: 127.127.1.0          Clock stratum: 2
 Reachabilities: 2               Poll interval: 64
 Last receive time: 71           Offset: -0.0
 Roundtrip delay: 0.0            Dispersion: 0.0

 Total sessions: 1
```

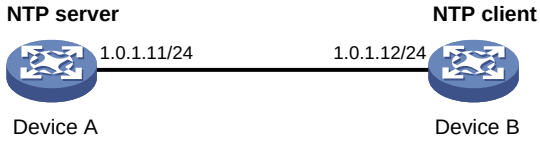
Example: Configuring NTP client/server association mode with authentication

Network configuration

As shown in Figure 11, perform the following tasks:

- Configure Device A's local clock as its reference source, with stratum level 2.
- Configure Device B to operate in client mode and specify Device A as the NTP server of Device B.
- Configure NTP authentication on both Device A and Device B.

Figure 11 Network diagram



Procedure

1. Assign an IP address to each interface, and make sure Device A and Device B can reach each other, as shown in Figure 11. (Details not shown.)
2. Configure Device A:

   # Enable the NTP service.

   ```
   <DeviceA> system-view
   [DeviceA] ntp-service enable
   ```

   # Specify the local clock as the reference source, with stratum level 2.

   ```
   [DeviceA] ntp-service refclock-master 2
   ```
3. Configure Device B:

   # Enable the NTP service.

   ```
   <DeviceB> system-view
   [DeviceB] ntp-service enable
   ```

   # Specify NTP for obtaining the time.

   ```
   [DeviceB] clock protocol ntp
   ```

   # Enable NTP authentication on Device B.

   ```
   [DeviceB] ntp-service authentication enable
   ```

   # Create a plaintext authentication key, with key ID **42** and key value **aNiceKey**.

   ```
   [DeviceB] ntp-service authentication-keyid 42 authentication-mode md5 simple
   aNiceKey
   ```

   # Specify the key as a trusted key.

   ```
   [DeviceB] ntp-service reliable authentication-keyid 42
   ```

   # Specify Device A as the NTP server of Device B, and associate the server with key 42.

   ```
   [DeviceB] ntp-service unicast-server 1.0.1.11 authentication-keyid 42
   ```

   To enable Device B to synchronize its clock with Device A, enable NTP authentication on Device A.
4. Configure NTP authentication on Device A:

   # Enable NTP authentication.

   ```
   [DeviceA] ntp-service authentication enable
   ```

   # Create a plaintext authentication key, with key ID **42** and key value **aNiceKey**.

   ```
   [DeviceA] ntp-service authentication-keyid 42 authentication-mode md5 simple
   aNiceKey
   ```

   # Specify the key as a trusted key.

   ```
   [DeviceA] ntp-service reliable authentication-keyid 42
   ```

Verifying the configuration

Verify that Device B has synchronized its time with Device A, and the clock stratum level of Device B is 3.

```
[DeviceB] display ntp-service status
 Clock status: synchronized
 Clock stratum: 3
```

```
 System peer: 1.0.1.11
 Local mode: client
 Reference clock ID: 1.0.1.11
 Leap indicator: 00
 Clock jitter: 0.005096 s
 Stability: 0.000 pps
 Clock precision: 2^-19
 Root delay: 0.00655 ms
 Root dispersion: 1.15869 ms
 Reference time: d0c62687.ab1bba7d  Wed, Dec 29 2010 21:28:39.668
 System poll interval: 64 s
```

Verify that an IPv4 NTP association has been established between Device B and Device A.

```
[DeviceB] display ntp-service sessions
       source          reference       stra reach poll  now offset  delay disper
**************************************************************************
 [1245]1.0.1.11        127.127.1.0        2     1   64  519   -0.0 0.0065    0.0
Notes: 1 source(master),2 source(peer),3 selected,4 candidate,5 configured.
 Total sessions: 1
```

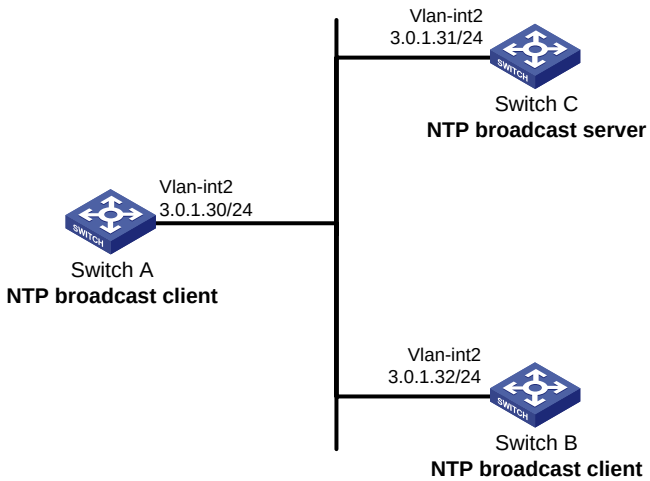
Example: Configuring NTP broadcast association mode with authentication

Network configuration

As shown in Figure 12, configure Switch C as the NTP server for multiple devices on the same network segment to synchronize the time of the devices. Configure Switch A and Switch B to authenticate the NTP server.

- Configure Switch C's local clock as its reference source, with stratum level 3.
- Configure Switch C to operate in broadcast server mode and send broadcast messages from VLAN-interface 2.
- Configure Switch A and Switch B to operate in broadcast client mode and receive broadcast messages on VLAN-interface 2.
- Enable NTP authentication on Switch A, Switch B, and Switch C.

Figure 12 Network diagram



Procedure

1. Assign an IP address to each interface, and make sure Switch A, Switch B, and Switch C can reach each other, as shown in Figure 12. (Details not shown.)
2. Configure Switch A:

   # Enable the NTP service.

   ```
   <SwitchA> system-view
   [SwitchA] ntp-service enable
   ```

   # Specify NTP for obtaining the time.

   ```
   [SwitchA] clock protocol ntp
   ```

   # Enable NTP authentication on Switch A. Create a plaintext NTP authentication key, with key ID of **88** and key value of **123456**. Specify it as a trusted key.

   ```
   [SwitchA] ntp-service authentication enable
   [SwitchA] ntp-service authentication-keyid 88 authentication-mode md5 simple 123456
   [SwitchA] ntp-service reliable authentication-keyid 88
   ```

   # Configure Switch A to operate in NTP broadcast client mode and receive NTP broadcast messages on VLAN-interface 2.

   ```
   [SwitchA] interface vlan-interface 2
   [SwitchA-Vlan-interface2] ntp-service broadcast-client
   ```

3. Configure Switch B:

   # Enable the NTP service.

   ```
   <SwitchB> system-view
   [SwitchB] ntp-service enable
   ```

   # Specify NTP for obtaining the time.

   ```
   [SwitchB] clock protocol ntp
   ```

   # Enable NTP authentication on Switch B. Create a plaintext NTP authentication key, with key ID of **88** and key value of **123456**. Specify it as a trusted key.

   ```
   [SwitchB] ntp-service authentication enable
   [SwitchB] ntp-service authentication-keyid 88 authentication-mode md5 simple 123456
   [SwitchB] ntp-service reliable authentication-keyid 88
   ```

   # Configure Switch B to operate in broadcast client mode and receive NTP broadcast messages on VLAN-interface 2.

   ```
   [SwitchB] interface vlan-interface 2
   [SwitchB-Vlan-interface2] ntp-service broadcast-client
   ```

4. Configure Switch C:

   # Enable the NTP service.

   ```
   <SwitchC> system-view
   [SwitchC] ntp-service enable
   ```

   # Specify NTP for obtaining the time.

   ```
   [SwitchC] clock protocol ntp
   ```

   # Specify the local clock as the reference source, with stratum level 3.

   ```
   [SwitchC] ntp-service refclock-master 3
   ```

   # Configure Switch C to operate in NTP broadcast server mode and use VLAN-interface 2 to send NTP broadcast packets.

   ```
   [SwitchC] interface vlan-interface 2
   [SwitchC-Vlan-interface2] ntp-service broadcast-server
   [SwitchC-Vlan-interface2] quit
   ```

5. Verify the configuration:

NTP authentication is enabled on Switch A and Switch B, but not on Switch C, so Switch A and Switch B cannot synchronize their local clocks to Switch C.

```
[SwitchB-Vlan-interface2] display ntp-service status
 Clock status: unsynchronized
 Clock stratum: 16
 Reference clock ID: none
```

6. Enable NTP authentication on Switch C:

Enable NTP authentication on Switch C. Create a plaintext NTP authentication key, with key ID of **88** and key value of **123456**. Specify it as a trusted key.

```
[SwitchC] ntp-service authentication enable
[SwitchC] ntp-service authentication-keyid 88 authentication-mode md5 simple 123456
[SwitchC] ntp-service reliable authentication-keyid 88
```

Specify Switch C as an NTP broadcast server, and associate key **88** with Switch C.

```
[SwitchC] interface vlan-interface 2
[SwitchC-Vlan-interface2] ntp-service broadcast-server authentication-keyid 88
```

Verifying the configuration

Verify that Switch B has synchronized its time with Switch C, and the clock stratum level of Switch B is 4.

```
[SwitchB-Vlan-interface2] display ntp-service status
 Clock status: synchronized
 Clock stratum: 4
 System peer: 3.0.1.31
 Local mode: bclient
 Reference clock ID: 3.0.1.31
 Leap indicator: 00
 Clock jitter: 0.006683 s
 Stability: 0.000 pps
 Clock precision: 2^-19
 Root delay: 0.00127 ms
 Root dispersion: 2.89877 ms
 Reference time: d0d287a7.3119666f  Sat, Jan  8 2011  6:50:15.191
 System poll interval: 64 s
```

Verify that an IPv4 NTP association has been established between Switch B and Switch C.

```
[SwitchB-Vlan-interface2] display ntp-service sessions
      source          reference       stra reach poll  now offset  delay disper
**************************************************************************
 [1245]3.0.1.31        127.127.1.0        3     3   64   68   -0.0 0.0000    0.0
Notes: 1 source(master),2 source(peer),3 selected,4 candidate,5 configured.
 Total sessions: 1
```

Configuring SNTP

About SNTP

SNTP is a simplified, client-only version of NTP specified in RFC 4330. It uses the same packet format and packet exchange procedure as NTP, but provides faster synchronization at the price of time accuracy.

SNTP working mode

SNTP supports only the client/server mode. An SNTP-enabled device can receive time from NTP servers, but cannot provide time services to other devices.

If you specify multiple NTP servers for an SNTP client, the server with the best stratum is selected. If multiple servers are at the same stratum, the NTP server whose time packet is first received is selected.

Protocols and standards

RFC 4330, *Simple Network Time Protocol (SNTP) Version 4 for IPv4, IPv6 and OSI*

Restrictions and guidelines: SNTP configuration

When you configure SNTP, follow these restrictions and guidelines:

- You cannot configure both NTP and SNTP on the same device.
- To use NTP for time synchronization, you must use the **`clock protocol`** command to specify NTP for obtaining the time. For more information about the **`clock protocol`** command, see device management commands in *Fundamentals Configuration Guide*.

SNTP tasks at a glance

To configure SNTP, perform the following tasks:

1. Enabling the SNTP service
2. Specifying an NTP server for the device
3. (Optional.) Configuring SNTP authentication
4. (Optional.) Specifying the SNTP time-offset thresholds for log and trap outputs

Enabling the SNTP service

Restrictions and guidelines

The NTP service and SNTP service are mutually exclusive. Before you enable SNTP, make sure NTP is disabled.

Procedure

1. Enter system view.

   `system-view`

2. Enable the SNTP service.

   sntp enable

   By default, the SNTP service is disabled.

Specifying an NTP server for the device

Restrictions and guidelines

To use an NTP server as the time source, make sure its clock has been synchronized. If the stratum level of the NTP server is greater than or equal to that of the client, the client does not synchronize with the NTP server.

Procedure

1. Enter system view.

   system-view

2. Specify an NTP server for the device.

   IPv4:

   sntp unicast-server { *server-name* | *ip-address* }
   [**authentication-keyid** *keyid* | **source** *interface-type interface-number* | **version** *number*] *

   IPv6:

   sntp ipv6 unicast-server { *server-name* | *ipv6-address* }
   [**authentication-keyid** *keyid* | **source** *interface-type interface-number*] *

   By default, no NTP server is specified for the device.

   You can specify multiple NTP servers for the client by repeating this step.

   To perform authentication, you need to specify the **authentication-keyid** *keyid* option.

Configuring SNTP authentication

About SNTP authentication

SNTP authentication ensures that an SNTP client is synchronized only to an authenticated trustworthy NTP server.

Restrictions and guidelines

Enable authentication on both the NTP server and the SNTP client.

Use the same authentication key ID, algorithm, and key on the NTP server and SNTP client. Specify the key as a trusted key on both the NTP server and the SNTP client. For information about configuring NTP authentication on an NTP server, see "Configuring NTP."

On the SNTP client, associate the specified key with the NTP server. Make sure the server is allowed to use the key ID for authentication on the client.

With authentication disabled, the SNTP client can synchronize with the NTP server regardless of whether the NTP server is enabled with authentication.

Procedure

1. Enter system view.

   system-view

2. Enable SNTP authentication.

   sntp authentication enable

By default, SNTP authentication is disabled.

3. Configure an SNTP authentication key.

   sntp authentication-keyid *keyid* **authentication-mode** { **hmac-sha-1** | **hmac-sha-256** | **hmac-sha-384** | **hmac-sha-512** | **md5** } { **cipher** | **simple** } *string* [**acl** *ipv4-acl-number* | **ipv6 acl** *ipv6-acl-number*]*

   By default, no SNTP authentication key exists.

4. Specify the key as a trusted key.

   sntp reliable authentication-keyid *keyid*

   By default, no trusted key is specified.

5. Associate the SNTP authentication key with an NTP server.

   IPv4:

   sntp unicast-server { *server-name* | *ip-address* } **authentication-keyid** *keyid*

   IPv6:

   sntp ipv6 unicast-server { *server-name* | *ipv6-address* } **authentication-keyid** *keyid*

   By default, no NTP server is specified.

Specifying the SNTP time-offset thresholds for log and trap outputs

About SNTP time-offset thresholds for log and trap outputs

By default, the system synchronizes the SNTP client's time to the server and outputs a log and a trap when the time offset exceeds 128 ms for multiple times.

After you set the SNTP time-offset thresholds for log and trap outputs, the system synchronizes the client's time to the server when the time offset exceeds 128 ms for multiple times, but outputs logs and traps only when the time offset exceeds the specified thresholds, respectively.

Procedure

1. Enter system view.

   system-view

2. Specify the SNTP time-offset thresholds for log and trap outputs.

   sntp time-offset-threshold { **log** *log-threshold* | **trap** *trap-threshold* } *

   By default, no SNTP time-offset thresholds are set for log and trap outputs.

Display and maintenance commands for SNTP

Execute **display** commands in any view.

Task	Command
Display information about all IPv6 SNTP associations.	**display sntp ipv6 sessions**
Display information about all IPv4 SNTP associations.	**display sntp sessions**

SNTP configuration examples

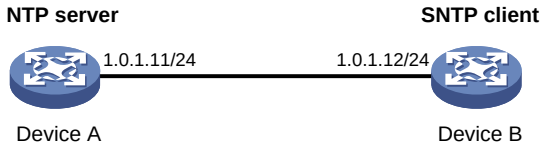
Example: Configuring SNTP

Network configuration

As shown in Figure 13, perform the following tasks:

- Configure Device A's local clock as its reference source, with stratum level 2.
- Configure Device B to operate in SNTP client mode, and specify Device A as the NTP server.
- Configure NTP authentication on Device A and SNTP authentication on Device B.

Figure 13 Network diagram



Procedure

1. Assign an IP address to each interface, and make sure Device A and Device B can reach each other, as shown in Figure 13. (Details not shown.)
2. Configure Device A:

   # Enable the NTP service.

   ```
   <DeviceA> system-view
   [DeviceA] ntp-service enable
   ```

   # Specify NTP for obtaining the time.

   ```
   [DeviceA] clock protocol ntp
   ```

   # Configure the local clock as the reference source, with stratum level 2.

   ```
   [DeviceA] ntp-service refclock-master 2
   ```

   # Enable NTP authentication on Device A.

   ```
   [DeviceA] ntp-service authentication enable
   ```

   # Configure a plaintext NTP authentication key, with key ID of **10** and key value of **aNiceKey**.

   ```
   [DeviceA] ntp-service authentication-keyid 10 authentication-mode md5 simple
   aNiceKey
   ```

   # Specify the key as a trusted key.

   ```
   [DeviceA] ntp-service reliable authentication-keyid 10
   ```

3. Configure Device B:

   # Enable the SNTP service.

   ```
   <DeviceB> system-view
   [DeviceB] sntp enable
   ```

   # Specify NTP for obtaining the time.

   ```
   [DeviceB] clock protocol ntp
   ```

   # Enable SNTP authentication on Device B.

   ```
   [DeviceB] sntp authentication enable
   ```

   # Configure a plaintext authentication key, with key ID of **10** and key value of **aNiceKey**.

   ```
   [DeviceB] sntp authentication-keyid 10 authentication-mode md5 simple aNiceKey
   ```

   # Specify the key as a trusted key.

```
[DeviceB] sntp reliable authentication-keyid 10
```

Specify Device A as the NTP server of Device B, and associate the server with key 10.

```
[DeviceB] sntp unicast-server 1.0.1.11 authentication-keyid 10
```

Verifying the configuration

Verify that an SNTP association has been established between Device B and Device A, and Device B has synchronized its time with Device A.

```
[DeviceB] display sntp sessions
NTP server     Stratum   Version    Last receive time
1.0.1.11        2         4          Tue, May 17 2011  9:11:20.833 (Synced)
```

Contents

Configuring PoE

About PoE

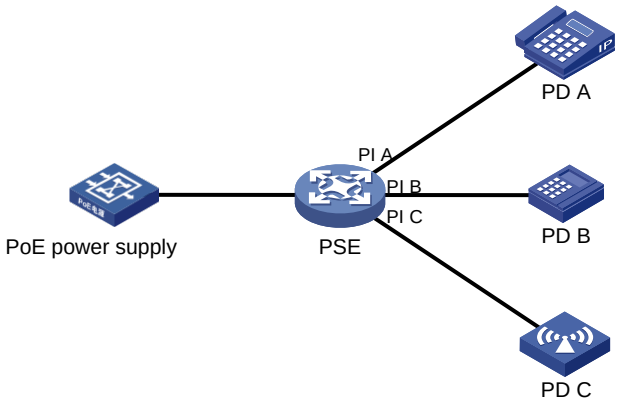
Power over Ethernet (PoE) enables a network device to supply power to terminals over twisted pair cables.

PoE system

As shown in Figure 1, a PoE system includes the following elements:

- **PoE power supply**—A PoE power supply provides power for the entire PoE system.
- **PSE**—A power sourcing equipment (PSE) supplies power to PDs. PSE devices are classified into single-PSE devices and multiple-PSE devices.
  - A single-PSE device has only one PSE firmware.
  - A multiple-PSE device has multiple PSEs. A multiple-PSE device uses PSE IDs to identify different PSEs. To view the mapping between the ID and slot number of a PSE, execute the **`display poe device`** command.
- **PI**—A power interface (PI) is a PoE-capable Ethernet interface on a PSE.
- **PD**—A powered device (PD) receives power from a PSE. PDs include IP telephones, APs, portable chargers, POS terminals, and Web cameras. You can also connect a PD to a redundant power source for reliability.

Figure 1 PoE system diagram



AI-driven PoE

AI-driven PoE innovatively integrates AI technologies into PoE switches and offers the following benefits:

- Adaptive power supply management

  AI-driven PoE can adaptively adjust the power supply parameters to fit power needs in various scenarios such as multiple types of PDs and address issues such as no power supply to a PD and power failure, minimizing human intervention.
- Priority-based power management

When the power demanded by PDs exceeds the power that can be supplied by the PoE switch, the system supplies power to PDs based on the PI priorities to ensure power supply to critical businesses and reduce power supply to PIs of lower priorities.

- Smart power module management

  For a PoE switch with a dual power module architecture, AI-driven PoE can automatically calculate and regulate power output of each power module based on the type and quantity of the power modules, maximizing the power usage of each power module. When a power module is removed, AI-driven PoE recalculates to preferentially guarantee power supply to PDs that are being powered.

- High PoE security

  When an exception such as short circuit or circuit break occurs, AI-driven PoE immediately starts self-protection to protect the PoE switch from being damaged or burned.

- Perpetual PoE

  During a hot reboot of the PoE switch from the **`reboot`** command, AI-driven PoE continuously monitors the PD states and ensures continued power supply to PDs, maintaining terminal service stability.

- Remote PoE

  AI-driven PoE adaptively adjusts the network bandwidth based on the transmission distance between a PSE and PD. When the transmission distance exceeds 100 m (328.08 ft), the system automatically decreases the port rate to reduce the line loss and ensure the signal and power transmission quality. With AI-driven PoE enabled, a PSE can transmit power to a PD of 200 to 250 m (656.17 to 820.21 ft) away.

Protocols and standards

- 802.3af-2003*, IEEE Standard for Information Technology - Telecommunications and Information Exchange Between Systems - Local and Metropolitan Area Networks - Specific Requirements - Part 3: Carrier Sense Multiple Access with Collision Detection (CSMA/CD) Access Method and Physical Layer Specifications - Data Terminal Equipment (DTE) Power Via Media Dependent Interface (MDI)*
- 802.3at-2009*, IEEE Standard for Information technology-- Local and metropolitan area networks-- Specific requirements-- Part 3: CSMA/CD Access Method and Physical Layer Specifications Amendment 3: Data Terminal Equipment (DTE) Power via the Media Dependent Interface (MDI) Enhancements*

Restrictions: Hardware compatibility with PoE

Only the PoE models support the PoE feature.

Restrictions and guidelines: PoE configuration

You can configure a PI through either of the following ways:

- Configure the settings directly on the PI.
- Configure a PoE profile and apply it to the PI. If you apply a PoE profile to multiple PIs, these PIs have the same PoE features. If you connect a PD to another PI, you can apply the PoE profile of the original PI to the new PI. This method relieves the task of configuring PoE on the new PI.

You can only use one way to configure a parameter for a PI. To use the other way to reconfigure a parameter, you must first remove the original configuration.

You must use the same configuration method for the **poe max-power** *max-power* and **poe priority** { **critical** | **high** | **low** } commands.

PoE configuration tasks at a glance

To configure PoE, perform the following tasks:

1. Enabling PoE on a PI
2. (Optional.) Enabling AI-driven PoE
3. (Optional.) Enabling fast PoE for a PSE
4. (Optional.) Allowing inrush currents drawn by PDs
5. (Optional.) Enabling PI power cycling upon a system warm reboot
6. (Optional.) Configuring PD detection
   - Enabling nonstandard PD detection
   - Configuring a PD detection mode
7. (Optional.) Configuring PoE power
   - Configuring the maximum PI power
8. (Optional.) Configuring the PI priority policy
9. (Optional.) Configuring PoE monitoring
   - Configuring PSE power monitoring
   - Associating PoE with Track
10. (Optional.) Upgrading PSE firmware in service
11. (Optional.) Enabling forced PoE power supply
12. (Optional.) Configuring the TMPDO for the MPS

To use a PoE profile to enable PoE and configure the priority and maximum power for a PI, see "Configuring a PI by using a PoE profile."

Prerequisites for configuring PoE

Before you configure PoE, make sure the PoE power supply and PSEs are operating correctly.

Enabling PoE on a PI

About enabling PoE on a PI

After you enable PoE on a PI, the PI supplies power to the connected PD if the PI will not result in PSE power overload. PSE overload occurs when the sum of the power consumption of all PIs exceeds the maximum power of the PSE.

If the PI will result in PSE power overload, the following restrictions apply:

- If the PI priority policy is not enabled, the PI does not supply power to the connected PD.
- If the PI priority policy is enabled, whether the PDs can be powered depends on the priority of the PI.

For more information about the PI priority policy, see "Configuring the PI priority policy."

Restrictions and guidelines

Power can be transmitted over a twisted pair cable in either of the following modes:

- **Signal pair mode**—Signal pairs 1, 2, 3, and 6 of the twisted pair cable are used for power transmission.
- **Spare pair mode**—Spare pairs 4, 5, 7, and 8 of the twisted pair cable are used for power transmission.

A PI can supply power to a PD only when the PI and PD use the same power transmission mode. If the PI and PD use different power transmission modes, a reconnection is required.

The device supports power transmission only over signal pairs.

Procedure

1. Enter system view.
   `system-view`
2. Enter PI view.
   `interface` *`interface-type interface-number`*
3. (Optional.) Configure a description for the PD connected to the PI.
   `poe pd-description` *`text`*
   By default, no description is configured for the PD connected to the PI.
4. Enable PoE on the PI.
   `poe enable`
   - S5110V2 switch series:
     The default differs depending on the software version, as shown below:

Versions	Default setting
Versions earlier than Release 6328	PoE is disabled on PIs.
Release 6328 and later	• If the device starts up with the initial configuration, PoE is disabled on PIs. • If the device starts up with the factory defaults, PoE is enabled on PIs.

   - S3100V3-SI switch series, S5130S-LI switch series, S5120V2-LI switch series, S5120V3-LI switch series, S5110V2-SI switch series, S5120V3-SI switch series, MS4300V2 switch series, MS4200 switch series, MS4320V2 switch series, MS4320V3 switch series, MS4320 switch series, WS5810-WiNet switch series, WS5820-WiNet switch series, S5000E-X switch series, S5000X-EI switch series, S5000V3-EI switch series, S5000V5-EI switch series, and WAS6000 switch series:
     PoE is enabled on PIs if the device starts up with the factory defaults and is disabled on PIs when the device starts up with the initial configuration.

   For more information about the device initial configuration and factory defaults, see configuration file management in *Fundamentals Configuration Guide*.

Enabling AI-driven PoE

Restrictions and guidelines

AI-driven PoE takes effect only on PSEs that run firmware V147 or later.

- **Firmware earlier than V147**—You must use the **`poe update`** command to upgrade the PSE firmware and then enable AI-driven PoE on the PSE.
- **Firmware V147 or later**—You do not need to re-enable AI-driven PoE after upgrading the firmware if you have enabled the feature before the upgrade.

This feature is supported only in Release 6318P01 and later.

Procedure

1. Enter system view.
   system-view
2. Enable AI-driven PoE.
   poe ai enable
   By default, AI-driven PoE is disabled.
   AI-driven PoE automatically adjusts the power supply parameters to fit the power needs. If you disable AI-driven PoE, the system reverts the parameters to the settings before the adjustment.

Enabling fast PoE for a PSE

About fast PoE for a PSE

This feature enables a PI on a PSE to supply power to PDs immediately after the PSE is powered on.

Restrictions and guidelines

You must re-configure this feature if you modified other PoE settings after configuring this feature.

Procedure

1. Enter system view.
   system-view
2. Enable fast PoE for a PSE.
   poe fast-on enable pse *pse-id*
   By default, fast PoE is disabled on a PSE.
   This command is supported only in Release 6328 and later.

Allowing inrush currents drawn by PDs

About allowing inrush currents drawn by PDs

Inrush current might occur at PD startup and trigger PSE self-protection, As a result, the PSE stops supplying power to the PDs. To continue power supply to the PDs, configure this feature to allow inrush currents drawn by PDs.

IEEE 802.3af and IEEE 802.3at define specifications for inrush current. Support for the specifications defined by IEEE 802.3af and/or IEEE 802.3at depends on the device model.

Restrictions and guidelines

△ **CAUTION:**
Inrush currents might damage the components on the device. Use this feature with caution.

This feature is available only for a PSE that has a model name ending with a character of **B**, **LSPPSE48B** for example. To obtain the PSE model name, execute the **display poe pse** command.

Procedure

1. Enter system view.
   system-view
2. Allow inrush currents drawn by PDs.

poe high-inrush enable pse *pse-id*

By default, inrush currents drawn by PDs are not allowed.

Enabling PI power cycling upon a system warm reboot

About enabling PI power cycling upon a system warm reboot

During the system warm reboot process (upon execution of the **reboot** command), the PIs continue supplying power to the PDs but data connections between the PDs and the device are interrupted. After the system reboots, PDs might not re-initiate data connections with the device. Power cycling PIs upon a system warm reboot allows the PDs to re-establish data connections with the device after a warm reboot.

Procedure

1. Enter system view.

   system-view
2. Enter PI power cycling upon a system warm reboot.

   poe reset enable

   By default, PI power cycling upon a system warm reboot is disabled.

Configuring PD detection

Enabling nonstandard PD detection

About enabling nonstandard PD detection

PDs are classified into standard PDs and nonstandard PDs. Standard PDs are compliant with IEEE 802.3af and IEEE 802.3at. A PSE supplies power to a nonstandard PD only after nonstandard PD detection is enabled.

The device supports PSE-based and PI-based nonstandard PD detection. Enabling nonstandard PD detection for a PSE enables this feature for all PIs on the PSE. As a best practice for disabling nonstandard PD detection for all PIs successfully in one operation, disable this feature in both system view and interface view.

Procedure

1. Enter system view.

   system-view
2. Enable nonstandard PD detection. Choose one option as needed.
   - Enable nonstandard PD detection for the PSE.

     poe legacy enable pse *pse-id*

     By default, nonstandard PD detection is disabled for a PSE.
   - Execute the following commands in sequence to enable nonstandard PD detection for a PI:

     interface *interface-type interface-number*

     poe legacy enable

     By default, nonstandard PD detection is disabled for a PI.

Configuring a PD detection mode

About PD detection modes

The device detects PDs in one of the following modes:

- **None**—The device supplies power to PDs that are correctly connected to the device without causing short circuit.
- **Simple**—The device supplies power to PDs that comply with basic requirements of 802.3af or 802.3at.
- **Strict**—The device supplies power to PDs that comply with all requirements of 802.3af or 802.3at.

Restrictions and guidelines

CAUTION:

A non-PD device might be damaged when power is supplied to it. To avoid device damage, do not use the **none** mode when the PI connects to a non-PD device.

This task is available only for a PSE that has a model name ending with a character of **B**, **LSPPSE48B** for example. To obtain the PSE model name, execute the **`display poe pse`** command.

For this task to take effect on nonstandard PDs, you must enable detection for nonstandard PDs by using the **`poe legacy enable`** command.

Procedure

1. Enter system view.

   `system-view`
2. Enter PI view.

   `interface` *`interface-type interface-number`*
3. Configure the PD detection mode.

   `poe detection-mode` { **`none`** | **`simple`** | **`strict`** }

   The default differs depending on the software version, as shown below:

Versions	Default setting
Versions earlier than Release 6350	The PD detection mode is **strict**.
Release 6350 and later	• If the device starts up with the initial configuration, the PD detection mode is **strict**. • If the device starts up with the factory defaults, the PD detection mode is **simple**.

Configuring PoE power

Configuring the maximum PI power

About the maximum PI power

The maximum PI power is the maximum power that a PI can provide to the connected PD. If the PD requires more power than the maximum PI power, the PI does not supply power to the PD.

Procedure

1. Enter system view.
   system-view
2. Enter PI view.
   interface *interface-type interface-number*
3. Configure the maximum power for the PI.
   poe max-power *max-power*
   The default differs depending on the software version, as shown below:

Versions	Default setting
Versions earlier than Release 6350	The maximum PI power is 30000 W.
Release 6350 and later	The maximum PI power is 35000 W.

Configuring the PI priority policy

About the PI priority policy

The PI priority policy enables the PSE to perform priority-based power allocation to PIs when PSE power overload occurs. The priority levels for PIs are critical, high, and low in descending order.

When PSE power overload occurs, the PSE supplies power to PDs as follows:

- If the PI priority policy is disabled, the PSE supplies power to PDs depending on whether you have configured the maximum PSE power.
  - If you have configured the maximum PSE power, the PSE does not supply power to the newly-added or existing PD that causes PSE power overload.
  - If you have not configured the maximum PSE power, the PoE self-protection mechanism is triggered. The PSE stops supplying power to all PDs.
- If the PI priority policy is enabled, the PSE supplies power to PDs as follows:
  - If a PD being powered causes PSE power overload, the PSE stops supplying power to the PD.
  - If a newly-added PD causes PSE power overload, the PSE supplies power to PDs in priority descending order of the PIs to which they are connected. If the newly-added PD and a PD being powered have the same priority, the PD being powered takes precedence. If multiple PIs being powered have the same priority, the PIs with smaller IDs takes precedence.

Restrictions and guidelines

Before you configure a PI with critical priority, make sure the remaining power from the maximum PSE power minus the maximum powers of the existing PIs with critical priority is greater than maximum power of the PI.

Configuration for a PI whose power is preempted remains unchanged.

Procedure

1. Enter system view.
   system-view
2. Enable the PI priority policy.
   poe pd-policy priority
   By default, the PI priority policy is disabled.

3. Enter PI view.
   interface *interface-type interface-number*
4. (Optional.) Configure a priority for the PI.
   poe priority { **critical** | **high** | **low** }
   By default, the priority for a PI is **low**.

Configuring PoE monitoring

Configuring PSE power monitoring

About PSE power monitoring

The system monitors PSE power utilization and sends notification messages when PSE power utilization exceeds or drops below the threshold. If PSE power utilization crosses the threshold multiple times in succession, the system sends notification messages only for the first crossing. For more information about the notification message, see "Configuring SNMP."

Procedure

1. Enter system view.
   system-view
2. Configure a power alarm threshold for a PSE.
   poe utilization-threshold *value* **pse** *pse-id*
   By default, the power alarm threshold for a PSE is 80%.

Associating PoE with Track

About this task

The PoE module can collaborate with the Track module to monitor the link status between the device and a PD. For example, if the PD supports the NQA ICMP echo test, you can specify a track entry associated with NQA to test the reachability of the PD. The NQA ICMP echo test must be configured on a Layer 3 interface. The PI is a Layer 2 interface. You are required to create a VLAN interface for the ICMP echo test and assign the PI to the VLAN.

The Track module notifies the PoE module of the following monitoring results:

- **Positive**—The monitored object is reachable.
- **Negative**—The monitored object is unreachable.
- **NotReady**—The monitoring result is not ready because of reasons such as nonexistence of the NQA group associated with the track entry.

When the Track module detects failure of the link, it changes the track entry state from positive to negative, which triggers the PoE module to take the following actions:

- **alarm-only**: Outputs an SNMP notification and log.
- **alarm-reboot-pd**: Outputs an SNMP notification and log and reboots the PD connected to the PI.

For information about SNMP notifications, see SNMP configuration in *Network Management and Monitoring Configuration Guide*.

For information about logs, see information center configuration in *Network Management and Monitoring Configuration Guide*.

For information about the Track module, see track configuration in *High Availability Configuration Guide*.

Software version and feature compatibility

This feature is supported only in Release 6348P01 and later.

Procedure

1. Enter system view.
   system-view
2. Enter PI view.
   interface *interface-type interface-number*
3. Associate the PI with a track entry.
   poe track *track-entry-number* **action** { **alarm** | **alarm-reboot-pd** }
   By default, a PI is not associated with a track entry.

Configuring a PI by using a PoE profile

Restrictions and guidelines

To modify a PoE profile applied on a PI, first remove the PoE profile from the PI.

You can configure a PI either on the PI or by using a PoE profile. The **poe max-power** *max-power* and **poe priority** { **critical** | **high** | **low** } commands must be configured using the same method.

Configuring a PoE profile

1. Enter system view.
   system-view
2. Create a PoE profile and enter its view.
   poe-profile *profile-name* [*index*]
   By default, no PoE profiles exist.
3. Enable PoE.
   poe enable
   By default, PoE is disabled.
4. (Optional.) Configure the maximum PI power.
   poe max-power *max-power*
   The default differs depending on the software version, as shown below:

Versions	Default setting
Versions earlier than Release 6350	The maximum PI power is 30000 W.
Release 6350 and later	The maximum PI power is 35000 W.

5. (Optional.) Configure a PI priority.
   poe priority { **critical** | **high** | **low** }
   The default priority is **low**.
   This command takes effect only after the PI priority policy is enabled.

Applying a PoE profile

Restrictions and guidelines

You can apply a PoE profile to multiple PIs in system view or a single PI in PI view. If you perform the operation in both views for the same PI, the most recent operation takes effect.

You can apply only one PoE profile to a PI.

Applying a PoE profile in system view

1. Enter system view.

   system-view

2. Apply a PoE profile to PIs.

   apply poe-profile { **index** *index* | **name** *profile-name* } **interface** *interface-range*

   By default, a PoE profile is not applied to a PI.

Applying a PoE profile in PI view

1. Enter system view.

   system-view

2. Enter PI view.

   interface *interface-type interface-number*

3. Apply the PoE profile to the interface.

   apply poe-profile { **index** *index* | **name** *profile-name* }

   By default, a PoE profile is not applied to a PI.

Upgrading PSE firmware in service

About upgrading PSE firmware in service

You can upgrade the PSE firmware in service in the following modes:

- **Refresh mode**—Updates the PSE firmware without deleting it. You can use the refresh mode in most cases.
- **Full mode**—Deletes the current PSE firmware and reloads a new one. Use the full mode if the PSE firmware is damaged and you cannot execute any PoE commands.

Restrictions and guidelines

If the PSE firmware upgrade fails because of interruption such as a device reboot, you can restart the device and upgrade it in full mode again. After the upgrade, restart the device manually for the new PSE firmware to take effect.

Procedure

1. Enter system view.

   system-view

2. Upgrade the PSE firmware in service.

   poe update { **full** | **refresh** } *filename* [**pse** *pse-id*]

Enabling forced PoE power supply

About this task

Before supplying power to a PD, the device performs a detection of the PD. It supplies power to the PD only after the PD passes the detection. If the PD fails the detection but the power provided by the device meets the PD specifications, you can configure this task to enable forced power supply to the PD.

Restrictions and guidelines

CAUTION:

This task enables the device to supply power to a PD directly without performing a detection of the PD. To avoid damaging the PD, make sure the power provided by the device meets the PD specifications before configuring this command.

This task is supported only in Release 6340 and later.

Procedure

1. Enter system view.

   system-view

2. Enter PI view.

   interface *interface-type interface-number*

3. Enable forced PoE power supply.

   poe force-power

   By default, forced PoE power supply is disabled.

Configuring the TMPDO for the MPS

About this task

The Maintain Power Signature (MPS) is an electrical signature provided by a PD. The PD uses this signature to maintain connection to the PSE in sleep mode. The PD sends a PoE-compliant pulse current to the PSE periodically. If the PSE detects the PoE-compliant pulse current from the PD within the TMPDO, it supplies power to the PD. If the PSE does not detect the PoE-compliant pulse current from the PD within the TMPDO, it will not supply power to the PD.

To send pulse currents at larger intervals for lower standby power, you can use this command to change the TMPDO to be longer.

Software version and feature compatibility

This feature is supported only in R6350 and later.

Restrictions and guidelines

Only PSE modules that have a model name of LSPPSE**A support this feature. To view the PSE models, execute the **display poe pse** command.

If you execute the command multiple times, the most recent configuration takes effect.

Procedure

1. Enter System view.

   system-view

2. Set the TMPDO for the MPS.

   poe mps pse *pse-id* **tmpdo** { *timer* | **long** |**normal** }

By default, the normal TMPDO mode is used for the MPS. The TMPDO for the MPS is 324 milliseconds.

Display and maintenance commands for PoE

Execute **display** commands in any view.

Task	Command
Display general PSE information.	**display poe device** [**slot** *slot-number*]
Display the power supplying information for the specified PI.	**display poe interface** [*interface-type interface-number*]
Display power information for PIs.	**display poe interface power** [*interface-type interface-number*]
Display detailed PSE information.	**display poe pse** [*pse-id*]
Display the power supplying information for all PIs on a PSE.	**display poe pse** *pse-id* **interface**
Display power information for all PIs on a PSE.	**display poe pse** *pse-id* **interface power**
Display all information about the PoE profile.	**display poe-profile** [**index** *index* | **name** *profile-name*]
Display all information about the PoE profile applied to the specified PI.	**display poe-profile interface** *interface-type interface-number*

PoE configuration examples

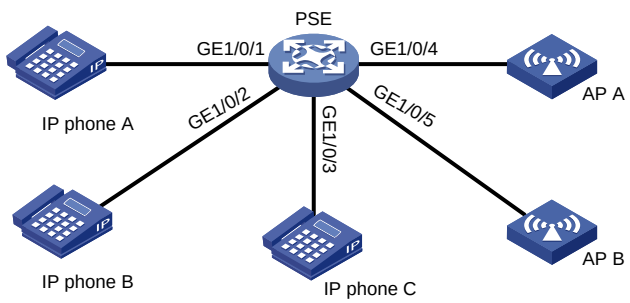
Example: Configuring PoE

Network configuration

As shown in Figure 2, configure PoE as follows:

- Enable the device to supply power to IP telephones and APs.
- Enable the device to supply power to IP telephones first when overload occurs.
- Supply AP B with a maximum power of 9000 milliwatts.

Figure 2 Network diagram



Procedure

Enable the PI priority policy.

```
<PSE> system-view
[PSE] poe pd-policy priority
```

Enable PoE on GigabitEthernet 1/0/1, GigabitEthernet 1/0/2, and GigabitEthernet 1/0/3, and configure their power supply priority as **critical**.

```
[PSE] interface gigabitethernet 1/0/1
[PSE-GigabitEthernet1/0/1] poe enable
[PSE-GigabitEthernet1/0/1] poe priority critical
[PSE-GigabitEthernet1/0/1] quit
[PSE] interface gigabitethernet 1/0/2
[PSE-GigabitEthernet1/0/2] poe enable
[PSE-GigabitEthernet1/0/2] poe priority critical
[PSE-GigabitEthernet1/0/2] quit
[PSE] interface gigabitethernet 1/0/3
[PSE-GigabitEthernet1/0/3] poe enable
[PSE-GigabitEthernet1/0/3] poe priority critical
[PSE-GigabitEthernet1/0/3] quit
```

Enable PoE on GigabitEthernet 1/0/4 and GigabitEthernet 1/0/5, and set the maximum power of GigabitEthernet 1/0/5 to 9000 milliwatts.

```
[PSE] interface gigabitethernet 1/0/4
[PSE-GigabitEthernet1/0/4] poe enable
[PSE-GigabitEthernet1/0/4] quit
[PSE] interface gigabitethernet 1/0/5
[PSE-GigabitEthernet1/0/5] poe enable
[PSE-GigabitEthernet1/0/5] poe max-power 9000
```

Verifying the configuration

Connect the IP telephones and APs to the PSE to verify that they can obtain power and operate correctly. (Details not shown.)

Troubleshooting PoE

Failure to set the priority of a PI to critical

Symptom

Power supply priority configuration for a PI failed.

Solution

To resolve the issue:

1. Identify whether the remaining guaranteed power of the PSE is lower than the maximum power of the PI. If it is, increase the maximum PSE power or reduce the maximum power of the PI.
2. Identify whether the priority has been configured through other methods. If the priority has been configured, remove the configuration.
3. If the issue persists, contact H3C Support.

Failure to apply a PoE profile to a PI

Symptom

PoE profile application for a PI failed.

Solution

To resolve the issue:

1. Identify whether some settings in the PoE profile have been configured. If they have been configured, remove the configuration.
2. Identify whether the settings in the PoE profile meet the requirements of the PI. If they do not, modify the settings in the PoE profile.
3. Identify whether another PoE profile is already applied to the PI. If it is, remove the application.
4. If the issue persists, contact H3C Support.

Contents

Configuring SNMP

About SNMP

Simple Network Management Protocol (SNMP) is used for a management station to access and operate the devices on a network, regardless of their vendors, physical characteristics, and interconnect technologies.

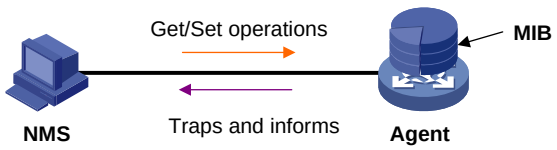
SNMP enables network administrators to read and set the variables on managed devices for state monitoring, troubleshooting, statistics collection, and other management purposes.

SNMP framework

The SNMP framework contains the following elements:

- **SNMP manager**—Works on an NMS to monitor and manage the SNMP-capable devices in the network. It can get and set values of MIB objects on the agent.
- **SNMP agent**—Works on a managed device to receive and handle requests from the NMS, and sends notifications to the NMS when events, such as an interface state change, occur.
- **Management Information Base (MIB)**—Specifies the variables (for example, interface status and CPU usage) maintained by the SNMP agent for the SNMP manager to read and set.

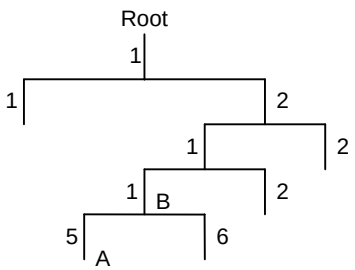
Figure 1 Relationship between NMS, agent, and MIB



MIB and view-based MIB access control

A MIB stores variables called "nodes" or "objects" in a tree hierarchy and identifies each node with a unique OID. An OID is a dotted numeric string that uniquely identifies the path from the root node to a leaf node. For example, object B in Figure 2 is uniquely identified by the OID {1.2.1.1}.

Figure 2 MIB tree



A MIB view represents a set of MIB objects (or MIB object hierarchies) with certain access privileges and is identified by a view name. The MIB objects included in the MIB view are accessible while those excluded from the MIB view are inaccessible.

A MIB view can have multiple view records each identified by a *view-name oid-tree* pair.

You control access to the MIB by assigning MIB views to SNMP groups or communities.

SNMP operations

SNMP provides the following basic operations:

- **Get**—NMS retrieves the value of an object node in an agent MIB.
- **Set**—NMS modifies the value of an object node in an agent MIB.
- **Notification**—SNMP notifications include traps and informs. The SNMP agent sends traps or informs to report events to the NMS. The difference between these two types of notification is that informs require acknowledgment but traps do not. Informs are more reliable but are also resource-consuming. Traps are available in SNMPv1, SNMPv2c, and SNMPv3. Informs are available only in SNMPv2c and SNMPv3.

Protocol versions

The device supports SNMPv1, SNMPv2c, and SNMPv3 in non-FIPS mode and supports only SNMPv3 in FIPS mode. An NMS and an SNMP agent must use the same SNMP version to communicate with each other.

- **SNMPv1**—Uses community names for authentication. To access an SNMP agent, an NMS must use the same community name as set on the SNMP agent. If the community name used by the NMS differs from the community name set on the agent, the NMS cannot establish an SNMP session to access the agent or receive traps from the agent.
- **SNMPv2c**—Uses community names for authentication. SNMPv2c is compatible with SNMPv1, but supports more operation types, data types, and error codes.
- **SNMPv3**—Uses a user-based security model (USM) to secure SNMP communication. You can configure authentication and privacy mechanisms to authenticate and encrypt SNMP packets for integrity, authenticity, and confidentiality.

Access control modes

SNMP uses the following modes to control access to MIB objects:

- **View-based Access Control Model**—VACM mode controls access to MIB objects by assigning MIB views to SNMP communities or users.
- **Role based access control**—RBAC mode controls access to MIB objects by assigning user roles to SNMP communities or users.
    - SNMP communities or users with predefined user role network-admin or level-15 have read and write access to all MIB objects.
    - SNMP communities or users with predefined user role network-operator have read-only access to all MIB objects.
    - SNMP communities or users with a user-defined user role have access rights to MIB objects as specified by the **`rule`** command.

RBAC mode controls access on a per MIB object basis, and VACM mode controls access on a MIB view basis. As a best practice to enhance MIB security, use the RBAC mode.

If you create the same SNMP community or user with both modes multiple times, the most recent configuration takes effect. For more information about RBAC, see *Fundamentals Command Reference*.

FIPS compliance

The device supports the FIPS mode that complies with NIST FIPS 140-2 requirements. Support for features, commands, and parameters might differ in FIPS mode and non-FIPS mode. For more information about FIPS mode, see *Security Configuration Guide*.

SNMP tasks at a glance

To configure SNMP, perform the following tasks:

1. Enabling the SNMP agent
2. Enabling SNMP versions
3. Configuring SNMP basic parameters
   - (Optional.) Configuring SNMP common parameters
   - Configuring an SNMPv1 or SNMPv2c community
   - Configuring an SNMPv3 group and user
4. (Optional.) Configuring SNMP notifications
5. (Optional.) Examining the system configuration for changes
6. (Optional.) Examining the system configuration for changes

About this task

The SNMP module examines the system running configuration, startup configuration, and next-startup configuration file for changes periodically and generates a log if any change is found. If SNMP notification for configuration changes has been enabled, the system generates also an SNMP notification.

Procedure

1. Enter system view.

   `system-view`
2. Set the interval at which the SNMP module examines the system configuration for changes.

   `snmp-agent configuration-examine interval` *`interval`*

   By default, the SNMP module examines the system configuration for changes at intervals of 600 seconds.

   This command is supported only in Release 6340 and later.
3. Enable SNMP notification for system configuration changes.

   `snmp-agent trap enable configuration`

   By default, SNMP notification is enabled for system configuration changes.
4. Configuring SNMP logging

Enabling the SNMP agent

Restrictions and guidelines

The SNMP agent is enabled when you use any command that begins with **`snmp-agent`** except for the **`snmp-agent calculate-password`** command.

The SNMP agent will fail to be enabled when the port that the agent will listen on is used by another service. You can use the **`snmp-agent port`** command to specify a listening port. To view the UDP port use information, execute the **`display udp verbose`** command. For more information about the **`display udp verbose`** command, see IP performance optimization commands in *Layer 3—IP Services Configuration Guide*.

If you disable the SNMP agent, the SNMP settings do not take effect. The **`display current-configuration`** command does not display the SNMP settings. The SNMP settings will not be saved in the configuration file. For the SNMP settings to take effect, enable the SNMP agent.

Procedure

1. Enter system view.
   `system-view`
2. Enable the SNMP agent.
   `snmp-agent`
   By default, the SNMP agent enabling status is as follows:
   - On the following switches, the SNMP agent is disabled.
     - S5110V2 switch series
     - S5110V2-SI switch series
     - S5120V2-LI switch series
     - S5130S-LI switch series
     - S3100V3-SI switch series
     - S5120V3-SI switch series
     - S5120V3-LI switch series
     - MS4320V3 switch series
     - MS4320V2 switch series
     - MS4320 switch series
     - MS4200 switch series
     - MS4300V2 switch series
   - On the following switches, the SNMP agent is enabled when the switch starts up with factory defaults and is disabled when the switch starts up with the initial configuration. For more information about the device initial configuration and factory defaults, see configuration file management in *Fundamentals Configuration Guide*.
     - S5000V3-EI switch series
     - S5000V5-EI switch series
     - WS5810-WiNet switch series
     - WS5820-WiNet switch series
     - S5000E-X switch series
     - S5000X-EI switch series
     - WAS6000 switch series

Enabling SNMP versions

Restrictions and guidelines

The device supports SNMPv1, SNMPv2c, and SNMPv3 in non-FIPS mode and supports only SNMPv3 in FIPS mode. An NMS and an SNMP agent must use the same SNMP version to communicate with each other.

To use SNMP notifications in IPv6, enable SNMPv2c or SNMPv3.

Procedure

1. Enter system view.
   `system-view`
2. Enable SNMP versions.
   In non-FIPS mode:

snmp-agent sys-info version { **all** | { **v1** | **v2c** | **v3** } * }

In FIPS mode:

snmp-agent sys-info version { **all** | **v3** }

By default, SNMPv3 is enabled.

If you execute the command multiple times with different options, all the configurations take effect, but only one SNMP version is used by the agent and NMS for communication.

Configuring SNMP common parameters

Restrictions and guidelines

An SNMP engine ID uniquely identifies a device in an SNMP managed network. Make sure the local SNMP engine ID is unique within your SNMP managed network to avoid communication problems. By default, the device is assigned a unique SNMP engine ID.

If you have configured SNMPv3 users, change the local SNMP engine ID only when necessary. The change can void the SNMPv3 usernames and encrypted keys you have configured.

The SNMP agent will fail to be enabled when the port that the agent will listen on is used by another service. You can use the **snmp-agent port** command to change the SNMP listening port. As a best practice, execute the **display udp verbose** command to view the UDP port use information before specifying a new SNMP listening port. For more information about the **display udp verbose** command, see IP performance optimization commands in *Layer 3—IP Services Configuration Guide*.

Procedure

1. Enter system view.

   system-view

2. Specify an SNMP listening port.

   snmp-agent port *port-number*

   By default, the SNMP listening port is UDP port 161.

3. Set a local SNMP engine ID.

   snmp-agent local-engineid *engineid*

   By default, the local SNMP engine ID is the company ID plus the device ID. Each device has a unique device ID.

4. Set an engine ID for a remote SNMP entity.

   snmp-agent remote { *ipv4-address* | **ipv6** *ipv6-address* } **engineid** *engineid*

   By default, no remote entity engine IDs exist.

   This step is required for the device to send SNMPv3 notifications to a host, typically NMS.

5. Create or update a MIB view.

   snmp-agent mib-view { **excluded** | **included** } *view-name oid-tree* [**mask** *mask-value*]

   By default, the MIB view **ViewDefault** is predefined. In this view, all the MIB objects in the **iso** subtree but the **snmpUsmMIB**, **snmpVacmMIB**, and **snmpModules.18** subtrees are accessible.

   Each *view-name oid-tree* pair represents a view record. If you specify the same record with different MIB sub-tree masks multiple times, the most recent configuration takes effect.

6. Configure the system management information.

   - Configure the system contact.

snmp-agent sys-info contact *sys-contact*

By default, the system contact is **New H3C Technologies Co., Ltd.**.

- Configure the system location.

  snmp-agent sys-info location *sys-location*

  By default, the system location is **Hangzhou, China**.

7. Create an SNMP context.

   snmp-agent context *context-name*

   By default, no SNMP contexts exist.

8. Configure the maximum SNMP packet size (in bytes) that the SNMP agent can handle.

   snmp-agent packet max-size *byte-count*

   By default, an SNMP agent can process SNMP packets with a maximum size of 1500 bytes.

9. Set the DSCP value for SNMP responses.

   snmp-agent packet response dscp *dscp-value*

   By default, the DSCP value for SNMP responses is 0.

Configuring an SNMPv1 or SNMPv2c community

About configuring an SNMPv1 or SNMPv2c community

You can create an SNMPv1 or SNMPv2c community by using a community name or by creating an SNMPv1 or SNMPv2c user. After you create an SNMPv1 or SNMPv2c user, the system automatically creates a community by using the username as the community name.

Restrictions and guidelines for configuring an SNMPv1 or SNMPv2c community

SNMPv1 and SNMPv2c settings are not supported in FIPS mode.

Make sure the NMS and agent use the same SNMP community name.

Only users with the network-admin or level-15 user role can create SNMPv1 or SNMPv2c communities, users, or groups. Users with other user roles cannot create SNMPv1 or SNMPv2c communities, users, or groups even if these roles are granted access to related commands or commands of the SNMPv1 or SNMPv2c feature.

Configuring an SNMPv1/v2c community by a community name

1. Enter system view.

   system-view

2. Create an SNMPv1/v2c community. Choose one option as needed.

   - In VACM mode:

     snmp-agent community { **read** | **write** } [**simple** | **cipher**] *community-name* [**mib-view** *view-name*] [**acl** { *ipv4-acl-number* | **name** *ipv4-acl-name* } | **acl ipv6** { *ipv6-acl-number* | **name** *ipv6-acl-name* }] *

   - In RBAC mode:

snmp-agent community [**simple** | **cipher**] *community-name* **user-role** *role-name* [**acl** { *ipv4-acl-number* | **name** *ipv4-acl-name* } | **acl ipv6** { *ipv6-acl-number* | **name** *ipv6-acl-name* }] *

3. (Optional.) Map the SNMP community name to an SNMP context.

   snmp-agent community-map *community-name* **context** *context-name*

Configuring an SNMPv1/v2c community by creating an SNMPv1/v2c user

1. Enter system view.

   system-view

2. Create an SNMPv1/v2c group.

   snmp-agent group { **v1** | **v2c** } *group-name* [**notify-view** *view-name* | **read-view** *view-name* | **write-view** *view-name*] * [**acl** { *ipv4-acl-number* | **name** *ipv4-acl-name* } | **acl ipv6** { *ipv6-acl-number* | **name** *ipv6-acl-name* }] *

3. Add an SNMPv1/v2c user to the group.

   snmp-agent usm-user { **v1** | **v2c** } *user-name group-name* [**acl** { *ipv4-acl-number* | **name** *ipv4-acl-name* } | **acl ipv6** { *ipv6-acl-number* | **name** *ipv6-acl-name* }] *

   The system automatically creates an SNMP community by using the username as the community name.

4. (Optional.) Map the SNMP community name to an SNMP context.

   snmp-agent community-map *community-name* **context** *context-name*

Configuring an SNMPv3 group and user

Restrictions and guidelines for configuring an SNMPv3 group and user

Only users with the network-admin or level-15 user role can create SNMPv3 users or groups.Users with other user roles cannot create SNMPv3 users or groups even if these roles are granted access to related commands or commands of the SNMPv3 feature.

SNMPv3 users are managed in groups. All SNMPv3 users in a group share the same security model, but can use different authentication and encryption algorithms and keys. Table 1 describes the basic configuration requirements for different security models.

Table 1 Basic configuration requirements for different security models

Security model	Keyword for the group	Parameters for the user	Remarks
Authentication with privacy	**privacy**	Authentication and encryption algorithms and keys	For an NMS to access the agent, make sure the NMS and agent use the same authentication and encryption keys.

Security model	Keyword for the group	Parameters for the user	Remarks
Authentication without privacy	**authentication**	Authentication algorithm and key	For an NMS to access the agent, make sure the NMS and agent use the same authentication key.
No authentication, no privacy	N/A	N/A	The authentication and encryption keys, if configured, do not take effect.

Configuring an SNMPv3 group and user in non-FIPS mode

1. Enter system view.

   system-view

2. Create an SNMPv3 group.

   snmp-agent group v3 *group-name* [**authentication** | **privacy**] [**notify-view** *view-name* | **read-view** *view-name* | **write-view** *view-name*] * [**acl** { *ipv4-acl-number* | **name** *ipv4-acl-name* } | **acl ipv6** { *ipv6-acl-number* | **name** *ipv6-acl-name* }] *

3. (Optional.) Calculate the encrypted form for the key in plaintext form.

   snmp-agent calculate-password *plain-password* **mode** { **3desmd5** | **3dessha** | **aes192md5** | **aes192sha** | **aes256md5** | **aes256sha** | **md5** | **sha** } { **local-engineid** | **specified-engineid** *engineid* }

4. Create an SNMPv3 user. Choose one option as needed.

   - In VACM mode:

     snmp-agent usm-user v3 *user-name group-name* [**remote** { *ipv4-address* | **ipv6** *ipv6-address* }] [{ **cipher** | **simple** } **authentication-mode** { **md5** | **sha** } *auth-password* [**privacy-mode** { **3des** | **aes128** | **aes192** | **aes256** | **des56** } *priv-password*]] [**acl** { *ipv4-acl-number* | **name** *ipv4-acl-name* } | **acl ipv6** { *ipv6-acl-number* | **name** *ipv6-acl-name* }] *

   - In RBAC mode:

     snmp-agent usm-user v3 *user-name* **user-role** *role-name* [**remote** { *ipv4-address* | **ipv6** *ipv6-address* }] [{ **cipher** | **simple** } **authentication-mode** { **md5** | **sha** } *auth-password* [**privacy-mode** { **3des** | **aes128** | **aes192** | **aes256** | **des56** } *priv-password*]] [**acl** { *ipv4-acl-number* | **name** *ipv4-acl-name* } | **acl ipv6** { *ipv6-acl-number* | **name** *ipv6-acl-name* }] *

   To send notifications to an SNMPv3 NMS, you must specify the **remote** keyword.

5. (Optional.) Assign a user role to the SNMPv3 user created in RBAC mode.

   snmp-agent usm-user v3 *user-name* **user-role** *role-name*

   By default, an SNMPv3 user has the user role assigned to it at its creation.

Configuring an SNMPv3 group and user in FIPS mode

1. Enter system view.

   system-view

2. Create an SNMPv3 group.

snmp-agent group v3 *group-name* { **authentication** | **privacy** } [**notify-view** *view-name* | **read-view** *view-name* | **write-view** *view-name*] * [**acl** { *ipv4-acl-number* | **name** *ipv4-acl-name* } | **acl ipv6** { *ipv6-acl-number* | **name** *ipv6-acl-name* }] *

3. (Optional.) Calculate the encrypted form for the key in plaintext form.

   snmp-agent calculate-password *plain-password* **mode** { **aes192sha** | **aes256sha** | **sha** } { **local-engineid** | **specified-engineid** *engineid* }

4. Create an SNMPv3 user. Choose one option as needed.
   - In VACM mode:

     snmp-agent usm-user v3 *user-name group-name* [**remote** { *ipv4-address* | **ipv6** *ipv6-address* }] { **cipher** | **simple** } **authentication-mode sha** *auth-password* [**privacy-mode** { **aes128** | **aes192** | **aes256** } *priv-password*] [**acl** { *ipv4-acl-number* | **name** *ipv4-acl-name* } | **acl ipv6** { *ipv6-acl-number* | **name** *ipv6-acl-name* }] *
   - In RBAC mode:

     snmp-agent usm-user v3 *user-name* **user-role** *role-name* [**remote** { *ipv4-address* | **ipv6** *ipv6-address* }] { **cipher** | **simple** } **authentication-mode sha** *auth-password* [**privacy-mode** { **aes128** | **aes192** | **aes256** } *priv-password*] [**acl** { *ipv4-acl-number* | **name** *ipv4-acl-name* } | **acl ipv6** { *ipv6-acl-number* | **name** *ipv6-acl-name* }] *

   To send notifications to an SNMPv3 NMS, you must specify the **remote** keyword.

5. (Optional.) Assign a user role to the SNMPv3 user created in RBAC mode.

   snmp-agent usm-user v3 *user-name* **user-role** *role-name*

   By default, an SNMPv3 user has the user role assigned to it at its creation.

Configuring SNMP notifications

About SNMP notifications

The SNMP agent sends notifications (traps and informs) to inform the NMS of significant events, such as link state changes and user logins or logouts. After you enable notifications for a module, the module sends the generated notifications to the SNMP agent. The SNMP agent sends the received notifications as traps or informs based on the current configuration. Unless otherwise stated, the **trap** keyword in the command line includes both traps and informs.

Enabling SNMP notifications

Restrictions and guidelines

Enable an SNMP notification only if necessary. SNMP notifications are memory-intensive and might affect device performance.

To generate linkUp or linkDown notifications when the link state of an interface changes, you must perform the following tasks:

- Enable linkUp or linkDown notification globally by using the **snmp-agent trap enable standard** [**linkdown** | **linkup**] * command.
- Enable linkUp or linkDown notification on the interface by using the **enable snmp trap updown** command.

After you enable notifications for a module, whether the module generates notifications also depends on the configuration of the module. For more information, see the configuration guide for each module.

To use SNMP notifications in IPv6, enable SNMPv2c or SNMPv3.

Procedure

1. Enter system view.

   system-view

2. Enable SNMP notifications.

   snmp-agent trap enable [**configuration** | *protocol* | **standard** [**authentication** | **coldstart** | **linkdown** | **linkup** | **warmstart**] * | **system**]

   By default, SNMP configuration notifications, standard notifications, and system notifications are enabled. Whether other SNMP notifications are enabled varies by modules.

   For the device to send SNMP notifications for a protocol, first enable the protocol.

3. Enter interface view.

   interface *interface-type interface-number*

4. Enable link state notifications.

   enable snmp trap updown

   By default, link state notifications are enabled.

Configuring parameters for sending SNMP notifications

About parameters for sending SNMP notifications

You can configure the SNMP agent to send notifications as traps or informs to a host, typically an NMS, for analysis and management. Traps are less reliable and use fewer resources than informs, because an NMS does not send an acknowledgment when it receives a trap.

When network congestion occurs or the destination is not reachable, the SNMP agent buffers notifications in a queue. You can set the queue size and the notification lifetime (the maximum time that a notification can stay in the queue). When the queue size is reached, the system discards the new notification it receives. If modification of the queue size causes the number of notifications in the queue to exceed the queue size, the oldest notifications are dropped for new notifications. A notification is deleted when its lifetime expires.

You can extend standard linkUp/linkDown notifications to include interface description and interface type, but must make sure the NMS supports the extended SNMP messages.

Configuring the parameters for sending SNMP traps

1. Enter system view.

   system-view

2. Configure a target host.

   In non-FIPS mode:

   snmp-agent target-host trap address udp-domain { *ipv4-target-host* | **ipv6** *ipv6-target-host* } [**udp-port** *port-number*] [**dscp** *dscp-value*] **params securityname** *security-string* [**v1** | **v2c** | **v3** [**authentication** | **privacy**]]

   In FIPS mode:

   snmp-agent target-host trap address udp-domain { *ipv4-target-host* | **ipv6** *ipv6-target-host* } [**udp-port** *port-number*] [**dscp** *dscp-value*] **params securityname** *security-string* **v3** { **authentication** | **privacy** }

By default, no target host is configured.

3. (Optional.) Configure a source address for sending traps.

   snmp-agent trap source *interface-type interface-number*

   By default, SNMP uses the IP address of the outgoing routed interface as the source IP address.

Configuring the parameters for sending SNMP informs

1. Enter system view.

   system-view

2. Configure a target host.

   In non-FIPS mode:

   snmp-agent target-host inform address udp-domain { *ipv4-target-host* | **ipv6** *ipv6-target-host* } [**udp-port** *port-number*] **params securityname** *security-string* { **v2c** | **v3** [**authentication** | **privacy**] }

   In FIPS mode:

   snmp-agent target-host inform address udp-domain { *ipv4-target-host* | **ipv6** *ipv6-target-host* } [**udp-port** *port-number*] **params securityname** *security-string* **v3** { **authentication** | **privacy** }

   By default, no target host is configured.

   Only SNMPv2c and SNMPv3 support inform packets.

3. (Optional.) Configure a source address for sending informs.

   snmp-agent inform source *interface-type interface-number*

   By default, SNMP uses the IP address of the outgoing routed interface as the source IP address.

Configuring common parameters for sending notifications

1. Enter system view.

   system-view

2. (Optional.) Enable extended linkUp/linkDown notifications.

   snmp-agent trap if-mib link extended

   By default, the SNMP agent sends standard linkUp/linkDown notifications.

   If the NMS does not support extended linkUp/linkDown notifications, do not use this command.

3. (Optional.) Set the notification queue size.

   snmp-agent trap queue-size *size*

   By default, the notification queue can hold 100 notification messages.

4. (Optional.) Set the notification lifetime.

   snmp-agent trap life *seconds*

   The default notification lifetime is 120 seconds.

Examining the system configuration for changes

About this task

The SNMP module examines the system running configuration, startup configuration, and next-startup configuration file for changes periodically and generates a log if any change is found. If SNMP notification for configuration changes has been enabled, the system generates also an SNMP notification.

Procedure

1. Enter system view.

   system-view

2. Set the interval at which the SNMP module examines the system configuration for changes.

   snmp-agent configuration-examine interval *interval*

   By default, the SNMP module examines the system configuration for changes at intervals of 600 seconds.

   This command is supported only in Release 6340 and later.

3. Enable SNMP notification for system configuration changes.

   snmp-agent trap enable configuration

   By default, SNMP notification is enabled for system configuration changes.

Configuring SNMP logging

About SNMP logging

The SNMP agent logs Get requests, Set requests, Set responses, SNMP notifications, and SNMP authentication failures, but does not log Get responses.

- **Get operation**—The agent logs the IP address of the NMS, name of the accessed node, and node OID.
- **Set operation**—The agent logs the NMS' IP address, name of accessed node, node OID, variable value, and error code and index for the Set operation.
- **Notification tracking**—The agent logs the SNMP notifications after sending them to the NMS.
- **SNMP authentication failure**—The agent logs related information when an NMS fails to be authenticated by the agent.

The SNMP module sends these logs to the information center. You can configure the information center to output these messages to certain destinations, such as the console and the log buffer. The total output size for the node field (MIB node name) and the value field (value of the MIB node) in each log entry is 1024 bytes. If this limit is exceeded, the information center truncates the data in the fields. For more information about the information center, see "Configuring the information center."

Restrictions and guidelines

Enable SNMP logging only if necessary. SNMP logging is memory-intensive and might impact device performance.

Procedure

1. Enter system view.

   system-view

2. Enable SNMP logging.

   snmp-agent log { **all** | **authfail** | **get-operation** | **set-operation** }

   By default, SNMP logging is disabled.

3. Enable SNMP notification logging.

   snmp-agent trap log

   By default, SNMP notification logging is disabled.

Display and maintenance commands for SNMP

Execute **display** commands in any view.

Task	Command
Display SNMPv1 or SNMPv2c community information. (This command is not supported in FIPS mode.)	**display snmp-agent community** [**read** | **write**]
Display SNMP contexts.	**display snmp-agent context** [*context-name*]
Display SNMP group information.	**display snmp-agent group** [*group-name*]
Display the local engine ID.	**display snmp-agent local-engineid**
Display SNMP MIB node information.	**display snmp-agent mib-node** [**details** | **index-node** | **trap-node** | **verbose**]
Display MIB view information.	**display snmp-agent mib-view** [**exclude** | **include** | **viewname** *view-name*]
Display remote engine IDs.	**display snmp-agent remote** [{ *ipv4-address* | **ipv6** *ipv6-address* }]
Display SNMP agent statistics.	**display snmp-agent statistics**
Display SNMP agent system information.	**display snmp-agent sys-info** [**contact** | **location** | **version**] *
Display basic information about the notification queue.	**display snmp-agent trap queue**
Display SNMP notifications enabling status for modules.	**display snmp-agent trap-list**
Display SNMPv3 user information.	**display snmp-agent usm-user** [**engineid** *engineid* | **username** *user-name* | **group** *group-name*] *

SNMP configuration examples

Example: Configuring SNMPv1/SNMPv2c

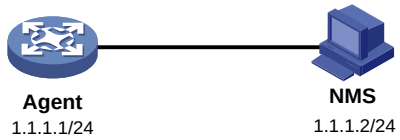
The device does not support this configuration example in FIPS mode.

The configuration procedure is the same for SNMPv1 and SNMPv2c. This example uses SNMPv1.

Network configuration

As shown in Figure 3, the NMS (1.1.1.2/24) uses SNMPv1 to manage the SNMP agent (1.1.1.1/24), and the agent automatically sends notifications to report events to the NMS.

Figure 3 Network diagram



Procedure

1. Configure the SNMP agent:

   # Assign IP address **1.1.1.1/24** to the agent and make sure the agent and the NMS can reach each other. (Details not shown.)

   # Specify SNMPv1, and create read-only community **public** and read and write community **private**.

   ```
   <Agent> system-view
   [Agent] snmp-agent sys-info version v1
   [Agent] snmp-agent community read public
   [Agent] snmp-agent community write private
   ```

   # Configure contact and physical location information for the agent.

   ```
   [Agent] snmp-agent sys-info contact Mr.Wang-Tel:3306
   [Agent] snmp-agent sys-info location telephone-closet,3rd-floor
   ```

   # Enable SNMP notifications, specify the NMS at 1.1.1.2 as an SNMP trap destination, and use **public** as the community name. (To make sure the NMS can receive traps, specify the same SNMP version in the **`snmp-agent target-host`** command as is configured on the NMS.)

   ```
   [Agent] snmp-agent trap enable
   [Agent] snmp-agent target-host trap address udp-domain 1.1.1.2 params securityname
   public v1
   ```

2. Configure the SNMP NMS:
   - Specify SNMPv1.
   - Create read-only community **public**, and create read and write community **private**.
   - Set the timeout timer and maximum number of retries as needed.

   For information about configuring the NMS, see the NMS manual.

   NOTE:

   The SNMP settings on the agent and the NMS must match.

Verifying the configuration

Try to get the MTU value of the NULL0 interface from the agent. The attempt succeeds.

```
Send request to 1.1.1.1/161 ...
Protocol version: SNMPv1
Operation: Get
Request binding:
1: 1.3.6.1.2.1.2.2.1.4.135471
Response binding:
1: Oid=ifMtu.135471 Syntax=INT Value=1500
Get finished
```

Use a wrong community name to get the value of a MIB node on the agent. You can see an authentication failure trap on the NMS.

```
1.1.1.1/2934 V1 Trap = authenticationFailure
SNMP Version = V1
Community = public
Command = Trap
Enterprise = 1.3.6.1.4.1.43.1.16.4.3.50
GenericID = 4
SpecificID = 0
Time Stamp = 8:35:25.68
```

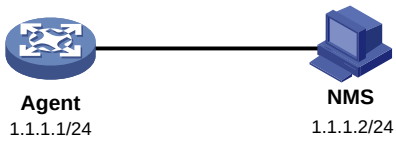
Example: Configuring SNMPv3

Network configuration

As shown in Figure 4, the NMS (1.1.1.2/24) uses SNMPv3 to monitor and manage the agent (1.1.1.1/24). The agent automatically sends notifications to report events to the NMS. The default UDP port 162 is used for SNMP notifications.

The NMS and the agent perform authentication when they establish an SNMP session. The authentication algorithm is **SHA-1** and the authentication key is **123456TESTauth&!**. The NMS and the agent also encrypt the SNMP packets between them by using the **AES** algorithm and encryption key **123456TESTencr&!**.

Figure 4 Network diagram



Configuring SNMPv3 in RBAC mode

1. Configure the agent:

   # Assign IP address **1.1.1.1/24** to the agent and make sure the agent and the NMS can reach each other. (Details not shown.)

   #Create user role **test**, and assign **test** read-only access to the objects under the **snmpMIB** node (OID:1.3.6.1.6.3.1), including the **linkUp** and **linkDown** objects.

   ```
   <Agent> system-view
   [Agent] role name test
   [Agent-role-test] rule 1 permit read oid 1.3.6.1.6.3.1
   ```

   # Assign user role **test** read-only access to the **system** node (OID:1.3.6.1.2.1.1) and read-write access to the **interfaces** node(OID:1.3.6.1.2.1.2).

   ```
   [Agent-role-test] rule 2 permit read oid 1.3.6.1.2.1.1
   [Agent-role-test] rule 3 permit read write oid 1.3.6.1.2.1.2
   [Agent-role-test] quit
   ```

   # Create SNMPv3 user **RBACtest**. Assign user role **test** to **RBACtest.** Set the authentication algorithm to **SHA-1**, authentication key to **123456TESTauth&!**, encryption algorithm to **AES**, and encryption key to **123456TESTencr&!**.

   ```
   [Agent] snmp-agent usm-user v3 RBACtest user-role test simple authentication-mode sha
   123456TESTauth&! privacy-mode aes128 123456TESTencr&!
   ```

   #Configure contact and physical location information for the agent.

   ```
   [Agent] snmp-agent sys-info contact Mr.Wang-Tel:3306
   [Agent] snmp-agent sys-info location telephone-closet,3rd-floor
   ```

   #Enable notifications on the agent. Specify the NMS at 1.1.1.2 as the notification destination, and **RBACtest** as the username.

   ```
   [Agent] snmp-agent trap enable
   [Agent] snmp-agent target-host trap address udp-domain 1.1.1.2 params
   securitynameRBACtest v3 privacy
   ```

2. Configure the NMS:
   - Specify SNMPv3.
   - Create SNMPv3 user **RBACtest**.

- Enable authentication and encryption. Set the authentication algorithm to **SHA-1**, authentication key to **123456TESTauth&!**, encryption algorithm to **AES**, and encryption key to **123456TESTencr&!**.
- Set the timeout timer and maximum number of retries.

For information about configuring the NMS, see the NMS manual.

NOTE:

The SNMP settings on the agent and the NMS must match.

Configuring SNMPv3 in VACM mode

1. Configure the agent:

Assign IP address 1.1.1.1/24 to the agent, and make sure the agent and the NMS can reach each other. (Details not shown.)

Create SNMPv3 group **managev3group** and assign **managev3group** read-only access to the objects under the **snmpMIB** node (OID: 1.3.6.1.2.1.2.2) in the **test** view, including the **linkUp** and **linkDown** objects.

```
<Agent> system-view
[Agent] undo snmp-agent mib-view ViewDefault
[Agent] snmp-agent mib-view included test snmpMIB
[Agent] snmp-agent group v3 managev3group privacy read-view test
```

#Assign SNMPv3 group **managev3group** read-write access to the objects under the **system** node (OID: 1.3.6.1.2.1.1) and **interfaces** node (OID:1.3.6.1.2.1.2) in the **test** view.

```
[Agent] snmp-agent mib-view included test 1.3.6.1.2.1.1
[Agent] snmp-agent mib-view included test 1.3.6.1.2.1.2
[Agent] snmp-agent group v3 managev3group privacy read-view test write-view test
```

Add user **VACMtest** to SNMPv3 group **managev3group**, and set the authentication algorithm to **SHA-1**, authentication key to **123456TESTauth&!**, encryption algorithm to **AES**, and encryption key to **123456TESTencr&!**.

```
[Agent] snmp-agent usm-user v3 VACMtest managev3group simple authentication-mode sha
123456TESTauth&! privacy-mode aes128 123456TESTencr&!
```

Configure contact and physical location information for the agent.

```
[Agent] snmp-agent sys-info contact Mr.Wang-Tel:3306
[Agent] snmp-agent sys-info location telephone-closet,3rd-floor
```

Enable notifications on the agent. Specify the NMS at 1.1.1.2 as the trap destination, and **VACMtest** as the username.

```
[Agent] snmp-agent trap enable
[Agent] snmp-agent target-host trap address udp-domain 1.1.1.2 params VACMtest v3
privacy
```

2. Configure the SNMP NMS:

- Specify SNMPv3.
- Create SNMPv3 user VACMtest.
- Enable authentication and encryption. Set the authentication algorithm to **SHA-1**, authentication key to **123456TESTauth&!**, encryption algorithm to **AES**, and encryption key to **123456TESTencr&!**.
- Set the timeout timer and maximum number of retries.

For information about configuring the NMS, see the NMS manual.

NOTE:

The SNMP settings on the agent and the NMS must match.

Verifying the configuration

- Use username **RBACtest** to access the agent.

  # Retrieve the value of the **sysName** node. The value **Agent** is returned.

  # Set the value for the **sysName** node to **Sysname**. The operation fails because the NMS does not have write access to the node.

  # Shut down or bring up an interface on the agent. The NMS receives linkUP (OID: 1.3.6.1.6.3.1.1.5.4) or linkDown (OID: 1.3.6.1.6.3.1.1.5.3) notifications.

- Use username **VACMtest** to access the agent.

  # Retrieve the value of the **sysName** node. The value **Agent** is returned.

  # Set the value for the **sysName** node to **Sysname**. The operation succeeds.

  # Shut down or bring up an interface on the agent. The NMS receives **linkUP** (OID: 1.3.6.1.6.3.1.1.5.4) or **linkDown** (OID: 1.3.6.1.6.3.1.1.5.3) notifications.

Contents

Configuring RMON

About RMON

Remote Network Monitoring (RMON) is an SNMP-based network management protocol. It enables proactive remote monitoring and management of network devices.

RMON working mechanism

RMON can periodically or continuously collect traffic statistics for an Ethernet port and monitor the values of MIB objects on a device. When a value reaches the threshold, the device automatically logs the event or sends a notification to the NMS. The NMS does not need to constantly poll MIB variables and compare the results.

RMON uses SNMP notifications to notify NMSs of various alarm conditions. SNMP reports function and interface operating status changes such as link up, link down, and module failure to the NMS.

RMON groups

Among standard RMON groups, the device implements the statistics group, history group, event group, alarm group, probe configuration group, and user history group. The Comware system also implements a private alarm group, which enhances the standard alarm group. The probe configuration group and user history group are not configurable from the CLI. To configure these two groups, you must access the MIB.

Statistics group

The statistics group samples traffic statistics for monitored Ethernet interfaces and stores the statistics in the Ethernet statistics table (ethernetStatsTable). The statistics include:

- Number of collisions.
- CRC alignment errors.
- Number of undersize or oversize packets.
- Number of broadcasts.
- Number of multicasts.
- Number of bytes received.
- Number of packets received.

The statistics in the Ethernet statistics table are cumulative sums.

History group

The history group periodically samples traffic statistics on interfaces and saves the history samples in the history table (etherHistoryTable). The statistics include:

- Bandwidth utilization.
- Number of error packets.
- Total number of packets.

The history table stores traffic statistics collected for each sampling interval.

Event group

The event group controls the generation and notifications of events triggered by the alarms defined in the alarm group and the private alarm group. The following are RMON alarm event handling methods:

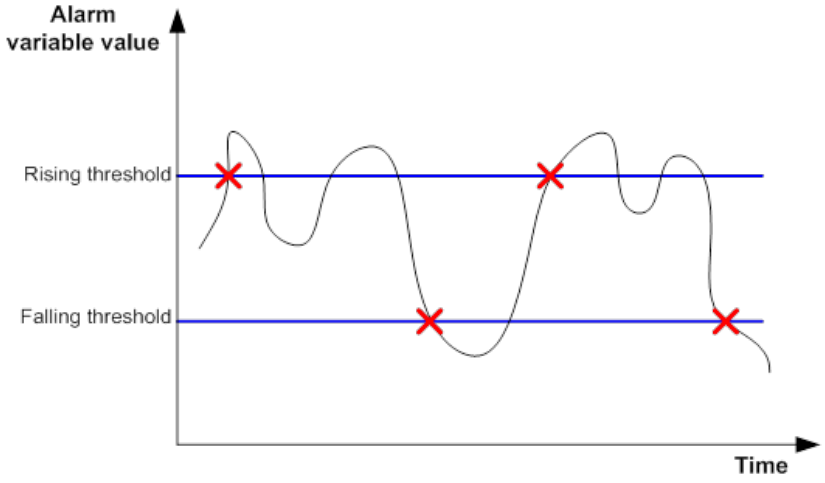
- **Log**—Logs event information (including event time and description) in the event log table so the management device can get the logs through SNMP.
- **Trap**—Sends an SNMP notification when the event occurs.
- **Log-Trap**—Logs event information in the event log table and sends an SNMP notification when the event occurs.
- **None**—Takes no actions.

Alarm group

The RMON alarm group monitors alarm variables, such as the count of incoming packets (etherStatsPkts) on an interface. After you create an alarm entry, the RMON agent samples the value of the monitored alarm variable regularly. If the value of the monitored variable is greater than or equal to the rising threshold, a rising alarm event is triggered. If the value of the monitored variable is smaller than or equal to the falling threshold, a falling alarm event is triggered. The event group defines the action to take on the alarm event.

If an alarm entry crosses a threshold multiple times in succession, the RMON agent generates an alarm event only for the first crossing. For example, if the value of a sampled alarm variable crosses the rising threshold multiple times before it crosses the falling threshold, only the first crossing triggers a rising alarm event, as shown in Figure 1.

Figure 1 Rising and falling alarm events



Private alarm group

The private alarm group enables you to perform basic math operations on multiple variables, and compare the calculation result with the rising and falling thresholds.

The RMON agent samples variables and takes an alarm action based on a private alarm entry as follows:

1. Samples the private alarm variables in the user-defined formula.
2. Processes the sampled values with the formula.
3. Compares the calculation result with the predefined thresholds, and then takes one of the following actions:
   - Triggers the event associated with the rising alarm event if the result is equal to or greater than the rising threshold.
   - Triggers the event associated with the falling alarm event if the result is equal to or less than the falling threshold.

If a private alarm entry crosses a threshold multiple times in succession, the RMON agent generates an alarm event only for the first crossing. For example, if the value of a sampled alarm variable

crosses the rising threshold multiple times before it crosses the falling threshold, only the first crossing triggers a rising alarm event.

Sample types for the alarm group and the private alarm group

The RMON agent supports the following sample types:

- **absolute**—RMON compares the value of the monitored variable with the rising and falling thresholds at the end of the sampling interval.
- **delta**—RMON subtracts the value of the monitored variable at the previous sample from the current value, and then compares the difference with the rising and falling thresholds.

Protocols and standards

- RFC 4502, *Remote Network Monitoring Management Information Base Version 2*
- RFC 2819, *Remote Network Monitoring Management Information Base Status of this Memo*

Configuring the RMON statistics function

About the RMON statistics function

RMON implements the statistics function through the Ethernet statistics group and the history group.

The Ethernet statistics group provides the cumulative statistic for a variable from the time the statistics entry is created to the current time.

The history group provides statistics that are sampled for a variable for each sampling interval. The history group uses the history control table to control sampling, and it stores samples in the history table.

Creating an RMON Ethernet statistics entry

Restrictions and guidelines

The index of an RMON statistics entry must be globally unique. If the index has been used by another interface, the creation operation fails.

You can create only one RMON statistics entry for an Ethernet interface.

Procedure

1. Enter system view.
   system-view
2. Enter Ethernet interface view.
   interface *interface-type interface-number*
3. Create an RMON Ethernet statistics entry.
   rmon statistics *entry-number* [**owner** *text*]

Creating an RMON history control entry

Restrictions and guidelines

You can configure multiple history control entries for one interface, but you must make sure their entry numbers and sampling intervals are different.

You can create a history control entry successfully even if the specified bucket size exceeds the available history table size. RMON will set the bucket size as closely to the expected bucket size as possible.

Procedure

1. Enter system view.

   system-view

2. Enter Ethernet interface view.

   interface *interface-type interface-number*

3. Create an RMON history control entry.

   rmon history *entry-number* **buckets** *number* **interval** *interval* [**owner** *text*]

   By default, no RMON history control entries exist.

   You can create multiple RMON history control entries for an Ethernet interface.

Configuring the RMON alarm function

Restrictions and guidelines

When you create a new event, alarm, or private alarm entry, follow these restrictions and guidelines:

- The entry must not have the same set of parameters as an existing entry.
- The maximum number of entries is not reached.

Table 1 shows the parameters to be compared for duplication and the entry limits.

Table 1 RMON configuration restrictions

Entry	Parameters to be compared	Maximum number of entries
Event	• Event description (**description** *string*) • Event type (**log**, **trap**, **logtrap**, or **none**) • Community name (*security-string*)	60
Alarm	• Alarm variable (*alarm-variable*) • Sampling interval (*sampling-interval*) • Sample type (**absolute** or **delta**) • Rising threshold (*threshold-value1*) • Falling threshold (*threshold-value2*)	60
Private alarm	• Alarm variable formula (*prialarm-formula*) • Sampling interval (*sampling-interval*) • Sample type (**absolute** or **delta**) • Rising threshold (*threshold-value1*) • Falling threshold (*threshold-value2*)	50

Prerequisites

To send notifications to the NMS when an alarm is triggered, configure the SNMP agent as described in "Configuring SNMP" before configuring the RMON alarm function.

Procedure

1. Enter system view.

   system-view

2. (Optional.) Create an RMON event entry.

   rmon event *entry-number* [**description** *string*] { **log** | **log-trap** *security-string* | **none** | **trap** *security-string* } [**owner** *text*]

   By default, no RMON event entries exist.

3. Create an RMON alarm entry.

   - Create an RMON alarm entry.

     rmon alarm *entry-number alarm-variable sampling-interval* { **absolute** | **delta** } [**startup-alarm** { **falling** | **rising** | **rising-falling** }] **rising-threshold** *threshold-value1 event-entry1* **falling-threshold** *threshold-value2 event-entry2* [**owner** *text*]

   - Create an RMON private alarm entry.

     rmon prialarm *entry-number prialarm-formula prialarm-des sampling-interval* { **absolute** | **delta** } [**startup-alarm** { **falling** | **rising** | **rising-falling** }] **rising-threshold** *threshold-value1 event-entry1* **falling-threshold** *threshold-value2 event-entry2* **entrytype** { **forever** | **cycle** *cycle-period* } [**owner** *text*]

   By default, no RMON alarm entries or RMON private alarm entries exist.

   You can associate an alarm with an event that has not been created yet. The alarm will trigger the event only after the event is created.

Display and maintenance commands for RMON

Execute **display** commands in any view.

Task	Command
Display RMON alarm entries.	**display rmon alarm** [*entry-number*]
Display RMON event entries.	**display rmon event** [*entry-number*]
Display log information for event entries.	**display rmon eventlog** [*entry-number*]
Display RMON history control entries and history samples.	**display rmon history** [*interface-type interface-number*]
Display RMON private alarm entries.	**display rmon prialarm** [*entry-number*]
Display RMON statistics.	**display rmon statistics** [*interface-type interface-number*]

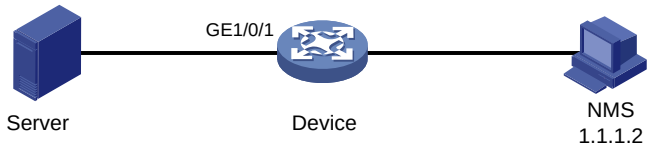
RMON configuration examples

Example: Configuring the Ethernet statistics function

Network configuration

As shown in Figure 2, create an RMON Ethernet statistics entry on the device to gather cumulative traffic statistics for GigabitEthernet 1/0/1.

Figure 2 Network diagram



Procedure

Create an RMON Ethernet statistics entry for GigabitEthernet 1/0/1.

```
<Sysname> system-view
[Sysname] interface gigabitethernet 1/0/1
[Sysname-GigabitEthernet1/0/1] rmon statistics 1 owner user1
```

Verifying the configuration

Display statistics collected for GigabitEthernet 1/0/1.

```
<Sysname> display rmon statistics gigabitethernet 1/0/1
EtherStatsEntry 1 owned by user1 is VALID.
  Interface : GigabitEthernet1/0/1<ifIndex.3>
  etherStatsOctets         : 21657     , etherStatsPkts          : 307
  etherStatsBroadcastPkts  : 56        , etherStatsMulticastPkts : 34
  etherStatsUndersizePkts  : 0         , etherStatsOversizePkts  : 0
  etherStatsFragments      : 0         , etherStatsJabbers       : 0
  etherStatsCRCAlignErrors : 0         , etherStatsCollisions    : 0
  etherStatsDropEvents (insufficient resources): 0
  Incoming packets by size:
  64     : 235       ,  65-127  : 67        ,  128-255  : 4
  256-511: 1         ,  512-1023: 0         ,  1024-1518: 0
```

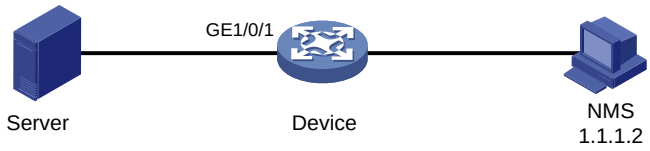
Get the traffic statistics from the NMS through SNMP. (Details not shown.)

Example: Configuring the history statistics function

Network configuration

As shown in Figure 3, create an RMON history control entry on the device to sample traffic statistics for GigabitEthernet 1/0/1 every minute.

Figure 3 Network diagram



Procedure

Create an RMON history control entry to sample traffic statistics every minute for GigabitEthernet 1/0/1. Retain a maximum of eight samples for the interface in the history statistics table.

```
<Sysname> system-view
[Sysname] interface gigabitethernet 1/0/1
[Sysname-GigabitEthernet1/0/1] rmon history 1 buckets 8 interval 60 owner user1
```

Verifying the configuration

Display the history statistics collected for GigabitEthernet 1/0/1.

```
[Sysname-GigabitEthernet1/0/1] display rmon history
HistoryControlEntry 1 owned by user1 is VALID
  Sampled interface     : GigabitEthernet1/0/1<ifIndex.3>
  Sampling interval     : 60(sec) with 8 buckets max
  Sampling record 1 :
    dropevents        : 0         , octets               : 834
    packets           : 8         , broadcast packets    : 1
    multicast packets : 6         , CRC alignment errors : 0
    undersize packets : 0         , oversize packets     : 0
    fragments         : 0         , jabbers              : 0
    collisions        : 0         , utilization          : 0
  Sampling record 2 :
    dropevents        : 0         , octets               : 962
    packets           : 10        , broadcast packets    : 3
    multicast packets : 6         , CRC alignment errors : 0
    undersize packets : 0         , oversize packets     : 0
    fragments         : 0         , jabbers              : 0
    collisions        : 0         , utilization          : 0
```

Get the traffic statistics from the NMS through SNMP. (Details not shown.)

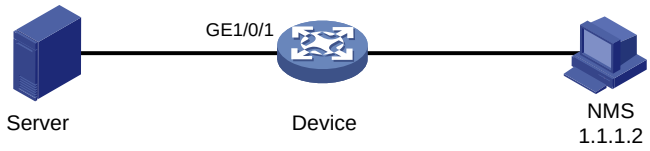
Example: Configuring the alarm function

Network configuration

As shown in Figure 4, configure the device to monitor the incoming traffic statistic on GigabitEthernet 1/0/1, and send RMON alarms when either of the following conditions is met:

- The 5-second delta sample for the traffic statistic crosses the rising threshold (100).
- The 5-second delta sample for the traffic statistic drops below the falling threshold (50).

Figure 4 Network diagram



Procedure

Configure the SNMP agent (the device) with the same SNMP settings as the NMS at 1.1.1.2. This example uses SNMPv1, read community **public**, and write community **private**.

```
<Sysname> system-view
[Sysname] snmp-agent
[Sysname] snmp-agent community read public
[Sysname] snmp-agent community write private
[Sysname] snmp-agent sys-info version v1
[Sysname] snmp-agent trap enable
[Sysname] snmp-agent trap log
[Sysname] snmp-agent target-host trap address udp-domain 1.1.1.2 params securityname
public
```

Create an RMON Ethernet statistics entry for GigabitEthernet 1/0/1.

```
[Sysname] interface gigabitethernet 1/0/1
[Sysname-GigabitEthernet1/0/1] rmon statistics 1 owner user1
[Sysname-GigabitEthernet1/0/1] quit
```

Create an RMON event entry and an RMON alarm entry to send SNMP notifications when the delta sample for 1.3.6.1.2.1.16.1.1.1.4.1 exceeds 100 or drops below 50.

```
[Sysname] rmon event 1 trap public owner user1
[Sysname] rmon alarm 1 1.3.6.1.2.1.16.1.1.1.4.1 5 delta rising-threshold 100 1
falling-threshold 50 1 owner user1
```

NOTE:

The string 1.3.6.1.2.1.16.1.1.1.4.1 is the object instance for GigabitEthernet 1/0/1. The digits before the last digit (1.3.6.1.2.1.16.1.1.1.4) represent the object for total incoming traffic statistics. The last digit (1) is the RMON Ethernet statistics entry index for GigabitEthernet 1/0/1.

Verifying the configuration

Display the RMON alarm entry.

```
<Sysname> display rmon alarm 1
AlarmEntry 1 owned by user1 is VALID.
  Sample type                    : delta
  Sampled variable               : 1.3.6.1.2.1.16.1.1.1.4.1<etherStatsOctets.1>
  Sampling interval (in seconds) : 5
  Rising threshold               : 100(associated with event 1)
  Falling threshold              : 50(associated with event 1)
  Alarm sent upon entry startup  : risingOrFallingAlarm
  Latest value                   : 0
```

Display statistics for GigabitEthernet 1/0/1.

```
<Sysname> display rmon statistics gigabitethernet 1/0/1
EtherStatsEntry 1 owned by user1 is VALID.
```

```
Interface : GigabitEthernet1/0/1<ifIndex.3>
etherStatsOctets         : 57329     , etherStatsPkts          : 455
etherStatsBroadcastPkts  : 53        , etherStatsMulticastPkts : 353
etherStatsUndersizePkts  : 0         , etherStatsOversizePkts  : 0
etherStatsFragments      : 0         , etherStatsJabbers       : 0
etherStatsCRCAlignErrors : 0         , etherStatsCollisions    : 0
etherStatsDropEvents (insufficient resources): 0
Incoming packets by size :
64     : 7         ,  65-127  : 413       ,  128-255  : 35
256-511: 0         ,  512-1023: 0         ,  1024-1518: 0
```

The NMS receives the notification when the alarm is triggered.

Contents

Configuring NETCONF

About NETCONF

Network Configuration Protocol (NETCONF) is an XML-based network management protocol. It provides programmable mechanisms to manage and configure network devices. Through NETCONF, you can configure device parameters, retrieve parameter values, and collect statistics. For a network that has devices from vendors, you can develop a NETCONF-based NMS system to configure and manage devices in a simple and effective way.

NETCONF structure

NETCONF has the following layers: content layer, operations layer, RPC layer, and transport protocol layer.

Table 1 NETCONF layers and XML layers

NETCONF layer	XML layer	Description
Content	Configuration data, status data, and statistics	Contains a set of managed objects, which can be configuration data, status data, and statistics. For information about the operable data, see the NETCONF XML API reference for the device.
Operations	<get>, <get-config>, <edit-config>…	Defines a set of base operations invoked as RPC methods with XML-encoded parameters. NETCONF base operations include data retrieval operations, configuration operations, lock operations, and session operations. For information about operations supported on the device, see "Supported NETCONF operations."
RPC	<rpc> and <rpc-reply>	Provides a simple, transport-independent framing mechanism for encoding RPCs. The <rpc> and <rpc-reply> elements are used to enclose NETCONF requests and responses (data at the operations layer and the content layer).
Transport protocol	In non-FIPS mode: Console, Telnet, SSH, HTTP, HTTPS, and TLS In FIPS mode: Console, SSH, HTTPS, and TLS	Provides reliable, connection-oriented, serial data links. The following transport layer sessions are available in non-FIPS mode: • CLI sessions, including NETCONF over Telnet sessions, NETCONF over SSH sessions, and NETCONF over console sessions. • NETCONF over HTTP sessions and NETCONF over HTTPS sessions. • NETCONF over SOAP sessions, including NETCONF over SOAP over HTTP sessions and NETCONF over SOAP over HTTPS sessions. The following transport layer sessions are available in FIPS mode: • CLI sessions, including NETCONF over SSH sessions and NETCONF over console sessions. • NETCONF over HTTPS sessions. • NETCONF over SOAP over HTTPS sessions.

NETCONF message format

NETCONF

All NETCONF messages are XML-based and comply with RFC 4741. An incoming NETCONF message must pass XML schema check before it can be processed. If a NETCONF message fails XML schema check, the device sends an error message to the client.

For information about the NETCONF operations supported by the device and the operable data, see the NETCONF XML API reference for the device.

The following example shows a NETCONF message for getting all parameters of all interfaces on the device:

```
<?xml version="1.0" encoding="utf-8"?>
<rpc message-id="100" xmlns="urn:ietf:params:xml:ns:netconf:base:1.0">
  <get-bulk>
    <filter type="subtree">
      <top xmlns="http://www.h3c.com/netconf/data:1.0">
        <Ifmgr>
          <Interfaces>
                 <Interface/>
          </Interfaces>
        </Ifmgr>
      </top>
    </filter>
  </get-bulk>
</rpc>
```

NETCONF over SOAP

All NETCONF over SOAP messages are XML-based and comply with RFC 4741. NETCONF messages are contained in the <Body> element of SOAP messages. NETCONF over SOAP messages also comply with the following rules:

- SOAP messages must use the SOAP Envelope namespaces.
- SOAP messages must use the SOAP Encoding namespaces.
- SOAP messages cannot contain the following information:
  - DTD reference.
  - XML processing instructions.

The following example shows a NETCONF over SOAP message for getting all parameters of all interfaces on the device:

```
<env:Envelope xmlns:env="http://www.w3.org/2003/05/soap-envelope">
  <env:Header>
    <auth:Authentication env:mustUnderstand="1"
xmlns:auth="http://www.h3c.com/netconf/base:1.0">
      <auth:AuthInfo>800207F0120020C</auth:AuthInfo>
    </auth:Authentication>
  </env:Header>
  <env:Body>
    <rpc message-id="100" xmlns="urn:ietf:params:xml:ns:netconf:base:1.0">
      <get-bulk>
        <filter type="subtree">
          <top xmlns="http://www.h3c.com/netconf/data:1.0">
```

```
            <Ifmgr>
              <Interfaces>
                <Interface/>
              </Interfaces>
            </Ifmgr>
          </top>
        </filter>
      </get-bulk>
    </rpc>
  </env:Body>
</env:Envelope>
```

How to use NETCONF

You can use NETCONF to manage and configure the device by using the methods in Table 2.

Table 2 NETCONF methods for configuring the device

Configuration tool	Login method	Remarks
CLI	• Console port • SSH • Telnet	To perform NETCONF operations, copy valid NETCONF messages to the CLI in XML view.
Standard Web interface for the device	• HTTP • HTTPS	The system automatically converts the configuration operations on the Web interface to NETCONF messages and sends them to the device to perform NETCONF operations.
Custom user interface	N/A	To use this method, you must enable NETCONF over SOAP. NETCONF messages will be encapsulated in SOAP for transmission.

Protocols and standards

- RFC 3339, *Date and Time on the Internet: Timestamps*
- RFC 4741, *NETCONF Configuration Protocol*
- RFC 4742, *Using the NETCONF Configuration Protocol over Secure SHell (SSH)*
- RFC 4743, *Using NETCONF over the Simple Object Access Protocol (SOAP)*
- RFC 5277, *NETCONF Event Notifications*
- RFC 5381, *Experience of Implementing NETCONF over SOAP*
- RFC 5539, *NETCONF over Transport Layer Security (TLS)*
- RFC 6241, *Network Configuration Protocol*

FIPS compliance

The device supports the FIPS mode that complies with NIST FIPS 140-2 requirements. Support for features, commands, and parameters might differ in FIPS mode (see *Security Configuration Guide*) and non-FIPS mode.

NETCONF tasks at a glance

To configure NETCONF, perform the following tasks:

1. Establishing a NETCONF session
   a. (Optional.) Setting NETCONF session attributes
   b. Establishing NETCONF over SOAP sessions
   c. Establishing NETCONF over SSH sessions
   d. Establishing NETCONF over Telnet or NETCONF over console sessions
   e. Exchanging capabilities
2. (Optional.) Retrieving device configuration information
   - Retrieving device configuration and state information
   - Retrieving non-default settings
   - Retrieving NETCONF information
   - Retrieving YANG file content
   - Retrieving NETCONF session information
3. (Optional.) Filtering data

- Table-based filtering
- Column-based filtering

4. (Optional.) Locking or unlocking the running configuration
   a. Locking the running configuration
   b. Unlocking the running configuration
5. (Optional.) Modifying the configuration
6. (Optional.) Managing configuration files
   - Saving the running configuration
   - Loading the configuration
   - Rolling back the configuration
7. (Optional.) Performing CLI operations through NETCONF
8. (Optional.) Subscribing to events
   - Subscribing to syslog events
   - Subscribing to events monitored by NETCONF
   - Subscribing to events reported by modules
9. (Optional.) Terminating NETCONF sessions
10. (Optional.) Returning to the CLI

Establishing a NETCONF session

Restrictions and guidelines for NETCONF session establishment

After a NETCONF session is established, the device automatically sends its capabilities to the client. You must send the capabilities of the client to the device before you can perform any other NETCONF operations.

Before performing a NETCONF operation, make sure no other users are configuring or managing the device. If multiple users simultaneously configure or manage the device, the result might be different from what you expect.

You can use the **aaa session-limit** command to set the maximum number of NETCONF sessions that the device can support. If the upper limit is reached, new NETCONF users cannot access the device. For information about this command, see AAA in *Security Configuration Guide*.

Setting NETCONF session attributes

About module-specific namespaces for NETCONF

NETCONF supports the following types of namespaces:

- **Common namespace**—The common namespace is shared by all modules. In a packet that uses the common namespace, the namespace is indicated in the <top> element, and the modules are listed under the <top> element.

  Example:

```
<rpc message-id="100" xmlns="urn:ietf:Params:xml:ns:netconf:base:1.0">
   <get-bulk>
      <filter type="subtree">
         <top xmlns="http://www.h3c.com/netconf/data:1.0">
            <Ifmgr>
               <Interfaces>
               </Interfaces>
            </Ifmgr>
         </top>
      </filter>
   </get-bulk>
</rpc>
```

- **Module-specific namespace**—Each module has its own namespace. A packet that uses a module-specific namespace does not have the <top> element. The namespace follows the module name.

  Example:

```
<rpc message-id="100" xmlns="urn:ietf:params:xml:ns:netconf:base:1.0">
   <get-bulk>
      <filter type="subtree">
            <Ifmgr xmlns="http://www.h3c.com/netconf/data:1.0-Ifmgr">
               <Interfaces>
               </Interfaces>
            </Ifmgr>
      </filter>
   </get-bulk>
</rpc>
```

The common namespace is incompatible with module-specific namespaces. To set up a NETCONF session, the device and the client must use the same type of namespaces. By default, the common namespace is used. If the client does not support the common namespace, use this feature to configure the device to use module-specific namespaces.

Procedure

1. Enter system view.

   system-view

2. Set the NETCONF session idle timeout time.

   netconf { **agent** | **soap** } **idle-timeout** *minute*

Keyword	Description
agent	Specifies the following sessions: • NETCONF over SSH sessions. • NETCONF over Telnet sessions. • NETCONF over console sessions. By default, the idle timeout time is 0, and the sessions never time out.
soap	Specifies the following sessions: • NETCONF over SOAP over HTTP sessions. • NETCONF over SOAP over HTTPS sessions. The default setting is 10 minutes.

3. Enable NETCONF logging.

   netconf log source { **all** | { **agent** | **soap** | **web** } * } { **protocol-operation** { **all** | { **action** | **config** | **get** | **set** | **session** | **syntax** | **others** } * } | **row-operation** | **verbose** }

   By default, NETCONF logging is disabled.

4. Configure NETCONF to use module-specific namespaces.

   netconf capability specific-namespace

   By default, the common namespace is used.

   For the setting to take effect, you must reestablish the NETCONF session.

Establishing NETCONF over SOAP sessions

About NETCONF over SOAP

You can use a custom user interface to establish a NETCONF over SOAP session to the device and perform NETCONF operations. NETCONF over SOAP encapsulates NETCONF messages into SOAP messages and transmits the SOAP messages over HTTP or HTTPS.

Restrictions and guidelines

You can add an authentication domain to the <UserName> parameter of a SOAP request. The authentication domain takes effect only on the current request.

The mandatory authentication domain configured by using the **netconf soap domain** command takes precedence over the authentication domain specified in the <UserName> parameter of a SOAP request.

Procedure

1. Enter system view.

   system-view

2. Enable NETCONF over SOAP.

   In non-FIPS mode:

   netconf soap { **http** | **https** } **enable**

   In FIPS mode:

   netconf soap https enable

   By default, the NETCONF over SOAP feature is disabled if the device starts up with the initial configuration.

If the device starts up with the factory defaults, the enabling state of NETCONF over SOAP varies depending on the hardware platform and software version, as shown in Table 3.

Table 3 Factory defaults for NETCONF over SOAP

Feature	Factory default	Applicable software versions
NETCONF over SOAP over HTTPS	Disabled	All versions
NETCONF over SOAP over HTTP	Disabled	Versions earlier than Release 6348P01
	Enabled	Release 6348P01 or later

For more information about initial configuration, factory defaults, and startup configuration, see configuration file management in *Fundamentals Configuration Guide*.

3. Set the DSCP value for NETCONF over SOAP packets.

   In non-FIPS mode:

   netconf soap { **http** | **https** } **dscp** *dscp-value*

   In FIPS mode:

   netconf soap https dscp *dscp-value*

   By default, the DSCP value is 0 for NETCONF over SOAP packets.

4. Use an IPv4 ACL to control NETCONF over SOAP access.

   In non-FIPS mode:

   netconf soap { **http** | **https** } **acl** { *ipv4-acl-number* | **name** *ipv4-acl-name* }

   In FIPS mode:

   netconf soap https acl { *ipv4-acl-number* | **name** *ipv4-acl-name* }

   By default, no IPv4 ACL is applied to control NETCONF over SOAP access.

   Only clients permitted by the IPv4 ACL can establish NETCONF over SOAP sessions.

5. Specify a mandatory authentication domain for NETCONF users.

   netconf soap domain *domain-name*

   By default, no mandatory authentication domain is specified for NETCONF users. For information about authentication domains, see *Security Configuration Guide*.

6. Use the custom user interface to establish a NETCONF over SOAP session with the device.

   For information about the custom user interface, see the user guide for the interface.

Establishing NETCONF over SSH sessions

Prerequisites

Before establishing a NETCONF over SSH session, make sure the custom user interface can access the device through SSH.

Procedure

1. Enter system view.

   system-view

2. Enable NETCONF over SSH.

   netconf ssh server enable

   By default, NETCONF over SSH is disabled.

3. Specify the listening port for NETCONF over SSH packets.

netconf ssh server port *port-number*

By default, the listening port number is 830.

4. Use the custom user interface to establish a NETCONF over SSH session with the device. For information about the custom user interface, see the user guide for the interface.

Establishing NETCONF over Telnet or NETCONF over console sessions

Restrictions and guidelines

To ensure the format correctness of a NETCONF message, do not enter the message manually. Copy and paste the message.

While the device is performing a NETCONF operation, do not perform any other operations, such as pasting a NETCONF message or pressing **Enter**.

For the device to identify NETCONF messages, you must add end mark **]]>]]>** at the end of each NETCONF message. Examples in this document do not necessarily have this end mark. Do add the end mark in actual operations.

Prerequisites

To establish a NETCONF over Telnet session or a NETCONF over console session, first log in to the device through Telnet or the console port.

Procedure

To enter XML view, execute the following command in user view:

xml

If the XML view prompt appears, the NETCONF over Telnet session or NETCONF over console session is established successfully.

Exchanging capabilities

About capability exchange

After a NETCONF session is established, the device sends its capabilities to the client. You must use a hello message to send the capabilities of the client to the device before you can perform any other NETCONF operations.

Hello message from the device to the client

```
<?xml version="1.0" encoding="UTF-8"?><hello
xmlns="urn:ietf:params:xml:ns:netconf:base:1.0"><capabilities><capability>urn:ietf:pa
rams:netconf:base:1.1</capability><capability>urn:ietf:params:netconf:writable-runnin
g</capability><capability>urn:ietf:params:netconf:capability:notification:1.0</capabi
lity><capability>urn:ietf:params:netconf:capability:validate:1.1</capability><capabil
ity>urn:ietf:params:netconf:capability:interleave:1.0</capability><capability>urn:h3c
:params:netconf:capability:h3c-netconf-ext:1.0</capability></capabilities><session-id
>1</session-id></hello>]]>]]>
```

The <capabilities> element carries the capabilities supported by the device. The supported capabilities vary by device model.

The <session-id> element carries the unique ID assigned to the NETCONF session.

Hello message from the client to the device

After receiving the hello message from the device, copy the following hello message to notify the device of the capabilities supported by the client:

```
<hello xmlns="urn:ietf:params:xml:ns:netconf:base:1.0">
  <capabilities>
    <capability>
     capability-set
   </capability>
 </capabilities>
</hello>
```

Item	Description
capability-set	Specifies a set of capabilities supported by the client. Use the <capability> and </capability> tags to enclose each user-defined capability set.

Retrieving device configuration information

Restrictions and guidelines for device configuration retrieval

During a <get>, <get-bulk>, <get-config>, or <get-bulk-config> operation, NETCONF replaces unidentifiable characters in the retrieved data with question marks (?) before sending the data to the client. If the process for a relevant module is not started yet, the operation returns the following message:

```
<?xml version="1.0"?>
<rpc-reply message-id="100" xmlns="urn:ietf:params:xml:ns:netconf:base:1.0">
  <data/>
</rpc-reply>
```

The <get><netconf-state/></get> operation does not support data filtering.

For more information about the NETCONF operations, see the NETCONF XML API references for the device.

Retrieving device configuration and state information

You can use the following NETCONF operations to retrieve device configuration and state information:

- **<get> operation**—Retrieves all device configuration and state information that match the specified conditions.
- **<get-bulk> operation**—Retrieves data entries starting from the data entry next to the one with the specified index. One data entry contains a device configuration entry and a state information entry. The returned output does not include the index information.

The <get> message and <get-bulk> message share the following format:

```
<?xml version="1.0" encoding="UTF-8"?>
<rpc message-id="100" xmlns="urn:ietf:params:xml:ns:netconf:base:1.0">
  <getoperation>
    <filter>
      <top xmlns="http://www.h3c.com/netconf/data:1.0">
          Specify the module, submodule, table name, and column name
      </top>
    </filter>
```

```
  </getoperation>
</rpc>
```

Item	Description
getoperation	Operation name, **get** or **get-bulk**.
filter	Specifies the filtering conditions, such as the module name, submodule name, table name, and column name. • If you specify a module name, the operation retrieves the data for the specified module. If you do not specify a module name, the operation retrieves the data for all modules. • If you specify a submodule name, the operation retrieves the data for the specified submodule. If you do not specify a submodule name, the operation retrieves the data for all submodules. • If you specify a table name, the operation retrieves the data for the specified table. If you do not specify a table name, the operation retrieves the data for all tables. • If you specify only the index column, the operation retrieves the data for all columns. If you specify the index column and any other columns, the operation retrieves the data for the index column and the specified columns.

A <get-bulk> message can carry the **count** and **index** attributes.

Item	Description
index	Specifies the index. If you do not specify this item, the index value starts with 1 by default.

count	Specifies the data entry quantity.
	The **count** attribute complies with the following rules:
	• The **count** attribute can be placed in the module node and table node. In other nodes, it cannot be resolved.
	• When the **count** attribute is placed in the module node, a descendant node inherits this count attribute if the descendant node does not contain the count attribute.
	• The <get-bulk> operation retrieves all the rest data entries starting from the data entry next to the one with the specified index if either of the following conditions occurs:
	  ○ You do not specify the **count** attribute.
	  ○ The number of matching data entries is less than the value of the **count** attribute.

The following <get-bulk> message example specifies the **count** and **index** attributes:

```
<?xml version="1.0" encoding="UTF-8"?>
<rpc message-id="100" xmlns="urn:ietf:params:xml:ns:netconf:base:1.0"
xmlns:xc="http://www.h3c.com/netconf/base:1.0">
  <get-bulk>
    <filter type="subtree">
      <top xmlns="http://www.h3c.com/netconf/data:1.0"
xmlns:base="http://www.h3c.com/netconf/base:1.0">
        <Syslog>
          <Logs xc:count="5">
            <Log>
              <Index>10</Index>
            </Log>
```

```
            </Logs>
          </Syslog>
        </top>
      </filter>
    </get-bulk>
</rpc>
```

When retrieving interface information, the device cannot identify whether an integer value for the <IfIndex> element represents an interface name or index. To resolve the issue, you can use the **valuetype** attribute to specify the value type.

The **valuetype** attribute has the following values:

Value	Description
name	The element is carrying a name.
index	The element is carrying an index.
auto	Default value. The device uses the value of the element as a name for information matching. If no match is found, the device uses the value as an index for interface or information matching.

The following example specifies an index-type value for the <IfIndex> element:

```
<rpc xmlns="urn:ietf:params:xml:ns:netconf:base:1.0">
  <getoperation>
    <filter>
      <top xmlns="http://www.h3c.com/netconf/config:1.0"
xmlns:base="http://www.h3c.com/netconf/base:1.0">
       <VLAN>
        <TrunkInterfaces>
          <Interface>
            <IfIndex base:valuetype="index">1</IfIndex>
          </Interface>
        </TrunkInterfaces>
       </VLAN>
      </top>
    </filter >
  </getoperation>
</rpc>
```

If the <get> or < get-bulk> operation succeeds, the device returns the retrieved data in the following format:

```
<?xml version="1.0"?>
 <rpc-reply message-id="100" xmlns="urn:ietf:params:xml:ns:netconf:base:1.0">
  <data>
     Device state and configuration data
  </data>
</rpc-reply>
```

Retrieving non-default settings

The <get-config> and <get-bulk-config> operations are used to retrieve all non-default settings. The <get-config> and <get-bulk-config> messages can contain the <filter> element for filtering data.

The <get-config> and <get-bulk-config> messages are similar. The following is a <get-config> message example:

```
<?xml version="1.0"?>
<rpc message-id="100" xmlns="urn:ietf:params:xml:ns:netconf:base:1.0">
  <get-config>
    <source>
      <running/>
    </source>
    <filter>
      <top xmlns="http://www.h3c.com/netconf/config:1.0">
          Specify the module name, submodule name, table name, and column name
      </top>
    </filter>
  </get-config>
</rpc>
```

If the <get-config> or <get-bulk-config> operation succeeds, the device returns the retrieved data in the following format:

```
<?xml version="1.0"?>
<rpc-reply message-id="100" xmlns="urn:ietf:params:xml:ns:netconf:base:1.0">
  <data>
    Data matching the specified filter
  </data>
</rpc-reply>
```

Retrieving NETCONF information

Use the <get><netconf-state/></get> message to retrieve NETCONF information.

Copy the following text to the client to retrieve NETCONF information:

```
<?xml version="1.0" encoding="UTF-8"?>
<rpc message-id="m-641" xmlns="urn:ietf:params:xml:ns:netconf:base:1.0">
  <get>
    <filter type='subtree'>
      <netconf-state xmlns='urn:ietf:params:xml:ns:yang:ietf-netconf-monitoring'>
        <getType/>
      </netconf-state>
    </filter>
  </get>
</rpc>
```

If you do not specify a value for *getType*, the retrieval operation retrieves all NETCONF information.

The value for *getType* can be one of the following operations:

Operation	Description
capabilities	Retrieves device capabilities.
datastores	Retrieves databases from the device.
schemas	Retrieves the list of the YANG file names from the device.
sessions	Retrieves session information from the device.

Operation	Description
statistics	Retrieves NETCONF statistics.

If the <get><netconf-state/></get> operation succeeds, the device returns a response in the following format:

```
<?xml version="1.0"?>
 <rpc-reply message-id="100" xmlns="urn:ietf:params:xml:ns:netconf:base:1.0">
  <data>
     Retrieved NETCONF information
  </data>
</rpc-reply>
```

Retrieving YANG file content

YANG files save the NETCONF operations supported by the device. A user can know the supported operations by retrieving and analyzing the content of YANG files.

YANG files are integrated in the device software and are named in the format of *yang_identifier@yang_version.yang*. You cannot view the YANG file names by executing the **dir** command. For information about how to retrieve the YANG file names, see "Retrieving NETCONF information."

Copy the following text to the client to retrieve the YANG file named **syslog-data@2017-01-01.yang**:

```
<rpc message-id="100" xmlns="urn:ietf:params:xml:ns:netconf:base:1.0">
  <get-schema xmlns='urn:ietf:params:xml:ns:yang:ietf-netconf-monitoring'>
    <identifier>syslog-data</identifier>
    <version>2017-01-01</version>
    <format>yang</format>
  </get-schema>
</rpc>
```

If the <get-schema> operation succeeds, the device returns a response in the following format:

```
<?xml version="1.0"?>
<rpc-reply message-id="100" xmlns="urn:ietf:params:xml:ns:netconf:base:1.0">
  <data>
     Content of the specified YANG file
  </data>
</rpc-reply>
```

Retrieving NETCONF session information

Use the <get-sessions> operation to retrieve NETCONF session information of the device.

Copy the following message to the client to retrieve NETCONF session information from the device:

```
<?xml version="1.0" encoding="UTF-8"?>
<rpc message-id="100" xmlns="urn:ietf:params:xml:ns:netconf:base:1.0">
  <get-sessions/>
</rpc>
```

If the <get-sessions> operation succeeds, the device returns a response in the following format:

```
<?xml version="1.0" encoding="UTF-8"?>
<rpc-reply message-id="100" xmlns="urn:ietf:params:xml:ns:netconf:base:1.0">
  <get-sessions>
    <Session>
      <SessionID>Configuration session ID</SessionID>
      <Line>Line information</Line>
      <UserName>Name of the user creating the session</UserName>
      <Since>Time when the session was created</Since>
      <LockHeld>Whether the session holds a lock</LockHeld>
    </Session>
  </get-sessions>
</rpc-reply>
```

Example: Retrieving a data entry for the interface table

Network configuration

Retrieve a data entry for the interface table.

Procedure

Enter XML view.

```
<Sysname> xml
```

Notify the device of the NETCONF capabilities supported on the client.

```
<hello xmlns="urn:ietf:params:xml:ns:netconf:base:1.0">
  <capabilities>
    <capability>urn:ietf:params:netconf:base:1.0</capability>
  </capabilities>
</hello>
```

Retrieve a data entry for the interface table.

```
<rpc message-id="100" xmlns="urn:ietf:params:xml:ns:netconf:base:1.0"
xmlns:web="urn:ietf:params:xml:ns:netconf:base:1.0">
  <get-bulk>
    <filter type="subtree">
      <top xmlns="http://www.h3c.com/netconf/data:1.0"
xmlns:web="http://www.h3c.com/netconf/base:1.0">
        <Ifmgr>
          <Interfaces web:count="1">
          </Interfaces>
        </Ifmgr>
      </top>
    </filter>
  </get-bulk>
</rpc>
```

Verifying the configuration

If the client receives the following text, the <get-bulk> operation is successful:

```
<rpc-reply xmlns="urn:ietf:params:xml:ns:netconf:base:1.0"
xmlns:web="urn:ietf:params:xml:ns:netconf:base:1.0" message-id="100">
  <data>
    <top xmlns="http://www.h3c.com/netconf/data:1.0">
```

```
      <Ifmgr>
        <Interfaces>
          <Interface>
            <IfIndex>3</IfIndex>
            <Name>GigabitEthernet1/0/2</Name>
            <AbbreviatedName>GE1/0/2</AbbreviatedName>
            <PortIndex>3</PortIndex>
            <ifTypeExt>22</ifTypeExt>
            <ifType>6</ifType>
            <Description>GigabitEthernet1/0/2 Interface</Description>
            <AdminStatus>2</AdminStatus>
            <OperStatus>2</OperStatus>
            <ConfigSpeed>0</ConfigSpeed>
            <ActualSpeed>100000</ActualSpeed>
            <ConfigDuplex>3</ConfigDuplex>
            <ActualDuplex>1</ActualDuplex>
          </Interface>
        </Interfaces>
      </Ifmgr>
    </top>
  </data>
</rpc-reply>
```

Example: Retrieving non-default configuration data

Network configuration

Retrieve all non-default configuration data.

Procedure

Enter XML view.

```
<Sysname> xml
```

Notify the device of the NETCONF capabilities supported on the client.

```
<hello xmlns="urn:ietf:params:xml:ns:netconf:base:1.0">
  <capabilities>
    <capability>
            urn:ietf:params:netconf:base:1.0
    </capability>
  </capabilities>
</hello>
```

Retrieve all non-default configuration data.

```
<rpc message-id="100" xmlns="urn:ietf:params:xml:ns:netconf:base:1.0">
  <get-config>
    <source>
      <running/>
    </source>
  </get-config>
</rpc>
```

Verifying the configuration

If the client receives the following text, the <get-config> operation is successful:

```
<rpc-reply xmlns="urn:ietf:params:xml:ns:netconf:base:1.0"
xmlns:web="urn:ietf:params:xml:ns:netconf:base:1.0" message-id="100">
    <data>
        <top xmlns="http://www.h3c.com/netconf/config:1.0">
            <Ifmgr>
                <Interfaces>
                    <Interface>
                        <IfIndex>1307</IfIndex>
                        <Shutdown>1</Shutdown>
                    </Interface>
                    <Interface>
                        <IfIndex>1308</IfIndex>
                        <Shutdown>1</Shutdown>
                    </Interface>
                    <Interface>
                        <IfIndex>1309</IfIndex>
                        <Shutdown>1</Shutdown>
                    </Interface>
                    <Interface>
                        <IfIndex>1311</IfIndex>
                            <VlanType>2</VlanType>
                    </Interface>
                    <Interface>
                        <IfIndex>1313</IfIndex>
                            <VlanType>2</VlanType>
                    </Interface>
                </Interfaces>
            </Ifmgr>
            <Syslog>
                <LogBuffer>
                    <BufferSize>120</BufferSize>
                </LogBuffer>
            </Syslog>
            <System>
                <Device>
                    <SysName>Sysname</SysName>
                    <TimeZone>
                        <Zone>+11:44</Zone>
                        <ZoneName>beijing</ZoneName>
                    </TimeZone>
                </Device>
            </System>
        </top>
    </data>
</rpc-reply>
```

Example: Retrieving syslog configuration data

Network configuration

Retrieve configuration data for the Syslog module.

Procedure

Enter XML view.

```
<Sysname> xml
```

Notify the device of the NETCONF capabilities supported on the client.

```
<hello xmlns="urn:ietf:params:xml:ns:netconf:base:1.0">
  <capabilities>
    <capability>
            urn:ietf:params:netconf:base:1.0
    </capability>
  </capabilities>
</hello>
```

Retrieve configuration data for the Syslog module.

```
<rpc message-id="100" xmlns="urn:ietf:params:xml:ns:netconf:base:1.0">
  <get-config>
    <source>
      <running/>
    </source>
    <filter type="subtree">
      <top xmlns="http://www.h3c.com/netconf/config:1.0">
        <Syslog/>
      </top>
    </filter>
  </get-config>
</rpc>
```

Verifying the configuration

If the client receives the following text, the <get-config> operation is successful:

```
<?xml version="1.0" encoding="UTF-8"?>
<rpc-reply xmlns="urn:ietf:params:xml:ns:netconf:base:1.0" message-id="100">
    <data>
        <top xmlns="http://www.h3c.com/netconf/config:1.0">
            <Syslog>
                    <LogBuffer>
                        <BufferSize>120</BufferSize>
                    </LogBuffer>
            </Syslog>
        </top>
    </data>
</rpc-reply>
```

Example: Retrieving NETCONF session information

Network configuration

Get NETCONF session information.

Procedure

Enter XML view.

```
<Sysname> xml
```

Copy the following message to the client to exchange capabilities with the device:

```
<hello xmlns="urn:ietf:params:xml:ns:netconf:base:1.0">
  <capabilities>
    <capability>
            urn:ietf:params:netconf:base:1.0
    </capability>
  </capabilities>
</hello>
```

Copy the following message to the client to get the current NETCONF session information on the device:

```
<?xml version="1.0" encoding="UTF-8"?>
<rpc message-id="100" xmlns="urn:ietf:params:xml:ns:netconf:base:1.0">
  <get-sessions/>
</rpc>
```

Verifying the configuration

If the client receives a message as follows, the operation is successful:

```
<?xml version="1.0" encoding="UTF-8"?>
<rpc-reply xmlns="urn:ietf:params:xml:ns:netconf:base:1.0" message-id="100">
    <get-sessions>
        <Session>
            <SessionID>1</SessionID>
            <Line>vty0</Line>
            <UserName></UserName>
            <Since>2017-01-07T00:24:57</Since>
            <LockHeld>false</LockHeld>
        </Session>
    </get-sessions>
</rpc-reply>
```

The output shows the following information:

- The session ID of an existing NETCONF session is 1.
- The login user type is vty0.
- The login time is 2017-01-07T00:24:57.
- The user does not hold the lock of the configuration.

Filtering data

About data filtering

You can define a filter to filter information when you perform a <get>, <get-bulk>, <get-config>, or <get-bulk-config> operation. Data filtering includes the following types:

- **Table-based filtering**—Filters table information.
- **Column-based filtering**—Filters information for a single column.

Restrictions and guidelines for data filtering

For table-based filtering to take effect, you must configure table-based filtering before column-based filtering.

Table-based filtering

About table-based filtering

The namespace is **http://www.h3c.com/netconf/base:1.0**. The attribute name is **filter**. For information about the support for table-based match, see the NETCONF XML API references.

Copy the following text to the client to retrieve the longest data with IP address **1.1.1.0** and mask length **24** from the IPv4 routing table:

```
<rpc message-id="100" xmlns="urn:ietf:params:xml:ns:netconf:base:1.0"
xmlns:h3c="http://www.h3c.com/netconf/base:1.0">
  <get>
    <filter type="subtree">
      <top xmlns="http://www.h3c.com/netconf/data:1.0">
        <Route>
         <Ipv4Routes>
           <RouteEntry h3c:filter="IP 1.1.1.0 MaskLen 24 longer"/>
         </Ipv4Routes>
        </Route>
      </top>
    </filter>
  </get>
</rpc>
```

Restrictions and guidelines

To use table-based filtering, specify a match criterion for the **filter** row attribute.

Column-based filtering

About column-based filtering

Column-based filtering includes full match filtering, regular expression match filtering, and conditional match filtering. Full match filtering has the highest priority and conditional match filtering has the lowest priority. When more than one filtering criterion is specified, the one with the highest priority takes effect.

Full match filtering

You can specify an element value in an XML message to implement full match filtering. If multiple element values are provided, the system returns the data that matches all the specified values.

Copy the following text to the client to retrieve configuration data of all interfaces in UP state:

```
<rpc message-id="100" xmlns="urn:ietf:params:xml:ns:netconf:base:1.0">
  <get>
    <filter type="subtree">
      <top xmlns="http://www.h3c.com/netconf/data:1.0">
        <Ifmgr>
          <Interfaces>
            <Interface>
              <AdminStatus>1</AdminStatus>
            </Interface>
          </Interfaces>
        </Ifmgr>
      </top>
    </filter>
  </get>
</rpc>
```

You can also specify an attribute name that is the same as a column name of the current table at the row to implement full match filtering. The system returns only configuration data that matches this attribute name. The XML message equivalent to the above element-value-based full match filtering is as follows:

```
<rpc message-id="100" xmlns="urn:ietf:params:xml:ns:netconf:base:1.0">
  <get>
    <filter type="subtree">
      <top
xmlns="http://www.h3c.com/netconf/data:1.0"xmlns:data="http://www.h3c.com/netconf/dat
a:1.0">
        <Ifmgr>
          <Interfaces>
            <Interface data:AdminStatus="1"/>
          </Interfaces>
        </Ifmgr>
      </top>
    </filter>
  </get>
</rpc>
```

The above examples show that both element-value-based full match filtering and attribute-name-based full match filtering can retrieve the same index and column information for all interfaces in up state.

Regular expression match filtering

To implement a complex data filtering with characters, you can add a **regExp** attribute for a specific element.

The supported data types include integer, date and time, character string, IPv4 address, IPv4 mask, IPv6 address, MAC address, OID, and time zone.

Copy the following text to the client to retrieve the descriptions of interfaces, of which all the characters must be upper-case letters from A to Z:

```
<rpc message-id="100" xmlns="urn:ietf:params:xml:ns:netconf:base:1.0"
xmlns:h3c="http://www.h3c.com/netconf/base:1.0">
  <get-config>
    <source>
      <running/>
    </source>
    <filter type="subtree">
      <top xmlns="http://www.h3c.com/netconf/config:1.0">
        <Ifmgr>
          <Interfaces>
            <Interface>
              <Description h3c:regExp="^[A-Z]*$"/>
            </Interface>
          </Interfaces>
        </Ifmgr>
      </top>
    </filter>
  </get-config>
</rpc>
```

Conditional match filtering

To implement a complex data filtering with digits and character strings, you can add a **match** attribute for a specific element. Table 4 lists the conditional match operators.

Table 4 Conditional match operators

Operation	Operator	Remarks
More than	match="more:*value*"	More than the specified value. The supported data types include date, digit, and character string.
Less than	match="less:*value*"	Less than the specified value. The supported data types include date, digit, and character string.
Not less than	match="notLess:*value*"	Not less than the specified value. The supported data types include date, digit, and character string.
Not more than	match="notMore:*value*"	Not more than the specified value. The supported data types include date, digit, and character string.
Equal	match="equal:*value*"	Equal to the specified value. The supported data types include date, digit, character string, OID, and BOOL.
Not equal	match="notEqual:*value*"	Not equal to the specified value. The supported data types include date, digit, character string, OID, and BOOL.
Include	match="include:*string*"	Includes the specified string. The supported data types include only character string.
Not include	match="exclude:*string*"	Excludes the specified string. The supported data types include only character string.
Start with	match="startWith:*string*"	Starts with the specified string. The supported data types include character string and OID.
End with	match="endWith:*string*"	Ends with the specified string. The supported data types include only character string.

Copy the following text to the client to retrieve extension information about the entity whose CPU usage is more than 50%:

```
<rpc message-id="100" xmlns="urn:ietf:params:xml:ns:netconf:base:1.0"
xmlns:h3c="http://www.h3c.com/netconf/base:1.0">
  <get>
    <filter type="subtree">
      <top xmlns="http://www.h3c.com/netconf/data:1.0">
        <Device>
          <ExtPhysicalEntities>
            <Entity>
              <CpuUsage h3c:match="more:50"></CpuUsage>
            </Entity>
          </ExtPhysicalEntities>
        </Device>
      </top>
    </filter>
  </get>
</rpc>
```

Example: Filtering data with regular expression match

Network configuration

Retrieve all data including **Gigabit** in the **Description** column of the Interfaces table under the Ifmgr module.

Procedure

Enter XML view.

```
<Sysname> xml
```

Notify the device of the NETCONF capabilities supported on the client.

```
<hello xmlns="urn:ietf:params:xml:ns:netconf:base:1.0">
  <capabilities>
    <capability>
           urn:ietf:params:netconf:base:1.0
    </capability>
  </capabilities>
</hello>
```

Retrieve all data including **Gigabit** in the **Description** column of the Interfaces table under the Ifmgr module.

```
<?xml version="1.0"?>
<rpc message-id="100" xmlns="urn:ietf:params:xml:ns:netconf:base:1.0"
xmlns:h3c="http://www.h3c.com/netconf/base:1.0">
  <get>
    <filter type="subtree">
      <top xmlns="http://www.h3c.com/netconf/data:1.0">
        <Ifmgr>
          <Interfaces>
            <Interface>
              <Description h3c:regExp="(Gigabit)+"/>
            </Interface>
          </Interfaces>
        </Ifmgr>
```

```
      </top>
    </filter>
  </get>
</rpc>
```

Verifying the configuration

If the client receives the following text, the operation is successful:

```
<?xml version="1.0" encoding="UTF-8"?>
<rpc-reply xmlns="urn:ietf:params:xml:ns:netconf:base:1.0"
xmlns:h3c="http://www.h3c.com/netconf/base:1.0" message-id="100">
    <data>
        <top xmlns="http://www.h3c.com/netconf/data:1.0">
            <Ifmgr>
                <Interfaces>
                    <Interface>
                        <IfIndex>2681</IfIndex>
                        <Description>GigabitEthernet1/0/1 Interface</Description>
                    </Interface>
                    <Interface>
                        <IfIndex>2685</IfIndex>
                        <Description>GigabitEthernet1/0/2 Interface</Description>
                    </Interface>
                    <Interface>
                        <IfIndex>2689</IfIndex>
                        <Description>GigabitEthernet1/0/3 Interface</Description>
                    </Interface>
                 <Interface>
            </Ifmgr>
        </top>
    </data>
</rpc-reply>
```

Example: Filtering data by conditional match

Network configuration

Retrieve data in the **Name** column with the ifindex value not less than 5000 in the Interfaces table under the Ifmgr module.

Procedure

Enter XML view.

```
<Sysname> xml
```

Notify the device of the NETCONF capabilities supported on the client.

```
<hello xmlns="urn:ietf:params:xml:ns:netconf:base:1.0">
  <capabilities>
    <capability>
            urn:ietf:params:netconf:base:1.0
    </capability>
  </capabilities>
</hello>
```

Retrieve data in the **Name** column with the ifindex value not less than 5000 in the Interfaces table under the Ifmgr module.

```
<rpc message-id="100" xmlns="urn:ietf:params:xml:ns:netconf:base:1.0"
xmlns:h3c="http://www.h3c.com/netconf/base:1.0">
  <get>
    <filter type="subtree">
      <top xmlns="http://www.h3c.com/netconf/data:1.0">
        <Ifmgr>
          <Interfaces>
            <Interface>
              <IfIndex h3c:match="notLess:5000"/>
              <Name/>
            </Interface>
          </Interfaces>
        </Ifmgr>
      </top>
    </filter>
  </get>
</rpc>
```

Verifying the configuration

If the client receives the following text, the operation is successful:

```
<?xml version="1.0" encoding="UTF-8"?>
<rpc-reply xmlns="urn:ietf:params:xml:ns:netconf:base:1.0"
xmlns:h3c="http://www.h3c.com/netconf/base:1.0" message-id="100">
    <data>
        <top xmlns="http://www.h3c.com/netconf/data:1.0">
            <Ifmgr>
                <Interfaces>
                    <Interface>
                        <IfIndex>7241</IfIndex>
                        <Name>NULL0</Name>
                    </Interface>
                </Interfaces>
            </Ifmgr>
        </top>
    </data>
</rpc-reply>
```

Locking or unlocking the running configuration

About configuration locking and unlocking

Multiple methods are available for configuring the device, such as CLI, NETCONF, and SNMP. Before configuring, managing, or troubleshooting the device, you can lock the configuration to prevent other users from changing the device configuration. After you lock the configuration, only you can perform <edit-config> operations to change the configuration or unlock the configuration. Other users can only read the configuration.

If you close your NETCONF session, the system unlocks the configuration. You can also manually unlock the configuration.

Restrictions and guidelines for configuration locking and unlocking

The <lock> operation locks the running configuration of the device. You cannot use it to lock the configuration for a specific module.

Locking the running configuration

Copy the following text to the client to lock the running configuration:

```
<?xml version="1.0" encoding="UTF-8"?>
  <rpc message-id="100" xmlns="urn:ietf:params:xml:ns:netconf:base:1.0">
    <lock>
      <target>
        <running/>
      </target>
    </lock>
  </rpc>
```

If the <lock> operation succeeds, the device returns a response in the following format:

```
<?xml version="1.0" encoding="UTF-8"?>
  <rpc-reply message-id="100" xmlns="urn:ietf:params:xml:ns:netconf:base:1.0">
     <ok/>
</rpc-reply>
```

Unlocking the running configuration

Copy the following text to the client to unlock the running configuration:

```
<?xml version="1.0" encoding="UTF-8"?>
  <rpc message-id="100" xmlns="urn:ietf:params:xml:ns:netconf:base:1.0">
    <unlock>
      <target>
        <running/>
      </target>
    </unlock>
  </rpc>
```

If the <unlock> operation succeeds, the device returns a response in the following format:

```
<?xml version="1.0" encoding="UTF-8"?>
    <rpc-reply message-id="100" xmlns="urn:ietf:params:xml:ns:netconf:base:1.0">
      <ok/>
</rpc-reply>
```

Example: Locking the running configuration

Network configuration

Lock the device configuration so other users cannot change the device configuration.

Procedure

Enter XML view.

```
<Sysname> xml
```

Notify the device of the NETCONF capabilities supported on the client.

```
<hello xmlns="urn:ietf:params:xml:ns:netconf:base:1.0">
    <capabilities>
        <capability>
            urn:ietf:params:netconf:base:1.0
        </capability>
    </capabilities>
</hello>
```

Lock the configuration.

```
<?xml version="1.0" encoding="UTF-8"?>
  <rpc message-id="100" xmlns="urn:ietf:params:xml:ns:netconf:base:1.0">
    <lock>
      <target>
        <running/>
      </target>
    </lock>
  </rpc>
```

Verifying the configuration

If the client receives the following response, the <lock> operation is successful:

```
<?xml version="1.0" encoding="UTF-8"?>
    <rpc-reply message-id="100" xmlns="urn:ietf:params:xml:ns:netconf:base:1.0">
      <ok/>
</rpc-reply>
```

If another client sends a lock request, the device returns the following response:

```
<?xml version="1.0" encoding="UTF-8"?>
<rpc-reply message-id="100" xmlns="urn:ietf:params:xml:ns:netconf:base:1.0">
<rpc-error>
  <error-type>protocol</error-type>
  <error-tag>lock-denied</error-tag>
  <error-severity>error</error-severity>
  <error-message xml:lang="en"> Lock failed because the NETCONF lock is held by another
session.</error-message>
  <error-info>
    <session-id>1</session-id>
  </error-info>
  </rpc-error>
</rpc-reply>
```

The output shows that the <lock> operation failed. The client with session ID 1 is holding the lock,

Modifying the configuration

About the <edit-config> operation

The <edit-config> operation includes the following operations: merge, create, replace, remove, delete, default-operation, error-option, test-option, and incremental. For more information about the operations, see "Supported NETCONF operations."

Procedure

Copy the following text to perform the <edit-config> operation:

```
<?xml version="1.0"?>
<rpc message-id="100" xmlns="urn:ietf:params:xml:ns:netconf:base:1.0">
  <edit-config>
    <target><running></running></target>
    <error-option>
       error-option
    </error-option>
    <config>
      <top xmlns="http://www.h3c.com/netconf/config:1.0">
        Specify the module name, submodule name, table name, and column name
      </top>
    </config>
  </edit-config>
</rpc>
```

The <error-option> element indicates the action to be taken in response to an error that occurs during the operation. It has the following values:

Value	Description
stop-on-error	Stops the <edit-config> operation.
continue-on-error	Continues the <edit-config> operation.
rollback-on-error	Rolls back the configuration to the configuration before the <edit-config> operation was performed. By default, an <edit-config> operation cannot be performed while the device is rolling back the configuration. If the rollback time exceeds the maximum time that the client can wait, the client determines that the <edit-config> operation has failed and performs the operation again. Because the previous rollback is not completed, the operation triggers another rollback. If this process repeats itself, CPU and memory resources will be exhausted and the device will reboot. To allow an <edit-config> operation to be performed during a configuration rollback, perform an <action> operation to change the value of the **DisableEditConfigWhenRollback** attribute to **false**.

If the <edit-config> operation succeeds, the device returns a response in the following format:

```
<?xml version="1.0">
<rpc-reply message-id="100" xmlns="urn:ietf:params:xml:ns:netconf:base:1.0">
  <ok/>
</rpc-reply>
```

You can also perform the <get> operation to verify that the current element value is the same as the value specified through the <edit-config> operation.

Example: Modifying the configuration

Network configuration

Change the log buffer size for the Syslog module to 512.

Procedure

Enter XML view.

```
<Sysname> xml
```

Notify the device of the NETCONF capabilities supported on the client.

```
<hello xmlns="urn:ietf:params:xml:ns:netconf:base:1.0">
  <capabilities>
    <capability>urn:ietf:params:netconf:base:1.0</capability>
  </capabilities>
</hello>
```

Change the log buffer size for the Syslog module to 512.

```
<rpc message-id="100" xmlns="urn:ietf:params:xml:ns:netconf:base:1.0"
xmlns:web="urn:ietf:params:xml:ns:netconf:base:1.0">
  <edit-config>
    <target>
      <running/>
    </target>
    <config>
      <top xmlns="http://www.h3c.com/netconf/config:1.0" web:operation="merge">
        <Syslog>
          <LogBuffer>
            <BufferSize>512</BufferSize>
          </LogBuffer>
        </Syslog>
      </top>
    </config>
  </edit-config>
</rpc>
```

Verifying the configuration

If the client receives the following text, the <edit-config> operation is successful:

```
<?xml version="1.0" encoding="UTF-8"?>
<rpc-reply message-id="100" xmlns="urn:ietf:params:xml:ns:netconf:base:1.0">
    <ok/>
</rpc-reply>
```

Saving the running configuration

About the <save> operation

A <save> operation saves the running configuration to a configuration file and specifies the file as the main next-startup configuration file.

Restrictions and guidelines

The <save> operation is resource intensive. Do not perform this operation when system resources are heavily occupied.

Procedure

Copy the following text to the client:

```
<?xml version="1.0" encoding="UTF-8"?>
<rpc message-id="100" xmlns="urn:ietf:params:xml:ns:netconf:base:1.0">
  <save OverWrite="false" Binary-only="false">
    <file>Configuration file name</file>
  </save>
</rpc>
```

Item	Description
file	Specifies a .cfg configuration file by its name. The name must start with the storage medium name. If you specify the file column, a file name is required. If the **Binary-only** attribute is **false**, the device saves the running configuration to both the text and binary configuration files. • If the specified .cfg file does not exist, the device creates the binary and text configuration files to save the running configuration. • If you do not specify the file column, the device saves the running configuration to the text and binary next-startup configuration files.
OverWrite	Determines whether to overwrite the specified file if the file already exists. The following values are available: • **true**—Overwrite the file. • **false**—Do not overwrite the file. The running configuration cannot be saved, and the system displays an error message. The default value is **true**.

Binary-only	Determines whether to save the running configuration only to the binary configuration file. The following values are available:
	• **true**—Save the running configuration only to the binary configuration file.
	  ◦ If **file** specifies a nonexistent file, the <save> operation fails.
	  ◦ If you do not specify the file column, the device identifies whether the main next-startup configuration file is specified. If yes, the device saves the running configuration to the corresponding binary file. If not, the <save> operation fails.
	• **false**—Save the running configuration to both the text and binary configuration files. For more information, see the description for the file column in this table.
	Saving the running configuration to both the text and binary configuration files

Item	Description
	requires more time. The default value is **false**.

If the <save> operation succeeds, the device returns a response in the following format:

```
<?xml version="1.0" encoding="UTF-8"?>
    <rpc-reply message-id="100" xmlns="urn:ietf:params:xml:ns:netconf:base:1.0">
      <ok/>
</rpc-reply>
```

Example: Saving the running configuration

Network configuration

Save the running configuration to the **config.cfg** file.

Procedure

Enter XML view.

```
<Sysname> xml
```

Notify the device of the NETCONF capabilities supported on the client.

```
<hello xmlns="urn:ietf:params:xml:ns:netconf:base:1.0">
  <capabilities>
    <capability>
            urn:ietf:params:netconf:base:1.0
    </capability>
  </capabilities>
</hello>
```

Save the running configuration of the device to the **config.cfg** file.

```
<?xml version="1.0" encoding="UTF-8"?>
<rpc message-id="100" xmlns="urn:ietf:params:xml:ns:netconf:base:1.0">
  <save>
    <file>config.cfg</file>
  </save>
</rpc>
```

Verifying the configuration

If the client receives the following response, the <save> operation is successful:

```
<?xml version="1.0" encoding="UTF-8"?>
    <rpc-reply message-id="100" xmlns="urn:ietf:params:xml:ns:netconf:base:1.0">
      <ok/>
</rpc-reply>
```

Loading the configuration

About the <load> operation

The <load> operation merges the configuration from a configuration file into the running configuration as follows:

- Loads settings that do not exist in the running configuration.
- Overwrites settings that already exist in the running configuration.

Restrictions and guidelines

When you perform a <load> operation, follow these restrictions and guidelines:

- The <load> operation is resource intensive. Do not perform this operation when the system resources are heavily occupied.
- Some settings in a configuration file might conflict with the existing settings. For the settings in the file to take effect, delete the existing conflicting settings, and then load the configuration file.

Procedure

Copy the following text to the client to load a configuration file for the device:

```
<?xml version="1.0" encoding="UTF-8"?>
<rpc message-id="100" xmlns="urn:ietf:params:xml:ns:netconf:base:1.0">
  <load>
   <file>Configuration file name</file>
  </load>
</rpc>
```

The configuration file name must start with the storage media name and end with the **.cfg** extension.

If the <load> operation succeeds, the device returns a response in the following format:

```
<?xml version="1.0" encoding="UTF-8"?>
    <rpc-reply message-id="100" xmlns="urn:ietf:params:xml:ns:netconf:base:1.0">
      <ok/>
</rpc-reply>
```

Rolling back the configuration

Restrictions and guidelines

The <rollback> operation is resource intensive. Do not perform this operation when the system resources are heavily occupied.

By default, an <edit-config> operation cannot be performed while the device is rolling back the configuration. To allow an <edit-config> operation to be performed during a configuration rollback, perform an <action> operation to change the value of the **DisableEditConfigWhenRollback** attribute to **false**.

Rolling back the configuration based on a configuration file

Copy the following text to the client to roll back the running configuration to the configuration in a configuration file:

```
<?xml version="1.0" encoding="UTF-8"?>
<rpc message-id="100" xmlns="urn:ietf:params:xml:ns:netconf:base:1.0">
  <rollback>
    <file>Specify the configuration file name</file>
  </rollback>
</rpc>
```

If the <rollback> operation succeeds, the device returns a response in the following format:

```
<?xml version="1.0" encoding="UTF-8"?>
    <rpc-reply message-id="100" xmlns="urn:ietf:params:xml:ns:netconf:base:1.0">
      <ok/>
</rpc-reply>
```

Rolling back the configuration based on a rollback point

About configuration rollback based on a rollback point

You can roll back the running configuration based on a rollback point when one of the following situations occurs:

- A NETCONF client sends a rollback request.
- The NETCONF session idle time is longer than the rollback idle timeout time.
- A NETCONF client is unexpectedly disconnected from the device.

Restrictions and guidelines

Multiple users might simultaneously configure the device. As a best practice, lock the system before rolling back the configuration to prevent other users from modifying the running configuration.

Procedure

1. Lock the running configuration. For more information, see "Locking or unlocking the running configuration."
2. Enable configuration rollback based on a rollback point.

   # Copy the following text to the client to perform a <save-point>/<begin> operation:

   ```
   <rpc message-id="100" xmlns="urn:ietf:params:xml:ns:netconf:base:1.0">
         <save-point>
           <begin>
             <confirm-timeout>100</confirm-timeout>
          </begin>
         </save-point>
   </rpc>
   ```

Item	Description
confirm-timeout	Specifies the rollback idle timeout time in the range of 1 to 65535 seconds. The default is 600 seconds. This item is optional.

   If the <save-point/begin> operation succeeds, the device returns a response in the following format:

   ```
   <rpc-reply message-id="100" xmlns="urn:ietf:params:xml:ns:netconf:base:1.0">
     <data>
       <save-point>
          <commit>
             <commit-id>1</commit-id>
          </commit>
       </save-point>
     </data>
   </rpc-reply>
   ```

3. Modify the running configuration. For more information, see "Modifying the configuration."
4. Mark the rollback point.

The system supports a maximum of 50 rollback points. If the limit is reached, specify the **force** attribute for the <save-point>/<commit> operation to overwrite the earliest rollback point.

Copy the following text to the client to perform a <save-point>/<commit> operation:

```
<rpc message-id="100" xmlns="urn:ietf:params:xml:ns:netconf:base:1.0">
  <save-point>
    <commit>
      <label>SUPPORT VLAN<label>
      <comment>vlan 1 to 100 and interfaces.</comment>
     </commit>
  </save-point>
</rpc>
```

The <label> and <comment> elements are optional.

If the <save-point>/<commit> operation succeeds, the device returns a response in the following format:

```
<rpc-reply message-id="100" xmlns="urn:ietf:params:xml:ns:netconf:base:1.0">
  <data>
    <save-point>
       <commit>
          <commit-id>2</commit-id>
       </commit>
    </save-point>
  </data>
</rpc-reply>
```

5. Retrieve the rollback point configuration records.

The following text shows the message format for a <save-point/get-commits> request:

```
<rpc message-id="100" xmlns="urn:ietf:params:xml:ns:netconf:base:1.0">
  <save-point>
    <get-commits>
      <commit-id/>
      <commit-index/>
      <commit-label/>
    </get-commits>
  </save-point>
</rpc>
```

Specify the <commit-id/>, <commit-index/>, or <commit-label/> element to retrieve the specified rollback point configuration records. If no element is specified, the operation retrieves records for all rollback point settings.

Copy the following text to the client to perform a <save-point>/<get-commits> operation:

```
<rpc message-id="100" xmlns="urn:ietf:params:xml:ns:netconf:base:1.0">
  <save-point>
    <get-commits>
      <commit-label>SUPPORT VLAN</commit-label>
    </get-commits>
  </save-point>
</rpc>
```

If the <save-point/get-commits> operation succeeds, the device returns a response in the following format:

```
<rpc-reply message-id="100" xmlns="urn:ietf:params:xml:ns:netconf:base:1.0">
   <data>
      <save-point>
         <commit-information>
```

```
            <CommitID>2</CommitID>
            <TimeStamp>Sun Jan 1 11:30:28 2017</TimeStamp>
            <UserName>test</UserName>
            <Label>SUPPORT VLAN</Label>
          </commit-information>
    </save-point>
  </data>
</rpc-reply>
```

6. Retrieve the configuration data corresponding to a rollback point.

The following text shows the message format for a <save-point>/<get-commit-information> request:

```
<rpc message-id="100" xmlns="urn:ietf:params:xml:ns:netconf:base:1.0">
  <save-point>
    <get-commit-information>
       <commit-information>
         <commit-id/>
         <commit-index/>
         <commit-label/>
       </commit-information>
       <compare-information>
         <commit-id/>
         <commit-index/>
         <commit-label/>
       </compare-information>
    </get-commit-information>
  </save-point>
</rpc>
```

Specify one of the following elements: <commit-id/>, <commit-index/>, and <commit-label/>. The <compare-information> element is optional.

Item	Description
commit-id	Uniquely identifies a rollback point.
commit-index	Specifies 50 most recently configured rollback points. The value of 0 indicates the most recently configured one and 49 indicates the earliest configured one.
commit-label	Specifies a unique label for a rollback point.
get-commit-information	Retrieves the configuration data corresponding to the most recently configured rollback point.

Copy the following text to the client to perform a <save-point>/<get-commit-information> operation:

```
<rpc message-id="100" xmlns="urn:ietf:params:xml:ns:netconf:base:1.0">
  <save-point>
    <get-commit-information>
               <commit-information>
                  <commit-label>SUPPORT VLAN</commit-label>
               </commit-information>
    </get-commit-information>
  </save-point>
</rpc>
```

If the <save-point/get-commit-information> operation succeeds, the device returns a response in the following format:

```
<rpc-reply message-id="100" xmlns="urn:ietf:params:xml:ns:netconf:base:1.0">
   <data>
     <save-point>
        <commit-information>
           <content>
              …
              interface vlan 1
              …
           </content>
        </commit-information>
     </save-point>
   </data>
</rpc-reply>
```

7. Roll back the configuration based on a rollback point.

The configuration can also be automatically rolled back based on the most recently configured rollback point when the NETCONF session idle timer expires.

Copy the following text to the client to perform a <save-point>/<rollback> operation:

```
<rpc message-id="100" xmlns="urn:ietf:params:xml:ns:netconf:base:1.0">
  <save-point>
    <rollback>
      <commit-id/>
      <commit-index/>
      <commit-label/>
    </rollback>
  </save-point>
</rpc>
```

Specify one of the following elements: <commit-id/>, <commit-index/>, and <commit-label/>. If no element is specified, the operation rolls back configuration based on the most recently configured rollback point.

Item	Description
commit-id	Uniquely identifies a rollback point.
commit-index	Specifies 50 most recently configured rollback points. The value of 0 indicates the most recently configured one and 49 indicates the earliest configured one.
commit-label	Specifies the unique label of a rollback point.

If the <save-point/rollback> operation succeeds, the device returns a response in the following format:

```
<rpc-reply message-id="100" xmlns="urn:ietf:params:xml:ns:netconf:base:1.0">
  <ok></ok>
</rpc-reply>
```

8. End the rollback configuration.

Copy the following text to the client to perform a <save-point>/<end> operation:

```
<rpc message-id="100" xmlns="urn:ietf:params:xml:ns:netconf:base:1.0">
  <save-point>
    <end/>
```

```
  </save-point>
</rpc>
```

If the <save-point/end> operation succeeds, the device returns a response in the following format:

```
<rpc-reply message-id="100" xmlns="urn:ietf:params:xml:ns:netconf:base:1.0">
   <ok/>
</rpc-reply>
```

9. Unlock the configuration. For more information, see "Locking or unlocking the running configuration."

Performing CLI operations through NETCONF

About CLI operations through NETCONF

You can enclose command lines in XML messages to configure the device.

Restrictions and guidelines

Performing CLI operations through NETCONF is resource intensive. As a best practice, do not perform the following tasks:

- Enclose multiple command lines in one XML message.
- Use NETCONF to perform a CLI operation when other users are performing NETCONF CLI operations.

Procedure

Copy the following text to the client to execute the commands:

```
<?xml version="1.0" encoding="UTF-8"?>
<rpc message-id="100" xmlns="urn:ietf:params:xml:ns:netconf:base:1.0">
  <CLI>
    <Execution>
      Commands
    </Execution>
  </CLI>
</rpc>
```

The <Execution> element can contain multiple commands, with one command on one line.

If the CLI operation succeeds, the device returns a response in the following format:

```
<?xml version="1.0" encoding="UTF-8"?>
<rpc-reply message-id="100" xmlns="urn:ietf:params:xml:ns:netconf:base:1.0">
  <CLI>
    <Execution>
      <![CDATA[Responses to the commands]]>
    </Execution>
  </CLI>
</rpc-reply>
```

Example: Performing CLI operations

Network configuration

Send the **`display vlan`** command to the device.

Procedure

Enter XML view.

```
<Sysname> xml
```

Notify the device of the NETCONF capabilities supported on the client.

```
<hello xmlns="urn:ietf:params:xml:ns:netconf:base:1.0">
  <capabilities>
    <capability>
           urn:ietf:params:netconf:base:1.0
    </capability>
  </capabilities>
</hello>
```

Copy the following text to the client to execute the **`display vlan`** command:

```
<?xml version="1.0" encoding="UTF-8"?>
<rpc message-id="100" xmlns="urn:ietf:params:xml:ns:netconf:base:1.0">
  <CLI>
    <Execution>
          display vlan
    </Execution>
  </CLI>
</rpc>
```

Verifying the configuration

If the client receives the following text, the operation is successful:

```
<?xml version="1.0" encoding="UTF-8"?>
<rpc-reply message-id="100" xmlns="urn:ietf:params:xml:ns:netconf:base:1.0">
  <CLI>
    <Execution><![CDATA[
<Sysname>display vlan
 Total VLANs: 1
 The VLANs include:
 1(default)
   ]]>
   </Execution>
  </CLI>
</rpc-reply>
```

Subscribing to events

About event subscription

When an event takes place on the device, the device sends information about the event to NETCONF clients that have subscribed to the event.

Restrictions and guidelines

Event subscription is not supported for NETCONF over SOAP sessions.

A subscription takes effect only on the current session. It is canceled when the session is terminated.

If you do not specify the event stream to be subscribed to, the device sends syslog event notifications to the NETCONF client.

Subscribing to syslog events

Copy the following message to the client to complete the subscription:

```
<?xml version="1.0" encoding="UTF-8"?>
<rpc message-id="100" xmlns="urn:ietf:params:xml:ns:netconf:base:1.0">
  <create-subscription xmlns="urn:ietf:params:xml:ns:netconf:notification:1.0">
    <stream>NETCONF</stream>
      <filter>
        <event xmlns="http://www.h3c.com/netconf/event:1.0">
          <Code>code</Code>
            <Group>group</Group>
              <Severity>severity</Severity>
        </event>
      </filter>
      <startTime>start-time</startTime>
      <stopTime>stop-time</stopTime>
   </create-subscription>
</rpc>
```

Item	Description
stream	Specifies the event stream. The name for the syslog event stream is **NETCONF**.
event	Specifies the event. For information about the events to which you can subscribe, see the system log message references for the device.
code	Specifies the mnemonic symbol of the log message.
group	Specifies the module name of the log message.
severity	Specifies the severity level of the log message.
start-time	Specifies the start time of the subscription.
stop-time	Specifies the end time of the subscription.

If the subscription succeeds, the device returns a response in the following format:

```
<?xml version="1.0" encoding="UTF-8"?>
<rpc-reply message-id="100" xmlns:netconf="urn:ietf:params:xml:ns:netconf:base:1.0">
    <ok/>
</rpc-reply>
```

If the subscription fails, the device returns an error message in the following format:

```
<?xml version="1.0" encoding="UTF-8"?>
<rpc-reply message-id="100" xmlns="urn:ietf:params:xml:ns:netconf:base:1.0">
```

```
<rpc-error>
   <error-type>error-type</error-type>
   <error-tag>error-tag</error-tag>
   <error-severity>error-severity</error-severity>
   <error-message xml:lang="en">error-message</error-message>
</rpc-error>
</rpc-reply>
```

For more information about error messages, see RFC 4741.

Subscribing to events monitored by NETCONF

After you subscribe to events as described in this section, NETCONF regularly polls the subscribed events and sends the events that match the subscription condition to the NETCONF client.

Copy the following message to the client to complete the subscription:

```
<?xml version="1.0" encoding="UTF-8"?>
<rpc message-id="100" xmlns="urn:ietf:params:xml:ns:netconf:base:1.0">
<create-subscription xmlns='urn:ietf:params:xml:ns:netconf:notification:1.0'>
  <stream>NETCONF_MONITOR_EXTENSION</stream>
  <filter>
    <NetconfMonitor xmlns='http://www.h3c.com/netconf/monitor:1.0'>
      <XPath>XPath</XPath>
      <Interval>interval</Interval>
      <ColumnConditions>
        <ColumnCondition>
          <ColumnName>ColumnName</ColumnName>
          <ColumnValue>ColumnValue</ColumnValue>
          <ColumnCondition>ColumnCondition</ColumnCondition>
        </ColumnCondition>
      </ColumnConditions>
      <MustIncludeResultColumns>
        <ColumnName>columnName</ColumnName>
      </MustIncludeResultColumns>
    </NetconfMonitor>
  </filter>
<startTime>start-time</startTime>
<stopTime>stop-time</stopTime>
</create-subscription>
</rpc>
```

Item	Description
stream	Specifies the event stream. The name for the event stream is **NETCONF_MONITOR_EXTENSION**.
NetconfMonitor	Specifies the filtering information for the event.
XPath	Specifies the path of the event in the format of *ModuleName*[/*SubmoduleName*]/*TableName*.
interval	Specifies the interval for NETCONF to obtain events that matches the subscription condition. The value range is 1 to 4294967 seconds. The default

Item	Description
	value is 300 seconds.
ColumnName	Specifies the name of a column in the format of [*GroupName*.]*ColumnName*.
ColumnValue	Specifies the baseline value.
ColumnCondition	Specifies the operator: • **more**. • **less**. • **notLess**. • **notMore**. • **equal**. • **notEqual**. • **include**. • **exclude**. • **startWith**. • **endWith**. Choose an operator according to the type of the baseline value.
start-time	Specifies the start time of the subscription.
stop-time	Specifies the end time of the subscription.

If the subscription succeeds, the device returns a response in the following format:

```
<?xml version="1.0" encoding="UTF-8"?>
<rpc-reply message-id="100" xmlns:netconf="urn:ietf:params:xml:ns:netconf:base:1.0">
    <ok/>
</rpc-reply>
```

Subscribing to events reported by modules

After you subscribe to events as described in this section, the specified modules report subscribed events to NETCONF. NETCONF sends the events to the NETCONF client.

Copy the following message to the client to complete the subscription:

```
<?xml version="1.0" encoding="UTF-8"?>
<rpc message-id="100" xmlns="urn:ietf:params:xml:ns:netconf:base:1.0"
xmlns:xs="http://www.h3c.com/netconf/base:1.0">
<create-subscription xmlns="urn:ietf:params:xml:ns:netconf:notification:1.0">
<stream>XXX_STREAM</stream>
   <filter type="subtree">
<event xmlns="http://www.h3c.com/netconf/event:1.0/xxx-features-list-name:1.0">
       <ColumnName xs:condition="Condition">value</ColumnName>
</event>
</filter>
<startTime>start-time</startTime>
<stopTime>stop-time</stopTime>
</create-subscription>
</rpc>
```

Item	Description
stream	Specifies the event stream. Supported event streams vary by device model.
event	Specifies the event name. An event stream includes multiple events. The events use the same namespaces as the event stream.
ColumnName	Specifies the name of a column.
ColumnCondition	Specifies the operator: • **more**. • **less**. • **notLess**. • **notMore**. • **equal**. • **notEqual**. • **include**. • **exclude**. • **startWith**. • **endWith**. Choose an operator according to the type of the baseline value.
value	Specifies the baseline value for the column.
start-time	Specifies the start time of the subscription.
stop-time	Specifies the end time of the subscription.

If the subscription succeeds, the device returns a response in the following format:

```
<?xml version="1.0" encoding="UTF-8"?>
<rpc-reply message-id="100" xmlns:netconf="urn:ietf:params:xml:ns:netconf:base:1.0">
    <ok/>
</rpc-reply>
```

Canceling a subscription

You can cancel a subscription that you have configured on the current session.

Copy the following message to the client to cancel a subscription:

```
<rpc message-id="100" xmlns="urn:ietf:params:xml:ns:netconf:base:1.0">
  <cancel-subscription xmlns="urn:ietf:params:xml:ns:netconf:notification:1.0">
    <stream>XXX_STREAM</stream>
  </cancel-subscription>
</rpc>
```

Item	Description
stream	Specifies the event stream.

If the cancel operation succeeds, the device returns a response in the following format:

```
<?xml version="1.0" encoding="UTF-8"?>
<rpc-reply xmlns="urn:ietf:params:xml:ns:netconf:base:1.0" message-id="100">
    <ok/>
</rpc-reply>
```

If the subscription does not exist, the device returns an error message in the following format:

```
<?xml version="1.0" encoding="UTF-8"?>
<rpc-reply message-id="100" xmlns="urn:ietf:params:xml:ns:netconf:base:1.0">
<rpc-error>
   <error-type>error-type</error-type>
   <error-tag>error-tag</error-tag>
   <error-severity>error-severity</error-severity>
<error-message xml:lang="en">The subscription stream to be canceled doesn't exist: Stream name=XXX_STREAM.</error-message>
</rpc-error>
</rpc-reply>
```

Example: Subscribing to syslog events

Network configuration

Configure a client to subscribe to syslog events with no time limitation. After the subscription, all events on the device are sent to the client before the session between the device and client is terminated.

Procedure

Enter XML view.

```
<Sysname> xml
```

Notify the device of the NETCONF capabilities supported on the client.

```
<hello xmlns="urn:ietf:params:xml:ns:netconf:base:1.0">
  <capabilities>
    <capability>
            urn:ietf:params:netconf:base:1.0
    </capability>
  </capabilities>
</hello>
```

Subscribe to syslog events with no time limitation.

```
<rpc message-id="100" xmlns="urn:ietf:params:xml:ns:netconf:base:1.0">
  <create-subscription xmlns="urn:ietf:params:xml:ns:netconf:notification:1.0">
    <stream>NETCONF</stream>
  </create-subscription>
</rpc>
```

Verifying the configuration

If the client receives the following response, the subscription is successful:

```
<?xml version="1.0" encoding="UTF-8"?>
<rpc-reply xmlns="urn:ietf:params:xml:ns:netconf:base:1.0" message-id="100">
    <ok/>
</rpc-reply>
```

When another client (192.168.100.130) logs in to the device, the device sends a notification to the client that has subscribed to all events:

```
<?xml version="1.0" encoding="UTF-8"?>
<notification xmlns="urn:ietf:params:xml:ns:netconf:notification:1.0">
    <eventTime>2011-01-04T12:30:52</eventTime>
    <event xmlns="http://www.h3c.com/netconf/event:1.0">
```

```
        <Group>SHELL</Group>
        <Code>SHELL_LOGIN</Code>
        <Slot>1</Slot>
        <Severity>Notification</Severity>
        <context>VTY logged in from 192.168.100.130.</context>
    </event>
</notification>
```

Terminating NETCONF sessions

About NETCONF session termination

NETCONF allows one client to terminate the NETCONF sessions of other clients. A client whose session is terminated returns to user view.

Procedure

Copy the following message to the client to terminate a NETCONF session:

```
<rpc message-id="100" xmlns="urn:ietf:params:xml:ns:netconf:base:1.0">
  <kill-session>
    <session-id>
      Specified session-ID
    </session-id>
  </kill-session>
</rpc>
```

If the <kill-session> operation succeeds, the device returns a response in the following format:

```
<?xml version="1.0" encoding="UTF-8"?>
    <rpc-reply message-id="100" xmlns="urn:ietf:params:xml:ns:netconf:base:1.0">
      <ok/>
</rpc-reply>
```

Example: Terminating another NETCONF session

Network configuration

The user whose session's ID is 1 terminates the session with session ID 2.

Procedure

Enter XML view.

```
<Sysname> xml
```

Notify the device of the NETCONF capabilities supported on the client.

```
<hello xmlns="urn:ietf:params:xml:ns:netconf:base:1.0">
  <capabilities>
    <capability>
            urn:ietf:params:netconf:base:1.0
    </capability>
  </capabilities>
</hello>
```

Terminate the session with session ID 2.

```
<rpc message-id="100"xmlns="urn:ietf:params:xml:ns:netconf:base:1.0">
  <kill-session>
    <session-id>2</session-id>
  </kill-session>
</rpc>
```

Verifying the configuration

If the client receives the following text, the NETCONF session with session ID 2 has been terminated, and the client with session ID 2 has returned from XML view to user view:

```
<?xml version="1.0" encoding="UTF-8"?>
  <rpc-reply message-id="100" xmlns="urn:ietf:params:xml:ns:netconf:base:1.0">
    <ok/>
</rpc-reply>
```

Returning to the CLI

Restrictions and guidelines

Before returning from XML view to the CLI, you must first complete capability exchange between the device and the client.

Procedure

Copy the following text to the client to return from XML view to the CLI:

```
<rpc message-id="100" xmlns="urn:ietf:params:xml:ns:netconf:base:1.0">
   <close-session/>
</rpc>
```

When the device receives the close-session request, it sends the following response and returns to CLI's user view:

```
<?xml version="1.0" encoding="UTF-8"?>
<rpc-reply message-id="100" xmlns="urn:ietf:params:xml:ns:netconf:base:1.0">
   <ok/>
</rpc-reply>
```

Supported NETCONF operations

This chapter describes NETCONF operations available with Comware 7.

action

Usage guidelines

This operation issues actions for non-default settings, for example, reset action.

XML example

Clear statistics information for all interfaces.

```
<rpc message-id="100" xmlns="urn:ietf:params:xml:ns:netconf:base:1.0">
  <action>
    <top xmlns="http://www.h3c.com/netconf/action:1.0">
      <Ifmgr>
            <ClearAllIfStatistics>
                <Clear>
                </Clear>
        </ClearAllIfStatistics>
      </Ifmgr>
    </top>
  </action>
</rpc>
```

CLI

Usage guidelines

This operation executes CLI commands.

A request message encloses commands in the <CLI> element. A response message encloses the command output in the <CLI> element.

You can use the following elements to execute commands:

- **Execution**—Executes commands in user view.
- **Configuration**—Executes commands in system view. To execute commands in a lower-level view of the system view, use the <Configuration> element to enter the view first.

  To use this element, include the **exec-use-channel** attribute and specify a value for the attribute:

  - **false**—Executes commands without using a channel.
  - **true**—Executes commands by using a temporary channel. The channel is automatically closed after the execution.
  - **persist**—Executes commands by using the persistent channel for the session.

    To use the persistent channel, first perform an <Open-channel> operation to open the persistent channel. If you do not do so, the system will automatically open the persistent channel.

    After using the persistent channel, perform a <Close-channel> operation to close the channel and return to system view. If you do not perform an <Open-channel> operation, the system stays in the view and will execute subsequent commands in the view.

You can also specify the **error-when-rollback** attribute in the <Configuration> element to indicate whether CLI operations are allowed during a configuration error-triggered configuration rollback. This attribute takes effect only if the value of the <error-option> element in <edit-config> operations is set to **rollback-on-error**. It has the following values:

- **true**—Rejects CLI operation requests and returns error messages.
- **false (the default)**—Allows CLI operations.

For CLI operations to be correctly performed, set the value of the **error-when-rollback** attribute to **true**.

A NETCONF session supports only one persistent channel and but supports multiple temporary channels.

NETCONF does not support executing interactive commands.

You cannot execute the **quit** command by using a channel to exit user view.

XML example

Execute the **vlan 3** command in system view without using a channel.

```
<rpc message-id="100" xmlns="urn:ietf:params:xml:ns:netconf:base:1.0">
  <CLI>
     <Configuration exec-use-channel="false" error-when-rollback="true">vlan
3</Configuration>
  </CLI>
</rpc>
```

close-session

Usage guidelines

This operation terminates the current NETCONF session, unlock the configuration, and release the resources (for example, memory) used by the session. After this operation, you exit the XML view.

XML example

Terminate the current NETCONF session.

```
<rpc message-id="100" xmlns="urn:ietf:params:xml:ns:netconf:base:1.0">
<close-session/>
</rpc>
```

edit-config: create

Usage guidelines

This operation creates target configuration items.

To use the **create** attribute in an <edit-config> operation, you must specify the target configuration item.

- If the table supports creating a target configuration item and the item does not exist, the operation creates the item and configures the item.
- If the specified item already exists, a data-exist error message is returned.

XML example

Set the buffer size to 120.

```
<rpc message-id="100" xmlns="urn:ietf:params:xml:ns:netconf:base:1.0"
xmlns:xc="urn:ietf:params:xml:ns:netconf:base:1.0">
  <edit-config>
```

```
    <target>
      <running/>
    </target>
    <config>
      <top xmlns="http://www.h3c.com/netconf/config:1.0">
        <Syslog xmlns="http://www.h3c.com/netconf/config:1.0" xc:operation="create">
           <LogBuffer>
             <BufferSize>120</BufferSize>
          </LogBuffer>
        </Syslog>
      </top>
    </config>
  </edit-config>
</rpc>
```

edit-config: delete

Usage guidelines

This operation deletes the specified configuration.

- If the specified target has only the table index, the operation removes all configuration of the specified target, and the target itself.
- If the specified target has the table index and configuration data, the operation removes the specified configuration data of this target.
- If the specified target does not exist, an error message is returned, showing that the target does not exist.

XML example

The syntax is the same as the edit-config message with the **create** attribute. Change the operation attribute from **create** to **delete**.

edit-config: merge

Usage guidelines

This operation commits target configuration items to the running configuration.

To use the **merge** attribute in an <edit-config> operation, you must specify the target configuration item (on a specific level):

- If the specified item exists, the operation directly updates the setting for the item.
- If the specified item does not exist, the operation creates the item and configures the item.
- If the specified item does not exist and it cannot be created, an error message is returned.

XML example

The XML data format is the same as the edit-config message with the **create** attribute. Change the operation attribute from **create** to **merge**.

edit-config: remove

Usage guidelines

This operation removes the specified configuration.

- If the specified target has only the table index, the operation removes all configuration of the specified target, and the target itself.
- If the specified target has the table index and configuration data, the operation removes the specified configuration data of this target.
- If the specified target does not exist, or the XML message does not specify any targets, a success message is returned.

XML example

The syntax is the same as the edit-config message with the **create** attribute. Change the operation attribute from **create** to **remove**.

edit-config: replace

Usage guidelines

This operation replaces the specified configuration.

- If the specified target exists, the operation replaces the configuration of the target with the configuration carried in the message.
- If the specified target does not exist but is allowed to be created, the operation creates the target and then applies the configuration.
- If the specified target does not exist and is not allowed to be created, the operation is not conducted and an invalid-value error message is returned.

XML example

The syntax is the same as the edit-config message with the **create** attribute. Change the operation attribute from **create** to **replace**.

edit-config: test-option

Usage guidelines

This operation determines whether to commit a configuration item in an <edit-configure> operation. The <test-option> element has one of the following values:

- **test-then-set**—Performs a syntax check, and commits an item if the item passes the check. If the item fails the check, the item is not committed. This is the default test-option value.
- **set**—Commits the item without performing a syntax check.
- **test-only**—Performs only a syntax check. If the item passes the check, a success message is returned. Otherwise, an error message is returned.

XML example

Test the configuration for an interface.

```
<rpc message-id="100" xmlns="urn:ietf:params:xml:ns:netconf:base:1.0">
  <edit-config>
    <target>
      <running/>
    </target>
    <test-option>test-only</test-option>
    <config xmlns:xc="urn:ietf:params:xml:ns:netconf:base:1.0">
      <top xmlns="http://www.h3c.com/netconf/config:1.0">
        <Ifmgr xc:operation="merge">
          <Interfaces>
            <Interface>
```

```
            <IfIndex>262</IfIndex>
            <Description>222</Description>
              <ConfigSpeed>2</ConfigSpeed>
              <ConfigDuplex>1</ConfigDuplex>
             </Interface>
          </Interfaces>
        </Ifmgr>
      </top>
    </config>
  </edit-config>
</rpc>
```

edit-config: default-operation

Usage guidelines

This operation modifies the running configuration of the device by using the default operation method.

NETCONF uses one of the following operation attributes to modify configuration: **merge**, **create**, **delete**, and **replace** If you do not specify an operation attribute for an edit-config message, NETCONF uses the default operation method. Your setting of the value for the <default-operation> element takes effect only once. If you do not specify an operation attribute or the default operation method for an <edit-config> message, **merge** always applies.

The <default-operation> element has the following values:

- **merge**—Default value for the <default-operation> element.
- **replace**—Value used when the operation attribute is not specified and the default operation method is specified as **replace**.
- **none**—Value used when the operation attribute is not specified and the default operation method is specified as **none**. If this value is specified, the <edit-config> operation is used only for schema verification rather than issuing a configuration. If the schema verification is passed, a successful message is returned. Otherwise, an error message is returned.

XML example

Issue an empty operation for schema verification purposes.

```
<rpc message-id="100" xmlns="urn:ietf:params:xml:ns:netconf:base:1.0">
  <edit-config>
    <target>
      <running/>
    </target>
    <default-operation>none</default-operation>
    <config xmlns:xc="urn:ietf:params:xml:ns:netconf:base:1.0">
      <top xmlns="http://www.h3c.com/netconf/config:1.0">
        <Ifmgr>
          <Interfaces>
            <Interface>
              <IfIndex>262</IfIndex>
              <Description>222222</Description>
            </Interface>
          </Interfaces>
        </Ifmgr>
```

```
      </top>
    </config>
  </edit-config>
</rpc>
```

edit-config: error-option

Usage guidelines

This operation determines the action to take in case of a configuration error.

The <error-option> element has the following values:

- **stop-on-error**—Stops the operation and returns an error message. This is the default error-option value.
- **continue-on-error**—Continues the operation and returns an error message.
- **rollback-on-error**—Rolls back the configuration.

XML example

Issue the configuration for two interfaces with the <error-option> element value as **continue-on-error**.

```
<rpc message-id="100" xmlns="urn:ietf:params:xml:ns:netconf:base:1.0">
  <edit-config>
    <target>
      <running/>
    </target>   <error-option>continue-on-error</error-option>
    <config xmlns:xc="urn:ietf:params:xml:ns:netconf:base:1.0">
      <top xmlns="http://www.h3c.com/netconf/config:1.0">
        <Ifmgr xc:operation="merge">
          <Interfaces>
            <Interface>
              <IfIndex>262</IfIndex>
              <Description>222</Description>
                <ConfigSpeed>1024</ConfigSpeed>
                <ConfigDuplex>1</ConfigDuplex>
            </Interface>
            <Interface>
              <IfIndex>263</IfIndex>
              <Description>333</Description>
                <ConfigSpeed>1024</ConfigSpeed>
                <ConfigDuplex>1</ConfigDuplex>
            </Interface>
          </Interfaces>
        </Ifmgr>
      </top>
    </config>
  </edit-config>
</rpc>
```

edit-config: incremental

Usage guidelines

This operation adds configuration data to a column without affecting the original data.

The **incremental** attribute applies to a list column such as the vlan permitlist column.

You can use the **incremental** attribute for <edit-config> operations except the <replace> operation.

Support for the **incremental** attribute varies by module. For more information, see NETCONF XML API documents.

XML example

Add VLANs 1 through 10 to an untagged VLAN list that has untagged VLANs 12 through 15.

```
<rpc message-id="100" xmlns="urn:ietf:params:xml:ns:netconf:base:1.0"
xmlns:h3c="http://www.h3c.com/netconf/base:1.0">
  <edit-config>
    <target>
      <running/>
    </target>
    <config xmlns:xc="urn:ietf:params:xml:ns:netconf:base:1.0">
      <top xmlns="http://www.h3c.com/netconf/config:1.0">
        <VLAN xc:operation="merge">
          <HybridInterfaces>
            <Interface>
              <IfIndex>262</IfIndex>
              <UntaggedVlanList  h3c: incremental="true">1-10</UntaggedVlanList>
               </Interface>
          </HybridInterfaces>
        </VLAN>
      </top>
    </config>
  </edit-config>
</rpc>
```

get

Usage guidelines

This operation retrieves device configuration and state information.

XML example

Retrieve device configuration and state information for the Syslog module.

```
<rpc message-id="100" xmlns="urn:ietf:params:xml:ns:netconf:base:1.0"
xmlns:xc="http://www.h3c.com/netconf/base:1.0">
  <get>
    <filter type="subtree">
      <top xmlns="http://www.h3c.com/netconf/data:1.0">
        <Syslog>
        </Syslog>
      </top>
    </filter>
```

```
  </get>
</rpc>
```

get-bulk

Usage guidelines

This operation retrieves a number of data entries (including device configuration and state information) starting from the data entry next to the one with the specified index.

XML example

Retrieve device configuration and state information for all interfaces.

```
<rpc message-id="100" xmlns="urn:ietf:params:xml:ns:netconf:base:1.0">
  <get-bulk>
    <filter type="subtree">
      <top xmlns="http://www.h3c.com/netconf/data:1.0">
        <Ifmgr>
          <Interfaces xc:count="5" xmlns:xc="http://www.h3c.com/netconf/base:1.0">
            <Interface/>
          </Interfaces>
        </Ifmgr>
      </top>
    </filter>
  </get-bulk>
</rpc>
```

get-bulk-config

Usage guidelines

This operation retrieves a number of non-default configuration data entries starting from the data entry next to the one with the specified index.

XML example

Retrieve non-default configuration for all interfaces.

```
<rpc message-id="100" xmlns="urn:ietf:params:xml:ns:netconf:base:1.0">
  <get-bulk-config>
    <source>
      <running/>
    </source>
    <filter type="subtree">
      <top xmlns="http://www.h3c.com/netconf/config:1.0">
        <Ifmgr>
        </Ifmgr>
      </top>
    </filter>
  </get-bulk-config>
</rpc>
```

get-config

Usage guidelines

This operation retrieves non-default configuration data. If no non-default configuration data exists, the device returns a response with empty data.

XML example

Retrieve non-default configuration data for the interface table.

```
<rpc message-id="100" xmlns="urn:ietf:params:xml:ns:netconf:base:1.0"
xmlns:xc="http://www.h3c.com/netconf/base:1.0">
  <get-config>
    <source>
      <running/>
    </source>
    <filter type="subtree">
      <top xmlns="http://www.h3c.com/netconf/config:1.0">
        <Ifmgr>
           <Interfaces>
              <Interface/>
            </Interfaces>
        </Ifmgr>
      </top>
    </filter>
  </get-config>
</rpc>
```

get-sessions

Usage guidelines

This operation retrieves information about all NETCONF sessions in the system. You cannot specify a session ID to retrieve information about a specific NETCONF session.

XML example

Retrieve information about all NETCONF sessions in the system.

```
<rpc message-id="100" xmlns="urn:ietf:params:xml:ns:netconf:base:1.0">
<get-sessions/>
</rpc>
```

kill-session

Usage guidelines

This operation terminates the NETCONF session for another user. This operation cannot terminate the NETCONF session for the current user.

XML example

Terminate the NETCONF session with session ID 1.

```
<rpc message-id="100" xmlns="urn:ietf:params:xml:ns:netconf:base:1.0">
  <kill-session>
    <session-id>1</session-id>
```

```
  </kill-session>
</rpc>
```

load

Usage guidelines

This operation loads the configuration. After the device finishes a <load> operation, the configuration in the specified file is merged into the running configuration of the device.

XML example

Merge the configuration in file **a1.cfg** to the running configuration of the device.

```
<rpc message-id="100" xmlns="urn:ietf:params:xml:ns:netconf:base:1.0">
  <load>
    <file>a1.cfg</file>
  </load>
</rpc>
```

lock

Usage guidelines

This operation locks the configuration. After the configuration is locked, you cannot perform <edit-config> operations. Other operations are allowed.

After a user locks the configuration, other users cannot use NETCONF or any other configuration methods such as CLI and SNMP to configure the device.

XML example

Lock the configuration.

```
<rpc message-id="100" xmlns="urn:ietf:params:xml:ns:netconf:base:1.0">
 <lock>
    <target>
        <running/>
    </target>
</lock>
</rpc>
```

rollback

Usage guidelines

This operation rolls back the configuration. To do so, you must specify the configuration file in the <file> element. After the device finishes the <rollback> operation, the current device configuration is totally replaced with the configuration in the specified configuration file.

XML example

Roll back the running configuration to the configuration in file **1A.cfg**.

```
<rpc message-id="100" xmlns="urn:ietf:params:xml:ns:netconf:base:1.0">
  <rollback>
    <file>1A.cfg</file>
  </rollback>
</rpc>
```

save

Usage guidelines

This operation saves the running configuration. You can use the <file> element to specify a file for saving the configuration. If the text does not include the file column, the running configuration is automatically saved to the main next-startup configuration file.

The **OverWrite** attribute determines whether the running configuration overwrites the original configuration file when the specified file already exists.

The **Binary-only** attribute determines whether to save the running configuration only to the binary configuration file.

XML example

Save the running configuration to file **test.cfg**.

```
<rpc message-id="100" xmlns="urn:ietf:params:xml:ns:netconf:base:1.0">
  <save OverWrite="false" Binary-only="true">
    <file>test.cfg</file>
  </save>
</rpc>
```

unlock

Usage guidelines

This operation unlocks the configuration, so other users can configure the device.

Terminating a NETCONF session automatically unlocks the configuration.

XML example

Unlock the configuration.

```
<rpc message-id="100" xmlns="urn:ietf:params:xml:ns:netconf:base:1.0">
<unlock>
    <target>
        <running/>
    </target>
</unlock>
</rpc>
```

Contents

Configuring CWMP

About CWMP

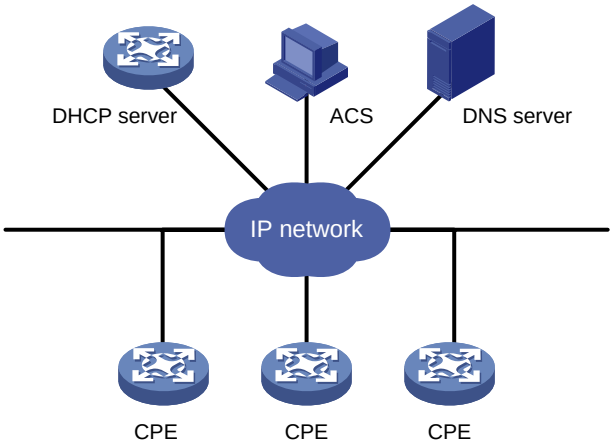
CPE WAN Management Protocol (CWMP), also called "TR-069," is a DSL Forum technical specification for remote management of network devices.

The protocol was initially designed to provide remote autoconfiguration through a server for large numbers of dispersed end-user devices in a network. CWMP can be used on different types of networks, including Ethernet.

CWMP network framework

Figure 1 shows a basic CWMP network framework.

Figure 1 CWMP network framework



A basic CWMP network includes the following network elements:

- **ACS**—Autoconfiguration server, the management device in the network.
- **CPE**—Customer premises equipment, the managed device in the network.
- **DNS server**—Domain name system server. CWMP defines that the ACS and the CPE use URLs to identify and access each other. DNS is used to resolve the URLs.
- **DHCP server**—Assigns ACS attributes along with IP addresses to CPEs when the CPEs are powered on. DHCP server is optional in CWMP. With a DHCP server, you do not need to configure ACS attributes manually on each CPE. The CPEs can contact the ACS automatically when they are powered on for the first time.

The device is operating as a CPE in the CWMP framework.

Basic CWMP functions

You can autoconfigure and upgrade CPEs in bulk from the ACS.

Autoconfiguration

You can create configuration files for different categories of CPEs on the ACS. Based on the device models and serial numbers of the CPEs, the ACS verifies the categories of the CPEs and issues the associated configuration to them.

The following are methods available for the ACS to issue configuration to the CPE:

- Transfers the configuration file to the CPE, and specifies the file as the next-startup configuration file. At a reboot, the CPE starts up with the ACS-specified configuration file.
- Runs the configuration in the CPE's RAM. The configuration takes effect immediately on the CPE. For the running configuration to survive a reboot, you must save the configuration on the CPE.

CPE software management

The ACS can manage CPE software upgrade.

When the ACS finds a software version update, the ACS notifies the CPE to download the software image file from a specific location. The location can be the URL of the ACS or an independent file server.

If the CPE successfully downloads the software image file and the file is validated, the CPE notifies the ACS of a successful download. If the CPE fails to download the software image file or the file is invalidated, the CPE notifies the ACS of an unsuccessful download.

Data backup

The ACS can require the CPE to upload a configuration file or log file to a specific location. The destination location can be the ACS or a file server.

CPE status and performance monitoring

The ACS can monitor the status and performance of CPEs. Table 1 shows the available CPE status and performance objects for the ACS to monitor.

Table 1 CPE status and performance objects available for the ACS to monitor

Category	Objects	Remarks
Device information	Manufacturer ManufacturerOUI SerialNumber HardwareVersion SoftwareVersion	N/A
Operating status and information	DeviceStatus UpTime	N/A
Configuration file	ConfigFile	Local configuration file stored on CPE for upgrade. The ACS can issue configuration to the CPE by transferring a configuration file to the CPE or running the configuration in CPE's RAM.
CWMP settings	ACS URL	URL address of the ACS to which the CPE initiates a CWMP connection. This object is also used for main/backup ACS switchover.
	ACS username ACS password	When the username and password of the ACS are changed, the ACS changes the ACS username and password on the CPE to the new username and password. When a main/backup ACS switchover occurs, the main ACS also changes the ACS username and password to the backup ACS username and password.
	PeriodicInformEnable	Whether to enable or disable the periodic Inform feature.
	PeriodicInformInterval	Interval for periodic connection from the CPE

Category	Objects	Remarks
		to the ACS for configuration and software update.
	PeriodicInformTime	Scheduled time for connection from the CPE to the ACS for configuration and software update.
	ConnectionRequestURL (CPE URL)	N/A
	ConnectionRequestUsername (CPE username) ConnectionRequestPassword (CPE password)	CPE username and password for authentication from the ACS to the CPE.

How CWMP works

RPC methods

CWMP uses remote procedure call (RPC) methods for bidirectional communication between CPE and ACS. The RPC methods are encapsulated in HTTP or HTTPS.

Table 2 shows the primary RPC methods used in CWMP.

Table 2 RPC methods

RPC method	Description
Get	The ACS obtains the values of parameters on the CPE.
Set	The ACS modifies the values of parameters on the CPE.
Inform	The CPE sends an Inform message to the ACS for the following purposes: • Initiates a connection to the ACS. • Reports configuration changes to the ACS. • Periodically updates CPE settings to the ACS.
Download	The ACS requires the CPE to download a configuration or software image file from a specific URL for software or configuration update.
Upload	The ACS requires the CPE to upload a file to a specific URL.
Reboot	The ACS reboots the CPE remotely for the CPE to complete an upgrade or recover from an error condition.

Autoconnect between ACS and CPE

The CPE automatically initiates a connection to the ACS when one of the following events occurs:

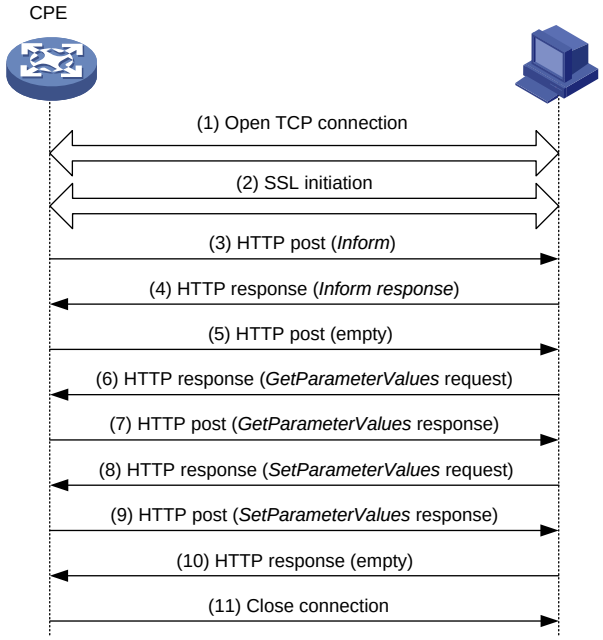
- ACS URL change. The CPE initiates a connection request to the new ACS URL.
- CPE startup. The CPE initiates a connection to the ACS after the startup.
- Timeout of the periodic Inform interval. The CPE re-initiates a connection to the ACS at the Inform interval.
- Expiration of the scheduled connection initiation time. The CPE initiates a connection to the ACS at the scheduled time.

CWMP connection establishment

Step 1 through step 5 in Figure 2 show the procedure of establishing a connection between the CPE and the ACS.

1. After obtaining the basic ACS parameters, the CPE initiates a TCP connection to the ACS.
2. If HTTPS is used, the CPE and the ACS initialize SSL for a secure HTTP connection.
3. The CPE sends an Inform message in HTTPS to initiate a CWMP session.
4. After the CPE passes authentication, the ACS returns an Inform response to establish the session.
5. After sending all requests, the CPE sends an empty HTTP post message.

Figure 2 CWMP connection establishment

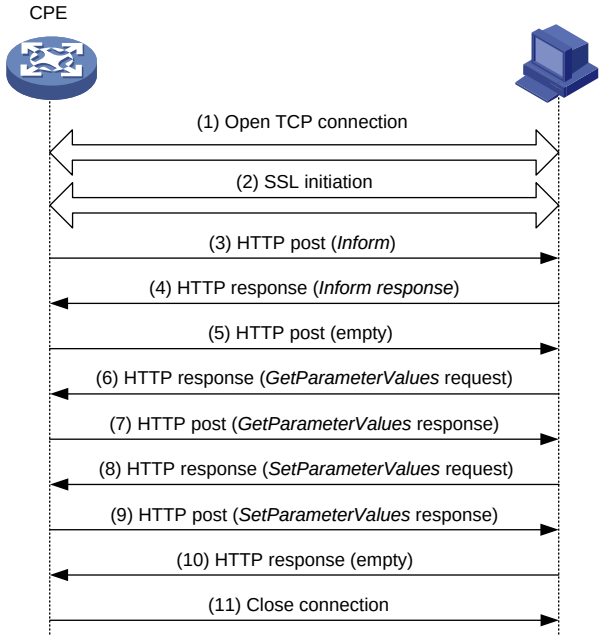


Main/backup ACS switchover

Typically, two ACSs are used in a CWMP network for consecutive monitoring on CPEs. When the main ACS needs to reboot, it points the CPE to the backup ACS. Step 6 through step 11 in Figure 3 show the procedure of a main/backup ACS switchover.

1. Before the main ACS reboots, it queries the ACS URL set on the CPE.
2. The CPE replies with its ACS URL setting.
3. The main ACS sends a Set request to change the ACS URL on the CPE to the backup ACS URL.
4. After the ACS URL is modified, the CPE sends a response.
5. The main ACS sends an empty HTTP message to notify the CPE that it has no other requests.
6. The CPE closes the connection, and then initiates a new connection to the backup ACS URL.

Figure 3 Main and backup ACS switchover



Restrictions and guidelines: CWMP configuration

You can configure ACS and CPE attributes from the CPE's CLI, the DHCP server, or the ACS. For an attribute, the CLI- and ACS-assigned values have higher priority than the DHCP-assigned value. The CLI- and ACS-assigned values overwrite each other, whichever is assigned later.

This document only describes configuring ACS and CPE attributes from the CLI and DHCP server. For more information about configuring and using the ACS, see ACS documentation.

CWMP tasks at a glance

To configure CWMP, perform the following tasks:

1. Enabling CWMP from the CLI

   You can also enable CWMP from a DHCP server.
2. Configuring ACS attributes
   a. Configuring the preferred ACS attributes
   b. (Optional.) Configuring the default ACS attributes from the CLI
3. Configuring CPE attributes
   a. Specifying an SSL client policy for HTTPS connection to ACS

      This task is required when the ACS uses HTTPS for secure access.
   b. (Optional.) Configuring ACS authentication parameters
   c. (Optional.) Configuring the provision code
   d. (Optional.) Configuring the CWMP connection interface
   e. (Optional.) Configuring autoconnect parameters
   f. (Optional.) Setting the close-wait timer
   g. (Optional.) Enabling NAT traversal for the CPE

Enabling CWMP from the CLI

1. Enter system view.
   system-view
2. Enter CWMP view.
   cwmp
3. Enable CWMP.
   cwmp enable
   By default, CWMP is disabled.

Configuring ACS attributes

About ACS attributes

You can configure two sets of ACS attributes for the CPE: preferred and default.

- The preferred ACS attributes are configurable from the CPE's CLI, the DHCP server, and ACS.
- The default ACS attributes are configurable only from the CLI.

If the preferred ACS attributes are not configured, the CPE uses the default ACS attributes for connection establishment.

Configuring the preferred ACS attributes

Assigning ACS attributes from the DHCP server

The DHCP server in a CWMP network assigns the following information to CPEs:

- IP addresses for the CPEs.
- DNS server address.
- ACS URL and ACS login authentication information.

This section introduces how to use DHCP option 43 to assign the ACS URL and ACS login authentication username and password. For more information about DHCP and DNS, see *Layer 3—IP Services Configuration Guide*.

If the DHCP server is an H3C device, you can configure DHCP option 43 by using the **option 43 hex 01***length URL username password* command.

- *length*—A hexadecimal number that indicates the total length of the *length*, *URL*, *username*, and *password* arguments, including the spaces between these arguments. No space is allowed between the **01** keyword and the length value.
- *URL*—ACS URL.
- *username*—Username for the CPE to authenticate to the ACS.
- *password*—Password for the CPE to authenticate to the ACS.

NOTE:

The ACS URL, username and password must use the hexadecimal format and be space separated.

The following example configures the ACS address as **http://169.254.76.31:7547/acs**, username as **1234**, and password as **5678**:

```
<Sysname> system-view
```

```
[Sysname] dhcp server ip-pool 0
[Sysname-dhcp-pool-0] option 43 hex
0127687474703A2F2F3136392E3235342E37362E33313A373534372F6163732031323334203536738
```

Table 3 Hexadecimal forms of the ACS attributes

Attribute	Attribute value	Hexadecimal form
Length	39 characters	27
ACS URL	http://169.254.76.31:7547/acs	687474703A2F2F3136392E3235342E37362E33313A373534372F61637320 **NOTE:** The two ending digits (20) represent the space.
ACS connect username	1234	3132333420 **NOTE:** The two ending digits (20) represent the space.
ACS connect password	5678	35363738

Configuring the preferred ACS attributes from the CLI

1. Enter system view.
   system-view
2. Enter CWMP view.
   cwmp
3. Configure the preferred ACS URL.
   cwmp acs url *url*
   By default, no preferred ACS URL has been configured.
4. Configure the username for authentication to the preferred ACS URL.
   cwmp acs username *username*
   By default, no username has been configured for authentication to the preferred ACS URL.
5. (Optional.) Configure the password for authentication to the preferred ACS URL.
   cwmp acs password { **cipher** | **simple** } *string*
   By default, no password has been configured for authentication to the preferred ACS URL.

Configuring the default ACS attributes from the CLI

1. Enter system view.
   system-view
2. Enter CWMP view.
   cwmp
3. Configure the default ACS URL.
   cwmp acs default url *url*
   By default, no default ACS URL has been configured.
4. Configure the username for authentication to the default ACS URL.
   cwmp acs default username *username*
   By default, no username has been configured for authentication to the default ACS URL.
5. (Optional.) Configure the password for authentication to the default ACS URL.

cwmp acs default password { **cipher** | **simple** } *string*

By default, no password has been configured for authentication to the default ACS URL.

Configuring CPE attributes

About CPE attributes

You can configure the following CPE attributes only from the CPE's CLI.

- CWMP connection interface.
- NAT traversal.
- Maximum number of connection retries.
- SSL client policy for HTTPS connection to ACS.

For other CPE attribute values, you can assign them to the CPE from the CPE's CLI or the ACS. The CLI- and ACS-assigned values overwrite each other, whichever is assigned later.

Specifying an SSL client policy for HTTPS connection to ACS

About specifying an SSL client policy for HTTPS connection to ACS

This task is required when the ACS uses HTTPS for secure access. CWMP uses HTTP or HTTPS for data transmission. When HTTPS is used, the ACS URL begins with **https://**. You must specify an SSL client policy for the CPE to authenticate the ACS for HTTPS connection establishment.

Prerequisites

Before you perform this task, first create an SSL client policy. For more information about configuring SSL client policies, see *Security Configuration Guide*.

Procedure

1. Enter system view.

   system-view
2. Enter CWMP view.

   cwmp
3. Specify an SSL client policy.

   ssl client-policy *policy-name*

   By default, no SSL client policy is specified.

Configuring ACS authentication parameters

About ACS authentication parameters

To protect the CPE against unauthorized access, configure a CPE username and password for ACS authentication. When an ACS initiates a connection to the CPE, the ACS must provide the correct username and password.

Procedure

1. Enter system view.

   system-view
2. Enter CWMP view.

   cwmp

3. Configure the username for authentication to the CPE.

   cwmp cpe username *username*

   By default, no username has been configured for authentication to the CPE.

4. (Optional.) Configure the password for authentication to the CPE.

   cwmp cpe password { **cipher** | **simple** } *string*

   By default, no password has been configured for authentication to the CPE.

   The password setting is optional. You can specify only a username for authentication.

Configuring the provision code

About the provision code

The ACS can use the provision code to identify services assigned to each CPE. For correct configuration deployment, make sure the same provision code is configured on the CPE and the ACS. For information about the support of your ACS for provision codes, see the ACS documentation.

Procedure

1. Enter system view.

   system-view

2. Enter CWMP view.

   cwmp

3. Configure the provision code.

   cwmp cpe provision-code *provision-code*

   The default provision code is **PROVISIONINGCODE**.

Configuring the CWMP connection interface

About CWMP connection interface configuration

The CWMP connection interface is the interface that the CPE uses to communicate with the ACS. To establish a CWMP connection, the CPE sends the IP address of this interface in the Inform messages, and the ACS replies to this IP address.

Typically, the CPE selects the CWMP connection interface automatically. If the CWMP connection interface is not the interface that connects the CPE to the ACS, the CPE fails to establish a CWMP connection with the ACS. In this case, you need to manually set the CWMP connection interface.

Procedure

1. Enter system view.

   system-view

2. Enter CWMP view.

   cwmp

3. Specify the interface that connects to the ACS as the CWMP connection interface.

   cwmp cpe connect interface *interface-type interface-number*

   By default, no CWMP connection interface is specified.

Configuring autoconnect parameters

About autoconnect parameters

You can configure the CPE to connect to the ACS periodically, or at a scheduled time for configuration or software update.

The CPE retries a connection automatically when one of the following events occurs:

- The CPE fails to connect to the ACS. The CPE considers a connection attempt as having failed when the close-wait timer expires. This timer starts when the CPE sends an Inform request. If the CPE fails to receive a response before the timer expires, the CPE resends the Inform request.
- The connection is disconnected before the session on the connection is completed.

To protect system resources, limit the number of retries that the CPE can make to connect to the ACS.

Configuring the periodic Inform feature

1. Enter system view.
   `system-view`
2. Enter CWMP view.
   `cwmp`
3. Enable the periodic Inform feature.
   `cwmp cpe inform interval enable`
   By default, this function is disabled.
4. Set the Inform interval.
   `cwmp cpe inform interval` *`interval`*
   By default, the CPE sends an Inform message to start a session every 600 seconds.

Scheduling a connection initiation

1. Enter system view.
   `system-view`
2. Enter CWMP view.
   `cwmp`
3. Schedule a connection initiation.
   `cwmp cpe inform time` *`time`*
   By default, no connection initiation has been scheduled.

Setting the maximum number of connection retries

1. Enter system view.
   `system-view`
2. Enter CWMP view.
   `cwmp`
3. Set the maximum number of connection retries.
   `cwmp cpe connect retry` *`retries`*
   By default, the CPE retries a failed connection until the connection is established.

Setting the close-wait timer

About the close-wait timer

The close-wait timer specifies the following:

- The maximum amount of time the CPE waits for the response to a session request. The CPE determines that its session attempt has failed when the timer expires.
- The amount of time the connection to the ACS can be idle before it is terminated. The CPE terminates the connection to the ACS if no traffic is sent or received before the timer expires.

Procedure

1. Enter system view.
   `system-view`
2. Enter CWMP view.
   `cwmp`
3. Set the close-wait timer.
   `cwmp cpe wait timeout` *`seconds`*
   By default, the close-wait timer is 30 seconds.

Enabling NAT traversal for the CPE

About NAT traversal

For the connection request initiated from the ACS to reach the CPE, you must enable NAT traversal on the CPE when a NAT gateway resides between the CPE and the ACS.

The NAT traversal feature complies with RFC 3489 Simple Traversal of UDP Through NATs (STUN). The feature enables the CPE to discover the NAT gateway, and obtain an open NAT binding (a public IP address and port binding) through which the ACS can send unsolicited packets. The CPE sends the binding to the ACS when it initiates a connection to the ACS. For the connection requests sent by the ACS at any time to reach the CPE, the CPE maintains the open NAT binding. For more information about NAT, see *Layer 3—IP Services Configuration Guide*.

Procedure

1. Enter system view.
   `system-view`
2. Enter CWMP view.
   `cwmp`
3. Enable NAT traversal.
   `cwmp cpe stun enable`
   By default, NAT traversal is disabled on the CPE.

Display and maintenance commands for CWMP

Execute **`display`** commands in any view.

Task	Command
Display CWMP configuration.	**`display cwmp configuration`**
Display the current status of CWMP.	**`display cwmp status`**

CWMP configuration examples

Example: Configuring CWMP

Network configuration

As shown in Figure 4, use H3C IMC BIMS as the ACS to bulk-configure the devices (CPEs), and assign ACS attributes to the CPEs from the DHCP server.

The configuration files for the CPEs in equipment rooms A and B are **configure1.cfg** and **configure2.cfg**, respectively.

Figure 4 Network diagram

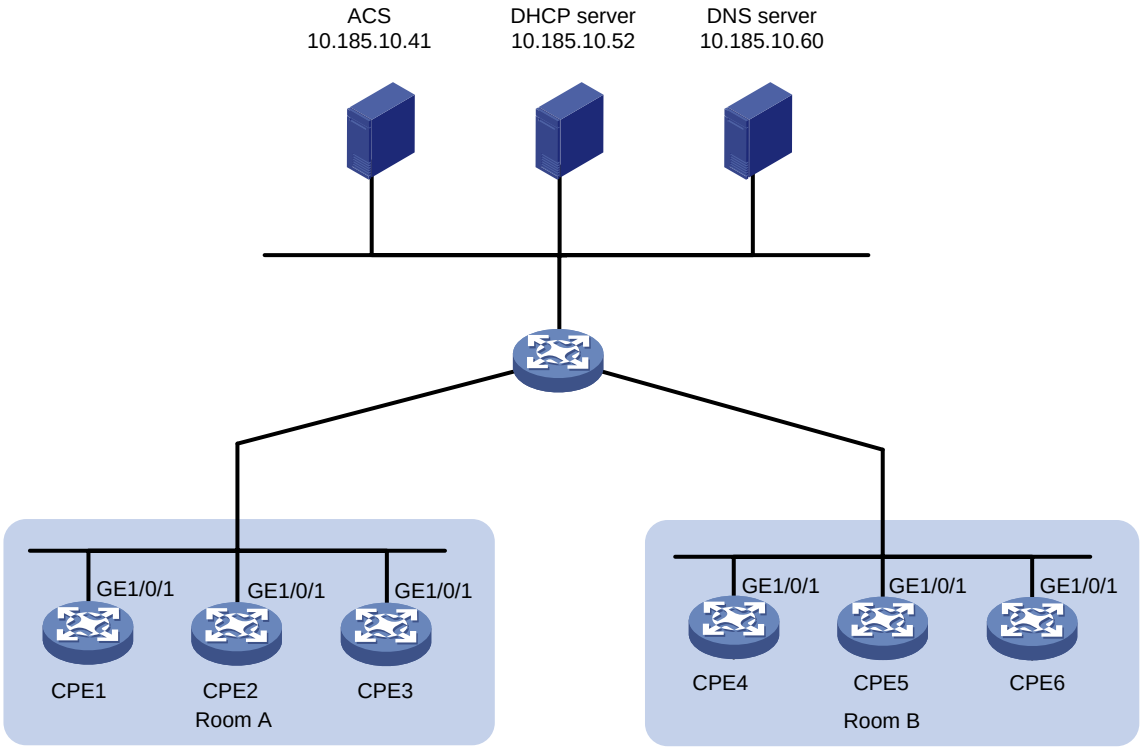


Table 4 shows the ACS attributes for the CPEs to connect to the ACS.

Table 4 ACS attributes

Item	Setting
Preferred ACS URL	http://10.185.10.41:9090
ACS username	admin
ACS password	12345

Table 5 lists serial numbers of the CPEs.

Table 5 CPE list

Room	Device	Serial number
A	CPE 1	210231A95YH10C000045
	CPE 2	210235AOLNH12000010

Room	Device	Serial number
	CPE 3	210235AOLNH12000015
B	CPE 4	210235AOLNH12000017
	CPE 5	210235AOLNH12000020
	CPE 6	210235AOLNH12000022

Configuring the ACS

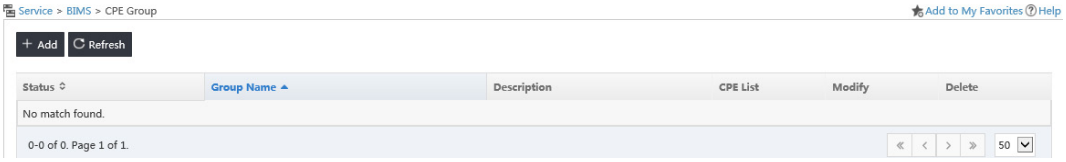
Figures in this section are for illustration only.

To configure the ACS:

1. Log in to the ACS:
   a. Launch a Web browser on the ACS configuration terminal.
   b. In the address bar of the Web browser, enter the ACS URL and port number. This example uses **http://10.185.10.41:8080/imc**.
   c. On the login page, enter the ACS login username and password, and then click **Login**.
2. Create a CPE group for each equipment room:
   a. Select **Service** > **BIMS** > **CPE Group** from the top navigation bar.

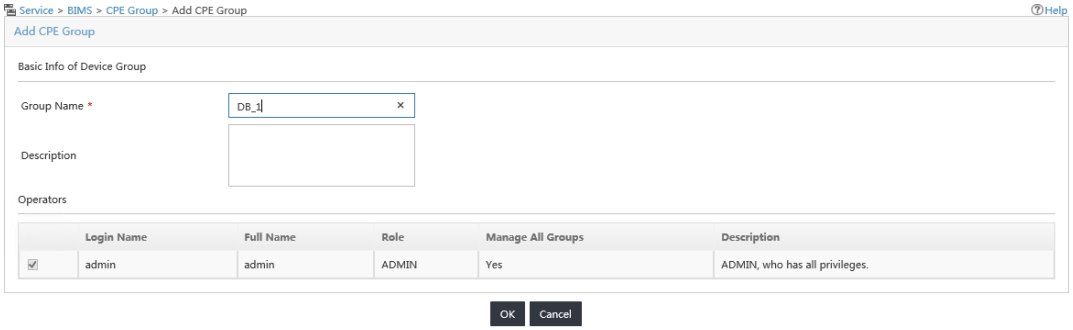
      The **CPE Group** page appears.

      Figure 5 CPE Group page

   b. Click **Add**.
   c. Enter a username, and then click **OK**.

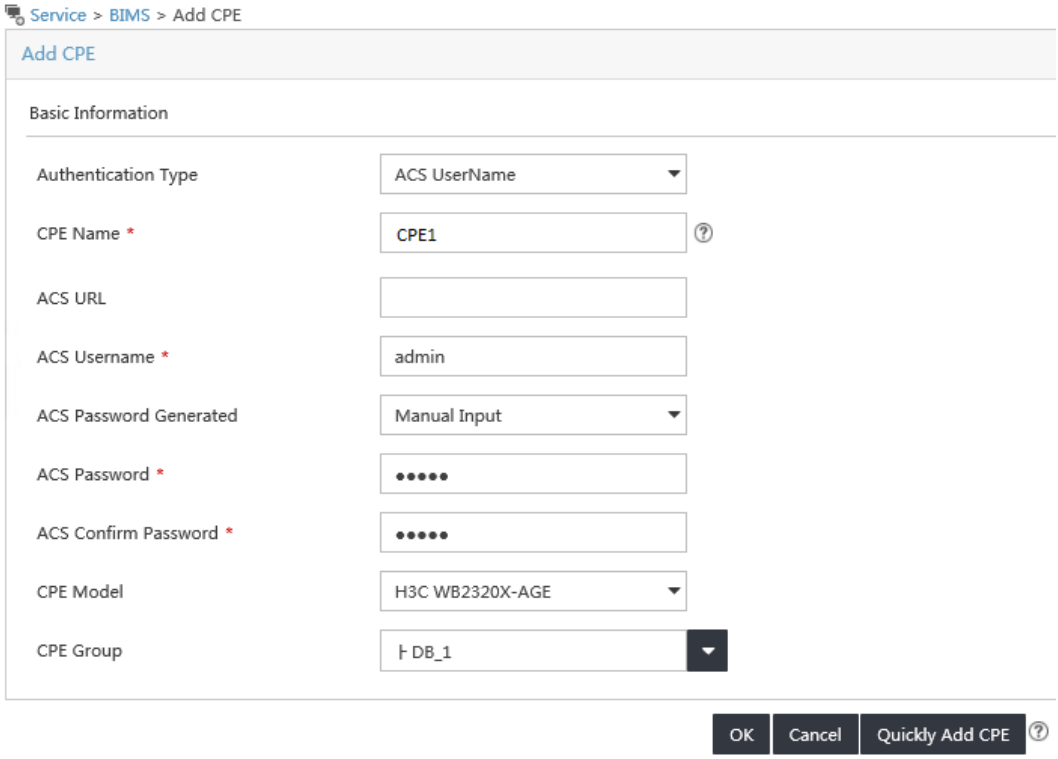
      Figure 6 Adding a CPE group

   d. Repeat the previous two steps to create a CPE group for CPEs in Room B.
3. Add CPEs to the CPE group for each equipment room:
   a. Select **Service** > **BIMS** > **Resource Management** > **Add CPE** from the top navigation bar.
   b. On the **Add CPE** page, configure the following parameters:
      - **Authentication Type**—Select **ACS UserName**.
      - **CPE Name**—Enter a CPE name.
      - **ACS Username**—Enter **admin**.
      - **ACS Password Generated**—Select **Manual Input**.

- **ACS Password**—Enter a password for ACS authentication.
- **ACS Confirm Password**—Re-enter the password.
- **CPE Model**—Select the CPE model.
- **CPE Group**—Select the CPE group.

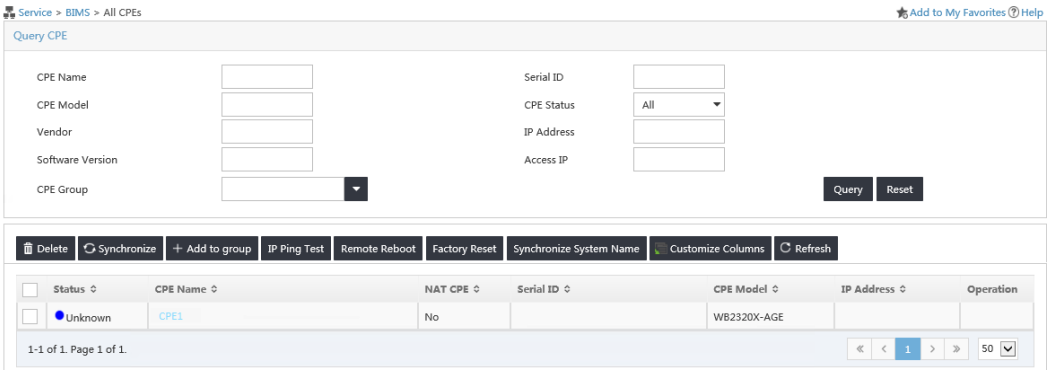
Figure 7 Adding a CPE



c. Click **OK**.

d. Verify that the CPE has been added successfully from the **All CPEs** page.

Figure 8 Viewing CPEs

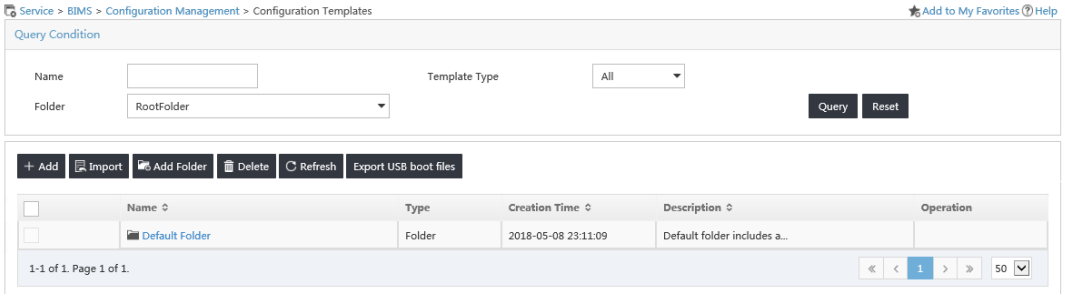


e. Repeat the previous steps to add CPE 2 and CPE 3 to the CPE group for Room A, and add CPEs in Room B to the CPE group for Room B.

4. Configure a configuration template for each equipment room:

a. Select **Service** > **BIMS** > **Configuration Management** > **Configuration Templates** from the top navigation bar.

Figure 9 Configuration Templates page



b. Click **Import**.

c. Select a source configuration file, select **Configuration Segment** as the template type, and then click **OK**.

The created configuration template will be displayed in the **Configuration Template** list after a successful file import.

IMPORTANT:

If the first command in the configuration template file is **`system-view`**, make sure no characters exist in front of the command.

Figure 10 Importing a configuration template

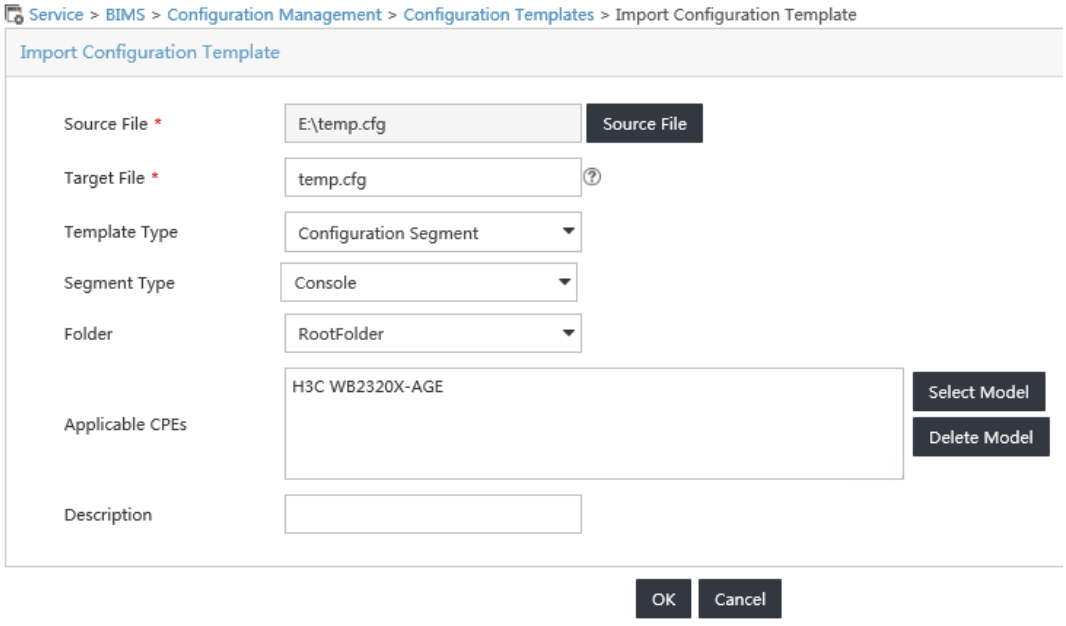
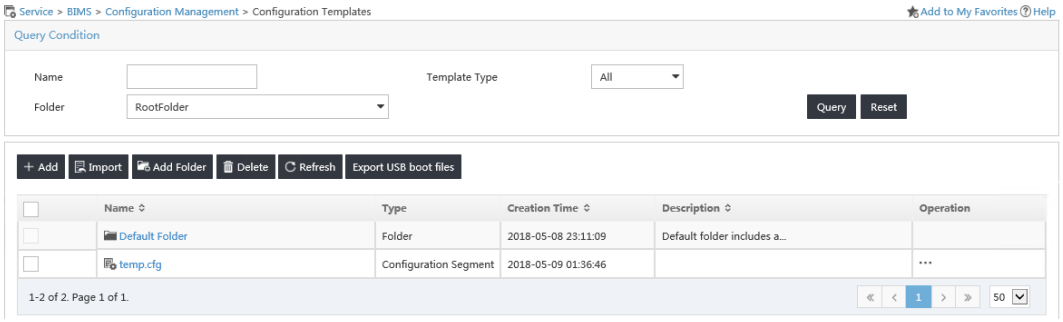


Figure 11 Configuration Template list

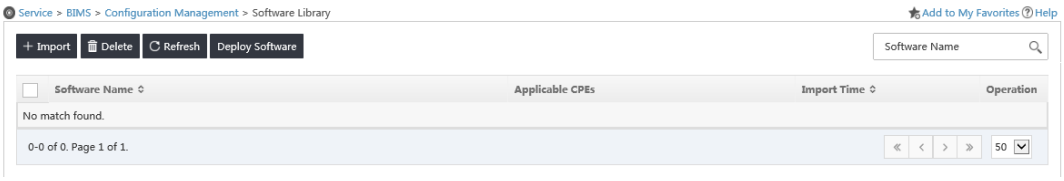


d. Repeat the previous steps to configure a configuration template for Room B.

5. Add software library entries:

a. Select **Service** > **BIMS** > **Configuration Management** > **Software Library** from the top navigation bar.

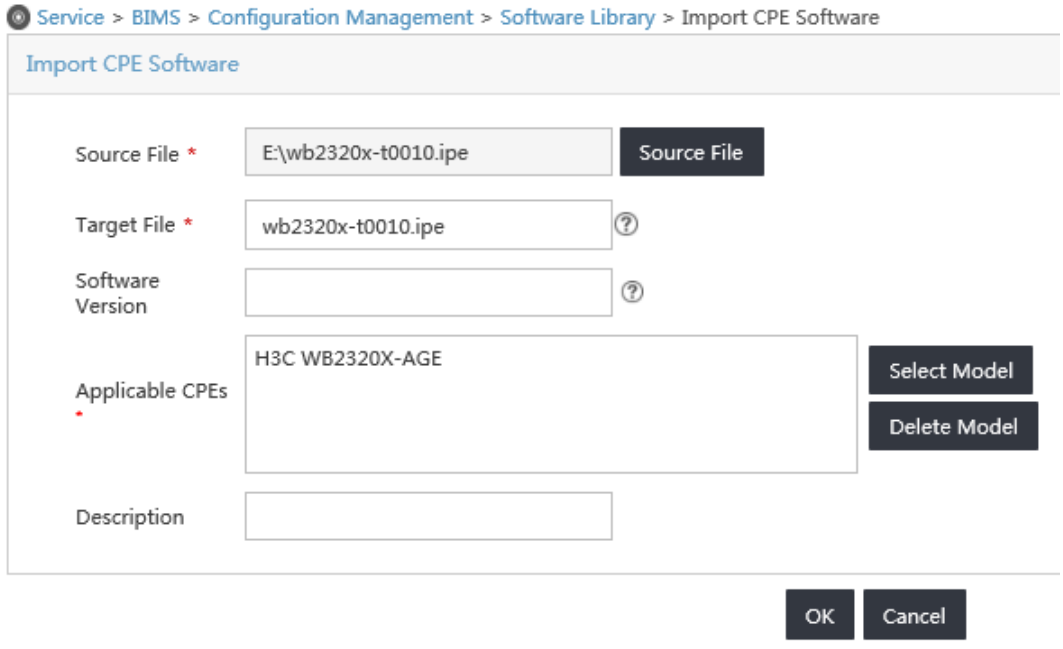
Figure 12 Software Library page



b. Click **Import**.

c. Select a source file, and then click **OK**.

Figure 13 Importing CPE software

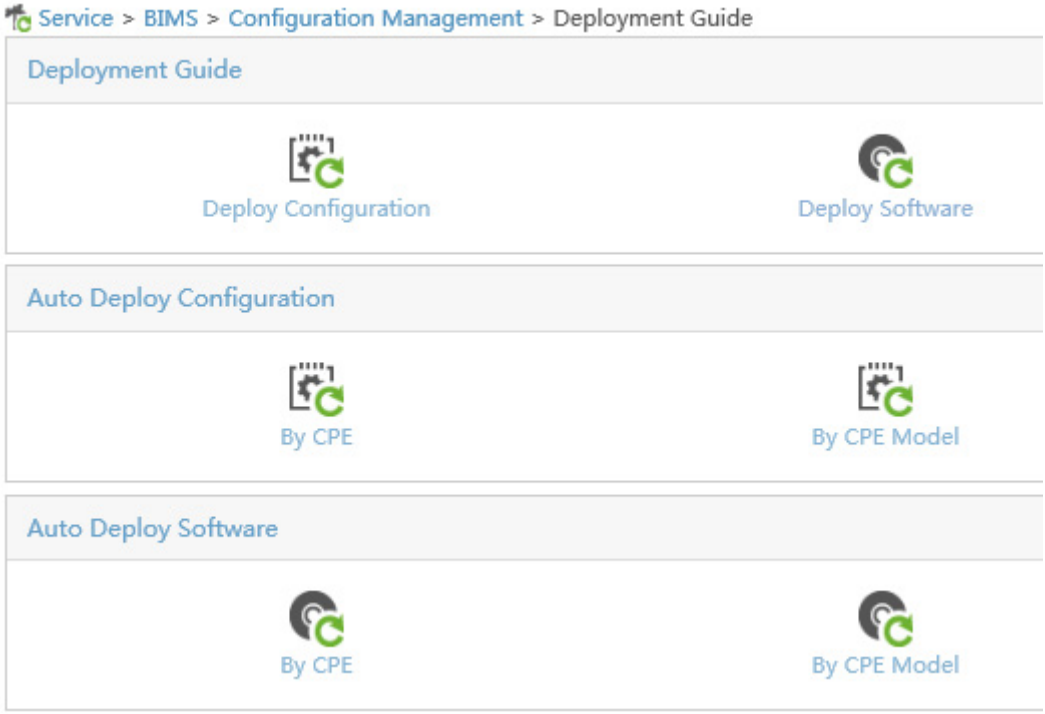


d. Repeat the previous steps to add software library entries for CPEs of different models.

6. Create an auto-deployment task for each equipment room:

a. Select **Service** > **BIMS** > **Configuration Management** > **Deployment Guide** from the top navigation bar.

Figure 14 Deployment Guide

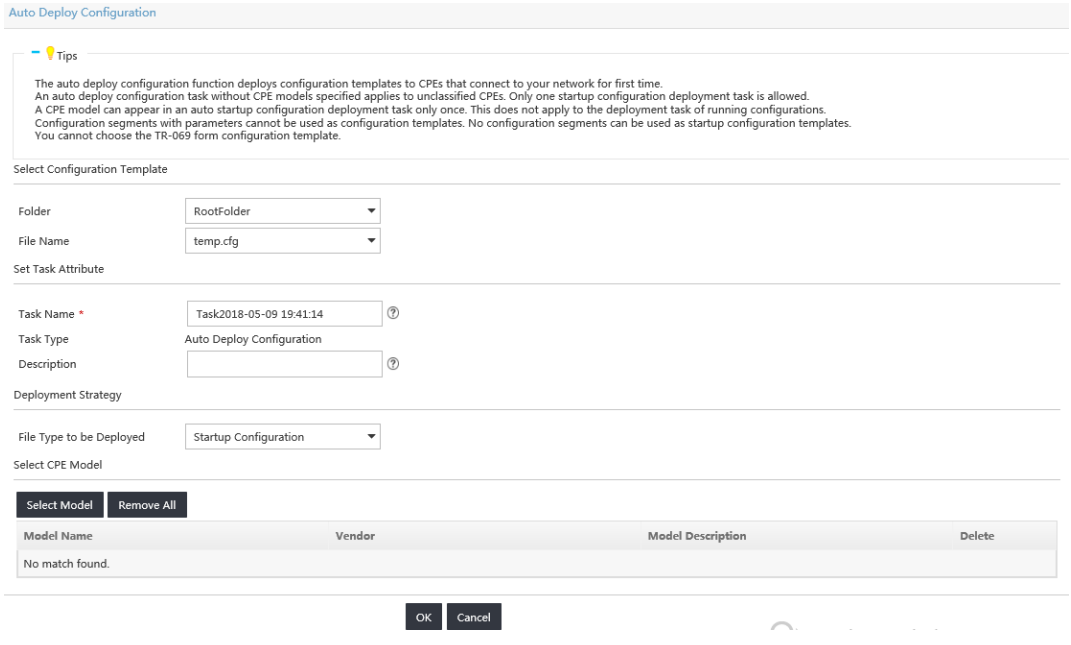


b. Click **By CPE Model** from the **Auto Deployment Configuration** field.

c. Select a configuration template, select **Startup Configuration** from the **File Type to be Deployed** list, and click **Select Model** to select CPEs in Room A. Then, click **OK**.

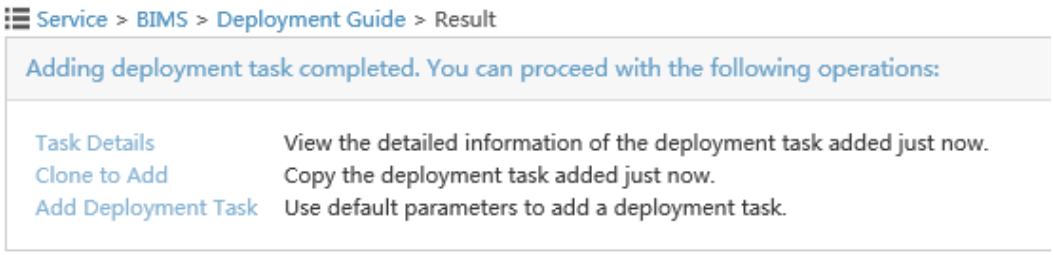
You can search for CPEs by CPE group.

Figure 15 Auto deployment configuration



d. Click **OK** on the **Auto Deploy Configuration** page.

Figure 16 Operation result



e. Repeat the previous steps to add a deployment task for CPEs in Room B.

Configuring the DHCP server

In this example, an H3C device is operating as the DHCP server.

1. Configure an IP address pool to assign IP addresses and DNS server address to the CPEs. This example uses subnet 10.185.10.0/24 for IP address assignment.

Enable DHCP.

```
<DHCP_server> system-view
[DHCP_server] dhcp enable
```

Enable DHCP server on VLAN-interface 1.

```
[DHCP_server] interface vlan-interface 1
[DHCP_server-Vlan-interface1] dhcp select server
[DHCP_server-Vlan-interface1] quit
```

Exclude the DNS server address 10.185.10.60 and the ACS IP address 10.185.10.41 from dynamic allocation.

```
[DHCP_server] dhcp server forbidden-ip 10.185.10.41
[DHCP_server] dhcp server forbidden-ip 10.185.10.60
```

Create DHCP address pool 0.

```
[DHCP_server] dhcp server ip-pool 0
```

Assign subnet 10.185.10.0/24 to the address pool, and specify the DNS server address 10.185.10.60 in the address pool.

```
[DHCP_server-dhcp-pool-0] network 10.185.10.0 mask 255.255.255.0
[DHCP_server-dhcp-pool-0] dns-list 10.185.10.60
```

2. Configure DHCP Option 43 to contain the ACS URL, username, and password in hexadecimal format.

```
[DHCP_server-dhcp-pool-0] option 43 hex
013B687474703A2F2F6163732E6461746162617365653A393039302F616373207669636B79203132333
435
```

Configuring the DNS server

Map http://acs.database:9090 to http://10.185.1.41:9090 on the DNS server. For more information about DNS configuration, see DNS server documentation.

Connecting the CPEs to the network

Connect CPE 1 to the network, and then power on the CPE. (Details not shown.)

Log in to CPE 1 and configure VLAN-interface 2 to use DHCP for IP address acquisition, and assign GigabitEthernet 1/0/1 to VLAN-interface 2. At startup, the CPE obtains the IP address and ACS information from the DHCP server to initiate a connection to the ACS. After the connection is established, the CPE interacts with the ACS to complete autoconfiguration.

```
<CPE1> system-view
[CPE1] vlan 2
```

```
[CPE1-vlan2] quit
[CPE1] interface gigabitethernet 1/0/1
[CPE1-GigabitEthernet1/0/1] port access vlan 2
[CPE1-GigabitEthernet1/0/1] quit
[CPE1] interface vlan-interface 2
[CPE1-Vlan-interface2] ip address dhcp-alloc
```

Repeat the previous steps to configure the other CPEs.

Verifying the configuration

Execute the **`display current-configuration`** command to verify that the running configurations on CPEs are the same as the configurations issued by the ACS.

Contents

Configuring EAA

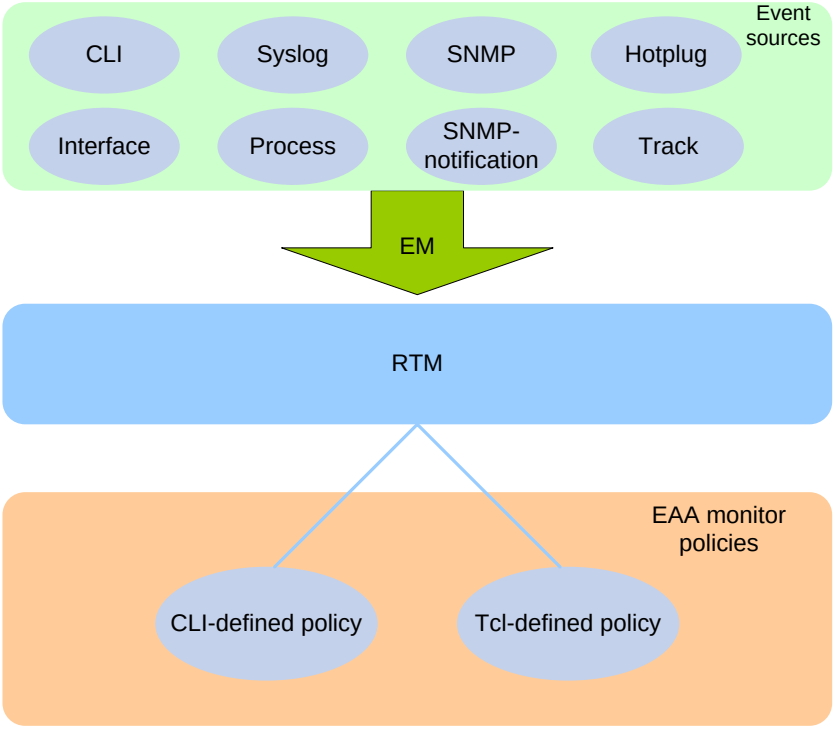
About EAA

Embedded Automation Architecture (EAA) is a monitoring framework that enables you to self-define monitored events and actions to take in response to an event. It allows you to create monitor policies by using the CLI or Tcl scripts.

EAA framework

EAA framework includes a set of event sources, a set of event monitors, a real-time event manager (RTM), and a set of user-defined monitor policies, as shown in Figure 1.

Figure 1 EAA framework



Event sources

Event sources are software or hardware modules that trigger events (see Figure 1).

For example, the CLI module triggers an event when you enter a command. The Syslog module (the information center) triggers an event when it receives a log message.

Event monitors

EAA creates one event monitor to monitor the system for the event specified in each monitor policy. An event monitor notifies the RTM to run the monitor policy when the monitored event occurs.

RTM

RTM manages the creation, state machine, and execution of monitor policies.

EAA monitor policies

A monitor policy specifies the event to monitor and actions to take when the event occurs.

You can configure EAA monitor policies by using the CLI or Tcl.

A monitor policy contains the following elements:

- One event.
- A minimum of one action.
- A minimum of one user role.
- One running time setting.

For more information about these elements, see "Elements in a monitor policy."

Elements in a monitor policy

Elements in an EAA monitor policy include event, action, user role, and runtime.

Event

Table 1 shows types of events that EAA can monitor.

Table 1 Monitored events

Event type	Description
CLI	CLI event occurs in response to monitored operations performed at the CLI. For example, a command is entered, a question mark (?) is entered, or the **Tab** key is pressed to complete a command.
Syslog	Syslog event occurs when the information center receives the monitored log within a specific period. NOTE: The log that is generated by the EAA RTM does not trigger the monitor policy to run.
Process	Process event occurs in response to a state change of the monitored process (such as an exception, shutdown, start, or restart). Both manual and automatic state changes can cause the event to occur.
Hotplug	Hot-swapping event occurs when the monitored member device joins or leaves the IRF fabric.
Interface	Each interface event is associated with two user-defined thresholds: start and restart. An interface event occurs when the monitored interface traffic statistic crosses the start threshold in the following situations: • The statistic crosses the start threshold for the first time. • The statistic crosses the start threshold each time after it crosses the restart threshold.
SNMP	Each SNMP event is associated with two user-defined thresholds: start and restart. SNMP event occurs when the monitored MIB variable's value crosses the start threshold in the following situations: • The monitored variable's value crosses the start threshold for the first time. • The monitored variable's value crosses the start threshold each time after it crosses the restart threshold.
SNMP-Notification	SNMP-Notification event occurs when the monitored MIB variable's value in an SNMP notification matches the specified condition. For example, the broadcast traffic rate on an Ethernet interface reaches or exceeds 30%.
Track	Track event occurs when the state of the track entry changes from Positive to Negative or from Negative to Positive. If you specify multiple track entries for a policy, EAA triggers the policy only when the state of all the track entries changes from Positive

Event type	Description
	(Negative) to Negative (Positive). If you set a suppress time for a policy, the timer starts when the policy is triggered. The system does not process the messages that report the track entry state change from Positive (Negative) to Negative (Positive) until the timer times out.

Action

You can create a series of order-dependent actions to take in response to the event specified in the monitor policy.

The following are available actions:

- Executing a command.
- Sending a log.
- Enabling an active/standby switchover.
- Executing a reboot without saving the running configuration.

User role

For EAA to execute an action in a monitor policy, you must assign the policy the user role that has access to the action-specific commands and resources. If EAA lacks access to an action-specific command or resource, EAA does not perform the action and all the subsequent actions.

For example, a monitor policy has four actions numbered from 1 to 4. The policy has user roles that are required for performing actions 1, 3, and 4. However, it does not have the user role required for performing action 2. When the policy is triggered, EAA executes only action 1.

For more information about user roles, see RBAC in *Fundamentals Configuration Guide*.

Runtime

The runtime limits the amount of time that the monitor policy runs its actions from the time it is triggered. This setting prevents a policy from running its actions permanently to occupy resources.

EAA environment variables

EAA environment variables decouple the configuration of action arguments from the monitor policy so you can modify a policy easily.

An EAA environment variable is defined as a <*variable_name variable_value*> pair and can be used in different policies. When you define an action, you can enter a variable name with a leading dollar sign (**$***variable_name*). EAA will replace the variable name with the variable value when it performs the action.

To change the value for an action argument, modify the value specified in the variable pair instead of editing each affected monitor policy.

EAA environment variables include system-defined variables and user-defined variables.

System-defined variables

System-defined variables are provided by default, and they cannot be created, deleted, or modified by users. System-defined variable names start with an underscore (_) sign. The variable values are set automatically depending on the event setting in the policy that uses the variables.

System-defined variables include the following types:

- **Public variable**—Available for any events.
- **Event-specific variable**—Available only for a type of event. The hotplug event-specific variable is _slot. When a member device in slot 1 joins or leaves the IRF fabric, the value of _slot is 1. When a member device in slot 2 joins or leaves the IRF fabric, the value of _slot is 2.

Table 2 shows all system-defined variables.

Table 2 System-defined EAA environment variables by event type

Event	Variable name and description
Any event	_event_id: Event ID _event_type: Event type _event_type_string: Event type description _event_time: Time when the event occurs _event_severity: Severity level of an event
CLI	_cmd: Commands that are matched
Syslog	_syslog_pattern: Log message content
Hotplug	_slot: ID of the member device that joins or leaves the IRF fabric
Interface	_ifname: Interface name
SNMP	_oid: OID of the MIB variable where an SNMP operation is performed _oid_value: Value of the MIB variable
SNMP-Notification	_oid: OID that is included in the SNMP notification.
Process	_process_name: Process name

User-defined variables

You can use user-defined variables for all types of events.

User-defined variable names can contain digits, characters, and the underscore sign (_), except that the underscore sign cannot be the leading character.

Configuring a user-defined EAA environment variable

About configuring a user-defined EAA environment variable

Configure user-defined EAA environment variables so that you can use them when creating EAA monitor policies.

Procedure

1. Enter system view.
   `system-view`
2. Configure a user-defined EAA environment variable.
   `rtm environment` *`var-name var-value`*
   For the system-defined variables, see Table 2.

Configuring a monitor policy

Restrictions and guidelines

Make sure the actions in different policies do not conflict. Policy execution result will be unpredictable if policies that conflict in actions are running concurrently.

You can assign the same policy name to a CLI-defined policy and a Tcl-defined policy. However, you cannot assign the same name to policies that are the same type.

A monitor policy supports only one event and runtime. If you configure multiple events for a policy, the most recent one takes effect.

A monitor policy supports a maximum of 64 valid user roles. User roles added after this limit is reached do not take effect.

Configuring a monitor policy from the CLI

Restrictions and guidelines

You can configure a series of actions to be executed in response to the event specified in a monitor policy. EAA executes the actions in ascending order of action IDs. When you add actions to a policy, you must make sure the execution order is correct. If two actions have the same ID, the most recent one takes effect.

Procedure

1. Enter system view.

   system-view

2. (Optional.) Set the size for the EAA-monitored log buffer.

   rtm event syslog buffer-size *buffer-size*

   By default, the EAA-monitored log buffer stores a maximum of 50000 logs

3. Create a CLI-defined policy and enter its view.

   rtm cli-policy *policy-name*

4. Configure an event for the policy.
   - Configure a CLI event.

     event cli { **async** [**skip**] | **sync** } **mode** { **execute** | **help** | **tab** } **pattern** *regular-exp*
   - Configure a hotplug event.

     event hotplug [**insert** | **remove**] **slot** *slot-number*
   - Configure an interface event.

     event interface *interface-list* **monitor-obj** *monitor-obj* **start-op** *start-op* **start-val** *start-val* **restart-op** *restart-op* **restart-val** *restart-val* [**interval** *interval*]
   - Configure a process event.

     event process { **exception** | **restart** | **shutdown** | **start** } [**name** *process-name* [**instance** *instance-id*]] [**slot** *slot-number*]
   - Configure an SNMP event.

     event snmp oid *oid* **monitor-obj** { **get** | **next** } **start-op** *start-op* **start-val** *start-val* **restart-op** *restart-op* **restart-val** *restart-val* [**interval** *interval*]
   - Configure an SNMP-Notification event.

     event snmp-notification oid *oid* **oid-val** *oid-val* **op** *op* [**drop**]
   - Configure a Syslog event.

     event syslog priority *priority* **msg** *msg* **occurs** *times* **period** *period*
   - Configure a track event.

     event track *track-list* **state { negative** | **positive** } [**suppress-time** *suppress-time*]

By default, a monitor policy does not contain an event.

If you configure multiple events for a policy, the most recent one takes effect.

5. Configure the actions to take when the event occurs.

   Choose the following tasks as needed:

   - Configure a CLI action.

     action *number* **cli** *command-line*
   - Configure a reboot action.

     action *number* **reboot** [**slot** *slot-number*]
   - Configure an active/standby switchover action.

     action *number* **switchover**
   - Configure a logging action.

     action *number* **syslog priority** *priority* **facility** *local-number* **msg** *msg-body*

   By default, a monitor policy does not contain any actions.

6. (Optional.) Assign a user role to the policy.

   user-role *role-name*

   By default, a monitor policy contains user roles that its creator had at the time of policy creation.

   An EAA policy cannot have both the **security-audit** user role and any other user roles. Any previously assigned user roles are automatically removed when you assign the **security-audit** user role to the policy. The previously assigned **security-audit** user role is automatically removed when you assign any other user roles to the policy.

7. (Optional.) Configure the policy action runtime.

   running-time *time*

   The default policy action runtime is 20 seconds.

   If you configure multiple action runtimes for a policy, the most recent one takes effect.

8. Enable the policy.

   commit

   By default, CLI-defined policies are not enabled.

   A CLI-defined policy can take effect only after you perform this step.

Configuring a monitor policy by using Tcl

About Tcl scripts

A Tcl script contains two parts: Line 1 and the other lines.

- Line 1

  Line 1 defines the event, user roles, and policy action runtime. After you create and enable a Tcl monitor policy, the device immediately parses, delivers, and executes Line 1.

  Line 1 must use the following format:

  ::comware::rtm::event_register *event-type arg1 arg2 arg3* … **user-role** *role-name1* | [**user-role** *role-name2* | […]] [**running-time** *running-time*]

  - The *arg1 arg2 arg3* … arguments represent event matching rules. If an argument value contains spaces, use double quotation marks ("") to enclose the value. For example, "a b c."
  - The configuration requirements for the *event-type*, *user-role*, and *running-time* arguments are the same as those for a CLI-defined monitor policy.
- The other lines

From the second line, the Tcl script defines the actions to be executed when the monitor policy is triggered. You can use multiple lines to define multiple actions. The system executes these actions in sequence. The following actions are available:

- Standard Tcl commands.
- EAA-specific Tcl actions:
  - switchover (**::comware::rtm::action switchover**)
  - syslog (**::comware::rtm::action syslog priority** *priority* **facility** *local-number* **msg** *msg-body*). For more information about these arguments, see EAA commands in *Network Management and Monitoring Command Reference*.
- Commands supported by the device.

Restrictions and guidelines

To revise the Tcl script of a policy, you must suspend all monitor policies first, and then resume the policies after you finish revising the script. The system cannot execute a Tcl-defined policy if you edit its Tcl script without first suspending these policies.

Procedure

1. Download the Tcl script file to the device by using FTP or TFTP.

   For more information about using FTP and TFTP, see *Fundamentals Configuration Guide*.
2. Create and enable a Tcl monitor policy.
   a. Enter system view.

      system-view
   b. Create a Tcl-defined policy and bind it to the Tcl script file.

      rtm tcl-policy *policy-name tcl-filename*

   By default, no Tcl policies exist.

   Make sure the script file is saved on all IRF member devices. This practice ensures that the policy can run correctly after a master/subordinate switchover occurs or the member device where the script file resides leaves the IRF.

Suspending monitor policies

About suspending monitor policies

This task suspends all CLI-defined and Tcl-defined monitor policies. If a policy is running when you perform this task, the system suspends the policy after it executes all the actions.

Restrictions and guidelines

To restore the operation of the suspended policies, execute the **undo rtm scheduler suspend** command.

Procedure

1. Enter system view.

   system-view
2. Suspend monitor policies.

   rtm scheduler suspend

Display and maintenance commands for EAA

Execute **display** commands except for the **display this** command in any view.

Task	Command
Display the running configuration of all CLI-defined monitor policies.	**display current-configuration**
Display user-defined EAA environment variables.	**display rtm environment** [*var-name*]
Display EAA monitor policies.	**display rtm policy** { **active** | **registered** [**verbose**] } [*policy-name*]
Display the running configuration of a CLI-defined monitor policy in CLI-defined monitor policy view.	**display this**

EAA configuration examples

Example: Configuring a CLI event monitor policy by using Tcl

Network configuration

As shown in Figure 2, use Tcl to create a monitor policy on the Device. This policy must meet the following requirements:

- EAA sends the log message "rtm_tcl_test is running" when a command that contains the **display this** string is entered.
- The system executes the command only after it executes the policy successfully.

Figure 2 Network diagram

Procedure

Edit a Tcl script file (rtm_tcl_test.tcl, in this example) for EAA to send the message "rtm_tcl_test is running" when a command that contains the **display this** string is executed.

```
::comware::rtm::event_register cli sync mode execute pattern display this user-role
network-admin
::comware::rtm::action syslog priority 1 facility local4 msg rtm_tcl_test is running
```

Download the Tcl script file from the TFTP server at **1.2.1.1**.

```
<Sysname> tftp 1.2.1.1 get rtm_tcl_test.tcl
```

Create Tcl-defined policy **test** and bind it to the Tcl script file.

```
<Sysname> system-view
[Sysname] rtm tcl-policy test rtm_tcl_test.tcl
[Sysname] quit
```

Verifying the configuration

Execute the **display rtm policy registered** command to verify that a Tcl-defined policy named **test** is displayed in the command output.

```
<Sysname> display rtm policy registered
Total number: 1
Type  Event             TimeRegistered       PolicyName
TCL   CLI               Jan 01 09:47:12 2019 test
```

Enable the information center to output log messages to the current monitoring terminal.

```
<Sysname> terminal monitor
The current terminal is enabled to display logs.
<Sysname> system-view
[Sysname] info-center enable
Information center is enabled.
[Sysname] quit
```

Execute the **display this** command. Verify that the system displays an "rtm_tcl_test is running" message and a message that the policy is being executed successfully.

```
<Sysname> display this
%Jan  1 09:50:04:634 2019 Sysname RTM/1/RTM_ACTION:rtm_tcl_test is running
%Jan  1 09:50:04:636 2019 Sysname RTM/6/RTM_POLICY: TCL policy test is running
successfully.
#
Return
```

Example: Configuring a CLI event monitor policy from the CLI

Network configuration

Configure a policy from the CLI to monitor the event that occurs when a question mark (?) is entered at the command line that contains letters and digits.

When the event occurs, the system executes the command and sends the log message "hello world" to the information center.

Procedure

Create CLI-defined policy **test** and enter its view.

```
<Sysname> system-view
[Sysname] rtm cli-policy test
```

Add a CLI event that occurs when a question mark (?) is entered at any command line that contains letters and digits.

```
[Sysname-rtm-test] event cli async mode help pattern [a-zA-Z0-9]
```

Add an action that sends the message "hello world" with a priority of 4 from the logging facility **local3** when the event occurs.

```
[Sysname-rtm-test] action 0 syslog priority 4 facility local3 msg “hello world”
```

Add an action that enters system view when the event occurs.

```
[Sysname-rtm-test] action 2 cli system-view
```

Add an action that creates VLAN 2 when the event occurs.

```
[Sysname-rtm-test] action 3 cli vlan 2
```

Set the policy action runtime to 2000 seconds.

```
[Sysname-rtm-test] running-time 2000
```

Specify the **network-admin** user role for executing the policy.

```
[Sysname-rtm-test] user-role network-admin
```

Enable the policy.

```
[Sysname-rtm-test] commit
```

Verifying the configuration

Execute the **display rtm policy registered** command to verify that a CLI-defined policy named **test** is displayed in the command output.

```
[Sysname-rtm-test] display rtm policy registered
Total number: 1
Type  Event      TimeRegistered       PolicyName
CLI   CLI        Jan  1 14:56:50 2019 test
```

Enable the information center to output log messages to the current monitoring terminal.

```
[Sysname-rtm-test] return
<Sysname> terminal monitor
The current terminal is enabled to display logs.
<Sysname> system-view
[Sysname] info-center enable
Information center is enabled.
[Sysname] quit
```

Enter a question mark (?) at a command line that contains a letter **d**. Verify that the system displays a "hello world" message and a message that the policy is being executed successfully on the terminal screen.

```
<Sysname> d?
  debugging
  delete
  diagnostic-logfile
  dir
  display

<Sysname>d%Jan  1 14:57:20:218 2019 Sysname RTM/4/RTM_ACTION: "hello world"
%Jan  1 14:58:11:170 2019 Sysname RTM/6/RTM_POLICY: CLI policy test is running
successfully.
```

Example: Configuring a CLI event monitor policy with EAA environment variables from the CLI

Network configuration

Define an environment variable to match the IP address 1.1.1.1.

Configure a policy from the CLI to monitor the event that occurs when a command line that contains **loopback0** is executed. In the policy, use the environment variable for IP address assignment.

When the event occurs, the system performs the following tasks:

- Creates the Loopback 0 interface.
- Assigns 1.1.1.1/24 to the interface.
- Sends the matching command line to the information center.

Procedure

Configure an EAA environment variable for IP address assignment. The variable name is **loopback0IP**, and the variable value is **1.1.1.1**.

```
<Sysname> system-view
[Sysname] rtm environment loopback0IP 1.1.1.1
```

Create the CLI-defined policy **test** and enter its view.

```
[Sysname] rtm cli-policy test
```

Add a CLI event that occurs when a command line that contains **loopback0** is executed.

```
[Sysname-rtm-test] event cli async mode execute pattern loopback0
```

Add an action that enters system view when the event occurs.

```
[Sysname-rtm-test] action 0 cli system-view
```

Add an action that creates the interface Loopback 0 and enters loopback interface view.

```
[Sysname-rtm-test] action 1 cli interface loopback 0
```

Add an action that assigns the IP address 1.1.1.1 to Loopback 0. The **loopback0IP** variable is used in the action for IP address assignment.

```
[Sysname-rtm-test] action 2 cli ip address $loopback0IP 24
```

Add an action that sends the matching **loopback0** command with a priority of 0 from the logging facility **local7** when the event occurs.

```
[Sysname-rtm-test] action 3 syslog priority 0 facility local7 msg $_cmd
```

Specify the **network-admin** user role for executing the policy.

```
[Sysname-rtm-test] user-role network-admin
```

Enable the policy.

```
[Sysname-rtm-test] commit
[Sysname-rtm-test] return
<Sysname>
```

Verifying the configuration

Enable the information center to output log messages to the current monitoring terminal.

```
<Sysname> terminal monitor
The current terminal is enabled to display logs.
<Sysname> terminal log level debugging
<Sysname> system-view
[Sysname] info-center enable
Information center is enabled.
```

Execute the **interface loopback0** command. Verify that the system displays an "interface loopback0" message and a message that the policy is being executed successfully on the terminal screen.

```
[Sysname] interface loopback0
[Sysname-LoopBack0]%Jan  1 09:46:10:592 2019 Sysname RTM/7/RTM_ACTION: interface
loopback0
%Jan  1 09:46:10:613 2019 Sysname RTM/6/RTM_POLICY: CLI policy test is running
successfully.
```

Verify that a Loopback 0 interface has been created and its IP address is 1.1.1.1.

```
<Sysname-LoopBack0> display interface loopback brief
Brief information on interfaces in route mode:
Link: ADM - administratively down; Stby - standby
Protocol: (s) - spoofing
Interface            Link Protocol Primary IP         Description
Loop0                UP   UP(s)    1.1.1.1

<Sysname-LoopBack0>
```

Contents

Monitoring and maintaining processes

About monitoring and maintaining processes

The system software of the device is a full-featured, modular, and scalable network operating system based on the Linux kernel. The system software features run the following types of independent processes:

- **User process**—Runs in user space. Most system software features run user processes. Each process runs in an independent space so the failure of a process does not affect other processes. The system automatically monitors user processes. The system supports preemptive multithreading. A process can run multiple threads to support multiple activities. Whether a process supports multithreading depends on the software implementation.
- **Kernel thread**—Runs in kernel space. A kernel thread executes kernel code. It has a higher security level than a user process. If a kernel thread fails, the system breaks down. You can monitor the running status of kernel threads.

Process monitoring and maintenance tasks at a glance

To monitor and maintain processes, perform the following tasks:

- Monitoring and maintaining user processes
  - Monitoring and maintaining processes

    The commands in this section apply to both user processes and kernel threads.
  - Monitoring and maintaining user processes

    The commands in this section apply only to user processes.
- Monitoring and maintaining kernel threads
  - Monitoring and maintaining processes

    The commands in this section apply to both user processes and kernel threads.
  - Monitoring and maintaining kernel threads

    The commands in this section apply only to kernel threads.

Monitoring and maintaining processes

About monitoring and maintaining processes

The commands in this section apply to both user processes and kernel threads. You can use the commands for the following purposes:

- Display the overall memory usage.
- Display the running processes and their memory and CPU usage.
- Locate abnormal processes.

If a process consumes excessive memory or CPU resources, the system identifies the process as an abnormal process.

- If an abnormal process is a user process, troubleshoot the process as described in "Monitoring and maintaining user processes."

- If an abnormal process is a kernel thread, troubleshoot the process as described in "Monitoring and maintaining kernel threads."

Procedure

Execute the following commands in any view.

Task	Command
Display memory usage.	**display memory** [**summary**] [**slot** *slot-number* [**cpu** *cpu-number*]]
Display process state information.	**display process** [**all** | **job** *job-id* | **name** *process-name*] [**slot** *slot-number* [**cpu** *cpu-number*]]
Display CPU usage for all processes.	**display process cpu** [**slot** *slot-number* [**cpu** *cpu-number*]]
Monitor process running state.	**monitor process** [**dumbtty**] [**iteration** *number*] [**slot** *slot-number* [**cpu** *cpu-number*]]
Monitor thread running state.	**monitor thread** [**dumbtty**] [**iteration** *number*] [**slot** *slot-number* [**cpu** *cpu-number*]]

For more information about the **display memory** command, see *Fundamentals Command Reference*.

Monitoring and maintaining user processes

About monitoring and maintaining user processes

Use this feature to monitor abnormal user processes and locate problems.

Configuring core dump

About core dump

The core dump feature enables the system to generate a core dump file each time a process crashes until the maximum number of core dump files is reached. A core dump file stores information about the process. You can send the core dump files to H3C technical support staff to troubleshoot the problems.

Restrictions and guidelines

Core dump files consume storage resources. Enable core dump only for processes that might have problems.

Procedure

Execute the following commands in user view:

1. (Optional.) Specify the directory for saving core dump files.

   exception filepath *directory*

   By default, the directory for saving core dump files is the root directory of the default file system. For more information about the default file system, see file system management in *Fundamentals Configuration Guide*.

2. Enable core dump for a process and specify the maximum number of core dump files, or disable core dump for a process.

process core { **maxcore** *value* | **off** } { **job** *job-id* | **name** *process-name* }

By default, a process generates a core dump file for the first exception and does not generate any core dump files for subsequent exceptions.

Display and maintenance commands for user processes

Execute **display** commands in any view and other commands in user view.

Task	Command
Display context information for process exceptions.	**display exception context** [**count** *value*] [**slot** *slot-number* [**cpu** *cpu-number*]]
Display the core dump file directory.	**display exception filepath** [**slot** *slot-number* [**cpu** *cpu-number*]]
Display log information for all user processes.	**display process log** [**slot** *slot-number* [**cpu** *cpu-number*]]
Display memory usage for all user processes.	**display process memory** [**slot** *slot-number* [**cpu** *cpu-number*]]
Display heap memory usage for a user process.	**display process memory heap job** *job-id* [**verbose**] [**slot** *slot-number* [**cpu** *cpu-number*]]
Display memory content starting from a specified memory block for a user process.	**display process memory heap job** *job-id* **address** *starting-address* **length** *memory-length* [**slot** *slot-number* [**cpu** *cpu-number*]]
Display the addresses of memory blocks with a specified size used by a user process.	**display process memory heap job** *job-id* **size** *memory-size* [**offset** *offset-size*] [**slot** *slot-number* [**cpu** *cpu-number*]]
Clear context information for process exceptions.	**reset exception context** [**slot** *slot-number* [**cpu** *cpu-number*]]

Monitoring and maintaining kernel threads

Configuring kernel thread deadloop detection

About kernel thread deadloop detection

Kernel threads share resources. If a kernel thread monopolizes the CPU, other threads cannot run, resulting in a deadloop.

This feature enables the device to detect deadloops. If a thread occupies the CPU for a specific interval, the device determines that a deadloop has occurred and generates a deadloop message.

Restrictions and guidelines

Change kernel thread deadloop detection settings only under the guidance of H3C technical support staff. Inappropriate configuration can cause system breakdown.

Procedure

1. Enter system view.

   system-view

2. Enable kernel thread deadloop detection.

   monitor kernel deadloop enable [**slot** *slot-number* [**cpu** *cpu-number* [**core** *core-number*&<1-64>]]]

   By default, kernel thread deadloop detection is enabled.

3. (Optional.) Set the interval for identifying a kernel thread deadloop.

   monitor kernel deadloop time *time* [**slot** *slot-number* [**cpu** *cpu-number*]]

   The default is 20 seconds.

4. (Optional.) Disable kernel thread deadloop detection for a kernel thread.

   monitor kernel deadloop exclude-thread *tid* [**slot** *slot-number* [**cpu** *cpu-number*]]

   When enabled, kernel thread deadloop detection monitors all kernel threads by default.

5. (Optional.) Specify the action to be taken in response to a kernel thread deadloop.

   monitor kernel deadloop action { **reboot** | **record-only** } [**slot** *slot-number* [**cpu** *cpu-number*]]

   The default action is **reboot**.

Configuring kernel thread starvation detection

About kernel thread starvation detection

Starvation occurs when a thread is unable to access shared resources.

Kernel thread starvation detection enables the system to detect and report thread starvation. If a thread is not executed within a specific interval, the system determines that a starvation has occurred and generates a starvation message.

Thread starvation does not impact system operation. A starved thread can automatically run when certain conditions are met.

Restrictions and guidelines

Configure kernel thread starvation detection only under the guidance of H3C technical support staff. Inappropriate configuration can cause system breakdown.

Procedure

1. Enter system view.

   system-view

2. Enable kernel thread starvation detection.

   monitor kernel starvation enable [**slot** *slot-number* [**cpu** *cpu-number*]]

   By default, kernel thread starvation detection is disabled.

3. (Optional.) Set the interval for identifying a kernel thread starvation.

   monitor kernel starvation time *time* [**slot** *slot-number* [**cpu** *cpu-number*]]

   The default is 120 seconds.

4. (Optional.) Disable kernel thread starvation detection for a kernel thread.

   monitor kernel starvation exclude-thread *tid* [**slot** *slot-number* [**cpu** *cpu-number*]]

When enabled, kernel thread starvation detection monitors all kernel threads by default.

Display and maintenance commands for kernel threads

Execute **display** commands in any view and **reset** commands in user view.

Task	Command
Display kernel thread deadloop detection configuration.	**display kernel deadloop configuration** [**slot** *slot-number* [**cpu** *cpu-number*]]
Display kernel thread deadloop information.	**display kernel deadloop** *show-number* [*offset*] [**verbose**] [**slot** *slot-number* [**cpu** *cpu-number*]]
Display kernel thread exception information.	**display kernel exception** *show-number* [*offset*] [**verbose**] [**slot** *slot-number* [**cpu** *cpu-number*]]
Display kernel thread reboot information.	**display kernel reboot** *show-number* [*offset*] [**verbose**] [**slot** *slot-number* [**cpu** *cpu-number*]]
Display kernel thread starvation detection configuration.	**display kernel starvation configuration** [**slot** *slot-number* [**cpu** *cpu-number*]]
Display kernel thread starvation information.	**display kernel starvation** *show-number* [*offset*] [**verbose**] [**slot** *slot-number* [**cpu** *cpu-number*]]
Clear kernel thread deadloop information.	**reset kernel deadloop** [**slot** *slot-number* [**cpu** *cpu-number*]]
Clear kernel thread exception information.	**reset kernel exception** [**slot** *slot-number* [**cpu** *cpu-number*]]
Clear kernel thread reboot information.	**reset kernel reboot** [**slot** *slot-number* [**cpu** *cpu-number*]]
Clear kernel thread starvation information.	**reset kernel starvation** [**slot** *slot-number* [**cpu** *cpu-number*]]

Contents

Configuring port mirroring

About port mirroring

Port mirroring copies the packets passing through a port to a port that connects to a data monitoring device for packet analysis.

Terminology

The following terms are used in port mirroring configuration.

Mirroring source

The mirroring sources can be one or more monitored ports called source ports.

Packets passing through mirroring sources are copied to a port connecting to a data monitoring device for packet analysis. The copies are called mirrored packets.

Source device

The device where the mirroring sources reside is called a source device.

Mirroring destination

The mirroring destination connects to a data monitoring device and is the destination port (also known as the monitor port) of mirrored packets. Mirrored packets are sent out of the monitor port to the data monitoring device.

A monitor port might receive multiple copies of a packet when it monitors multiple mirroring sources. For example, two copies of a packet are received on Port A when the following conditions exist:

- Port A is monitoring bidirectional traffic of Port B and Port C on the same device.
- The packet travels from Port B to Port C.

Destination device

The device where the monitor port resides is called the destination device.

Mirroring direction

The mirroring direction specifies the direction of the traffic that is copied on a mirroring source.

- **Inbound**—Copies packets received.
- **Outbound**—Copies packets sent.
- **Bidirectional**—Copies packets received and sent.

Mirroring group

Port mirroring is implemented through mirroring groups. Mirroring groups can be classified into local mirroring groups, remote source groups, and remote destination groups.

Reflector port, egress port, and remote probe VLAN

Reflector ports, remote probe VLANs, and egress ports are used for Layer 2 remote port mirroring. The remote probe VLAN is a dedicated VLAN for transmitting mirrored packets to the destination device. Both the reflector port and egress port reside on a source device and send mirrored packets to the remote probe VLAN.

On port mirroring devices, all ports except source, destination, reflector, and egress ports are called common ports.

Port mirroring classification

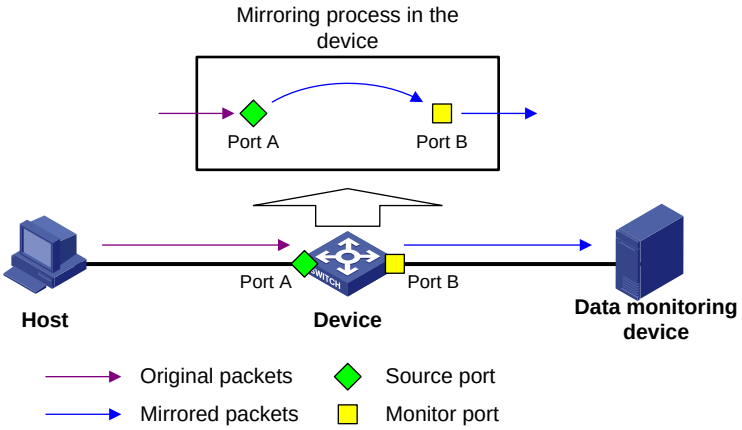
Port mirroring can be classified into local port mirroring and remote port mirroring.

- **Local port mirroring**—The source device is directly connected to a data monitoring device. The source device also acts as the destination device and forwards mirrored packets directly to the data monitoring device.
- **Remote port mirroring**—The source device is not directly connected to a data monitoring device. The source device sends mirrored packets to the destination device, which forwards the packets to the data monitoring device.

  Remote port mirroring is also known as Layer 2 remote port mirroring because the source device and destination device are on the same Layer 2 network.

Local port mirroring

Figure 1 Local port mirroring implementation



As shown in Figure 1, the source port (Port A) and the monitor port (Port B) reside on the same device. Packets received on Port A are copied to Port B. Port B then forwards the packets to the data monitoring device for analysis.

Layer 2 remote port mirroring

In Layer 2 remote port mirroring, the mirroring sources and destination reside on different devices and are in different mirroring groups.

A remote source group is a mirroring group that contains the mirroring sources. A remote destination group is a mirroring group that contains the mirroring destination. Intermediate devices are the devices between the source device and the destination device.

Layer 2 remote port mirroring can be implemented through the reflector port method or the egress port method.

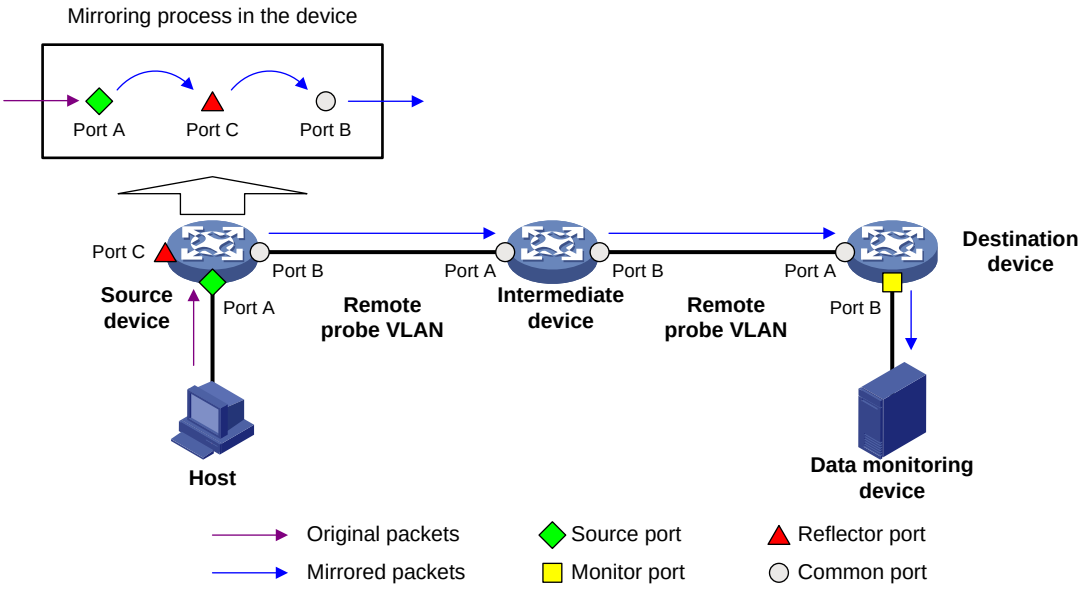
Reflector port method

In Layer 2 remote port mirroring that uses the reflector port method, packets are mirrored as follows:

1. The source device copies packets received on the mirroring sources to the reflector port.
2. The reflector port broadcasts the mirrored packets in the remote probe VLAN.
3. The intermediate devices transmit the mirrored packets to the destination device through the remote probe VLAN.

4. Upon receiving the mirrored packets, the destination device determines whether the ID of the mirrored packets is the same as the remote probe VLAN ID. If the two VLAN IDs match, the destination device forwards the mirrored packets to the data monitoring device through the monitor port.

Figure 2 Layer 2 remote port mirroring implementation through the reflector port method

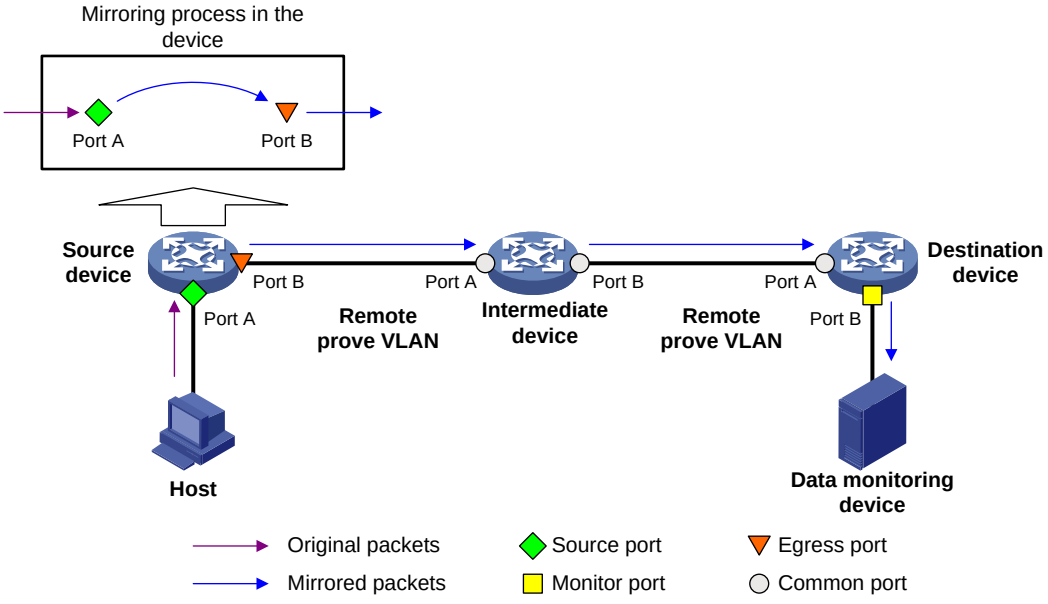


Egress port method

In Layer 2 remote port mirroring that uses the egress port method, packets are mirrored as follows:

1. The source device copies packets received on the mirroring sources to the egress port.
2. The egress port forwards the mirrored packets to the intermediate devices.
3. The intermediate devices flood the mirrored packets in the remote probe VLAN and transmit the mirrored packets to the destination device.
4. Upon receiving the mirrored packets, the destination device determines whether the ID of the mirrored packets is the same as the remote probe VLAN ID. If the two VLAN IDs match, the destination device forwards the mirrored packets to the data monitoring device through the monitor port.

Figure 3 Layer 2 remote port mirroring implementation through the egress port method



Restrictions and guidelines: Port mirroring configuration

The reflector port method for Layer 2 remote port mirroring can be used to implement local port mirroring with multiple data monitoring devices.

In the reflector port method, the reflector port broadcasts mirrored packets in the remote probe VLAN. By assigning the ports that connect to data monitoring devices to the remote probe VLAN, you can implement local port mirroring to mirror packets to multiple data monitoring devices. The egress port method cannot implement local port mirroring in this way.

For inbound traffic mirroring, the VLAN tag in the original packet is copied to the mirrored packet.

For outbound traffic mirroring, the VLAN tag in the mirrored packet identifies the VLAN to which the packet belongs before it is sent out of the source port.

Configuring local port mirroring

Restrictions and guidelines for local port mirroring configuration

A local mirroring group takes effect only after it is configured with the monitor port and mirroring sources.

A Layer 2 or Layer 3 aggregate interface, tunnel interface, or VLAN interface cannot be configured as a source port of a local mirroring group. You can configure member ports of a Layer 2 or Layer 3 aggregate interface as mirroring source ports.

A Layer 2 or Layer 3 aggregate interface cannot be configured as the monitor port of a local mirroring group.

The member port of an aggregate interface cannot be configured as a monitor port.

Local port mirroring tasks at a glance

To configure local port mirroring, perform the following tasks:

1. Creating a local mirroring group
2. Configuring mirroring sources
3. Configuring the monitor port

Creating a local mirroring group

1. Enter system view.
   system-view
2. Create a local mirroring group.
   mirroring-group *group-id* **local**

Configuring mirroring sources

Restrictions and guidelines for mirroring source configuration

When you configure source ports for a local mirroring group, follow these restrictions and guidelines:

- A mirroring group can contain multiple source ports.
- A port can act as a source port for only one mirroring group.
- A source port cannot be configured as a reflector port, egress port, or monitor port.
- A Layer 2 or Layer 3 aggregate interface, tunnel interface, or VLAN interface cannot be configured as a source port of a local mirroring group.

Configuring source ports

- Configure source ports in system view:
  a. Enter system view.
     system-view
  b. Configure source ports for a local mirroring group.
     mirroring-group *group-id* **mirroring-port** *interface-list* { **both** | **inbound** | **outbound** }
     By default, no source port is configured for a local mirroring group.
- Configure source ports in interface view:
  a. Enter system view.
     system-view
  b. Enter interface view.
     interface *interface-type interface-number*
  c. Configure the port as a source port for a local mirroring group.
     mirroring-group *group-id* **mirroring-port** { **both** | **inbound** | **outbound** }
     By default, a port does not act as a source port for any local mirroring groups.

Configuring the monitor port

Restrictions and guidelines

Do not enable the spanning tree feature on the monitor port.

Use a monitor port only for port mirroring, so the data monitoring device receives only the mirrored traffic.

Only one monitor port can be configured for a mirroring group.

The member port of an aggregate interface cannot be configured as a monitor port.

Procedure

- Configure the monitor port in system view:
  1. Enter system view.
     system-view
  2. Configure the monitor port for a local mirroring group.
     mirroring-group *group-id* **monitor-port** *interface-type interface-number*
     By default, no monitor port is configured for a local mirroring group.
- Configure the monitor port in interface view:
  1. Enter system view.
     system-view
  2. Enter interface view.
     interface *interface-type interface-number*
  3. Configure the port as the monitor port for a mirroring group.
     mirroring-group *group-id* **monitor-port**
     By default, a port does not act as the monitor port for any local mirroring groups.

Configuring local port mirroring group with multiple monitoring devices

About local port mirroring with multiple monitoring devices

To monitor interesting traffic passing through a device on multiple directly connected data monitoring devices, configure local port mirroring with a remote probe VLAN as follows:

1. Configure a remote source group on the device.
2. Configure mirroring sources and a reflector port for the remote source group.
3. Specify a VLAN as the remote probe VLAN and assign the ports connecting to the data monitoring devices to the VLAN.

This configuration enables the device to copy packets received on the mirroring sources to the reflector port, which broadcasts the packets in the remote probe VLAN. The packets are then sent out of the member ports of the remote probe VLAN to the data monitoring devices.

Restrictions and guidelines

The reflector port must be a port not in use. Do not connect a network cable to the reflector port.

When a port is configured as a reflector port, the port restores to the factory default settings. You cannot configure other features on the reflector port.

Do not assign a source port of a mirroring group to the remote probe VLAN of the mirroring group.

A VLAN can act as the remote probe VLAN for only one remote source group. As a best practice, use the VLAN for port mirroring exclusively. Do not create a VLAN interface for the VLAN or configure other features for the VLAN.

The remote probe VLAN must be a static VLAN.

To delete a VLAN that has been configured as the remote probe VLAN for a mirroring group, remove the remote probe VLAN from the mirroring group first.

The device supports only one remote probe VLAN.

Procedure

1. Enter system view.
   system-view
2. Create a remote source group.
   mirroring-group *group-id* **remote-source**
3. Configure mirroring sources for the remote source group. Choose one option as needed:
   - Configure mirroring ports in system view.
     mirroring-group *group-id* **mirroring-port** *interface-list* { **both** | **inbound** | **outbound** }
   - Execute the following commands in sequence to enter interface view and then configure the interface as a source port.
     interface *interface-type interface-number*
     mirroring-group *group-id* **mirroring-port** { **both** | **inbound** | **outbound** }
     quit
4. Configure the reflector port for the remote source group.
   mirroring-group *group-id* **reflector-port** *reflector-port*
   By default, no reflector port is configured for a remote source group.
5. Create a VLAN and enter its view.
   vlan *vlan-id*
6. Assign the ports that connect to the data monitoring devices to the VLAN.
   port *interface-list*
   By default, a VLAN does not contain any ports.
7. Return to system view.
   quit
8. Specify the VLAN as the remote probe VLAN for the remote source group.
   mirroring-group *group-id* **remote-probe vlan** *vlan-id*
   By default, no remote probe VLAN is configured for a remote source group.

Configuring Layer 2 remote port mirroring

Restrictions and guidelines for Layer 2 remote port mirroring configuration

To ensure successful traffic mirroring, configure devices in the order of the destination device, the intermediate devices, and the source device.

If intermediate devices exist, configure the intermediate devices to allow the remote probe VLAN to pass through.

For a mirrored packet to successfully arrive at the remote destination device, make sure its VLAN ID is not removed or changed.

Do not configure both MVRP and Layer 2 remote port mirroring. Otherwise, MVRP might register the remote probe VLAN with incorrect ports, which would cause the monitor port to receive undesired copies. For more information about MVRP, see *Layer 2—LAN Switching Configuration Guide*.

To monitor the bidirectional traffic of a source port, disable MAC address learning for the remote probe VLAN on the source, intermediate, and destination devices. For more information about MAC address learning, see *Layer 2—LAN Switching Configuration Guide*.

The member port of a Layer 2 aggregate interface cannot be configured as the monitor port for Layer 2 remote port mirroring.

Layer 2 remote port mirroring with reflector port configuration task list

Configuring the destination device

1. Creating a remote destination group
2. Configuring the monitor port
3. Configuring the remote probe VLAN
4. Assigning the monitor port to the remote probe VLAN

Configuring the source device

1. Creating a remote source group
2. Configuring mirroring sources
3. Configuring the reflector port
4. Configuring the remote probe VLAN

Layer 2 remote port mirroring with egress port configuration task list

Configuring the destination device

1. Creating a remote destination group
2. Configuring the monitor port
3. Configuring the remote probe VLAN
4. Assigning the monitor port to the remote probe VLAN

Configuring the source device

1. Creating a remote source group
2. Configuring mirroring sources
3. Configuring the egress port
4. Configuring the remote probe VLAN

Creating a remote destination group

Restrictions and guidelines

Perform this task on the destination device only.

Procedure

1. Enter system view.
   system-view
2. Create a remote destination group.
   mirroring-group *group-id* **remote-destination**

Configuring the monitor port

Restrictions and guidelines for monitor port configuration

Perform this task on the destination device only.

Do not enable the spanning tree feature on the monitor port.

Use a monitor port only for port mirroring, so the data monitoring device receives only the mirrored traffic.

A monitor port can belong to only one mirroring group.

A Layer 2 aggregate interface cannot be configured as the monitor port for a mirroring group.

Configuring the monitor port in system view

1. Enter system view.
   system-view
2. Configure the monitor port for a remote destination group.
   mirroring-group *group-id* **monitor-port** *interface-type interface-number*
   By default, no monitor port is configured for a remote destination group.

Configuring the monitor port in interface view

1. Enter system view.
   system-view
2. Enter interface view.
   interface *interface-type interface-number*
3. Configure the port as the monitor port for a remote destination group.
   mirroring-group *group-id* **monitor-port**
   By default, a port does not act as the monitor port for any remote destination groups.

Configuring the remote probe VLAN

Restrictions and guidelines

This task is required on the both the source and destination devices.

Only an existing static VLAN can be configured as a remote probe VLAN.

When a VLAN is configured as a remote probe VLAN, use the remote probe VLAN for port mirroring exclusively.

Configure the same remote probe VLAN for the remote source group and the remote destination group.

The device supports only one remote probe VLAN.

Procedure

1. Enter system view.
   system-view
2. Configure the remote probe VLAN for the remote source or destination group.
   mirroring-group *group-id* **remote-probe vlan** *vlan-id*
   By default, no remote probe VLAN is configured for a remote source or destination group.

Assigning the monitor port to the remote probe VLAN

Restrictions and guidelines

Perform this task on the destination device only.

Procedure

1. Enter system view.
   system-view
2. Enter the interface view of the monitor port.
   interface *interface-type interface-number*
3. Assign the port to the remote probe VLAN.
   - Assign an access port to the remote probe VLAN.
     port access vlan *vlan-id*
   - Assign a trunk port to the remote probe VLAN.
     port trunk permit vlan *vlan-id*
   - Assign a hybrid port to the remote probe VLAN.
     port hybrid vlan *vlan-id* { **tagged** | **untagged** }

   For more information about the **port access vlan**, **port trunk permit vlan**, and **port hybrid vlan** commands, see *Layer 2—LAN Switching Command Reference*.

Creating a remote source group

Restrictions and guidelines

Perform this task on the source device only.

Procedure

1. Enter system view.
   system-view
2. Create a remote source group.
   mirroring-group *group-id* **remote-source**

Configuring mirroring sources

Restrictions and guidelines for mirroring source configuration

Perform this task on the source device only.

When you configure source ports for a remote source group, follow these restrictions and guidelines:

- Do not assign a source port of a mirroring group to the remote probe VLAN of the mirroring group.
- A mirroring group can contain multiple source ports.
- A port can be configured as a unidirectional source port for a maximum of two mirroring groups: one for inbound traffic mirroring and the other for outbound traffic mirroring. As a bidirectional source port, a port can be assigned to only one mirroring group
- The device supports only one mirroring group for outbound or bidirectional traffic mirroring.
- A source port cannot be configured as a reflector port, monitor port, or egress port.
- A Layer 2 aggregate interface cannot be configured as a source port for a mirroring group.

Configuring source ports

- Configure source ports in system view:
  1. Enter system view.

     system-view
  2. Configure source ports for a remote source group.

     mirroring-group *group-id* **mirroring-port** *interface-list* { **both** | **inbound** | **outbound** }

     By default, no source port is configured for a remote source group.
- Configure source ports in interface view:
  1. Enter system view.

     system-view
  2. Enter interface view.

     interface *interface-type interface-number*
  3. Configure the port as a source port for a remote source group.

     mirroring-group *group-id* **mirroring-port** { **both** | **inbound** | **outbound** }

     By default, a port does not act as a source port for any remote source groups.

Configuring the reflector port

Restrictions and guidelines for reflector port configuration

Perform this task on the source device only.

A remote source group supports only one reflector port.

Configuring the reflector port in system view

1. Enter system view.

   system-view
2. Configure the reflector port for a remote source group.

   mirroring-group *group-id* **reflector-port** *interface-type interface-number*

CAUTION:

- The port to be configured as a reflector port must be a port not in use. Do not connect a network cable to a reflector port.
- When a port is configured as a reflector port, the default settings of the port are automatically restored. You cannot configure other features on the reflector port.
- If an IRF port is bound to only one physical interface, do not configure the physical interface as a reflector port. Otherwise, the IRF might split.

By default, no reflector port is configured for a remote source group.

Configuring the reflector port in interface view

1. Enter system view.
   system-view
2. Enter interface view.
   interface *interface-type interface-number*
3. Configure the port as the reflector port for a remote source group.
   mirroring-group *group-id* **reflector-port**

CAUTION:

- The port to be configured as a reflector port must be a port not in use. Do not connect a network cable to a reflector port.
- When a port is configured as a reflector port, the default settings of the port are automatically restored. You cannot configure other features on the reflector port.
- If an IRF port is bound to only one physical interface, do not configure the physical interface as a reflector port. Otherwise, the IRF might split.

By default, a port does not act as the reflector port for any remote source groups.

Configuring the egress port

Restrictions and guidelines for egress port configuration

Perform this task on the source device only.

Disable the following features on the egress port:

- Spanning tree.
- 802.1X.
- IGMP snooping.
- Static ARP.
- MAC address learning.

A port of an existing mirroring group cannot be configured as an egress port.

A mirroring group supports only one egress port.

Configuring the egress port in system view

1. Enter system view.
   system-view
2. Configure the egress port for a remote source group.
   mirroring-group *group-id* **monitor-egress** *interface-type interface-number*
   By default, no egress port is configured for a remote source group.

3. Enter the egress port view.
   interface *interface-type interface-number*
4. Assign the egress port to the remote probe VLAN.
   - Assign a trunk port to the remote probe VLAN.
     port trunk permit vlan *vlan-id*
   - Assign a hybrid port to the remote probe VLAN.
     port hybrid vlan *vlan-id* { **tagged** | **untagged** }

   For more information about the **port trunk permit vlan** and **port hybrid vlan** commands, see *Layer 2—LAN Switching Command Reference*.

Configuring the egress port in interface view

1. Enter system view.
   system-view
2. Enter interface view.
   interface *interface-type interface-number*
3. Configure the port as the egress port for a remote source group.
   mirroring-group *group-id* **monitor-egress**

   By default, a port does not act as the egress port for any remote source groups.

Display and maintenance commands for port mirroring

Execute **display** commands in any view.

Task	Command
Display mirroring group information.	**display mirroring-group** { *group-id* | **all** | **local** | **remote-destination** | **remote-source** }

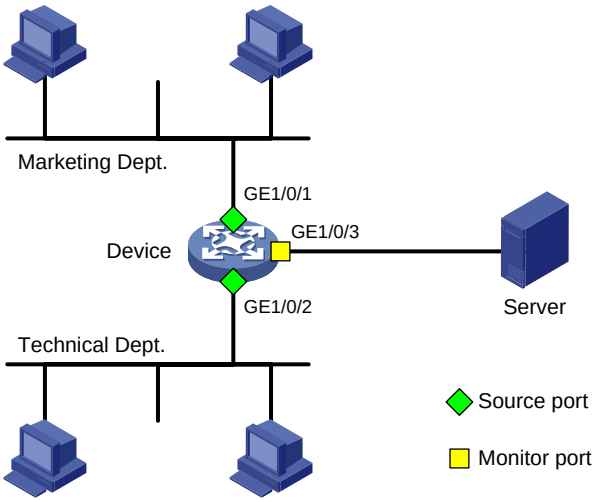
Port mirroring configuration examples

Example: Configuring local port mirroring

Network configuration

As shown in Figure 4, configure local port mirroring in source port mode to enable the server to monitor the bidirectional traffic of the two departments.

Figure 4 Network diagram



Procedure

Create local mirroring group 1.

```
<Device> system-view
[Device] mirroring-group 1 local
```

Configure GigabitEthernet 1/0/1 and GigabitEthernet 1/0/2 as source ports for local mirroring group 1.

```
[Device] mirroring-group 1 mirroring-port gigabitethernet 1/0/1 gigabitethernet 1/0/2
both
```

Configure GigabitEthernet 1/0/3 as the monitor port for local mirroring group 1.

```
[Device] mirroring-group 1 monitor-port gigabitethernet 1/0/3
```

Disable the spanning tree feature on the monitor port (GigabitEthernet 1/0/3).

```
[Device] interface gigabitethernet 1/0/3
[Device-GigabitEthernet1/0/3] undo stp enable
[Device-GigabitEthernet1/0/3] quit
```

Verifying the configuration

Verify the mirroring group configuration.

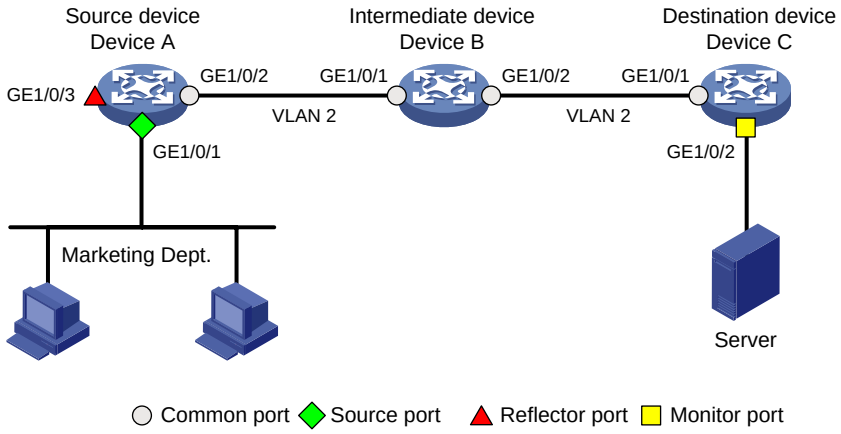
```
[Device] display mirroring-group all
Mirroring group 1:
    Type: Local
    Status: Active
    Mirroring port:
        GigabitEthernet1/0/1  Both
        GigabitEthernet1/0/2  Both
    Monitor port: GigabitEthernet1/0/3
```

Example: Configuring Layer 2 remote port mirroring (with reflector port)

Network configuration

As shown in Figure 5, configure Layer 2 remote port mirroring to enable the server to monitor the bidirectional traffic of the Marketing Department.

Figure 5 Network diagram



Procedure

1. Configure Device C (the destination device):

   # Configure GigabitEthernet 1/0/1 as a trunk port, and assign the port to VLAN 2.

   ```
   <DeviceC> system-view
   [DeviceC] interface gigabitethernet 1/0/1
   [DeviceC-GigabitEthernet1/0/1] port link-type trunk
   [DeviceC-GigabitEthernet1/0/1] port trunk permit vlan 2
   [DeviceC-GigabitEthernet1/0/1] quit
   ```

   # Create a remote destination group.

   ```
   [DeviceC] mirroring-group 2 remote-destination
   ```

   # Create VLAN 2.

   ```
   [DeviceC] vlan 2
   ```

   # Disable MAC address learning for VLAN 2.

   ```
   [DeviceC-vlan2] undo mac-address mac-learning enable
   [DeviceC-vlan2] quit
   ```

   # Configure VLAN 2 as the remote probe VLAN for the mirroring group.

   ```
   [DeviceC] mirroring-group 2 remote-probe vlan 2
   ```

   # Configure GigabitEthernet 1/0/2 as the monitor port for the mirroring group.

   ```
   [DeviceC] interface gigabitethernet 1/0/2
   [DeviceC-GigabitEthernet1/0/2] mirroring-group 2 monitor-port
   ```

   # Disable the spanning tree feature on GigabitEthernet 1/0/2.

   ```
   [DeviceC-GigabitEthernet1/0/2] undo stp enable
   ```

   # Assign GigabitEthernet 1/0/2 to VLAN 2.

   ```
   [DeviceC-GigabitEthernet1/0/2] port access vlan 2
   [DeviceC-GigabitEthernet1/0/2] quit
   ```

2. Configure Device B (the intermediate device):

   # Create VLAN 2.

   ```
   <DeviceB> system-view
   [DeviceB] vlan 2
   ```

   # Disable MAC address learning for VLAN 2.

   ```
   [DeviceB-vlan2] undo mac-address mac-learning enable
   [DeviceB-vlan2] quit
   ```

   # Configure GigabitEthernet 1/0/1 as a trunk port, and assign the port to VLAN 2.

```
[DeviceB] interface gigabitethernet 1/0/1
[DeviceB-GigabitEthernet1/0/1] port link-type trunk
[DeviceB-GigabitEthernet1/0/1] port trunk permit vlan 2
[DeviceB-GigabitEthernet1/0/1] quit
```

Configure GigabitEthernet 1/0/2 as a trunk port, and assign the port to VLAN 2.

```
[DeviceB] interface gigabitethernet 1/0/2
[DeviceB-GigabitEthernet1/0/2] port link-type trunk
[DeviceB-GigabitEthernet1/0/2] port trunk permit vlan 2
[DeviceB-GigabitEthernet1/0/2] quit
```

3. Configure Device A (the source device):

Create a remote source group.

```
<DeviceA> system-view
[DeviceA] mirroring-group 1 remote-source
```

Create VLAN 2.

```
[DeviceA] vlan 2
```

Disable MAC address learning for VLAN 2.

```
[DeviceA-vlan2] undo mac-address mac-learning enable
[DeviceA-vlan2] quit
```

Configure VLAN 2 as the remote probe VLAN for the mirroring group.

```
[DeviceA] mirroring-group 1 remote-probe vlan 2
```

Configure GigabitEthernet 1/0/1 as a source port for the mirroring group.

```
[DeviceA] mirroring-group 1 mirroring-port gigabitethernet 1/0/1 both
```

Configure GigabitEthernet 1/0/3 as the reflector port for the mirroring group.

```
[DeviceA] mirroring-group 1 reflector-port gigabitethernet 1/0/3
This operation may delete all settings made on the interface. Continue? [Y/N]: y
```

Configure GigabitEthernet 1/0/2 as a trunk port, and assign the port to VLAN 2.

```
[DeviceA] interface gigabitethernet 1/0/2
[DeviceA-GigabitEthernet1/0/2] port link-type trunk
[DeviceA-GigabitEthernet1/0/2] port trunk permit vlan 2
[DeviceA-GigabitEthernet1/0/2] quit
```

Verifying the configuration

Verify the mirroring group configuration on Device C.

```
[DeviceC] display mirroring-group all
Mirroring group 2:
    Type: Remote destination
    Status: Active
    Monitor port: GigabitEthernet1/0/2
    Remote probe VLAN: 2
```

Verify the mirroring group configuration on Device A.

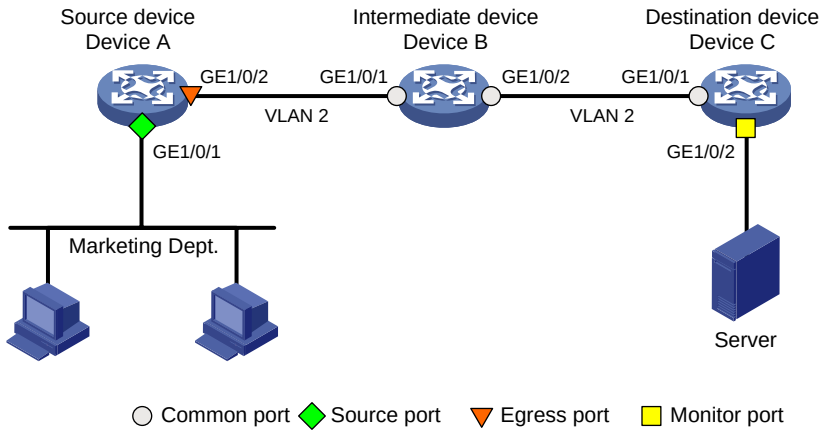
```
[DeviceA] display mirroring-group all
Mirroring group 1:
    Type: Remote source
    Status: Active
    Mirroring port:
        GigabitEthernet1/0/1  Both
    Reflector port: GigabitEthernet1/0/3
    Remote probe VLAN: 2
```

Example: Configuring Layer 2 remote port mirroring (with egress port)

Network configuration

On the Layer 2 network shown in Figure 6, configure Layer 2 remote port mirroring to enable the server to monitor the bidirectional traffic of the Marketing Department.

Figure 6 Network diagram



Procedure

1. Configure Device C (the destination device):

   # Configure GigabitEthernet 1/0/1 as a trunk port, and assign the port to VLAN 2.

   ```
   <DeviceC> system-view
   [DeviceC] interface gigabitethernet 1/0/1
   [DeviceC-GigabitEthernet1/0/1] port link-type trunk
   [DeviceC-GigabitEthernet1/0/1] port trunk permit vlan 2
   [DeviceC-GigabitEthernet1/0/1] quit
   ```

   # Create a remote destination group.

   ```
   [DeviceC] mirroring-group 2 remote-destination
   ```

   # Create VLAN 2.

   ```
   [DeviceC] vlan 2
   ```

   # Disable MAC address learning for VLAN 2.

   ```
   [DeviceC-vlan2] undo mac-address mac-learning enable
   [DeviceC-vlan2] quit
   ```

   # Configure VLAN 2 as the remote probe VLAN for the mirroring group.

   ```
   [DeviceC] mirroring-group 2 remote-probe vlan 2
   ```

   # Configure GigabitEthernet 1/0/2 as the monitor port for the mirroring group.

   ```
   [DeviceC] interface gigabitethernet 1/0/2
   [DeviceC-GigabitEthernet1/0/2] mirroring-group 2 monitor-port
   ```

   # Disable the spanning tree feature on GigabitEthernet 1/0/2.

   ```
   [DeviceC-GigabitEthernet1/0/2] undo stp enable
   ```

   # Assign GigabitEthernet 1/0/2 to VLAN 2 as an access port.

   ```
   [DeviceC-GigabitEthernet1/0/2] port access vlan 2
   [DeviceC-GigabitEthernet1/0/2] quit
   ```

2. Configure Device B (the intermediate device):

Create VLAN 2.

```
<DeviceB> system-view
[DeviceB] vlan 2
```

Disable MAC address learning for VLAN 2.

```
[DeviceB-vlan2] undo mac-address mac-learning enable
[DeviceB-vlan2] quit
```

Configure GigabitEthernet 1/0/1 as a trunk port, and assign the port to VLAN 2.

```
[DeviceB] interface gigabitethernet 1/0/1
[DeviceB-GigabitEthernet1/0/1] port link-type trunk
[DeviceB-GigabitEthernet1/0/1] port trunk permit vlan 2
[DeviceB-GigabitEthernet1/0/1] quit
```

Configure GigabitEthernet 1/0/2 as a trunk port, and assign the port to VLAN 2.

```
[DeviceB] interface gigabitethernet 1/0/2
[DeviceB-GigabitEthernet1/0/2] port link-type trunk
[DeviceB-GigabitEthernet1/0/2] port trunk permit vlan 2
[DeviceB-GigabitEthernet1/0/2] quit
```

3. Configure Device A (the source device):

Create a remote source group.

```
<DeviceA> system-view
[DeviceA] mirroring-group 1 remote-source
```

Create VLAN 2.

```
[DeviceA] vlan 2
```

Disable MAC address learning for VLAN 2.

```
[DeviceA-vlan2] undo mac-address mac-learning enable
[DeviceA-vlan2] quit
```

Configure VLAN 2 as the remote probe VLAN of the mirroring group.

```
[DeviceA] mirroring-group 1 remote-probe vlan 2
```

Configure GigabitEthernet 1/0/1 as a source port for the mirroring group.

```
[DeviceA] mirroring-group 1 mirroring-port gigabitethernet 1/0/1 both
```

Configure GigabitEthernet 1/0/2 as the egress port for the mirroring group.

```
[DeviceA] mirroring-group 1 monitor-egress gigabitethernet 1/0/2
```

Configure GigabitEthernet 1/0/2 as a trunk port, and assign the port to VLAN 2.

```
[DeviceA] interface gigabitethernet 1/0/2
[DeviceA-GigabitEthernet1/0/2] port link-type trunk
[DeviceA-GigabitEthernet1/0/2] port trunk permit vlan 2
```

Disable the spanning tree feature on the port.

```
[DeviceA-GigabitEthernet1/0/2] undo stp enable
[DeviceA-GigabitEthernet1/0/2] quit
```

Verifying the configuration

Verify the mirroring group configuration on Device C.

```
[DeviceC] display mirroring-group all
Mirroring group 2:
    Type: Remote destination
    Status: Active
    Monitor port: GigabitEthernet1/0/2
    Remote probe VLAN: 2
```

Verify the mirroring group configuration on Device A.

```
[DeviceA] display mirroring-group all
Mirroring group 1:
    Type: Remote source
    Status: Active
    Mirroring port:
        GigabitEthernet1/0/1  Both
    Monitor egress port: GigabitEthernet1/0/2
    Remote probe VLAN: 2
```

Configuring flow mirroring

About flow mirroring

Flow mirroring copies packets matching a class to a destination for packet analyzing and monitoring. It is implemented through QoS.

To implement flow mirroring through QoS, perform the following tasks:

- Define traffic classes and configure match criteria to classify packets to be mirrored. Flow mirroring allows you to flexibly classify packets to be analyzed by defining match criteria.
- Configure traffic behaviors to mirror the matching packets to the specified destination.

You can configure an action to mirror the matching packets to one of the following destinations:

- **Interface**—The matching packets are copied to an interface and then forwarded to a data monitoring device for analysis.
- **CPU**—The matching packets are copied to the CPU of an IRF member device. The CPU analyzes the packets or delivers them to upper layers.

For more information about QoS policies, traffic classes, and traffic behaviors, see *ACL and QoS Configuration Guide*.

Restrictions and guidelines: Flow mirroring configuration

For information about the configuration commands except the **`mirror-to`** command, see *ACL and QoS Command Reference*.

Flow mirroring tasks at a glance

To configure flow mirroring, perform the following tasks:

1. Configuring a traffic class

   A traffic class defines the criteria that filters the traffic to be mirrored.
2. Configuring a traffic behavior

   A traffic behavior specifies mirroring destinations.
3. Configuring a QoS policy
4. Applying a QoS policy

   Choose one of the following tasks:
   - Applying a QoS policy to an interface
   - Applying a QoS policy to VLANs
   - Applying a QoS policy globally

Configuring a traffic class

1. Enter system view.

   `system-view`
2. Create a class and enter class view.

traffic classifier *classifier-name* [**operator** { **and** | **or** }]

3. Configure match criteria.
   if-match *match-criteria*
   By default, no match criterion is configured in a traffic class.
4. (Optional.) Display traffic class information.
   display traffic classifier
   This command is available in any view.

Configuring a traffic behavior

1. Enter system view.
   system-view
2. Create a traffic behavior and enter traffic behavior view.
   traffic behavior *behavior-name*
3. Configure mirroring destinations for the traffic behavior. Choose one option as needed:
   - Mirror traffic to interfaces.
     mirror-to interface *interface-type interface-number*
     mirror-to interface destination-ip *destination-ip-address* **source-ip** *source-ip-address* [**truncation**] [**dscp** *dscp-value* | **vlan** *vlan-id* | **vrf-instance** *vrf-name*] *
     By default, no mirroring actions exist to mirror traffic to interfaces.
     You can mirror traffic to only one interface in a traffic behavior. If you execute this command for a traffic behavior multiple times, only the most recent configuration takes effect.
   - Mirror traffic to the CPU.
     mirror-to cpu
     By default, no mirroring actions exist to mirror traffic to the CPU.
4. (Optional.) Display traffic behavior configuration.
   display traffic behavior
   This command is available in any view.

Configuring a QoS policy

1. Enter system view.
   system-view
2. Create a QoS policy and enter QoS policy view.
   qos policy *policy-name*
3. Associate a class with a traffic behavior in the QoS policy.
   classifier *classifier-name* **behavior** *behavior-name*
   By default, no traffic behavior is associated with a class.
4. (Optional.) Display QoS policy configuration.
   display qos policy
   This command is available in any view.

Applying a QoS policy

Applying a QoS policy to an interface

Restrictions and guidelines

You can apply a QoS policy to an interface to mirror the traffic of the interface.

A policy can be applied to multiple interfaces.

A QoS policy cannot be applied in the outbound direction of an interface. In the inbound direction of an interface, only one QoS policy can be applied.

Procedure

1. Enter system view.
   system-view
2. Enter interface view.
   interface *interface-type interface-number*
3. Apply a policy to the interface.
   qos apply policy *policy-name* **inbound**
4. (Optional.) Display the QoS policy applied to the interface.
   display qos policy interface
   This command is available in any view.

Applying a QoS policy to VLANs

Restrictions and guidelines

You can apply a QoS policy to a VLAN to mirror the traffic on all ports in the VLAN.

A QoS policy cannot be applied in the outbound direction of a VLAN. In the inbound direction of a VLAN, only one QoS policy can be applied.

Procedure

1. Enter system view.
   system-view
2. Apply a QoS policy to VLANs.
   qos vlan-policy *policy-name* **vlan** *vlan-id-list* **inbound**
3. (Optional.) Display the QoS policy applied to VLANs.
   display qos vlan-policy
   This command is available in any view.

Applying a QoS policy globally

Restrictions and guidelines

You can apply a QoS policy globally to mirror the traffic on all ports.

A QoS policy cannot be applied in the outbound direction globally. In the inbound direction, only one QoS policy can be applied globally.

Procedure

1. Enter system view.

system-view

2. Apply a QoS policy globally.
   qos apply policy *policy-name* **global inbound**
3. (Optional.) Display global QoS policies.
   display qos policy global
   This command is available in any view.

Flow mirroring configuration examples

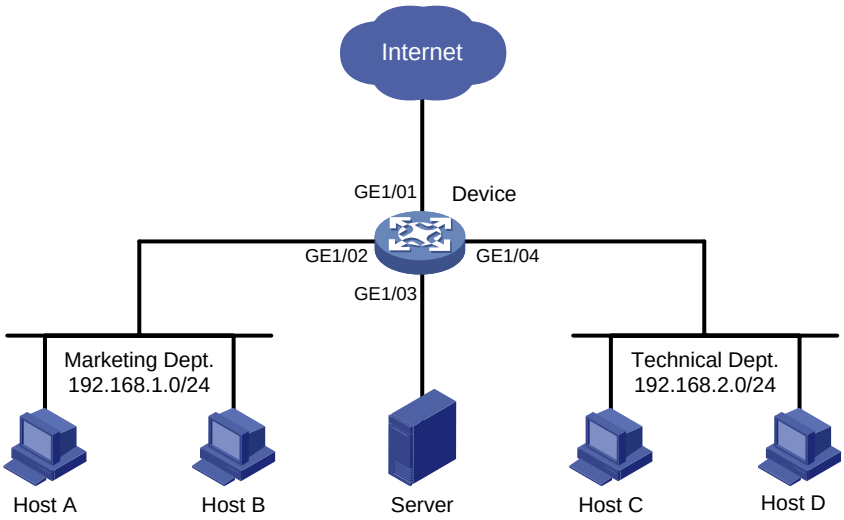
Example: Configuring flow mirroring

Network configuration

As shown in Figure 7, configure flow mirroring so that the server can monitor the following traffic:

- All traffic that the Technical Department sends to access the Internet.
- IP traffic that the Technical Department sends to the Marketing Department during working hours (8:00 to 18:00) on weekdays.

Figure 7 Network diagram



Procedure

Create working hour range **work**, in which working hours are from 8:00 to 18:00 on weekdays.

```
<Device> system-view
[Device] time-range work 8:00 to 18:00 working-day
```

Create IPv4 advanced ACL 3000 to allow packets from the Technical Department to access the Internet and the Marketing Department during working hours.

```
[Device] acl advanced 3000
[Device-acl-ipv4-adv-3000] rule permit tcp source 192.168.2.0 0.0.0.255 destination-port
eq www
[Device-acl-ipv4-adv-3000] rule permit ip source 192.168.2.0 0.0.0.255 destination
192.168.1.0 0.0.0.255 time-range work
[Device-acl-ipv4-adv-3000] quit
```

Create traffic class **tech_c**, and configure the match criterion as ACL 3000.

```
[Device] traffic classifier tech_c
```

```
[Device-classifier-tech_c] if-match acl 3000
[Device-classifier-tech_c] quit
```

Create traffic behavior **tech_b**, configure the action of mirroring traffic to GigabitEthernet 1/0/3.

```
[Device] traffic behavior tech_b
[Device-behavior-tech_b] mirror-to interface gigabitethernet 1/0/3
[Device-behavior-tech_b] quit
```

Create QoS policy **tech_p**, and associate traffic class **tech_c** with traffic behavior **tech_b** in the QoS policy.

```
[Device] qos policy tech_p
[Device-qospolicy-tech_p] classifier tech_c behavior tech_b
[Device-qospolicy-tech_p] quit
```

Apply QoS policy **tech_p** to the incoming packets of GigabitEthernet 1/0/4.

```
[Device] interface gigabitethernet 1/0/4
[Device-GigabitEthernet1/0/4] qos apply policy tech_p inbound
[Device-GigabitEthernet1/0/4] quit
```

Verifying the configuration

Verify that the server can monitor the following traffic:

- All traffic sent by the Technical Department to access the Internet.
- IP traffic that the Technical Department sends to the Marketing Department during working hours on weekdays.

(Details not shown.)

Contents

Configuring sFlow

About sFlow

sFlow is a traffic monitoring technology.

As shown in Figure 1, the sFlow system involves an sFlow agent embedded in a device and a remote sFlow collector. The sFlow agent collects interface counter information and packet information and encapsulates the sampled information in sFlow packets. When the sFlow packet buffer is full, or the aging timer (fixed to 1 second) expires, the sFlow agent performs the following actions:

- Encapsulates the sFlow packets in the UDP datagrams.
- Sends the UDP datagrams to the specified sFlow collector.

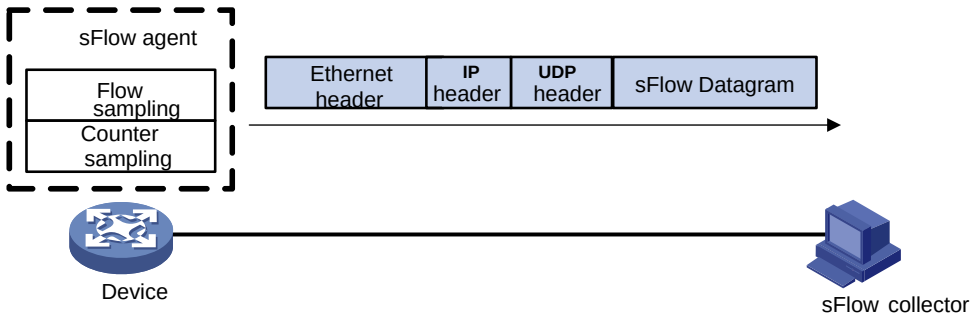
The sFlow collector analyzes the information and displays the results. One sFlow collector can monitor multiple sFlow agents.

sFlow provides the following sampling mechanisms:

- **Flow sampling**—Obtains packet information.
- **Counter sampling**—Obtains interface counter information.

sFlow can use flow sampling and counter sampling at the same time.

Figure 1 sFlow system



Protocols and standards

- RFC 3176, *InMon Corporation's sFlow: A Method for Monitoring Traffic in Switched and Routed Networks*
- sFlow.org, *sFlow Version 5*

Configuring basic sFlow information

Restrictions and guidelines

As a best practice, manually configure an IP address for the sFlow agent. The device periodically checks whether the sFlow agent has an IP address. If the sFlow agent does not have an IP address, the device automatically selects an IPv4 address for the sFlow agent but does not save the IPv4 address in the configuration file.

Only one IP address can be configured for the sFlow agent on the device, and a newly configured IP address overwrites the existing one.

Procedure

1. Enter system view.

   system-view

2. Configure an IP address for the sFlow agent.

   sflow agent { **ip** *ipv4-address* | **ipv6** *ipv6-address* }

   By default, no IP address is configured for the sFlow agent.

3. Configure the sFlow collector information.

   sflow collector *collector-id* { **ip** *ipv4-address* | **ipv6** *ipv6-address* } [**port** *port-number* | **datagram-size** *size* | **time-out** *seconds* | **description** *string*] *

   By default, no sFlow collector information is configured.

4. Specify the source IP address of sFlow packets.

   sflow source { **ip** *ipv4-address* | **ipv6** *ipv6-address* } *

   By default, the source IP address is determined by routing.

Configuring flow sampling

About flow sampling

Perform this task to configure flow sampling on an Ethernet interface. The sFlow agent performs the following tasks:

1. Samples packets on that interface according to the configured parameters.
2. Encapsulates the packets into sFlow packets.
3. Encapsulates the sFlow packets in the UDP packets and sends the UDP packets to the specified sFlow collector.

Procedure

1. Enter system view.

   system-view

2. Enter Layer 2 Ethernet interface view.

   interface *interface-type interface-number*

3. (Optional.) Set the flow sampling mode.

   sflow sampling-mode random

   By default, random sampling is used.

4. Enable flow sampling and specify the number of packets out of which flow sampling samples a packet on the interface.

   sflow sampling-rate *rate*

   By default, flow sampling is disabled.

   As a best practice, set the sampling interval to 2^n that is greater than or equal to 8192, for example, 32768.

5. (Optional.) Set the maximum number of bytes (starting from the packet header) that flow sampling can copy per packet.

   sflow flow max-header *length*

   The default setting is 128 bytes.

   As a best practice, use the default setting.

6. Specify the sFlow instance and sFlow collector for flow sampling.

   sflow flow [**instance** *instance-id*] **collector** *collector-id*

By default, no sFlow instance or sFlow collector is specified for flow sampling.

Configuring counter sampling

About flow sampling

Perform this task to configure counter sampling on an Ethernet interface. The sFlow agent performs the following tasks:

1. Periodically collects the counter information on that interface.
2. Encapsulates the counter information into sFlow packets.
3. Encapsulates the sFlow packets in the UDP packets and sends the UDP packets to the specified sFlow collector.

Procedure

1. Enter system view.
   `system-view`
2. Enter Layer 2 Ethernet interface view.
   `interface` *`interface-type interface-number`*
3. Enable counter sampling and set the counter sampling interval.
   `sflow counter interval` *`interval`*
   By default, counter sampling is disabled.
4. Specify the sFlow instance and sFlow collector for counter sampling.
   `sflow counter` [**`instance`** *`instance-id`*] **`collector`** *`collector-id`*
   By default, no sFlow instance or sFlow collector is specified for counter sampling.

Display and maintenance commands for sFlow

Execute **`display`** commands in any view.

Task	Command
Display sFlow configuration.	**`display sflow`**

sFlow configuration examples

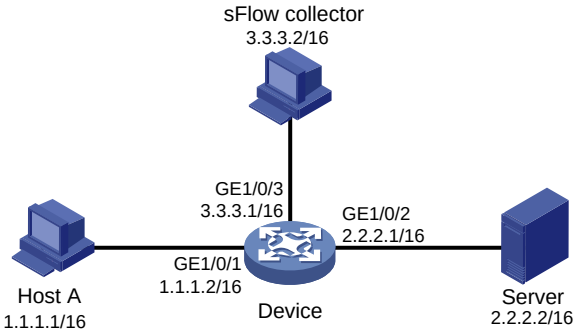
Example: Configuring sFlow

Network configuration

As shown in Figure 2, perform the following tasks:

- Configure flow sampling in random mode and counter sampling on GigabitEthernet 1/0/1 of the device to monitor traffic on the port.
- Configure the device to send sampled information in sFlow packets through GigabitEthernet 1/0/3 to the sFlow collector.

Figure 2 Network diagram



Procedure

1. Configure the IP addresses and subnet masks for interfaces, as shown in Figure 2. (Details not shown.)
2. Configure the sFlow agent and configure information about the sFlow collector:

   # Configure the IP address for the sFlow agent.

   ```
   <Device> system-view
   [Device] sflow agent ip 3.3.3.1
   ```

   # Configure information about the sFlow collector. Specify the sFlow collector ID as 1, IP address as 3.3.3.2, port number as 6343 (default), and description as **netserver**.

   ```
   [Device] sflow collector 1 ip 3.3.3.2 description netserver
   ```

3. Configure counter sampling:

   # Enable counter sampling and set the counter sampling interval to 120 seconds on GigabitEthernet 1/0/1.

   ```
   [Device] interface gigabitethernet 1/0/1
   [Device-GigabitEthernet1/0/1] sflow counter interval 120
   ```

   # Specify sFlow collector 1 for counter sampling.

   ```
   [Device-GigabitEthernet1/0/1] sflow counter collector 1
   ```

4. Configure flow sampling:

   # Enable flow sampling and set the flow sampling mode to random and sampling interval to 32768.

   ```
   [Device-GigabitEthernet1/0/1] sflow sampling-mode random
   [Device-GigabitEthernet1/0/1] sflow sampling-rate 32768
   ```

   # Specify sFlow collector 1 for flow sampling.

   ```
   [Device-GigabitEthernet1/0/1] sflow flow collector 1
   ```

Verifying the configuration

Verify the following items:

- GigabitEthernet 1/0/1 enabled with sFlow is active.
- The counter sampling interval is 120 seconds.
- The flow sampling interval is 4000 (one packet is sampled from every 4000 packets).

```
[Device-GigabitEthernet1/0/1] display sflow
sFlow datagram version: 5
Global information:
Agent IP: 3.3.3.1(CLI)
Source address:
Collector information:
```

```
ID    IP              Port  Aging      Size VPN-instance Description
1     3.3.3.2         6343  N/A        1400              netserver
Port counter sampling information:
Interface   Instance   CID   Interval(s)
GE1/0/1     1          1     120
Port flow sampling information:
Interface   Instance   FID   MaxHLen Rate       Mode      Status
GE1/0/1     1          1     128     32768      Random    Active
```

Troubleshooting sFlow

The remote sFlow collector cannot receive sFlow packets

Symptom

The remote sFlow collector cannot receive sFlow packets.

Analysis

The possible reasons include:

- The sFlow collector is not specified.
- sFlow is not configured on the interface.
- The IP address of the sFlow collector specified on the sFlow agent is different from that of the remote sFlow collector.
- The physical link between the device and the sFlow collector fails.
- The length of an sFlow packet is less than the sum of the following two values:
  - The length of the sFlow packet header.
  - The number of bytes that flow sampling can copy per packet.

Solution

To resolve the problem:

1. Use the **`display sflow`** command to verify that sFlow is correctly configured.
2. Verify that a correct IP address is configured for the device to communicate with the sFlow collector.
3. Verify that the physical link between the device and the sFlow collector is up.
4. Verify that the length of an sFlow packet is greater than the sum of the following two values:
   - The length of the sFlow packet header.
   - The number of bytes (as a best practice, use the default setting) that flow sampling can copy per packet.

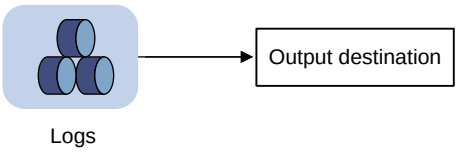
Contents

Configuring the information center

About the information center

The information center on the device receives logs generated by source modules and outputs logs to different destinations according to log output rules. Based on the logs, you can monitor device performance and troubleshoot network problems.

Figure 1 Information center diagram



Log types

Logs are classified into the following types:

- **Standard system logs**—Record common system information. Unless otherwise specified, the term "logs" in this document refers to standard system logs.
- **Diagnostic logs**—Record debug messages.
- **Security logs**—Record security information, such as authentication and authorization information.
- **Hidden logs**—Record log information not displayed on the terminal, such as input commands.
- **Trace logs**—Record system tracing and debug messages, which can be viewed only after the devkit package is installed.

Log levels

Logs are classified into eight severity levels from 0 through 7 in descending order. The information center outputs logs with a severity level that is higher than or equal to the specified level. For example, if you specify a severity level of 6 (informational), logs that have a severity level from 0 to 6 are output.

Table 1 Log levels

Severity value	Level	Description
0	Emergency	The system is unusable. For example, the system authorization has expired.
1	Alert	Action must be taken immediately. For example, traffic on an interface exceeds the upper limit.
2	Critical	Critical condition. For example, the device temperature exceeds the upper limit, the power module fails, or the fan tray fails.
3	Error	Error condition. For example, the link state changes.
4	Warning	Warning condition. For example, an interface is disconnected, or the memory resources are used up.
5	Notification	Normal but significant condition. For example, a terminal logs in to the device, or the device reboots.

Severity value	Level	Description
6	Informational	Informational message. For example, a command or a ping operation is executed.
7	Debugging	Debug message.

Log destinations

The system outputs logs to the following destinations: console, monitor terminal, log buffer, log host, and log file. Log output destinations are independent and you can configure them after enabling the information center. One log can be sent to multiple destinations.

Default output rules for logs

A log output rule specifies the source modules and severity level of logs that can be output to a destination. Logs matching the output rule are output to the destination. Table 2 shows the default log output rules.

Table 2 Default output rules

Destination	Log source modules	Output switch	Severity
Console	All supported modules	Enabled	Debugging
Monitor terminal	All supported modules	Disabled	Debugging
Log host	All supported modules	Enabled	Informational
Log buffer	All supported modules	Enabled	Informational
Log file	All supported modules	Enabled	Informational

Default output rules for diagnostic logs

Diagnostic logs can only be output to the diagnostic log file, and cannot be filtered by source modules and severity levels. Table 3 shows the default output rule for diagnostic logs.

Table 3 Default output rule for diagnostic logs

Destination	Log source modules	Output switch	Severity
Diagnostic log file	All supported modules	Enabled	Debugging

Default output rules for security logs

Security logs can only be output to the security log file, and cannot be filtered by source modules and severity levels. Table 4 shows the default output rule for security logs.

Table 4 Default output rule for security logs

Destination	Log source modules	Output switch	Severity
Security log file	All supported modules	Disabled	Debugging

Default output rules for hidden logs

Hidden logs can be output to the log host, the log buffer, and the log file. Table 5 shows the default output rules for hidden logs.

Table 5 Default output rules for hidden logs

Destination	Log source modules	Output switch	Severity
Log host	All supported modules	Enabled	Informational
Log buffer	All supported modules	Enabled	Informational
Log file	All supported modules	Enabled	Informational

Default output rules for trace logs

Trace logs can only be output to the trace log file, and cannot be filtered by source modules and severity levels. Table 6 shows the default output rules for trace logs.

Table 6 Default output rules for trace logs

Destination	Log source modules	Output switch	Severity
Trace log file	All supported modules	Enabled	Debugging

Log formats and field descriptions

Log formats

The format of logs varies by output destinations. Table 7 shows the original format of log information, which might be different from what you see. The actual format varies by the log resolution tool used.

Table 7 Log formats

Output destination	Format
Console, monitor terminal, log buffer, or log file	Prefix Timestamp Sysname Module/Level/Mnemonic: Content **Example**: %Nov 24 14:21:43:502 2016 Sysname SHELL/5/SHELL_LOGIN: VTY logged in from 192.168.1.26
Log host	• **Standard format**: <PRI>Timestamp Sysname %%vvModule/Level/Mnemonic: Source; Content **Example**: <190>Nov 24 16:22:21 2016 Sysname %%10 SHELL/5/SHELL_LOGIN: -DevIP=1.1.1.1; VTY logged in from 192.168.1.26<190>Nov 24 16:22:21 2016 Sysname %%10SHELL/5/SHELL_LOGIN: -DevIP=1.1.1.1; VTY logged in from 192.168.1.26 • **Unicom format**: <PRI>Timestamp Hostip vvModule/Level/Serial_number: Content **Example**: <189>Oct 13 16:48:08 2016 10.1.1.1 10SHELL/5/210231a64jx073000020: VTY logged in from 192.168.1.21 • **CMCC format**: <PRI>Timestamp Sysname %vvModule/Level/Mnemonic: Source; Content

	Example: <189>Oct 9 14:59:04 2016 Sysname %10SHELL/5/SHELL_LOGIN: -DevIP=1.1.1.1; VTY logged in from 192.168.1.21

Log field description

Table 8 Log field description

Field	Description
Prefix (information type)	A log to a destination other than the log host has an identifier in front of the timestamp: • An identifier of percent sign (%) indicates a log with a level equal to or higher than informational. • An identifier of asterisk (*) indicates a debug log or a trace log. • An identifier of caret (^) indicates a diagnostic log.
PRI (priority)	A log destined for the log host has a priority identifier in front of the timestamp. The priority is calculated by using this formula: facility*8+level, where: • **facility** is the facility name. Facility names local0 through local7 correspond to values 16 through 23. The facility name can be configured using the **info-center loghost** command. It is used to identify log sources on the log host, and to query and filter the logs from specific log sources. • **level** is in the range of 0 to 7. See Table 1 for more information about severity levels.
Timestamp	Records the time when the log was generated. Logs sent to the log host and those sent to the other destinations have different timestamp precisions, and their timestamp formats are configured with different commands. For more information, see Table 9 and Table 10.
Hostip	Source IP address of the log. If the **info-center loghost source** command is configured, this field displays the IP address of the specified source interface. Otherwise, this field displays the sysname. This field exists only in logs that are sent to the log host in unicom format.
Serial number	Serial number of the device that generated the log. This field exists only in logs that are sent to the log host in unicom format.
Sysname (host name or host IP address)	The sysname is the host name or IP address of the device that generated the log. You can use the **sysname** command to modify the name of the device.
%% (vendor ID)	Indicates that the information was generated by an H3C device. This field exists only in logs sent to the log host.
vv (version information)	Identifies the version of the log, and has a value of 10. This field exists only in logs that are sent to the log host.
Module	Specifies the name of the module that generated the log. You can enter the **info-center source ?** command in system view to view the module list.
Level	Identifies the level of the log. See Table 1 for more information about severity levels.
Mnemonic	Describes the content of the log. It contains a string of up to 32 characters.
Source	Optional field that identifies the log sender. This field exists only in logs that are sent to the log host in unicom or standard format. The field contains the following information: • **DevIp**—IP address of the log sender. • **Slot**—Member ID of the IRF member device that sent the log.
Content	Provides the content of the log.

Table 9 Timestamp precisions and configuration commands

Item	Destined for the log host	Destined for the console, monitor terminal, log buffer, and log file
Precision	Seconds (default) or milliseconds	Milliseconds
Command used to set the timestamp format	**info-center timestamp loghost**	**info-center timestamp**

Table 10 Description of the timestamp parameters

Timestamp parameters	Description
boot	Time that has elapsed since system startup, in the format of xxx.yyy. xxx represents the higher 32 bits, and yyy represents the lower 32 bits, of milliseconds elapsed. Logs that are sent to all destinations other than a log host support this parameter. **Example**: `%0.109391473 Sysname FTPD/5/FTPD_LOGIN: User ftp (192.168.1.23) has logged in successfully.` 0.109391473 is a timestamp in the **boot** format.
date	Current date and time. • For logs output to a log host, the timestamp can be in the format of MMM DD hh:mm:ss YYYY (accurate to seconds) or MMM DD hh:mm:ss.ms YYYY (accurate to milliseconds). • For logs output to other destinations, the timestamp is in the format of MMM DD hh:mm:ss:ms YYYY. All logs support this parameter. **Example**: `%May 30 05:36:29:579 2018 Sysname FTPD/5/FTPD_LOGIN: User ftp (192.168.1.23) has logged in successfully.` May 30 05:36:29:579 2018 is a timestamp in the **date** format in logs sent to the console.
iso	Timestamp format stipulated in ISO 8601, accurate to seconds (default) or milliseconds. Only logs that are sent to a log host support this parameter. **Example**: `<189>2018-05-30T06:42:44 Sysname %%10FTPD/5/FTPD_LOGIN: User ftp (192.168.1.23) has logged in successfully.` 2018-05-30T06:42:44 is a timestamp in the **iso** format accurate to seconds. A timestamp accurate to milliseconds is like 2018-05-30T06:42:44.708.
none	No timestamp is included. All logs support this parameter. **Example**: `% Sysname FTPD/5/FTPD_LOGIN: User ftp (192.168.1.23) has logged in successfully.` No timestamp is included.

Timestamp parameters	Description
no-year-date	Current date and time without year or millisecond information, in the format of MMM DD hh:mm:ss. Only logs that are sent to a log host support this parameter. **Example**: `<189>May 30 06:44:22 Sysname %%10FTPD/5/FTPD_LOGIN: User ftp (192.168.1.23) has logged in successfully.` May 30 06:44:22 is a timestamp in the **no-year-date** format.

FIPS compliance

The device supports the FIPS mode that complies with NIST FIPS 140-2 requirements. Support for features, commands, and parameters might differ in FIPS mode and non-FIPS mode. For more information about FIPS mode, see *Security Configuration Guide*.

Information center tasks at a glance

Managing standard system logs

1. Enabling the information center
2. Outputting logs to various destinations

   Choose the following tasks as needed:
   - Outputting logs to the console
   - Outputting logs to the monitor terminal
   - Outputting logs to log hosts
   - Outputting logs to the log buffer
   - Saving logs to the log file
3. (Optional.) Setting the minimum storage period for logs
4. (Optional.) Enabling synchronous information output
5. (Optional.) Configuring log suppression

   Choose the following tasks as needed:
   - Enabling duplicate log suppression
   - Configuring log suppression for a module
   - Disabling an interface from generating link up or link down logs
6. (Optional.) Enabling SNMP notifications for system logs

Managing hidden logs

1. Enabling the information center
2. Outputting logs to various destinations

   Choose the following tasks as needed:
   - Outputting logs to log hosts
   - Outputting logs to the log buffer
   - Saving logs to the log file
3. (Optional.) Setting the minimum storage period for logs

4. (Optional.) Configuring log suppression
   Choose the following tasks as needed:
   - Enabling duplicate log suppression
   - Configuring log suppression for a module

Managing security logs

1. Enabling the information center
2. (Optional.) Configuring log suppression
   Choose the following tasks as needed:
   - Enabling duplicate log suppression
   - Configuring log suppression for a module
3. Managing security logs
   - Saving security logs to the security log file
   - Managing the security log file

Managing diagnostic logs

1. Enabling the information center
2. (Optional.) Configuring log suppression
   Choose the following tasks as needed:
   - Enabling duplicate log suppression
   - Configuring log suppression for a module
3. Saving diagnostic logs to the diagnostic log file

Managing trace logs

1. Enabling the information center
2. (Optional.) Configuring log suppression
   Choose the following tasks as needed:
   - Enabling duplicate log suppression
   - Configuring log suppression for a module
3. Setting the maximum size of the trace log file

Enabling the information center

About enabling the information center

The information center can output logs only after it is enabled.

Procedure

1. Enter system view.
   `system-view`
2. Enable the information center.
   `info-center enable`
   The information center is enabled by default.

Outputting logs to various destinations

Outputting logs to the console

Restrictions and guidelines

The **terminal monitor**, **terminal debugging**, and **terminal logging** commands take effect only for the current connection between the terminal and the device. If a new connection is established, the default is restored.

Procedure

1. Enter system view.
   system-view
2. (Optional.) Configure an output rule for sending logs to the console.
   info-center source { *module-name* | **default** } **console** { **deny** | **level** *severity* }
   For information about the default output rules, see "Default output rules for logs."
3. (Optional.) Configure the timestamp format.
   info-center timestamp { **boot** | **date** | **none** }
   The default timestamp format is **date**.
4. Return to user view.
   quit
5. Enable log output to the console.
   terminal monitor
   By default, log output to the console is enabled.
6. Enable the display of debug information on the current terminal.
   terminal debugging
   By default, the display of debug information on the current terminal is disabled .
7. Set the lowest severity level of logs that can be output to the console.
   terminal logging level *severity*
   The default setting is 6 (informational).

Outputting logs to the monitor terminal

About monitor terminals

Monitor terminals refer to terminals that log in to the device through the AUX, VTY, or TTY line.

Restrictions and guidelines

The **terminal monitor**, **terminal debugging**, and **terminal logging** commands take effect only for the current connection between the terminal and the device. If a new connection is established, the default is restored.

Procedure

1. Enter system view.
   system-view
2. (Optional.) Configure an output rule for sending logs to the monitor terminal.
   info-center source { *module-name* | **default** } **monitor** { **deny** | **level** *severity* }

For information about the default output rules, see "Default output rules for logs."

3. (Optional.) Configure the timestamp format.

   info-center timestamp { **boot** | **date** | **none** }

   The default timestamp format is **date**.

4. Return to user view.

   quit

5. Enable log output to the monitor terminal.

   terminal monitor

   By default, log output to the monitor terminal is disabled.

6. Enable the display of debug information on the current terminal.

   terminal debugging

   By default, the display of debug information on the current terminal is disabled.

7. Set the lowest level of logs that can be output to the monitor terminal.

   terminal logging level *severity*

   The default setting is 6 (informational).

Outputting logs to log hosts

Restrictions and guidelines

The device supports the following methods (in descending order of priority) for outputting logs of a module to designated log hosts:

- Fast log output.

  For information about the modules that support fast log output and how to configure fast log output, see "Configuring fast log output."

- Flow log.

  For information about the modules that support flow log output and how to configure flow log output, see "Configuring flow log."

- Information center.

If you configure multiple log output methods for a module, only the method with the highest priority takes effect.

Procedure

1. Enter system view.

   system-view

2. (Optional.) Configure a log output filter or a log output rule. Choose one option as needed:

   - Configure a log output filter.

     info-center filter *filter-name* { *module-name* | **default** } { **deny** | **level** *severity* }

     You can create multiple log output filters. When specifying a log host, you can apply a log output filter to the log host to control log output.

   - Configure a log output rule for the log host output destination.

     info-center source { *module-name* | **default** } **loghost** { **deny** | **level** *severity* }

     For information about the default log output rules for the log host output destination, see "Default output rules for logs."

   The system chooses the settings to control log output to a log host in the following order:

a. Log output filter applied to the log host by using the **info-center loghost** command.
b. Log output rules configured for the log host output destination by using the **info-center source** command.
c. Default log output rules (see "Default output rules for logs").

3. (Optional.) Specify a source IP address for logs sent to log hosts.

   info-center loghost source *interface-type interface-number*

   By default, the source IP address of logs sent to log hosts is the primary IP address of their outgoing interfaces.

4. (Optional.) Specify the format in which logs are output to log hosts.

   info-center format { **unicom** | **cmcc** }

   By default, logs are output to log hosts in standard format.

5. (Optional.) Configure the timestamp format.

   info-center timestamp loghost { **date** [**with-milliseconds**] | **iso** [**with-milliseconds** | **with-timezone**] * | **no-year-date** | **none** }

   The default timestamp format is **date**.

6. Specify a log host and configure related parameters.

   info-center loghost { *hostname* | *ipv4-address* | **ipv6** *ipv6-address* } [**port** *port-number*] [**dscp** *dscp-value*] [**facility** *local-number*] [**filter** *filter-name*]

   By default, no log hosts or related parameters are specified.

   The value for the *port-number* argument must be the same as the value configured on the log host. Otherwise, the log host cannot receive logs.

Outputting logs to the log buffer

1. Enter system view.

   system-view

2. (Optional.) Configure an output rule for sending logs to the log buffer.

   info-center source { *module-name* | **default** } **logbuffer** { **deny** | **level** *severity* }

   For information about the default output rules, see "Default output rules for logs."

3. (Optional.) Configure the timestamp format.

   info-center timestamp { **boot** | **date** | **none** }

   The default timestamp format is **date**.

4. Enable log output to the log buffer.

   info-center logbuffer

   By default, log output to the log buffer is enabled.

5. (Optional.) Set the maximum log buffer size.

   info-center logbuffer size *buffersize*

   By default, a maximum of 512 logs can be buffered.

Saving logs to the log file

About log saving to the log file

By default, the log file feature saves logs from the log file buffer to the log file at the specified saving interval. You can also manually trigger an immediate saving of buffered logs to the log file. After saving logs to the log file, the system clears the log file buffer.

The log file is automatically created when needed and has a maximum capacity. When no log file space or storage device space is available, the system will replace the oldest logs with new logs.

You can enable log file overwrite-protection to stop the device from saving new logs when no log file space or storage device space is available.

TIP:

Clean up the storage space of the device regularly to ensure sufficient storage space for the log file feature.

Procedure

1. Enter system view.
   system-view
2. (Optional.) Configure an output rule for sending logs to the log file.
   info-center source { *module-name* | **default** } **logfile** { **deny** | **level** *severity* }
   For information about the default output rules, see "Default output rules for logs."
3. Enable the log file feature.
   info-center logfile enable
   By default, the log file feature is enabled.
4. (Optional.) Enable log file overwrite-protection.
   info-center logfile overwrite-protection [**all-port-powerdown**]
   By default, log file overwrite-protection is disabled.
   Log file overwrite-protection is supported only in FIPS mode.
5. (Optional.) Set the maximum log file size.
   info-center logfile size-quota *size*
   The default maximum log file size is 10 MB.
6. (Optional.) Specify the log file directory.
   info-center logfile directory *dir-name*
   The default log file directory is **flash:/logfile**.
   This command cannot survive an IRF reboot or a master/subordinate switchover.
7. Save logs in the log file buffer to the log file. Choose one option as needed:
   - Configure the automatic log file saving interval.
     info-center logfile frequency *freq-sec*
     The default saving interval is 86400 seconds.
   - Manually save logs in the log file buffer to the log file.
     logfile save
     This command is available in any view.

Setting the minimum storage period for logs

About setting the log minimum storage period

Use this feature to set the minimum storage period for logs in the log buffer and log file. This feature ensures that logs will not be overwritten by new logs during a set period of time.

By default, when the log buffer or log file is full, new logs will automatically overwrite the oldest logs. After the minimum storage period is set, the system identifies the storage period of a log to determine whether to delete the log. The system current time minus a log's generation time is the log's storage period.

- If the storage period of a log is shorter than or equal to the minimum storage period, the system does not delete the log. The new log will not be saved.
- If the storage period of a log is longer than the minimum storage period, the system deletes the log to save the new log.

Procedure

1. Enter system view.
   `system-view`
2. Set the log minimum storage period.
   `info-center syslog min-age` *`min-age`*
   By default, the log minimum storage period is not set.

Enabling synchronous information output

About synchronous information output

System log output interrupts ongoing configuration operations, obscuring previously entered commands. Synchronous information output shows the obscured commands. It also provides a command prompt in command editing mode, or a `[Y/N]` string in interaction mode so you can continue your operation from where you were stopped.

Procedure

1. Enter system view.
   `system-view`
2. Enable synchronous information output.
   `info-center synchronous`
   By default, synchronous information output is disabled.

Configuring log suppression

Enabling duplicate log suppression

About duplicate log suppression

The information center on the device outputs logs generated by service modules. The device identifies logs that have the same module name, level, mnemonic, location, and text as duplicate logs.

In some scenarios, for example, ARP attack or link failure, the service modules will generate a large volume of duplicate logs during a short period of time. Recording and output of consecutive duplicate

logs wastes system and network resources. To resolve this issue, you can enable duplicate log suppression.

With this feature enabled, when a service module generates a log, the information center outputs the log and starts the duplicate log suppression timer. The suppression period of the duplicate log suppression timer is incremental in phases. The suppression periods in phase 1, 2, and later phases are 30 seconds, 2 minutes, and 10 minutes, respectively.

After you enable duplicate log suppression, the system starts suppression upon outputting a log:

- If only duplicate logs of the log are received during the suppression period of a phase, the information center does not output the duplicate logs. When the suppression period of the phase expires, the information center outputs the suppressed log and the number of times the log is suppressed, and starts the next suppression phase.
- If a different log is received during the suppression period of a phase, the information center performs the following operations:
  - Stops suppression on the log, and outputs the suppressed log and the number of times the log is suppressed.
  - Outputs the different log and starts phase-1 suppression for that log.
- If no log is received within the suppression period of any phase, the information center stops suppression on the log and does not output any log.

Procedure

1. Enter system view.

   `system-view`

2. Enable duplicate log suppression.

   `info-center logging suppress duplicates`

   By default, duplicate log suppression is disabled.

Examples

The following example uses SHELL_CMD logs to verify the duplicate log suppression feature. After the user executes a command on the device, the information center receives a SHELL_CMD log generated by the shell module, encapsulates the log, and then outputs the log to the log buffer.

1. Verify the suppression effect in phases 1, 2, 3, and 4 of a log (with suppression period of 30 seconds, 2 minutes, 10 minutes, and 10 minutes):

   # In a lab environment, continuously execute the **`display logbuffer`** command for 25 minutes.

   # View the output logs in the log buffer.

```
<Sysname> display logbuffer
Log buffer: Enabled
Max buffer size: 1024
Actual buffer size: 512
Dropped messages: 0
Overwritten messages: 0
Current messages: 5
%Jul 20 13:01:20:615 2022 Sysname SHELL/6/SHELL_CMD: -Line=con0-IPAddr=**-User=**;
Command is display logbuffer
%Jul 20 13:01:50:718 2022 Sysname SHELL/6/SHELL_CMD: -Line=con0-IPAddr=**-User=**;
Command is display logbuffer This message repeated 2 times in last 30 seconds.
%Jul 20 13:03:50:732 2022 Sysname SHELL/6/SHELL_CMD: -Line=con0-IPAddr=**-User=**;
Command is display logbuffer This message repeated 5 times in last 2 minutes.
%Jul 20 13:13:50:830 2022 Sysname SHELL/6/SHELL_CMD: -Line=con0-IPAddr=**-User=**;
Command is display logbuffer This message repeated 10 times in last 10 minutes.
```

```
%Jul 20 13:23:50:211 2022 Sysname SHELL/6/SHELL_CMD: -Line=con0-IPAddr=**-User=**;
Command is display logbuffer This message repeated 6 times in last 10 minutes.
```

The output shows the following information:

- The information center received the log **SHELL/6/SHELL_CMD: -Line=con0-IPAddr=**-User=**; Command is display logbuffer**.
- In phase 1, the log was suppressed twice by the information center.
- In phase 2, the log was suppressed five times by the information center.
- In phase 3, the log was suppressed 10 times by the information center.

2. Continue to verify how duplicate log suppression works when a different log is received during the suppression period of a log:

Execute the **`display logbuffer`** command three times, and then execute the **`display interface brief`** command.

View the output logs in the log buffer.

```
<Sysname> display logbuffer
Log buffer: Enabled
Max buffer size: 1024
Actual buffer size: 512
Dropped messages: 0
Overwritten messages: 0
Current messages: 5
%Jul 20 13:01:20:615 2022 Sysname SHELL/6/SHELL_CMD: -Line=con0-IPAddr=**-User=**;
Command is display logbuffer
%Jul 20 13:01:50:718 2022 Sysname SHELL/6/SHELL_CMD: -Line=con0-IPAddr=**-User=**;
Command is display logbuffer This message repeated 2 times in last 30 seconds.
%Jul 20 13:03:50:732 2022 Sysname SHELL/6/SHELL_CMD: -Line=con0-IPAddr=**-User=**;
Command is display logbuffer This message repeated 5 times in last 2 minutes.
%Jul 20 13:13:50:830 2022 Sysname SHELL/6/SHELL_CMD: -Line=con0-IPAddr=**-User=**;
Command is display logbuffer This message repeated 10 times in last 10 minutes.
%Jul 20 13:23:50:211 2022 Sysname SHELL/6/SHELL_CMD: -Line=con0-IPAddr=**-User=**;
Command is display logbuffer This message repeated 6 times in last 10 minutes.
%Jul 20 13:24:56:205 2022 Sysname SHELL/6/SHELL_CMD: -Line=con0-IPAddr=**-User=**;
Command is display logbuffer This message repeated 3 times in last 1 minute 6 seconds.
%Jul 20 13:25:41:205 2022 Sysname SHELL/6/SHELL_CMD: -Line=con0-IPAddr=**-User=**;
Command is display interface brief.
<Sysname>
```

The output shows the following information:

- The information center stopped suppression for the log **SHELL/6/SHELL_CMD: -Line=con0-IPAddr=**-User=**; Command is display logbuffer**.
- The information center output the log **SHELL/6/SHELL_CMD: -Line=con0-IPAddr=**-User=**; Command is display interface brief**, and started suppression for it.

Configuring log suppression for a module

About log suppression for a module

This feature suppresses output of logs. You can use this feature to filter out the logs that you are not concerned with.

Perform this task to configure a log suppression rule to suppress output of all logs or logs with a specific mnemonic value for a module.

Procedure

1. Enter system view.
   system-view
2. Configure a log suppression rule for a module.
   info-center logging suppress module *module-name* **mnemonic** { **all** | *mnemonic-value* }
   By default, the device does not suppress output of any logs from any modules.

Disabling an interface from generating link up or link down logs

About disabling an interface from generating link up or link down logs

By default, an interface generates link up or link down log information when the interface state changes. In some cases, you might want to disable certain interfaces from generating this information. For example:

- You are concerned about the states of only some interfaces. In this case, you can use this function to disable other interfaces from generating link up and link down log information.
- An interface is unstable and continuously outputs log information. In this case, you can disable the interface from generating link up and link down log information.

Use the default setting in normal cases to avoid affecting interface status monitoring.

Procedure

1. Enter system view.
   system-view
2. Enter interface view.
   interface *interface-type interface-number*
3. Disable the interface from generating link up or link down logs.
   undo enable log updown
   By default, an interface generates link up and link down logs when the interface state changes.

Enabling SNMP notifications for system logs

About enabling SNMP notifications for system logs

This feature enables the device to send an SNMP notification for each log message it outputs. The device encapsulates the logs in SNMP notifications and then sends them to the SNMP module and the log trap buffer.

You can configure the SNMP module to send received SNMP notifications in SNMP traps or informs to remote hosts. For more information, see "Configuring SNMP."

To view the traps in the log trap buffer, access the MIB corresponding to the log trap buffer.

Procedure

1. Enter system view.
   system-view
2. Enable SNMP notifications for system logs.
   snmp-agent trap enable syslog
   By default, the device does not send SNMP notifications for system logs.

3. Set the maximum number of traps that can be stored in the log trap buffer.
   info-center syslog trap buffersize *buffersize*
   By default, the log trap buffer can store a maximum of 1024 traps.

Managing security logs

Saving security logs to the security log file

About security log management

Security logs are very important for locating and troubleshooting network problems. Generally, security logs are output together with other logs. It is difficult to identify security logs among all logs.

To solve this problem, you can save security logs to the security log file without affecting the current log output rules.

After you enable the security log file feature, the system processes security logs as follows:

1. Outputs security logs to the security log file buffer.
2. Saves logs from the security log file buffer to the security log file at the specified interval.
   If you have the security-audit role, you can also manually save security logs to the security log file.
3. Clears the security log file buffer immediately after the security logs are saved to the security log file.

Restrictions and guidelines

The device supports only one security log file. The system will overwrite old logs with new logs when the security log file is full. To avoid security log loss, you can set an alarm threshold for the security log file usage ratio. When the alarm threshold is reached, the system outputs a message to inform you of the alarm. You can log in to the device with the security-audit user role and back up the security log file to prevent the loss of important data.

Procedure

1. Enter system view.
   system-view
2. Enable the security log file feature.
   info-center security-logfile enable
   By default, the security log file feature is disabled.
3. Set the interval at which the system saves security logs.
   info-center security-logfile frequency *freq-sec*
   The default security log file saving interval is 86400 seconds.
4. (Optional.) Set the maximum size for the security log file.
   info-center security-logfile size-quota *size*
   The default maximum security log file size is 10 MB.
5. (Optional.) Set the alarm threshold of the security log file usage.
   info-center security-logfile alarm-threshold *usage*
   By default, the alarm threshold of the security log file usage ratio is 80. When the usage of the security log file reaches 80%, the system will send a message.

Managing the security log file

Restrictions and guidelines

To use the security log file management commands, you must have the security-audit user role. For information about configuring the security-audit user role, see AAA in *Security Configuration Guide*.

Procedure

1. Enter system view.
   system-view
2. Change the directory of the security log file.
   info-center security-logfile directory *dir-name*
   By default, the security log file is saved in the **seclog** directory in the root directory of the storage device.
   This command cannot survive an IRF reboot or a master/subordinate switchover.
3. Manually save all logs in the security log file buffer to the security log file.
   security-logfile save
   This command is available in any view.
4. (Optional.) Display the summary of the security log file.
   display security-logfile summary
   This command is available in any view.

Saving diagnostic logs to the diagnostic log file

About diagnostic log saving

By default, the diagnostic log file feature saves diagnostic logs from the diagnostic log file buffer to the diagnostic log file at the specified saving interval. You can also manually trigger an immediate saving of diagnostic logs to the diagnostic log file. After saving diagnostic logs to the diagnostic log file, the system clears the diagnostic log file buffer.

The device supports only one diagnostic log file. The diagnostic log file has a maximum capacity. When the capacity is reached, the system replaces the oldest diagnostic logs with new logs.

Procedure

1. Enter system view.
   system-view
2. Enable the diagnostic log file feature.
   info-center diagnostic-logfile enable
   By default, the diagnostic log file feature is enabled.
3. (Optional.) Set the maximum diagnostic log file size.
   info-center diagnostic-logfile quota *size*
   By default, the maximum diagnostic log file size is 10 MB.
4. (Optional.) Specify the diagnostic log file directory.
   info-center diagnostic-logfile directory *dir-name*
   The default diagnostic log file directory is **flash:/diagfile**.
   This command cannot survive an IRF reboot or a master/subordinate switchover.
5. Save diagnostic logs in the diagnostic log file buffer to the diagnostic log file. Choose one option as needed:

- Configure the automatic diagnostic log file saving interval.
  info-center diagnostic-logfile frequency *freq-sec*
  The default saving interval is 86400 seconds.
- Manually save diagnostic logs to the diagnostic log file.
  diagnostic-logfile save
  This command is available in any view.

Setting the maximum size of the trace log file

About setting the maximum size of the trace log file

The device has only one trace log file. When the trace log file is full, the device overwrites the oldest trace logs with new ones.

Procedure

1. Enter system view.
   system-view
2. Set the maximum size for the trace log file.
   info-center trace-logfile quota *size*
   The default maximum size of the trace log file is 1 MB.

Display and maintenance commands for information center

Execute **display** commands in any view and **reset** commands in user view.

Task	Command
Display the diagnostic log file configuration.	**display diagnostic-logfile summary**
Display the information center configuration.	**display info-center**
Display information about log output filters.	**display info-center filter** [*filter-name*]
Display log buffer information and buffered logs.	**display logbuffer** [**reverse**] [**level** *severity* | **size** *buffersize* | **slot** *slot-number*] * [**last-mins** *mins*]
Display the log buffer summary.	**display logbuffer summary** [**level** *severity* | **slot** *slot-number*] *
Display the content of the log file buffer.	**display logfile buffer**
Display the log file configuration.	**display logfile summary**
Display the content of the security log file buffer. (To execute this command, you must have the security-audit user role.)	**display security-logfile buffer**

Task	Command
Display summary information of the security log file. (To execute this command, you must have the security-audit user role.)	**display security-logfile summary**
Clear the log buffer.	**reset logbuffer**

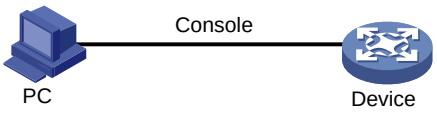
Information center configuration examples

Example: Outputting logs to the console

Network configuration

Configure the device to output to the console FTP logs that have a minimum severity level of **warning**.

Figure 2 Network diagram



Procedure

Enable the information center.

```
<Device> system-view
[Device] info-center enable
```

Disable log output to the console.

```
[Device] info-center source default console deny
```

To avoid output of unnecessary information, disable all modules from outputting log information to the specified destination (**console** in this example) before you configure the output rule.

Configure an output rule to output to the console FTP logs that have a minimum severity level of **warning**.

```
[Device] info-center source ftp console level warning
[Device] quit
```

Enable the display of logs on the console. (This function is enabled by default.)

```
<Device> terminal logging level 6
<Device> terminal monitor
The current terminal is enabled to display logs.
```

Now, if the FTP module generates logs, the information center automatically sends the logs to the console, and the console displays the logs.

Example: Outputting logs to a UNIX log host

Network configuration

Configure the device to output to the UNIX log host FTP logs that have a minimum severity level of **informational**.

Figure 3 Network diagram

Procedure

1. Make sure the device and the log host can reach each other. (Details not shown.)
2. Configure the device:

   # Enable the information center.

   ```
   <Device> system-view
   [Device] info-center enable
   ```

   # Specify log host 1.2.0.1/16 with **local4** as the logging facility.

   ```
   [Device] info-center loghost 1.2.0.1 facility local4
   ```

   # Disable log output to the log host.

   ```
   [Device] info-center source default loghost deny
   ```

   To avoid output of unnecessary information, disable all modules from outputting logs to the specified destination (**loghost** in this example) before you configure an output rule.

   # Configure an output rule to output to the log host FTP logs that have a minimum severity level of **informational**.

   ```
   [Device] info-center source ftp loghost level informational
   ```

3. Configure the log host:

   The log host configuration procedure varies by the vendor of the UNIX operating system. The following shows an example:

   a. Log in to the log host as a root user.

   b. Create a subdirectory named **Device** in directory **/var/log/**, and then create file **info.log** in the **Device** directory to save logs from the device.

      ```
      # mkdir /var/log/Device
      # touch /var/log/Device/info.log
      ```

   c. Edit file **syslog.conf** in directory **/etc/** and add the following contents:

      ```
      # Device configuration messages
      local4.info /var/log/Device/info.log
      ```

      In this configuration, **local4** is the name of the logging facility that the log host uses to receive logs. The value **info** indicates the **informational** severity level. The UNIX system records the log information that has a minimum severity level of **informational** to file **/var/log/Device/info.log**.

      NOTE:

      Follow these guidelines while editing file **/etc/syslog.conf**:

      - Comments must be on a separate line and must begin with a pound sign (#).
      - No redundant spaces are allowed after the file name.
      - The logging facility name and the severity level specified in the **/etc/syslog.conf** file must be identical to those configured on the device by using the **`info-center loghost`** and **`info-center source`** commands. Otherwise, the log information might not be output to the log host correctly.

   d. Display the process ID of **syslogd**, kill the **syslogd** process, and then restart **syslogd** by using the **–r** option to validate the configuration.

      ```
      # ps -ae | grep syslogd
      ```

```
147
# kill -HUP 147
# syslogd -r &
```

Now, the device can output FTP logs to the log host, which stores the logs to the specified file.

Example: Outputting logs to a Linux log host

Network configuration

Configure the device to output to the Linux log host 1.2.0.1/16 FTP logs that have a minimum severity level of **informational**.

Figure 4 Network diagram

Procedure

1. Make sure the device and the log host can reach each other. (Details not shown.)
2. Configure the device:

   # Enable the information center.

   ```
   <Device> system-view
   [Device] info-center enable
   ```

   # Specify log host 1.2.0.1/16 with **local5** as the logging facility.

   ```
   [Device] info-center loghost 1.2.0.1 facility local5
   ```

   # Disable log output to the log host.

   ```
   [Device] info-center source default loghost deny
   ```

   To avoid outputting unnecessary information, disable all modules from outputting log information to the specified destination (**loghost** in this example) before you configure an output rule.

   # Configure an output rule to enable output to the log host FTP logs that have a minimum severity level of **informational**.

   ```
   [Device] info-center source ftp loghost level informational
   ```

3. Configure the log host:

   The log host configuration procedure varies by the vendor of the Linux operating system. The following shows an example:

   a. Log in to the log host as a root user.

   b. Create a subdirectory named **Device** in directory **/var/log/**, and create file **info.log** in the **Device** directory to save logs from the device.

      ```
      # mkdir /var/log/Device
      # touch /var/log/Device/info.log
      ```

   c. Edit file **syslog.conf** in directory **/etc/** and add the following contents:

      ```
      # Device configuration messages
      local5.info /var/log/Device/info.log
      ```

      In this configuration, **local5** is the name of the logging facility that the log host uses to receive logs. The value **info** indicates the **informational** severity level. The Linux system will store the log information with a severity level equal to or higher than **informational** to file **/var/log/Device/info.log**.

NOTE:

Follow these guidelines while editing file **/etc/syslog.conf**:

- Comments must be on a separate line and must begin with a pound sign (#).
- No redundant spaces are allowed after the file name.
- The logging facility name and the severity level specified in the **/etc/syslog.conf** file must be identical to those configured on the device by using the **info-center loghost** and **info-center source** commands. Otherwise, the log information might not be output to the log host correctly.

d. Display the process ID of **syslogd**, kill the **syslogd** process, and then restart **syslogd** by using the **-r** option to validate the configuration.

Make sure the **syslogd** process is started with the **-r** option on the Linux log host.

```
# ps -ae | grep syslogd
147
# kill -9 147
# syslogd -r &
```

Now, the device can output FTP logs to the log host, which stores the logs to the specified file.

Contents

Configuring VCF fabric

About VCF fabric

Based on OpenStack Networking, the Virtual Converged Framework (VCF) solution provides virtual network services from Layer 2 to Layer 7 for cloud tenants. This solution breaks the boundaries between the network, cloud management, and terminal platforms and transforms the IT infrastructure to a converged framework to accommodate all applications. It also implements automated topology discovery and automated deployment of underlay networks to reduce the administrators' workload and speed up network deployment and upgrade.

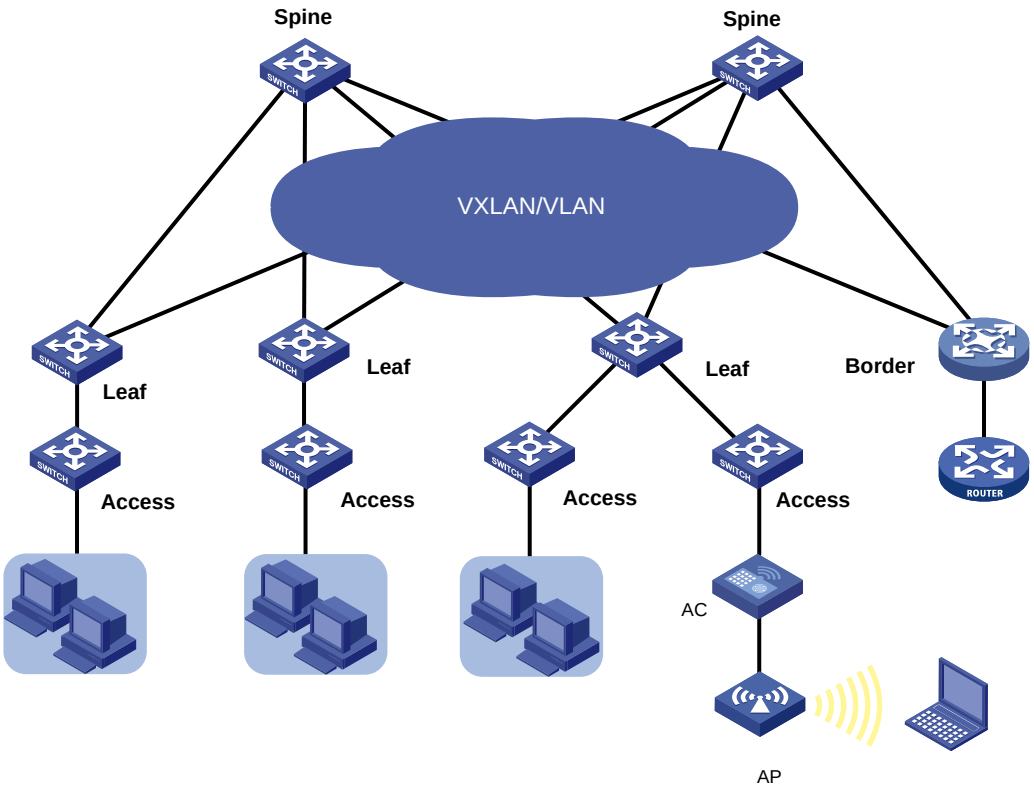
VCF fabric topology

In a campus VCF fabric, a device has one of the following roles:

- **Spine node**—Connects to leaf nodes.
- **Leaf node**—Connects to access nodes.
- **Access node**—Connects to an upstream leaf node and downstream terminal devices. Cascading of access nodes is supported.
- **Border node**—Located at the border of a VCF fabric to provide access to the external network.

Spine nodes and leaf nodes form a large Layer 2 network, which can be a VLAN, a VXLAN with a centralized IP gateway, or a VXLAN with distributed IP gateways.

Figure 1 VCF fabric topology for a campus network



Automated VCF fabric deployment

VCF provides the following features to ease deployment:

- Automated topology discovery.

  In a VCF fabric, each device uses LLDP to collect local topology information from directly-connected peer devices. The local topology information includes connection interfaces, roles, MAC addresses, and management interface addresses of the peer devices.

- Automated underlay network deployment.

  Automated underlay network deployment sets up a Layer 3 underlay network (a physical Layer 3 network) for users. It is implemented by automatically executing configurations (such as IRF configuration and Layer 3 reachability configurations) in user-defined template files.

Process of automated VCF fabric deployment

The device finishes automated VCF fabric deployment as follows:

1. Starts up without loading configuration and then obtains an IP address, the IP address of the TFTP server, and a template file name from the DHCP server.
2. Determines the name of the template file to be downloaded based on the device role and the template file name obtained from the DHCP server. For example, 1_access**.template** represents a template file for access nodes.
3. Downloads the template file from the TFTP server.
4. Parses the template file and performs the following operations:
   - Deploys static configurations that are independent from the VCF fabric topology.
   - Deploys dynamic configurations according to the VCF fabric topology.

     The topology process notifies the automation process of creation, deletion, and status change of neighbors. Based on the topology information, the automation process completes role discovery, automatic aggregation, and IRF fabric setup.

Template file

A template file contains the following contents:

- **System-predefined variables**—The variable names cannot be edited, and the variable values are set by the VCF topology discovery feature.
- **User-defined variables**—The variable names and values are defined by the user. These variables include the username and password, network type, and so on. The following are examples of user-defined variables:
  - IPv4:

    ```
    #USERDEF
    _username = aaa
    _password = 123
    _rbacUserRole = network-admin
    _loghost_ip = 110.0.0.111
    _ntp_server = 110.0.0.111
    …
    ```

  - IPv6:

    ```
    #USERDEF
    _username = aaa
    _password = hello12345
    _rbacUserRole = network-admin
    ```

```
_loghost_ip = 200:0:0:0:0:0:0:210
_network_type = distributed-vxlan
_OOB = True
_lagg_enable = false
_lagg_mode = dynamic
…
```

- **Static configurations**—Static configurations are independent from the VCF fabric topology and can be directly executed. The following are examples of static configurations:

```
#STATICCFG
#
 clock timezone beijing add 08:00:00
#
 lldp global enable
#
 stp global enable
#
```

- **Dynamic configurations**—Dynamic configurations are dependent on the VCF fabric topology. The device first obtains the topology information through LLDP and then executes dynamic configurations. The following are examples of dynamic configurations:

```
#
interface $$_underlayIntfUp
 port link-type trunk
 port trunk permit vlan all
#
interface $$_underlayIntfDown
 port link-type trunk
 port trunk pvid vlan 4093
 port trunk permit vlan all
#
```

Restrictions: Hardware compatibility with VCF fabric

The following switch series do not support VCF fabric:

- S5110V2-SI
- S5000V3-EI
- S5000V5-EI
- S5000E-X
- S5000X-EI
- S5120V2-LI
- S5130S-LI
- S3100V3-SI
- S5120V3-LI
- S5120V3-SI
- MS4320V2, MS4320, MS4200, MS4300V2, MS4320V3
- WS5810-WiNet, WS5820-WiNet
- WAS6000

VCF fabric task at a glance

To configure a VCF fabric, perform the following tasks:

- Configuring automated VCF fabric deployment

  No tasks are required to be made on the device for automated VCF fabric deployment. However, you must make related configuration on the DHCP server and the TFTP server so the device can download and parse a template file to complete automated VCF fabric deployment.

- (Optional.) Adjust VCF fabric deployment

  If the device cannot obtain or parse the template file to complete automated VCF fabric deployment, choose the following tasks as needed:

  - Enabling VCF fabric topology discovery
  - Configuring automated underlay network deployment

Configuring automated VCF fabric deployment

Restrictions and guidelines

On a campus network, links between two access nodes cascaded through GigabitEthernet interfaces and links between leaf nodes and access nodes are automatically aggregated. For links between spine nodes and leaf nodes, the **`trunk permit vlan`** command is automatically executed.

Do not perform link migration when devices in the VCF fabric are in the process of coming online or powering down after the automated VCF fabric deployment finishes. A violation might cause link-related configuration fails to update.

The version format of a template file for automated VCF fabric deployment is *x*.*y*. Only the *x* part is examined during a version compatibility check. For successful automated deployment, make sure *x* in the version of the template file to be used is not greater than *x* in the supported version. To display the supported version of the template file for automated VCF fabric deployment, use the **`display vcf-fabric underlay template-version`** command.

If the template file does not include IRF configurations, the device does not save the configurations after executing all configurations in the template file. To save the configurations, use the **`save`** command.

Two devices with the same role can automatically set up an IRF fabric only when the IRF physical interfaces on the devices are connected.

Two IRF member devices in an IRF fabric use the following rules to elect the IRF master during automated VCF fabric deployment:

- If the uptime of both devices is shorter than two hours, the device with the higher bridge MAC address becomes the IRF master.
- If the uptime of one device is equal to or longer than two hours, that device becomes the IRF master.
- If the uptime of both devices are equal to or longer than two hours, the IRF fabric cannot be set up. You must manually reboot one of the member devices. The rebooted device will become the IRF subordinate.

If the IRF member ID of a device is not 1, the IRF master might reboot during automatic IRF fabric setup.

Procedure

1. Finish the underlay network planning (such as IP address assignment, reliability design, and routing deployment) based on user requirements.

2. Configure the DHCP server.

   Configure the IP address of the device, the IP address of the TFTP server, and names of template files saved on the TFTP server. For more information, see the user manual of the DHCP server.

3. Configure the TFTP server.

   Create template files and save the template files to the TFTP server.

   The H3C DR1000 ADCAM network management software can automatically create template files and save the files to the TFTP server. If no H3C DR1000 ADDC or ADCAM is available on the network, you must manually create template files and save the files to the TFTP server. For more information about template files, see "Template file."

4. (Optional.) Configure the NTP server.

5. Connect the device to the VCF fabric and start the device.

   After startup, the device uses VLAN-interface 1 to connect to the fabric management network. Then, it downloads the template file corresponding to its device role and parses the template file to complete automated VCF fabric deployment.

6. (Optional.) Save the deployed configuration.

   If the template file does not include IRF configurations, the device will not save the configurations after executing all configurations in the template file. To save the configurations, use the **save** command. For more information about this command, see configuration file management commands in *Fundamentals Command Reference*.

Enabling VCF fabric topology discovery

1. Enter system view.

   system-view

2. Enable LLDP globally.

   lldp global enable

   By default, LLDP is disabled globally.

   You must enable LLDP globally before you enable VCF fabric topology discovery, because the device needs LLDP to collect topology data of directly-connected devices.

3. Enable VCF fabric topology discovery.

   vcf-fabric topology enable

   By default, VCF fabric topology discovery is disabled.

Configuring automated underlay network deployment

Feature and software version compatibility

Automated IPv6 underlay network deployment is supported in Release 6333 and later.

Restrictions and guidelines

Automated deployment is supported for both IPv4 and IPv6 underlay networks.

Specify the template file for automated underlay network deployment

1. Enter system view.
   system-view
2. Specify the template file for automated underlay network deployment.
   vcf-fabric underlay autoconfigure *template*
   By default, no template file is specified for automated underlay network deployment.

Pausing automated underlay network deployment

About pausing automated underlay network deployment

If you pause automated underlay network deployment, the VCF fabric will save the current status of the device. It will not respond to new LLDP events, set up the IRF fabric, aggregate links, or discover uplink or downlink interfaces.

Perform this task if all devices in the VCF fabric complete automated deployment and new devices are to be added to the VCF fabric.

Procedure

1. Enter system view.
   system-view
2. Pause automated underlay network deployment.
   vcf-fabric underlay pause
   By default, automated underlay network deployment is not paused.

Display and maintenance commands for VCF fabric

Execute **display** commands in any view.

Task	Command
Display the role of the device in the VCF fabric.	**display vcf-fabric role**
Display information about automated underlay network deployment.	**display vcf-fabric underlay autoconfigure**
Display the supported version and the current version of the template file for automated VCF fabric provisioning.	**display vcf-fabric underlay template-version**

Contents

Configuring cloud connections

About cloud connections

A cloud connection is a management tunnel established between a local device and the H3C cloud server. It enables you to manage the local device from the cloud server without accessing the network where the device resides.

Multiple subconnections

After a local device establishes a connection with the cloud server, service modules on the local device can establish multiple subconnections with the microservices on the cloud server. These subconnections are independent from each other and provide separate communication channels for different services. This mechanism avoids interference among different services.

Cloud connection establishment

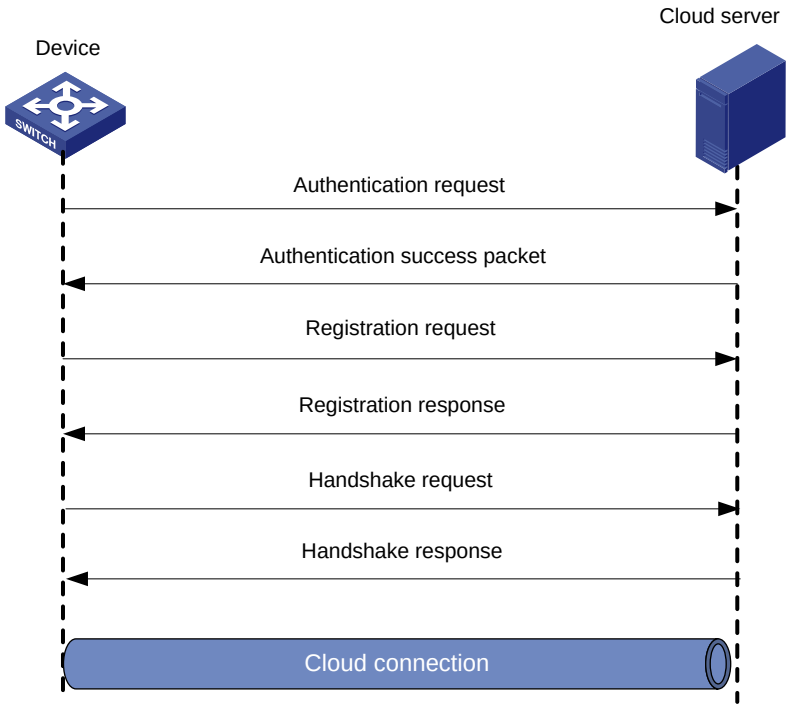
The cloud connection is established as follows:

1. The device sends an authentication request to the cloud server.
2. The cloud server sends an authentication success packet to the device.

   The device passes the authentication only if the serial number of the device has been added to the cloud server. If the authentication fails, the cloud server sends an authentication failure packet to the device.
3. The device sends a registration request to the cloud server.
4. The cloud server sends a registration response to the device.

   The registration response contains the uniform resource locator (URL) used to establish a cloud connection.
5. The device uses the URL to send a handshake request (changing the protocol from HTTP to WebSocket) to the cloud server.
6. The cloud server sends a handshake response to the device to finish establishing the cloud connection.
7. The device sends a subconnection URL request to the cloud server.
8. The cloud server sends a response that contains the microservice list and all subconnection URLs to the device.
9. The service module registers on the cloud connection management module.
10. The cloud connection management module sends the corresponding URLs to the service module.
11. The service module establishes subconnections with the cloud server.

Figure 1 Establishing a cloud connection



Restrictions: Hardware compatibility with cloud connections

The following switch series do not support cloud connections:

- S5110V2.
- S5110V2-SI.
- S5000V3-EI.
- S5000E-X.
- S3100V3-SI.
- MS4320V2, MS4320, MS4200, and MS4300V2.

Configuring a cloud connection

About configuring a cloud connection

For a device to establish a cloud connection to the cloud server, perform either of the following tasks:

- Specify the domain name of the cloud server on the device through CLI.
- Configure the device as a DHCP client and the cloud server as the DHCP server. The device obtains the IP address of the DHCP server and parses the option 253 field in the DHCP packets to obtain the domain name of the cloud server. For more information about the option 253 field, see DHCP configuration in *Layer—3 IP Services Configuration Guide*.

To establish cloud connections to the cloud server, a password is required. A device can use either of the following methods to obtain the password for establishing cloud connections to the cloud server:

- Execute the **cloud-management server password** command on the device to specify the password for establishing cloud connections to the cloud server.
- Configure the device as a DHCP client and the cloud server as the DHCP server. The device obtains the IP address of the DHCP server and parses the option 252 field in the DHCP packets to obtain the password for connection to the cloud server. For more information about the option 252 field, see DHCP configuration in *Layer 3—IP Services Configuration Guide*.

After establishing the cloud connection, the local device sends keepalive packets to the cloud server periodically. If the device does not receive a response from the cloud server within three keepalive intervals, the device sends a registration request to re-establish the cloud connection.

Restrictions and guidelines

Only the WS5810-WiNet, WS5820-WiNet, and WAS6000 switch series support obtaining the domain name of the cloud server automatically.

The domain name obtained through DHCP has a higher priority than the domain name configured manually.

If a device obtains the domain name of the cloud server through DHCP after establishing a cloud connection to the cloud server with the manually configured domain name, the device performs the following tasks:

- If the automatically obtained and manually configured domain names are identical, the device retains the cloud connection.
- If the automatically obtained and manually configured domain names are different, the device tears down the cloud connection and then establishes a cloud connection to the cloud server with the automatically obtained domain name.

The password obtained through DHCP has a higher priority than the password configured manually.

If a device obtains the password for connection to the cloud server through DHCP after establishing a cloud connection to the cloud server with the manually configured password, the device performs the following tasks:

- If the automatically obtained and manually configured passwords are identical, the device retains the cloud connection.
- If the automatically obtained and manually configured passwords are different, the device tears down the cloud connection and then establishes a cloud connection to the cloud server with the automatically obtained password.

Prerequisites

Add the serial number of the device to be managed to the cloud server.

Configure DNS to ensure that the domain name of the cloud server can be translated into an IP address.

To obtain the domain name of the cloud server automatically, first configure the option 253 field as the domain name of the cloud server.

Procedure

1. Enter system view.

   system-view

2. Configure the domain name of the cloud server.

   cloud-management server domain *domain-name*

   The default settings are as follows:

   - The domain name of the cloud server is not configured for the S5120V2-LI or S5130S-LI switch series.
   - For the WS5810-WiNet, WS5820-WiNet, and WAS6000 switch series:

- The domain name of the cloud server is not configured for a switch that starts up with the initial configuration.
- The domain name of the cloud server is **oasis.h3c.com** for a switch that starts up with the factory defaults.

For more information about the initial configuration and factory defaults, see configuration file management in *Fundamentals Configuration Guide*.

3. (Optional) Set the keepalive interval.
   cloud-management keepalive *interval*
   By default, the keepalive interval is 180 seconds.
4. (Optional.) Set the password for establishing cloud connections to the cloud server.
   cloud-management server password { **cipher** | **simple** } *string*
   By default, no password is set for establishing cloud connections to the cloud server.
   This command is supported only in Release 6328 and later.

Display and maintenance commands for cloud connections

Execute **display** commands in any view and **reset** commands in user view.

Task	Command
Display cloud connection state information.	**display cloud-management state**
Re-establish the cloud connection to the cloud server.	**reset cloud-management tunnel**

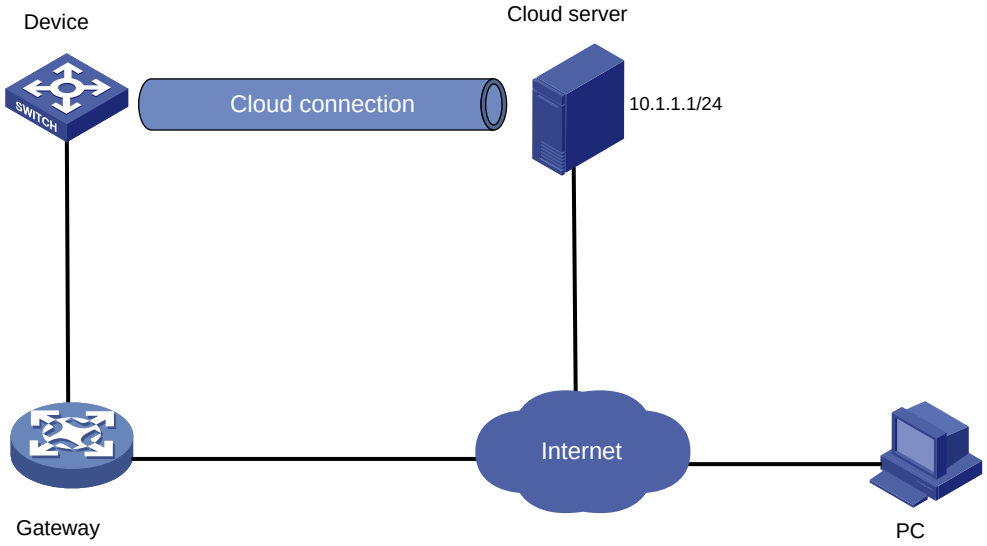
Cloud connection configuration examples

Example: Configuring a cloud connection

Network configuration

As shown in Figure 2, configure the device to establish a cloud connection with the cloud server.

Figure 2 Network diagram



Procedure

1. Configure IP addresses for interfaces, and configure a routing protocol to ensure that the devices can reach each other. (Details not shown.)
2. Log in to the cloud server to add the serial number of the device to the server. (Details not shown.)

   The IP address of the cloud server is 10.1.1.1/24 and the domain name is **cloud.com**.
3. Configure the domain name of the cloud server as **cloud.com**.

   ```
   <Device> system-view
   [Device] cloud-management server domain cloud.com
   ```

   # Map IP address 10.1.1.1 to host name **cloud.com**.

   ```
   [Device] ip host cloud.com 10.1.1.1
   ```

Verifying the configuration

Verify that the device and the cloud server have established a cloud connection.

```
[Device] display cloud-management state
Cloud connection state   : Established
Device state             : Request_success
Cloud server address     : 10.1.1.1
Cloud server domain name : cloud.com
Cloud server port        : 443
Connected at             : Wed Jan  27 14:18:40 2016
Duration                 : 00d 00h 02m 01s
```

Contents

Configuring SmartMC

About SmartMC

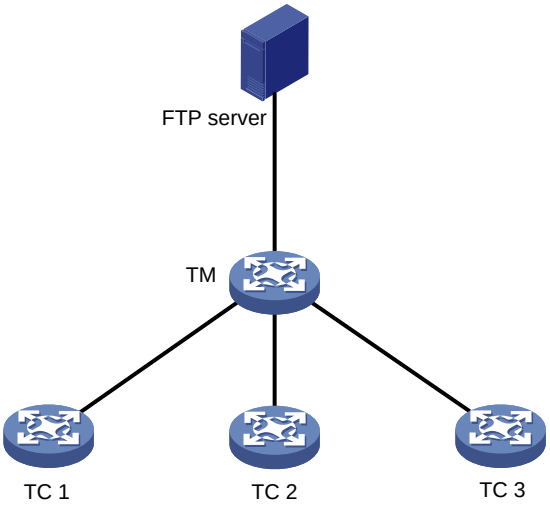
Smart Management Center (SmartMC) centrally manages and maintains dispersed network devices at network edges. In a SmartMC network, only one device acts as the commander and the remaining devices all act as members. SmartMC provides the following features for you to manage the members from the commander:

- Configuration file backup and download.
- Software upgrade.
- Configuration deployment.
- Faulty member replacement.

SmartMC network framework

Figure 1 shows the basic framework of a SmartMC network.

Figure 1 SmartMC network framework



The SmartMC network contains the following elements:

- **Commander**—Also called topology master (TM), which manages all members in the SmartMC network.
- **Member**—Also called topology client (TC), which is managed by the commander.
- **File server**—Stores startup software images and configuration files for the commander and members.

SmartMC network establishment

A SmartMC network can be established automatically or manually. In an automatically established SmartMC network, the commander obtains member information through NETCONF sessions to form the network topology. The member information includes port information, LLDP neighbor information, STP information, device type, and software version. In a manually established SmartMC network, the commander obtains member's LLDP neighbor information through NETCONF sessions and member's hardware information through SNMP Get operations.

Automatic SmartMC network establishment

The commander and members use the following procedure to establish a SmartMC network:

1. After SmartMC is enabled, the commander broadcasts a SmartMC packet at an interval of 15 seconds to detect members in the network. The SmartMC packet contains information of the commander, such as its bridge MAC address and the IP address of VLAN-interface 1.
2. When a member receives the packet, it records the commander information, and returns a response packet to the commander. The response packet contains information of the member, such as its bridge MAC address and the IP address of VLAN-interface 1.
3. When the commander receives the response packet, it initiates a NETCONF session to the member with the default username **admin** and the default password **admin**. The commander then obtains detailed information about the member through the session, including port information, LLDP neighbor information, STP information, device type, and software version.
4. The commander establishes a connection to the member for tracking the liveliness of the member, and adds the member to the SmartMC network.
5. Based on the LLDP neighbor information obtained from all members, the commander forms a SmartMC topology.

After the SmartMC network is established, the commander and members check for the existence of each other by exchanging SmartMC packets.

- When a member receives a SmartMC broadcast packet from the commander, it compares the bridge MAC address in the packet with the recorded bridge MAC address. If the two bridge MAC addresses are the same, the member returns a response packet to the commander. If the member does not receive a broadcast packet from the commander within the time limit, the member determines that the commander does not exist in the network anymore. Then, the member clears the commander information. The time limit is a random value in the range of 60 to 120 seconds.
- When the commander receives a response packet from a member, it compares the bridge MAC address in the packet with the recorded bridge MAC address. If the two bridge MAC addresses are the same, the commander determines that the member still exists in the network. If the commander does not receive a response packet from a member within 150 seconds, the commander determines that the member is offline. Then, the commander sets the status of the member to offline.

Manual SmartMC network establishment

You can log in to the Web interface of the commander, and enter the IP address, username, and password of the members to manually add them to the network. The members can join the network without exchanging SmartMC packets with the commander. For more information, see *Comware 7 Web-Based Products User Guide*.

After you specify the information of a member on the commander, the commander performs the following operations to add the member to the network:

- Verify that the member can be accessed through Telnet.
- Obtain basic member information, including LLDP neighbor information through NETCONF.
- Obtain hardware information through SNMP Get operations.

SmartMC features

Bulk configuration deployment for members

This feature allows you to deploy multiple command lines to members from the commander, eliminating the need to log in to members and configure the command one by one.

The procedure for bulk configuration deployment is as follows:

1. The commander acts as a Telnet client and establishes Telnet connections to the members.

2. The commander deploys a batch file to the members through Telnet connections. The batch file is created on the commander and contains command lines to be deployed.
3. The members run the command lines in the file.

Bulk configuration deployment for ports connecting APs and IP phones

With batch file deployment enabled, the commander automatically deploys configurations in the specified batch file to a port connecting an AP or IP phone, simplifying access port configuration.

When the commander first detects the association of an AP or IP phone on a port through LLDP, it deploys the command lines in the specified batch file to the port. If no batch file is specified for the device type, the configurations on the port remain unchanged.

If the AP or IP phone disconnects from the port, the configurations on the port remain. When a new device comes online from the port, configurations used by the port depend on the new device type.

- If the new device is an AP or IP phone and has the same type as the disconnected device, the configurations on the port remain unchanged.
- If the new device is an AP or IP phone but has a different type as the disconnected device, the commander deploys the command lines in the specified batch file to the port. If no batch file is specified for the device type, the configurations on the port remain unchanged.
- If the new device is neither an AP nor an IP phone, the configurations on the port remain unchanged.

To disable the commander from deploying a batch file to ports, remove the specified batch file or execute the **`undo smartmc batch-file-apply enable`** command to disable batch file deployment. This command is supported only in Release 6328 and later.

Configuration file backup

You can use the following methods to back up the next-startup configuration file on the commander and members:

- **Automatic backup**—Enable this feature for the commander and all members in the network to immediately perform a backup. After that, the commander and members back up the configuration file at a user-specified interval.
- **Manual backup**—Manually trigger a backup on the commander or the specified members or SmartMC groups.

To back up the configuration file on a member, the commander instructs the member by unicasting a SmartMC packet to them. When a member receives the packet, it saves the running configuration to the next-startup configuration file and uploads the file to the file server.

Startup software and configuration file upgrade

This feature enables users to upgrade startup software and the configuration file of member devices from the commander.

Before upgrade, you must upload the upgrade files from the commander to the file server and specify the upgrade files on the file server for the members to download.

The procedure for startup software and configuration file upgrade is as follows:

1. The commander instructs the members (or SmartMC group) to download the upgrade files from the file server.
2. The members download the upgrade files from the file server.
3. The members upgrade the startup software and configuration file as follows:
    - **Startup software upgrade**—Uses the boot-loader method to upgrade the startup software. The members might be restarted during the upgrade process.
    - **Configuration file upgrade**—Replaces the current configuration file with the upgrade configuration file. The members will not be restarted during the upgrade process.

Faulty member replacement

You can use the following methods to replace a faulty member:

- **Automatic replacement**—Enables the commander to record the positions of all members in the topology for replacement. When the commander discovers that the new member has physically replaced the faulty member, it compares the new member with the faulty one. The commander performs a replacement if the following requirements are met:
  - The new member is deployed at the same topological position as the faulty one.
  - The models of the new member and faulty member are the same.

  The commander then instructs the new member to download the configuration file of the faulty member from the file server. After downloading the configuration file, the new member runs the configuration file to complete the replacement.
- **Manual replacement**—After the faulty member is physically replaced, you manually trigger a configuration replacement. The new member will download the configuration file of the faulty member from the file server and run the file to complete the replacement.

Outgoing interface for a SmartMC network

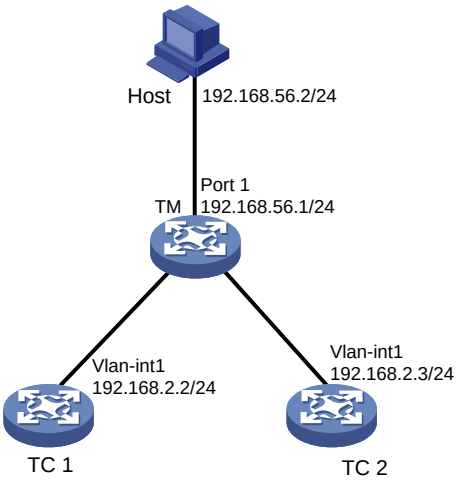
The outgoing interface feature allows hosts connecting to an outgoing interface to access all the members in a SmartMC network. You can configure multiple outgoing interfaces for a SmartMC network.

As shown in Figure 2, the host is connected to port 1 on the TM and TC 1 and TC 2 are in a different network segment than the host. The host can access the Web interface of the TM but cannot access the Web interface of any member.

If port 1 on the TM is configured as the outgoing interface, the system mirrors the IP address of each member to a new address. The new address contains the IP address of the outgoing interface and the port number assigned by the commander to the member in the format of *IP address*:*Port number*. This enables the host to access the Web interfaces of members from the Web interface of the TM.

To access the Web interface of a member, enter the Web interface of the commander, and click **Visibility** from the navigation pane. Then, click the **Topology** tab, select the target member, and click **Login to Web interface**.

Figure 2 SmartMC network



Automatic link aggregation

Automatic link aggregation automatically bundles multiple physical Ethernet links between two members into one logical link, called an aggregate link. This feature provides increased link bandwidth and improved link reliability.

NOTE:

- Automatic link aggregation cannot be performed between the commander and a member, or between a member and a device outside the SmartMC network. You can aggregate the links between the commander and a member manually. For more information about manual link aggregation, see Ethernet link aggregation in *Layer 2—LAN Switching Configuration Guide*.
- If a member enabled with automatic link aggregation joins a SmartMC network whose commander is disabled with the aggregation feature, the feature will be disabled for the member as well. This might affect service traffic forwarding on the member.

VLAN creation for members

To simplify configuration and management, you can create a VLAN for members. Then, all access ports on a member that are not connected to other members or the commander are assigned to the VLAN.

If a member has access ports that are connected to offline devices, you must remove the offline devices before creating a VLAN for the member.

The VLAN creation fails for a member if one or more access ports cannot be assigned to the VLAN. If the VLAN creation fails, the VLAN memberships for the access ports are restored to the state before the VLAN was created.

The failure to create a VLAN for a member does not affect the VLAN creation for other members.

Resource monitoring

Resource monitoring allows you to view resource usage, memory usage, temperature information, and packet dropping information of commanders and members on the commander. Packet dropping monitoring monitors packet dropping on members and on interfaces and is available only in Release 6328 and later.

You can view the usage and temperature information on the commander, and view packet dropping information from the **SmartMC** > **Intelligent O&M** > **Resource monitoring** page of the commander's Web interface.

Restrictions: Hardware compatibility with SmartMC

Only the WS5820-WiNet and WS5810-WiNet switch series do not support SmartMC. All switch series that support SmartMC can only act as members.

Restrictions and guidelines: SmartMC configuration

You need to enable SmartMC on both the commander and members and perform all the other tasks only on the commander.

The following features take effect only on members added to the SmartMC network automatically:

- Configuration file backup.
- Faulty member replacement.
- Startup software and configuration file upgrade.
- Automatic link aggregation.

A SmartMC network is established in VLAN 1. For the network to work correctly, make sure interfaces that connect the network member devices are added to VLAN 1.

As from Release 6346, the following settings are added to the factory defaults of network member devices in SmartMC:

- Telnet is enabled and the **scheme** authentication method is configured for VTY user lines.
- Local user named **admin** of the Telnet, HTTP, and HTTPS types is added. The user password is **admin** and user role is network-admin.
- NETCONF over SOAP over HTTP is enabled.
- LLDP is enabled globally.
- SmartMC is enabled and the device role is specified as member upon the device startup.

SmartMC tasks at a glance

To configure SmartMC, perform the following tasks:

1. Enabling SmartMC
2. Setting the file server information

   This task is required for configuring automatic configuration file backup, replacing faulty members, and upgrading the startup software and configuration file on members.
3. (Optional.) Configuring an outgoing interface for the SmartMC network
4. (Optional.) Enabling automatic Ethernet link aggregation
5. (Optional.) Modifying the password of the default user for members
6. Creating a SmartMC group

   This task is required for upgrading the startup software and configuration file on members and deploying a batch file to a SmartMC group.
7. (Optional.) Deploying and managing configuration
   - Creating a VLAN for members
   - Deploying a batch file to members
   - Configuring a batch file for ports connecting APs or IP phones
   - Backing up configuration files
8. (Optional.) Monitoring and maintaining the SmartMC network
   - Configuring resource monitoring
   - Upgrading the startup software and configuration file on members
   -

     CAUTION:

     After you update the configuration file, the configuration in the new configuration file will become the running configuration. Before upgrading the configuration file, make sure the contents of the new configuration file are correct.
   - Managing the network topology
   - Replacing faulty members

Prerequisites for SmartMC

Before you configure SmartMC, perform the following tasks on the commander and members:

- Enable the Telnet service, and configure scheme authentication for VTY user lines. For information about Telnet service and VTY user lines, see CLI login configuration in *Fundamentals Configuration Guide*.
- Configure a local user.

- Specify the username and password.
  - On the commander, the username and password must be the same as the username and password configured by using the **smartmc tm username** *username* **password** { **cipher** | **simple** } *string* **enable** command.
  - On members of S5000E-X, WAS6100, S5000V5-EI, and S5000X-EI models, username **admin** and password **admin** already exist on the devices. For security purposes, change the password on the member devices and execute **smartmc tc password** on the commander to change the default member device password. Make sure the new password set on the commander is the same as the password configured on each member device. After configuration, the commander uses the default username **admin** to establish NETCONF sessions to members to add members to the network.
  - On member of other models, set both the username and password to **admin**, and execute the **password-control length 4**, **password-control composition type-number 1 type-length 1**, and **undo password-control complexity user-name check** commands to lower the password complexity requirements.

    This is because SmartMC requires that the commander use username **admin** and password **admin** to communicate with members, which does not meet the default password complexity requirements. For more information about these commands, see password control commands in *Security Command Reference*.

    After the SmartMC network is established, you can increase the password complexity requirements and use the **smartmc tc password** command to modify the username and password.
- Specify the Telnet, HTTP, and HTTPS services for the user.
- Set the RBAC role of the local user to network-admin.

For information about local users, see AAA configuration in *Security Configuration Guide*. For information about user roles, see RBAC configuration in *Fundamentals Configuration Guide*.

- Enable NETCONF over SOAP over HTTP. For information about NETCONF over SOAP, see NETCONF configuration in *Network Management and Monitoring Configuration Guide*.
- Enable LLDP globally. For information about LLDP, see *Layer 2—LAN Switching Configuration Guide*.
- To manage the commander and members through a Web interface, you must enable the HTTP and HTTPS services, and set the service type to HTTP and HTTPS for the local user. For information about Web login, HTTP, and HTTPS, see *Fundamentals Configuration Guide*.
- To manually establish a SmartMC network, you must configure the **snmp-agent community read public** and **snmp-agent sys-info version v2c** commands on the members. For information about SNMP, see *Network Management and Monitoring Configuration Guide*.

Enabling SmartMC

About SmartMC

Enable this feature on both the commander and members to enable management of members from the commander.

Restrictions and guidelines

A SmartMC network must have one and only one commander.

If you change the role of the commander to member or disable SmartMC on the commander, all SmartMC settings in its running configuration will be cleared.

SmartMC fails to be enabled if ACL resources are insufficient. If ACL resources are insufficient, use the **undo acl** command to delete unnecessary ACLs and then enable SmartMC. You can execute

the **display acl** command to view ACL configuration and match statistics. For more information about ACLs, see *ACL and QoS Configuration Guide*.

SmartMC fails to be enabled if ports 80 and 443 have been used.

If you execute the **smartmc enable** command multiple times, the most recent configuration takes effect. You can execute the command to change the device role or the password.

Procedure

1. Enter system view.

   system-view

2. Enable SmartMC and set the device role.

   smartmc { **tc** | **tm username** *username* **password** { **cipher** | **simple** } *string* } **enable**

   By default, SmartMC is disabled.

Setting the file server information

About files stored on the file server

In a SmartMC network, a file server is used to store the following files:

- Upgrade startup software files and upgrade configuration file for members.
- Backup configuration files of the commander and members.

Restrictions and guidelines

You can use the following methods to specify a file server:

- Specify the IP address of a file server.
- Specify the IP address of the commander. The commander will act as a file server.

To configure the commander to act as a file server, make sure the commander has enough storage space for storing the files required by members.

To use an independent file server, connect the file server to the commander instead of the members as a best practice. The file server uses VLAN 1 to communicate with the SmartMC network. If you connect the file server to members, creating a VLAN for members will assign member interfaces connecting to the file server to the created VLAN, causing file server disconnection. For more information about member VLAN creation, see "Creating a VLAN for members."

Procedure

1. Enter system view.

   system-view

2. Set the file server information.

   Release 6318P01 and earlier:

   smartmc ftp-server *server-address* **username** *username* **password** { **cipher** | **simple** } *string*

   Release 6328 and later:

   smartmc { **ftp-server** | **sftp-***server* } { *ipv4-address* | **ipv6** *ipv6-address* } [**port** *port*] [**vpn-instance** *vpn-instance-name*] [**directory** *directory*] **username** *username* **password** { **cipher** | **simple** } *string*

   By default, no file server information is set.

Configuring an outgoing interface for the SmartMC network

Restrictions and guidelines

VLAN interface 1 cannot be used as an outgoing interface, because the SmartMC network is established in VLAN 1.

Procedure

1. Enter system view.
   system-view
2. Enter VLAN interface view.
   interface vlan *interface-number*
3. Configure the interface as an outgoing interface.
   smartmc outbound
   By default, no interface is used as an outgoing interface.

Enabling automatic Ethernet link aggregation

Restrictions and guidelines

Enabling or disabling automatic link aggregation might cause network flapping, and the members might go offline for a short period of time.

Procedure

1. Enter system view.
   system-view
2. Enable automatic Ethernet link aggregation.
   smartmc auto-link-aggregation enable
   By default, automatic Ethernet link aggregation is disabled.

Modifying the password of the default user for members

About modifying the password of the default user for members

For members of S5000E-X, WAS6100, S5000V5-EI, and S5000X-EI models, username **admin** and password **admin** already exist on the devices. For security purposes, change the password on the member devices and execute **smartmc tc password** on the commander to change the default member device password. Make sure the new password set on the commander is the same as the password configured on each member device. After configuration, the commander uses the default username **admin** to establish NETCONF sessions to members to add members to the network.

For member device of other models, during SmartMC network establishment, the commander uses the default username and password to establish NETCONF sessions to members automatically added to the network. The default username and password of the members for NETCONF session establishment are **admin** and **admin**.

To enhance security, you can perform this task to change the password for the default user **admin** of the members after the commander adds the members to the network.

Restrictions and guidelines

Do not modify the password for members that are manually added to the SmartMC network. If you modify the password for a manually added member, you will not be able to manage that member from the commander.

You can use the **display smartmc tc verbose** command to identify the method used to add the members.

Procedure

1. Enter system view.

   system-view

2. Modify the password of the default user for members.

   smartmc tc password [**cipher**] *string*

   The **cipher** keyword is supported only in Release 6328 and later.

Creating a SmartMC group

About SmartMC groups

This feature allows you to create a SmartMC group on the commander and add members to the group. When you perform the following operations, you can specify a SmartMC group to apply the operations to all members in the group:

- Startup software upgrade.
- Configuration file upgrade.
- Configuration deployment.

Procedure

1. Enter system view.

   system-view

2. Create a SmartMC group and enter its view.

   smartmc group *group-name*

3. (Optional.) Display predefined device types.

   match device-type ?

4. Set a match criterion.

   match { **device-type** *device-type* | **ip-address** *ip-address* { *ip-mask-length* | *ip-mask* } | **mac-address** *mac-address mac-mask-length* }

   By default, no match criterion is set.

5. If the device type of the members is not predefined on the commander, perform the following tasks to manually define the device type on the commander:

   a. Return to system view.

      quit

   b. Define a device type on the commander.

      smartmc tc sysoid *sysoid* **device-type** *device-type*

      To obtain the SYSOID of a member, execute the **display smartmc tc verbose** command.

      You cannot define a predefined member type as another type.

Creating a VLAN for members

Restrictions and guidelines

If you perform this task multiple times to create a VLAN for members, the most recent configuration takes effect.

Procedure

1. Enter system view.

   system-view

2. Creating a VLAN for members and assign access ports on the members to the VLAN.

   smartmc vlan *vlan-id* { **group** *group-name-list* | **tc** *tc-id-list* }

Deploying a batch file to members

1. Execute the following command in user view to create a batch file and edit the command lines to be deployed to members.

   create batch-file *cmd-filename*

   Each command occupies a line in the batch file. When you finish editing, enter a percent sign (%) to return to user view.

   Make sure the command lines that you enter are correct because the system does not verify whether the command lines are correct.

2. Enter system view.

   system-view

3. Deploy the batch file to a list of members or SmartMC groups.

   smartmc batch-file *cmd-filename* **deploy** { **group** *group-name-list* | **tc** *tc-id-list* }

Configuring a batch file for ports connecting APs or IP phones

Restrictions and guidelines

All commands in the batch file must be commands used in interface view.

The size of the batch file cannot exceed 8190 characters.

Make sure the file name is correct when specifying the batch file because the system does not verify whether the file name is correct. After specifying the batch file, do not delete the file or rename the file.

Procedure

1. (Optional.) Execute the following command in user view to create a batch file and edit the command lines to be deployed to members.

   create batch-file *cmd-filename*

   Each command occupies a line in the batch file. When you finish editing, enter a percent sign (%) to return to user view.

   Make sure the command lines that you enter are correct because the system does not verify whether the command lines are correct.

2. Enter system view.

system-view

3. Specify the batch file for ports connecting APs or IP phones.

   smartmc batch-file *batch-file-name* **apply** { **ap** | **phone** }

4. (Optional.) Disable batch file deployment.

   undo smartmc batch-file-apply enable

   By default, batch file deployment is enabled.

   This command is supported only in Release 6328 and later.

Backing up configuration files

About backing up configuration files

Perform this task to back up the configuration file of the commander or the specified members. Configuration files automatically backed up to the file server are named in the format of *device bridge MAC address*_**backup.cfg**.

Restrictions and guidelines

When you change the commander in the SmartMC network, make sure the backup configuration file of the original commander on the file server is deleted. If the file still exists, the new commander might download the file and run the settings. This will cause a conflict in the network.

The maximum number of members that can perform automatic configuration at the same time is limited by the performance of the file server. If automatic configuration backup fails, set the maximum number of members to a smaller value.

Prerequisites

Before performing this task, you must set the file server information (see "Setting the file server information").

Procedure

1. Enter system view.

   system-view

2. Set the maximum number of members that can perform configuration file backup at the same time.

   smartmc backup configuration max-number *max-number*

   By default, a maximum of five members can perform automatic configuration backup at the same time.

3. Back up configuration files.

   Choose one option as needed:

   - Enable automatic configuration file backup and set the backup interval.

     smartmc backup startup-configuration interval *interval-time*

     By default, automatic configuration file backup is disabled.

   - Manually back up the configuration file on members.

     smartmc backup configuration { **group** *group-name-list* | **tc** [*tc-id-list*] }

     TC ID 0 represents the commander.

Configuring resource monitoring

1. Enter system view.

   system-view

2. Set the interval for the commander to obtain resource monitoring information.

   smartmc resource-monitor interval *interval*

   The default setting is 1 minute.

3. Set the aging time for resource monitoring information.

   smartmc resource-monitor max-age *max-age*

   The default setting is 24 hours.

4. Enable resource monitoring.

   smartmc resource-monitor [**cpu** | **memory** | **packet-drop** | **temperature**] * [**group** *group-name-list* | **tc** { *tc-id-list* | **mac-address** *mac-address* } | **tm**]

   By default, resource monitoring is disabled.

   If you do not specify a resource type, this command enables resource monitoring for all resource types.

   If you do not specify a device to monitor (member or commander), this command enables resource monitoring on the commander and all members.

   The **packet-drop** keyword is supported only in Release 6328 and later.

Upgrading the startup software and configuration file on members

About upgrading the startup software and configuration file on members

You can use the following methods to upgrade the startup software and configuration file on members:

- Schedule an upgrade by specifying an upgrade time or upgrade delay.
- Upgrade immediately by not specifying an upgrade time or upgrade delay.

Restrictions and guidelines for startup software and configuration file upgrade

A member can perform only one upgrade task at a time.

An immediate upgrade cannot be cancelled. If you specify a delay time or upgrade time to perform a scheduled upgrade, the upgrade operation can be cancelled by using the **undo smartmc upgrade** command before it starts.

Prerequisites

Before performing this task, you must set the file server information (see "Setting the file server information").

Upgrading the startup software and configuration file on members

Upgrading the startup software and configuration file in one step

1. Enter system view.

   system-view

2. Upgrade the startup software on members in one step.

   smartmc upgrade boot-loader tc { *tc-id-list* { **boot** *boot-filename* **system** *system-filename* | **file** *ipe-filename* } }&<1-40> [**delay** *delay-time* | **time** *in-time*]

   CAUTION:

   Upgrading the startup software might interrupt services. Before upgrading the startup software, make sure no services will be interrupted.

3. Upgrade the configuration file on members in one step.

   smartmc upgrade startup-configuration tc { *tc-id-list cfg-filename* }&<1-40> [**delay** *delay-time* | **time** *in-time*]

   CAUTION:

   After you update the configuration file, the configuration in the new configuration file will become the running configuration. Before upgrading the configuration file, make sure the contents of the new configuration file are correct.

Configuring startup software and configuration file upgrade step by step

1. Enter system view.

   system-view

2. Configure startup software upgrade for members step by step:

   a. Specify the upgrade startup software files.

      smartmc tc *tc-id* **boot-loader** { *ipe-filename* | **boot** *boot-filename* **system** *system-filename* }

   b. Upgrade the startup software on members.

      smartmc upgrade boot-loader tc *tc-id-list*

   CAUTION:

   Upgrading the startup software might interrupt services. Before upgrading the startup software, make sure no services will be interrupted.

3. Configure configuration file upgrade for members step by step:

   a. Specify the upgrade configuration file.

      smartmc tc *tc-id* **startup-configuration** *cfg-filename*

   b. Upgrade the configuration file on members.

      smartmc upgrade startup-configuration tc *tc-id-list*

   CAUTION:

   After you update the configuration file, the configuration in the new configuration file will become the running configuration. Before upgrading the configuration file, make sure the contents of the new configuration file are correct.

Upgrading the startup software and configuration file on all members in SmartMC groups

Upgrading the startup software and configuration file in one step

1. Enter system view.

   system-view

2. Upgrade the startup software on all members in SmartMC groups in one step.

   smartmc upgrade boot-loader group { *group-name-list* [**boot** *boot-filename* **system** *system-filename* | **file** *ipe-filename*] }&<1-40> [**delay** *minutes* | **time** *in-time*]

CAUTION:

Upgrading the startup software might interrupt services. Before upgrading the startup software, make sure no services will be interrupted.

3. Upgrade the configuration file on all members in SmartMC groups in one step.

   smartmc upgrade startup-configuration group { *group-name-list* **file** *cfg-filename* }&<1-40> [**delay** *minutes* | **time** *in-time*]

   The **file** keyword needs to be entered only in Release 6328 and later.

CAUTION:

After you update the configuration file, the configuration in the new configuration file will become the running configuration. Before upgrading the configuration file, make sure the contents of the new configuration file are correct.

Configuring startup software and configuration file upgrade step by step

1. Enter system view.

   system-view

2. Enter SmartMC group view.

   smartmc group *group-name*

3. Specify the upgrade startup software files for the SmartMC group.

   boot-loader file { *ipe-filename* | **boot** *boot-filename* **system** *system-filename* }

   By default, no upgrade startup software files are specified for a SmartMC group.

4. Specify the upgrade configuration file for the SmartMC group.

   startup-configuration *cfgfile*

   By default, no upgrade configuration file is specified for a SmartMC group.

5. Return to system view.

   quit

6. Upgrade the startup software and configuration file on all members in the SmartMC group.

   Choose one option as needed:

   - Upgrade the startup software.

     smartmc upgrade boot-loader group *group-name-list* [**delay** *minutes* | **time** *in-time*]

CAUTION:

Upgrading the startup software might interrupt services. Before upgrading the startup software, make sure no services will be interrupted.

- Upgrade the configuration file.

  smartmc upgrade startup-configuration group *group-name-list* [**delay** *minutes* | **time** *in-time*]

CAUTION:

After you update the configuration file, the configuration in the new configuration file will become the running configuration. Before upgrading the configuration file, make sure the contents of the new configuration file are correct.

Managing the network topology

Refreshing the network topology

About refreshing the network topology

You can use the following methods to refresh the network topology:

- **Automatic topology refresh**—Specify the refresh interval to allow the commander to refresh the network topology periodically.
- **Manual topology refresh**—Execute the **smartmc topology-refresh** command to manually refresh the network topology.

Restrictions and guidelines

The topology refresh time depends on the number of members in the network.

Procedure

Choose one option as needed:

- Manually refresh the network topology in any view.

  smartmc topology-refresh
- Configure automatic network topology refresh.
  1. Enter system view.

     system-view
  2. Set the automatic topology refresh interval.

     smartmc topology-refresh interval *interval*

     By default, the automatic topology refresh interval is 60 seconds.

Saving the network topology

About saving the network topology

This task allows you to save the current network topology to the **topology.dba** file in the flash memory. After the commander reboots, it uses the **topology.dba** file to restore the network topology.

Procedure

1. Enter system view.

   system-view

2. Save the network topology.
   smartmc topology-save

Replacing faulty members

Restrictions and guidelines

Make sure the new member for replacement and the faulty member have the same neighbor relationship, device model, and IRF member ID.

Make sure the new member has a different member ID than all the members in the SmartMC network, including offline members. Faulty members are considered offline.

To automatically replace a faulty member, first enable automatic replacement, and then install the new member at the location where the faulty member was installed and connect all cables.

To manually replace a faulty member, first install the new member at the location where the faulty member was installed, connect all cables, and then execute the manual replacement command.

Prerequisites

Before you replace a faulty member, set the file server information (see "Setting the file server information").

Procedure

1. Enter system view.
   system-view
2. Replace faulty members.
   Choose one option as needed:
   - Enable automatic faulty member replacement.
     smartmc auto-replace enable
     By default, automatic faulty member replacement is disabled.
   - Manually replace a faulty member.
     smartmc replace tc *tc-id1* **faulty-tc** *tc-id2*

Display and maintenance commands for SmartMC

Execute **display** commands in any view.

Task	Command
Display the backup status on members.	**display smartmc backup configuration status**
Display the batch file execution results.	**display smartmc batch-file status** [**ap** | **last** *number* | **phone**]
Display SmartMC configuration.	**display smartmc configuration**
Display connections between the devices in the SmartMC network.	**display smartmc device-link**
Display SmartMC group information.	**display smartmc group** [*group-name*] [**verbose**]
Display the faulty member replacement status.	**display smartmc replace status**

Task	Command
Display resource monitoring information.	**display smartmc resource-monitor** [**cpu** | **memory** | **temperature**] * [**tc** *tc-id* | **tm**]
Display resource monitoring configuration.	**display smartmc resource-monitor configuration**
Display member information.	**display smartmc tc** [*tc-id*][**verbose**]
Display log information in the log buffer on a member.	**display smartmc tc** *tc-id* **log buffer** [**module** *module-name* [**mnemonic** *mnemonic-value*]]
Display restart log information for a member.	**display smartmc tc** *tc-id* **log restart**
Display VLAN creation results for members.	**display smartmc vlan**
Display member upgrade status.	**display smartmc upgrade status**

SmartMC configuration examples

Example: Configuring SmartMC

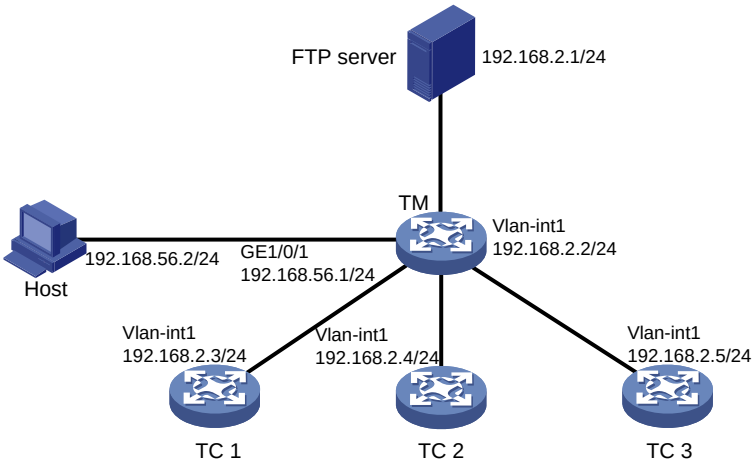
Network configuration

As shown in Figure 3, member 1, member 2, and member 3 belong to the same device type: S5130S-LI series. The IP address of the FTP server is 192.168.2.1. The FTP username is **admin** and the FTP password is **hello12345**.

Perform the following tasks to establish a SmartMC network and upgrade the configuration file on the members:

1. Configure the commander and members to automatically establish a SmartMC network.
2. Configure interface GigabitEthernet 1/0/1 as the outgoing interface for the SmartMC network.
3. Create a SmartMC group and add the members to the group.
4. Upgrade the configuration file on all members in the SmartMC group.
5. Save configuration file **startup.cfg** on the FTP server.

Figure 3 Network diagram



Procedure

1. Configure TC 1:

Configure VLAN-interface 1.

```
<TC1> system-view
[TC1] interface vlan-interface 1
[TC1-Vlan-interface1] ip address 192.168.2.3 24
[TC1-Vlan-interface1] quit
```

Enable HTTP and HTTPS.

```
[TC1] ip http enable
[TC1] ip https enable
```

Enable the Telnet service.

```
[TC1] telnet server enable
```

Enable NETCONF over SOAP over HTTP.

```
[TC1] netconf soap http enable
```

Enable LLDP globally.

```
[TC1] lldp global enable
```

Create a user named **admin**.

```
[TC1] local-user admin
```

Lower password complexity requirements. For more information about these commands, see password control commands in *Security Command Reference*.

```
[TC1-luser-manage-admin] password-control length 4
[TC1-luser-manage-admin] password-control composition type-number 1 type-length 1
[TC1-luser-manage-admin] undo password-control complexity user-name check
```

Set the password to **admin**, add the **telnet**, **http**, and **https** service types, and authorize the user to use the **network-admin** user role.

```
[TC1-luser-manage-admin] password simple admin
[TC1-luser-manage-admin] service-type telnet http https
[TC1-luser-manage-admin] authorization-attribute user-role network-admin
[TC1-luser-manage-admin] quit
```

Set scheme authentication for VTY user lines 0 to 63.

```
[TC1] line vty 0 63
[TC1-line-vty0-63] authentication-mode scheme
[TC1-line-vty0-63] quit
```

Enable SmartMC and set the device role to **tc**.

```
[TC1] smartmc tc enable
```

2. Configure TC 2 and TC 3 in the same way TC 1 is configured. (Details not shown.)

3. Configure the TM:

Configure GigabitEthernet 1/0/1.

```
<TM> system-view
[TM] interface gigabitethernet 1/0/1
[TM-GigabitEthernet1/0/1] port link-mode route
[TM-GigabitEthernet1/0/1] ip address 192.168.52.2 24
[TM-GigabitEthernet1/0/1] quit
```

Configure VLAN-interface 1.

```
[TM] interface vlan-interface 1
[TM-Vlan-interface1] ip address 192.168.2.2 24
[TM-Vlan-interface1] quit
```

Enable HTTP and HTTPS.

```
[TM] ip http enable
```

```
[TM] ip https enable
```

Enable the Telnet service.

```
[TM] telnet server enable
```

Enable NETCONF over SOAP over HTTP.

```
[TM] netconf soap http enable
```

Enable LLDP globally.

```
[TM] lldp global enable
```

Create a user. Set the username to **admin** and the password to **hello12345**, add the **telnet**, **http**, and **https** service types, and authorize the user to use the **network-admin** user role.

```
[TM] local-user admin
[TM-luser-manage-admin] password simple hello12345
[TM-luser-manage-admin] service-type telnet http https
[TM-luser-manage-admin] authorization-attribute user-role network-admin
[TM-luser-manage-admin] quit
```

Set scheme authentication for VTY user lines 0 to 63.

```
[TM] line vty 0 63
[TM-line-vty0-63] authentication-mode scheme
[TM-line-vty0-63] quit
```

Enable SmartMC, set the device role to commander, and set the username to **admin** and the password (plaintext) to **hello12345**.

```
[TM] smartmc tm username admin password simple hello12345 enable
```

Specify GigabitEthernet 1/0/1 as the outgoing interface.

```
[TM] interface gigabitethernet 1/0/1
[TM-GigabitEthernet1/0/1] smartmc outbound
[TM-GigabitEthernet1/0/1] quit
```

Set the FTP server IP address, username, and plaintext password to 192.168.2.1, **admin**, and **hello12345**, respectively.

```
[TM] smartmc ftp-server 192.168.2.1 username admin password simple hello12345
```

Create SmartMC group **S1** and enter its view.

```
[TM] smartmc group S1
```

Create an IP address match criterion to add all members in the specified network segment to SmartMC group **S1**.

```
[TM-smartmc-group-S1] match ip-address 192.168.2.0 24
```

Specify the upgrade configuration file **startup.cfg** for SmartMC group **S1**.

```
[TM-smartmc-group-S1] startup-configuration startup.cfg
[TM-smartmc-group-S1] quit
```

Upgrade the configuration file on all members in SmartMC group **S1**.

```
[TM] smartmc upgrade startup-configuration group S1 file startup.cfg
```

Verifying the configuration

Display brief information about all members after the SmartMC network is established.

```
[TM] display smartmc tc
TCID DeviceType Sysname  IpAddress       MacAddress     Status   Version
1    S5130S-LI  TC1      192.168.2.3     201c-e7c3-0300 Normal   COMWAREV700R001
2    S5130S-LI  TC2      192.168.2.4     201c-e7c3-0301 Normal   COMWAREV700R001
3    S5130S-LI  TC3      192.168.2.5     201c-e7c3-0302 Normal   COMWAREV700R001
```

Display the configuration file upgrade status on the members.

```
<TM> display smartmc upgrade status
```

ID	IpAddress	MacAddress	Status	UpdateTime	UpdateFile
1	192.168.2.3	201c-e7c3-0300	Finished	Immediately	startup.cfg
2	192.168.2.4	201c-e7c3-0301	Finished	Immediately	startup.cfg
3	192.168.2.5	201c-e7c3-0302	Finished	Immediately	startup.cfg

Contents

Configuring WiNet

About WiNet

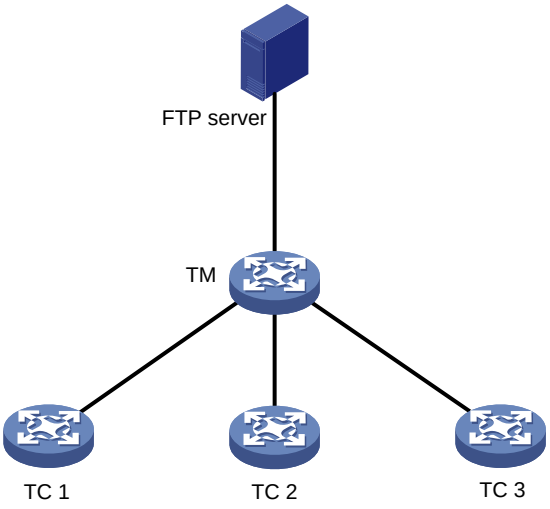
Wisdom Network (WiNet) centrally manages and maintains dispersed network devices at network edges. In a WiNet network, only one device acts as the commander and the remaining devices all act as members. WiNet provides the following features for you to manage the members from the commander:

- Configuration file backup and download.
- Software upgrade.
- Configuration deployment.
- Faulty member replacement.

WiNet network framework

Figure 1 shows the basic framework of a WiNet network.

Figure 1 WiNet network framework



The WiNet network contains the following elements:

- **Commander**—Also called topology master (TM), which manages all members in the WiNet network.
- **Member**—Also called topology client (TC), which is managed by the commander.
- **File server**—Stores startup software images and configuration files for the commander and members.

WiNet network establishment

A WiNet network can be established automatically or manually. In an automatically established WiNet network, the commander obtains member information through NETCONF sessions to form the network topology. The member information includes port information, LLDP neighbor information, STP information, device type, and software version. In a manually established WiNet network, the commander obtains member's LLDP neighbor information through NETCONF sessions and member's hardware information through SNMP Get operations.

Automatic WiNet network establishment

The commander and members use the following procedure to establish a WiNet network:

1. After WiNet is enabled, the commander broadcasts a WiNet packet at an interval of 15 seconds to detect members in the network. The WiNet packet contains information of the commander, such as its bridge MAC address and the IP address of VLAN-interface 1.
2. When a member receives the packet, it records the commander information, and returns a response packet to the commander. The response packet contains information of the member, such as its bridge MAC address and the IP address of VLAN-interface 1.
3. When the commander receives the response packet, it initiates a NETCONF session to the member with the default username **admin** and the default password **admin**. The commander then obtains detailed information about the member through the session, including port information, LLDP neighbor information, STP information, device type, and software version.
4. The commander establishes a connection to the member for tracking the liveliness of the member, and adds the member to the WiNet network.
5. Based on the LLDP neighbor information obtained from all members, the commander forms a WiNet topology.

After the WiNet network is established, the commander and members check for the existence of each other by exchanging WiNet packets.

- When a member receives a WiNet broadcast packet from the commander, it compares the bridge MAC address in the packet with the recorded bridge MAC address. If the two bridge MAC addresses are the same, the member returns a response packet to the commander. If the member does not receive a broadcast packet from the commander within the time limit, the member determines that the commander does not exist in the network anymore. Then, the member clears the commander information. The time limit is a random value in the range of 60 to 120 seconds.
- When the commander receives a response packet from a member, it compares the bridge MAC address in the packet with the recorded bridge MAC address. If the two bridge MAC addresses are the same, the commander determines that the member still exists in the network. If the commander does not receive a response packet from a member within 150 seconds, the commander determines that the member is offline. Then, the commander sets the status of the member to offline.

Manual WiNet network establishment

You can log in to the Web interface of the commander, and enter the IP address, username, and password of the members to manually add them to the network. The members can join the network without exchanging WiNet packets with the commander. For more information, see *Comware 7 Web-Based Products User Guide*.

After you specify the information of a member on the commander, the commander performs the following operations to add the member to the network:

- Verify that the member can be accessed through Telnet.
- Obtain basic member information, including LLDP neighbor information through NETCONF.
- Obtain hardware information through SNMP Get operations.

WiNet features

Bulk configuration deployment for members

This feature allows you to deploy multiple command lines to members from the commander, eliminating the need to log in to members and configure the command one by one.

The procedure for bulk configuration deployment is as follows:

1. The commander acts as a Telnet client and establishes Telnet connections to the members.

2. The commander deploys a batch file to the members through Telnet connections. The batch file is created on the commander and contains command lines to be deployed.
3. The members run the command lines in the file.

Bulk configuration deployment for ports connecting APs and IP phones

With batch file deployment enabled, the commander automatically deploys configurations in the specified batch file to a port connecting an AP or IP phone, simplifying access port configuration.

When the commander first detects the association of an AP or IP phone on a port through LLDP, it deploys the command lines in the specified batch file to the port. If no batch file is specified for the device type, the configurations on the port remain unchanged.

If the AP or IP phone disconnects from the port, the configurations on the port remain. When a new device comes online from the port, configurations used by the port depend on the new device type.

- If the new device is an AP or IP phone and has the same type as the disconnected device, the configurations on the port remain unchanged.
- If the new device is an AP or IP phone but has a different type as the disconnected device, the commander deploys the command lines in the specified batch file to the port. If no batch file is specified for the device type, the configurations on the port remain unchanged.
- If the new device is neither an AP nor an IP phone, the configurations on the port remain unchanged.

To disable the commander from deploying a batch file to ports, remove the specified batch file or execute the **undo winet batch-file-apply enable** command to disable batch file deployment. This command is supported only in Release 6328 and later.

Configuration file backup

You can use the following methods to back up the next-startup configuration file on the commander and members:

- **Automatic backup**—Enable this feature for the commander and all members in the network to immediately perform a backup. After that, the commander and members back up the configuration file at a user-specified interval.
- **Manual backup**—Manually trigger a backup on the commander or the specified members or WiNet groups.

To back up the configuration file on a member, the commander instructs the member by unicasting a WiNet packet to them. When a member receives the packet, it saves the running configuration to the next-startup configuration file and uploads the file to the file server.

Startup software and configuration file upgrade

This feature enables users to upgrade startup software and the configuration file of member devices from the commander.

Before upgrade, you must upload the upgrade files from the commander to the file server and specify the upgrade files on the file server for the members to download.

The procedure for startup software and configuration file upgrade is as follows:

1. The commander instructs the members (or WiNet group) to download the upgrade files from the file server.
2. The members download the upgrade files from the file server.
3. The members upgrade the startup software and configuration file as follows:
    - **Startup software upgrade**—Uses the boot loader method to perform the software upgrade. The members might be restarted during the upgrade process.
    - **Configuration file upgrade**—Replaces the current configuration file with the upgrade configuration file. The members will not be restarted during the upgrade process.

Faulty member replacement

You can use the following methods to replace a faulty member:

- **Automatic replacement**—Enables the commander to record the positions of all members in the topology for replacement. When the commander discovers that the new member has physically replaced the faulty member, it compares the new member with the faulty one. The commander performs a replacement if the following requirements are met:
  - The new member is deployed at the same topological position as the faulty one.
  - The models of the new member and faulty member are the same.

  The commander then instructs the new member to download the configuration file of the faulty member from the file server. After downloading the configuration file, the new member runs the configuration file to complete the replacement.
- **Manual replacement**—After the faulty member is physically replaced, you manually trigger a configuration replacement. The new member will download the configuration file of the faulty member from the file server and run the file to complete the replacement.

Outgoing interface for a WiNet network

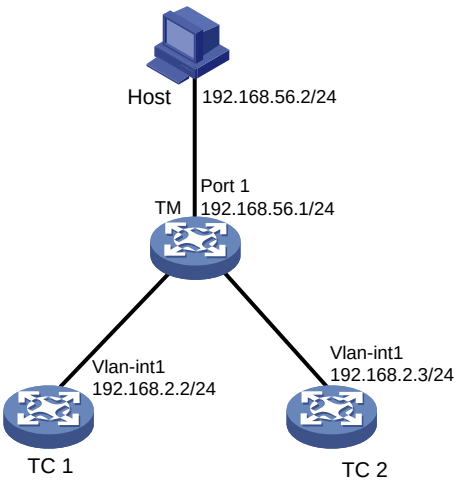
The outgoing interface feature allows hosts connecting to an outgoing interface to access all the members in a WiNet network. You can configure multiple outgoing interfaces for a WiNet network.

As shown in Figure 2, the host is connected to port 1 on the TM and TC 1 and TC 2 are in a different network segment than the host. The host can access the Web interface of the TM but cannot access the Web interface of any member.

If port 1 on the TM is configured as the outgoing interface, the system mirrors the IP address of each member to a new address. The new address contains the IP address of the outgoing interface and the port number assigned by the commander to the member in the format of *IP address*:*Port number*. This enables the host to access the Web interfaces of members from the Web interface of the TM.

To access the Web interface of a member, enter the Web interface of the commander, and click **Visibility** from the navigation pane. Then, click the **Topology** tab, select the target member, and click **Login to Web interface**.

Figure 2 WiNet network



Automatic link aggregation

Automatic link aggregation automatically bundles multiple physical Ethernet links between two members into one logical link, called an aggregate link. This feature provides increased link bandwidth and improved link reliability.

NOTE:

- Automatic link aggregation cannot be performed between the commander and a member, or between a member and a device outside the WiNet network. You can aggregate the links between the commander and a member manually. For more information about manual link aggregation, see Ethernet link aggregation in *Layer 2—LAN Switching Configuration Guide*.
- If a member enabled with automatic link aggregation joins a WiNet network whose commander is disabled with the aggregation feature, the feature will be disabled for the member as well. This might affect service traffic forwarding on the member.

VLAN creation for members

To simplify configuration and management, you can create a VLAN for members. Then, all access ports on a member that are not connected to other members or the commander are assigned to the VLAN.

If a member has access ports that are connected to offline devices, you must remove the offline devices before creating a VLAN for the member.

The VLAN creation fails for a member if one or more access ports cannot be assigned to the VLAN. If the VLAN creation fails, the VLAN memberships for the access ports are restored to the state before the VLAN was created.

The failure to create a VLAN for a member does not affect the VLAN creation for other members.

Resource monitoring

Resource monitoring allows you to view resource usage, memory usage, temperature information, and packet dropping information of commanders and members on the commander. Packet dropping monitoring monitors packet dropping on members and on interfaces and is available only in Release 6328 and later.

You can view the usage and temperature information on the commander, and view packet dropping information from the **WiNet** > **Intelligent O&M** > **Resource monitoring** page of the commander's Web interface.

Restrictions: Hardware compatibility with WiNet

Only the WS5820-WiNet and WS5810-WiNet switch series support WiNet. A WS5810-WiNet switch cannot act as the commander.

Restrictions and guidelines: WiNet configuration

The WS5820-WiNet provides a port mode LED switch button (MODE) on the front panel. You can press the button for 3 to 5 seconds when the server is powered on to set the device role to commander. The default username and password are **admin** and **admin**.

You need to enable WiNet on both the commander and members and perform all the other tasks only on the commander.

The following features take effect only on members added to the WiNet network automatically:

- Configuration file backup.
- Faulty member replacement.
- Startup software and configuration file upgrade.
- Automatic link aggregation.

A WiNet network is established in VLAN 1. For the network to work correctly, make sure interfaces that connect the network member devices are added to VLAN 1.

As from Release 6346, the following settings are added to the factory defaults of network member devices in WiNet:

- Telnet is enabled and the **scheme** authentication method is configured for VTY user lines.
- Local user named **admin** of the Telnet, HTTP, and HTTPS types is added. The user password is **admin** and user role is network-admin.
- NETCONF over SOAP over HTTP is enabled.
- LLDP is enabled globally.
- SmartMC is enabled and the device role is specified as member upon the device startup.

WiNet tasks at a glance

To configure WiNet, perform the following tasks:

1. Enabling
2. Setting the file server information

   This task is required for configuring automatic configuration file backup, replacing faulty members, and upgrading the startup software and configuration file on members.
3. (Optional.) Configuring an outgoing interface for the WiNet network
4. (Optional.) Enabling automatic Ethernet link aggregation
5. (Optional.) Modifying the password of the default user for members
6. Creating a WiNet group

   This task is required for upgrading the startup software and configuration file on members and deploying a batch file to a WiNet group.
7. (Optional.) Deploying and managing configuration
   - Creating a VLAN for members
   - Deploying a batch file to members
   - Configuring a batch file for ports connecting APs or IP phones
   - Backing up configuration files
8. (Optional.) Monitoring and maintaining the WiNet network
   - Configuring resource monitoring
   - Upgrading the startup software and configuration file on members
   - **CAUTION:**

     After you update the configuration file, the configuration in the new configuration file will become the running configuration. Before upgrading the configuration file, make sure the contents of the new configuration file are correct.
   - Managing the network topology
   - Replacing faulty members

Prerequisites for WiNet

Before you configure WiNet, perform the following tasks on the commander and members:

- Enable the Telnet service, and configure scheme authentication for VTY user lines. For information about Telnet service and VTY user lines, see CLI login configuration in *Fundamentals Configuration Guide*.
- Configure a local user.
  - Specify the username and password.

- On the commander, the username and password must be the same as the username and password configured by using the **winet tm username** *username* **password** { **cipher** | **simple** } *string* **enable** command.
- On a member, set both the username and password to **admin**, and execute the **password-control length 4**, **password-control composition type-number 1 type-length 1**, and **undo password-control complexity user-name check** commands to lower the password complexity requirements.

  This is because WiNet requires that the commander use username **admin** and password **admin** to communicate with members, which does not meet the default password complexity requirements. For more information about these commands, see password control commands in *Security Command Reference*.

  After the WiNet network is established, you can increase the password complexity requirements and use the **winet tc password** command to modify the username and password.

  - Specify the Telnet, HTTP, and HTTPS services for the user.
  - Set the RBAC role of the local user to network-admin.

  For information about local users, see AAA configuration in *Security Configuration Guide*. For information about user roles, see RBAC configuration in *Fundamentals Configuration Guide*.

- Enable NETCONF over SOAP over HTTP. For information about NETCONF over SOAP, see NETCONF configuration in *Network Management and Monitoring Configuration Guide*.
- Enable LLDP globally. For information about LLDP, see *Layer 2—LAN Switching Configuration Guide*.
- To manage the commander and members through a Web interface, you must enable the HTTP and HTTPS services, and set the service type to HTTP and HTTPS for the local user. For information about Web login, HTTP, and HTTPS, see *Fundamentals Configuration Guide*.
- To manually establish a WiNet network, you must configure the **snmp-agent community read public** and **snmp-agent sys-info version v2c** commands on the members. For information about SNMP, see *Network Management and Monitoring Configuration Guide*.

Enabling WiNet

About WiNet

Enable this feature on both the commander and members to enable management of members from the commander.

Restrictions and guidelines

A WiNet network must have one and only one commander.

If you change the role of the commander to member or disable WiNet on the commander, all WiNet settings in its running configuration will be cleared.

WiNet fails to be enabled if ACL resources are insufficient. If ACL resources are insufficient, use the **undo acl** command to delete unnecessary ACLs and then enable WiNet. You can execute the **display acl** command to view ACL configuration and match statistics. For more information about ACLs, see *ACL and QoS Configuration Guide*.

WiNet fails to be enabled if ports 80 and 443 have been used.

If you execute the **winet enable** command multiple times, the most recent configuration takes effect. You can execute the command to change the device role or the password.

Procedure

1. Enter system view.

   system-view

2. Enable WiNet and set the device role.

   winet { **tc** | **tm** **username** *username* **password** { **cipher** | **simple** } *string* } **enable**

   By default, WiNet is disabled.

Setting the file server information

About files stored on the file server

In a WiNet network, a file server is used to store the following files:

- Upgrade startup software files and upgrade configuration file for members.
- Backup configuration files of the commander and members.

Only FTP servers are supported in Release 6318P01 and earlier. Both FTP servers and SFTP servers are supported in Release 6328 and later. For information about FTP servers, see configuring FTP in *Fundamentals Configuration Guide*. For information about SFTP servers, see configuring SSH in *Security Configuration Guide*.

Restrictions and guidelines

You can use the following methods to specify a file server:

- Specify the IP address of a file server.
- Specify the IP address of the commander. The commander will act as a file server.

To configure the commander to act as a file server, make sure the commander has enough storage space for storing the files required by members.

To use an independent file server, connect the file server to the commander instead of the members as a best practice. The file server uses VLAN 1 to communicate with the WiNet network. If you connect the file server to members, creating a VLAN for members will assign member interfaces connecting to the file server to the created VLAN, causing file server disconnection. For more information about member VLAN creation, see "Creating a VLAN for members."

Procedure

1. Enter system view.

   system-view

2. Set the file server information.

   Release 6318P01 and earlier:

   winet ftp-server *server-address* **username** *username* **password** { **cipher** | **simple** } *string*

   Release 6328 and later:

   winet { **ftp-server** | **sftp-***server* } { *ipv4-address* | **ipv6** *ipv6-address* } [**port** *port*] [**vpn-instance** *vpn-instance-name*] [**directory** *directory*] **username** *username* **password** { **cipher** | **simple** } *string*

   By default, no file server information is set.

Configuring an outgoing interface for the WiNet network

Restrictions and guidelines

VLAN interface 1 cannot be used as an outgoing interface, because the WiNet network is established in VLAN 1.

Procedure

1. Enter system view.
   system-view
2. Enter VLAN interface view or Layer 3 Ethernet interface view.
   - Enter VLAN interface view.
     interface vlan *interface-number*
   - Enter Layer 3 Ethernet interface view.
     interface *interface-type interface-number*
3. Configure the interface as an outgoing interface.
   winet outbound

   By default, no interface is used as an outgoing interface.

Enabling automatic Ethernet link aggregation

Restrictions and guidelines

Enabling or disabling automatic link aggregation might cause network flapping, and the members might go offline for a short period of time.

Procedure

1. Enter system view.
   system-view
2. Enable automatic Ethernet link aggregation.
   winet auto-link-aggregation enable

   By default, automatic Ethernet link aggregation is disabled.

Modifying the password of the default user for members

About modifying the password of the default user for members

During WiNet network establishment, the commander uses the default username and password to establish NETCONF sessions to members automatically added to the network. The default username and password of the members for NETCONF session establishment are **admin** and **admin**.

To enhance security, you can perform this task to change the password for the default user **admin** of the members after the commander adds the members to the network.

Restrictions and guidelines

Do not modify the password for members that are manually added to the WiNet network. If you modify the password for a manually added member, you will not be able to manage that member from the commander.

You can use the **display winet tc verbose** command to identify the method used to add the members.

Procedure

1. Enter system view.
   system-view
2. Modify the password of the default user for members.

winet tc password [**cipher**] *string*

The **cipher** keyword is supported only in Release 6328 and later.

Creating a WiNet group

About WiNet groups

This feature allows you to create a WiNet group on the commander and add members to the group. When you perform the following operations, you can specify a WiNet group to apply the operations to all members in the group:

- Startup software upgrade.
- Configuration file upgrade.
- Configuration deployment.

Procedure

1. Enter system view.
   system-view
2. Create a WiNet group and enter its view.
   winet group *group-name*
3. (Optional.) Display predefined device types.
   match device-type ?
4. Set a match criterion.
   match { **device-type** *device-type* | **ip-address** *ip-address* { *ip-mask-length* | *ip-mask* } | **mac-address** *mac-address mac-mask-length* }
   By default, no match criterion is set.
5. If the device type of the members is not predefined on the commander, perform the following tasks to manually define the device type on the commander:
   a. Return to system view.
      quit
   b. Define a device type on the commander.
      winet tc sysoid *sysoid* **device-type** *device-type*
      To obtain the SYSOID of a member, execute the **display winet tc verbose** command.
      You cannot define a predefined member type as another type.

Creating a VLAN for members

Restrictions and guidelines

If you perform this task multiple times to create a VLAN for members, the most recent configuration takes effect.

Procedure

1. Enter system view.
   system-view
2. Creating a VLAN for members and assign access ports on the members to the VLAN.
   winet vlan *vlan-id* { **group** *group-name-list* | **tc** *tc-id-list* }

Deploying a batch file to members

1. Execute the following command in user view to create a batch file and edit the command lines to be deployed to members.

   create batch-file *cmd-filename*

   Each command occupies a line in the batch file. When you finish editing, enter a percent sign (%) to return to user view.

   Make sure the command lines that you enter are correct because the system does not verify whether the command lines are correct.

2. Enter system view.

   system-view

3. Deploy the batch file to a list of members or WiNet groups.

   winet batch-file *cmd-filename* **deploy** { **group** *group-name-list* | **tc** *tc-id-list* }

Configuring a batch file for ports connecting APs or IP phones

Restrictions and guidelines

All commands in the batch file must be commands used in interface view.

The size of the batch file cannot exceed 8190 characters.

Make sure the file name is correct when specifying the batch file because the system does not verify whether the file name is correct. After specifying the batch file, do not delete the file or rename the file.

Procedure

1. (Optional.) Execute the following command in user view to create a batch file and edit the command lines to be deployed to members.

   create batch-file *cmd-filename*

   Each command occupies a line in the batch file. When you finish editing, enter a percent sign (%) to return to user view.

   Make sure the command lines that you enter are correct because the system does not verify whether the command lines are correct.

2. Enter system view.

   system-view

3. Specify the batch file for ports connecting APs or IP phones.

   winet batch-file *batch-file-name* **apply** { **ap** | **phone** }

4. (Optional.) Disable batch file deployment.

   undo winet batch-file-apply enable

   By default, batch file deployment is enabled.

   This command is supported only in Release 6328 and later.

Backing up configuration files

About backing up configuration files

Perform this task to back up the configuration file of the commander or the specified members. Configuration files automatically backed up to the file server are named in the format of *device bridge MAC address*_**backup.cfg**.

Restrictions and guidelines

When you change the commander in the WiNet network, make sure the backup configuration file of the original commander on the file server is deleted. If the file still exists, the new commander might download the file and run the settings. This will cause a conflict in the network.

The maximum number of members that can perform automatic configuration at the same time is limited by the performance of the file server. If automatic configuration backup fails, set the maximum number of members to a smaller value.

Prerequisites

Before performing this task, you must set the file server information (see "Setting the file server information").

Procedure

1. Enter system view.
   system-view
2. Set the maximum number of members that can perform configuration file backup at the same time.
   winet backup configuration max-number *max-number*
   By default, a maximum of five members can perform automatic configuration backup at the same time.
3. Back up configuration files.
   Choose one option as needed:
   - Enable automatic configuration file backup and set the backup interval.
     winet backup startup-configuration interval *interval-time*
     By default, automatic configuration file backup is disabled.
   - Manually back up the configuration file on members.
     winet backup configuration { **group** *group-name-list* | **tc** [*tc-id-list*] }
     TC ID 0 represents the commander.

Configuring resource monitoring

1. Enter system view.
   system-view
2. Set the interval for the commander to obtain resource monitoring information.
   winet resource-monitor interval *interval*
   The default setting is 1 minute.
3. Set the aging time for resource monitoring information.
   winet resource-monitor max-age *max-age*
   The default setting is 24 hours.
4. Enable resource monitoring.

winet resource-monitor [**cpu** | **memory** | **packet-drop** | **temperature**] * [**group** *group-name-list* | **tc** { *tc-id-list* | **mac-address** *mac-address* } | **tm**]

By default, resource monitoring is disabled.

If you do not specify a resource type, this command enables resource monitoring for all resource types.

If you do not specify a device to monitor (member or commander), this command enables resource monitoring on the commander and all members.

The **packet-drop** keyword is supported only in Release 6328 and later.

Upgrading the startup software and configuration file on members

About upgrading the startup software and configuration file on members

You can use the following methods to upgrade the startup software and configuration file on members:

- Schedule an upgrade by specifying an upgrade time or upgrade delay.
- Upgrade immediately by not specifying an upgrade time or upgrade delay.

Restrictions and guidelines for startup software and configuration file upgrade

A member can perform only one upgrade task at a time.

An immediate upgrade cannot be cancelled. If you specify a delay time or upgrade time to perform a scheduled upgrade, the upgrade operation can be cancelled by using the **undo winet upgrade** command before it starts.

Prerequisites

Before performing this task, you must set the file server information (see "Setting the file server information").

Upgrading the startup software and configuration file on members

Upgrading the startup software and configuration file in one step

1. Enter system view.

   system-view

2. Upgrade the startup software on members in one step.

   winet upgrade boot-loader tc { *tc-id-list* { **boot** *boot-filename* **system** *system-filename* | **file** *ipe-filename* } }&<1-40> [**delay** *delay-time* | **time** *in-time*]

CAUTION:

Upgrading the startup software might interrupt services. Before upgrading the startup software, make sure no services will be interrupted.

3. Upgrade the configuration file on members in one step.

   winet upgrade startup-configuration tc { *tc-id-list cfg-filename* }&<1-40> [**delay** *delay-time* | **time** *in-time*]

CAUTION:

After you update the configuration file, the configuration in the new configuration file will become the running configuration. Before upgrading the configuration file, make sure the contents of the new configuration file are correct.

Configuring startup software and configuration file upgrade step by step

1. Enter system view.

   system-view

2. Configure startup software upgrade for members step by step:

   a. Specify the upgrade startup software files.

      winet tc *tc-id* **boot-loader** { *ipe-filename* | **boot** *boot-filename* **system** *system-filename* }

   b. Upgrade the startup software on members.

      winet upgrade boot-loader tc *tc-id-list*

CAUTION:

Upgrading the startup software might interrupt services. Before upgrading the startup software, make sure no services will be interrupted.

3. Configure configuration file upgrade for members step by step:

   a. Specify the upgrade configuration file.

      winet tc *tc-id* **startup-configuration** *cfg-filename*

   b. Upgrade the configuration file on members.

      winet upgrade startup-configuration tc *tc-id-list*

CAUTION:

After you update the configuration file, the configuration in the new configuration file will become the running configuration. Before upgrading the configuration file, make sure the contents of the new configuration file are correct.

Upgrading the startup software and configuration file on all members in WiNet groups

Upgrading the startup software and configuration file in one step

1. Enter system view.

   system-view

2. Upgrade the startup software on all members in WiNet groups in one step.

   winet upgrade boot-loader group { *group-name-list* [**boot** *boot-filename* **system** *system-filename* | **file** *ipe-filename*]}&<1-40> [**delay** *minutes* | **time** *in-time*]

CAUTION:

Upgrading the startup software might interrupt services. Before upgrading the startup software, make sure no services will be interrupted.

3. Upgrade the configuration file on all members in WiNet groups in one step.

   winet upgrade startup-configuration group { *group-name-list* **file** *cfg-filename* }&<1-40> [**delay** *minutes* | **time** *in-time*]

   The **file** keyword needs to be entered only in Release 6328 and later.

CAUTION:

After you update the configuration file, the configuration in the new configuration file will become the running configuration. Before upgrading the configuration file, make sure the contents of the new configuration file are correct.

Configuring startup software and configuration file upgrade step by step

1. Enter system view.

   system-view

2. Enter WiNet group view.

   winet group *group-name*

3. Specify the upgrade startup software files for the WiNet group.

   boot-loader file { *ipe-filename* | **boot** *boot-filename* **system** *system-filename* }

   By default, no upgrade startup software files are specified for a WiNet group.

4. Specify the upgrade configuration file for the WiNet group.

   startup-configuration *cfgfile*

   By default, no upgrade configuration file is specified for a WiNet group.

5. Return to system view.

   quit

6. Upgrade the startup software and configuration file on all members in the WiNet group.

   Choose one option as needed:

   - Upgrade the startup software.

     winet upgrade boot-loader group *group-name-list* [**delay** *minutes* | **time** *in-time*]

     CAUTION:

     Upgrading the startup software might interrupt services. Before upgrading the startup software, make sure no services will be interrupted.

   - Upgrade the configuration file.

     winet upgrade startup-configuration group *group-name-list* [**delay** *minutes* | **time** *in-time*]

     CAUTION:

     After you update the configuration file, the configuration in the new configuration file will become the running configuration. Before upgrading the configuration file, make sure the contents of the new configuration file are correct.

Managing the network topology

Refreshing the network topology

About refreshing the network topology

You can use the following methods to refresh the network topology:

- **Automatic topology refresh**—Specify the refresh interval to allow the commander to refresh the network topology periodically.
- **Manual topology refresh**—Execute the **winet topology-refresh** command to manually refresh the network topology.

Restrictions and guidelines

The topology refresh time depends on the number of members in the network.

Procedure

Choose one option as needed:

- Manually refresh the network topology in any view.
  winet topology-refresh
- Configure automatic network topology refresh.
  a. Enter system view.
  system-view
  b. Set the automatic topology refresh interval.
  winet topology-refresh interval *interval*
  By default, the automatic topology refresh interval is 60 seconds.

Saving the network topology

About saving the network topology

This task allows you to save the current network topology to the **topology.dba** file in the flash memory. After the commander reboots, it uses the **topology.dba** file to restore the network topology.

Procedure

1. Enter system view.
   system-view
2. Save the network topology.
   winet topology-save

Replacing faulty members

Restrictions and guidelines

Make sure the new member for replacement and the faulty member have the same neighbor relationship, device model, and IRF member ID.

Make sure the new member has a different member ID than all the members in the WiNet network, including offline members. Faulty members are considered offline.

To automatically replace a faulty member, first enable automatic replacement, and then install the new member at the location where the faulty member was installed and connect all cables.

To manually replace a faulty member, first install the new member at the location where the faulty member was installed, connect all cables, and then execute the manual replacement command.

Prerequisites

Before you replace a faulty member, set the file server information (see "Setting the file server information").

Procedure

1. Enter system view.
   system-view
2. Replace faulty members.
   Choose one option as needed:
   - Enable automatic faulty member replacement.
     winet auto-replace enable
     By default, automatic faulty member replacement is disabled.
   - Manually replace a faulty member.
     winet replace tc *tc-id1* **faulty-tc** *tc-id2*

Display and maintenance commands for WiNet

Execute **display** commands in any view.

Task	Command
Display the backup status on members.	**display winet backup configuration status**
Display the batch file execution results.	**display winet batch-file status** [**ap** | **last** *number* | **phone**]
Display WiNet configuration.	**display winet configuration**
Display connections between the devices in the WiNet network.	**display winet device-link**
Display WiNet group information.	**display winet group** [*group-name*] [**verbose**]
Display the faulty member replacement status.	**display winet replace status**
Display resource monitoring information.	**display winet resource-monitor** [**cpu** | **memory** | **temperature**] * [**tc** *tc-id* | **tm**]
Display resource monitoring configuration.	**display winet resource-monitor configuration**
Display member information.	**display winet tc** [*tc-id*] [**verbose**]
Display log information in the log buffer on a member.	**display winet tc** *tc-id* **log buffer** [**module** *module-name* [**mnemonic** *mnemonic-value*]]
Display restart log information for a member.	**display winet tc** *tc-id* **log restart**
Display VLAN creation results for members.	**display winet vlan**
Display member upgrade status.	**display winet upgrade status**

WiNet configuration examples

Example: Configuring WiNet

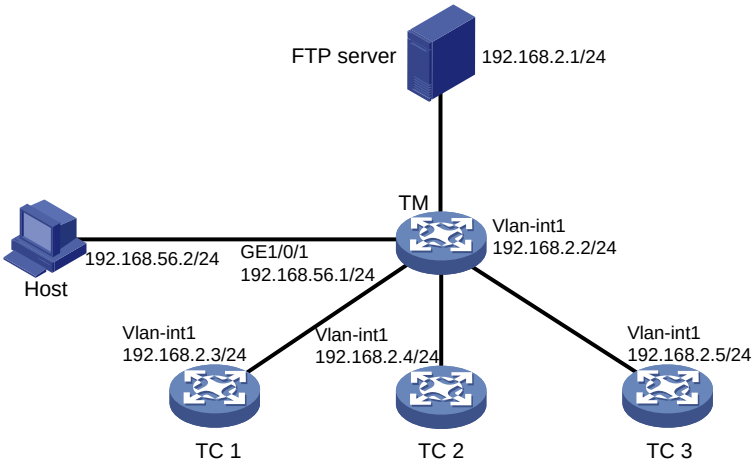
Network configuration

As shown in Figure 3, member 1, member 2, and member 3 belong to the same device type: WS5820-WiNet. The IP address of the FTP server is 192.168.2.1. The FTP username is **admin** and the FTP password is **hello12345**.

Perform the following tasks to establish a WiNet network and upgrade the configuration file on the members:

1. Configure the commander and members to automatically establish a WiNet network.
2. Configure interface GigabitEthernet 1/0/1 as the outgoing interface for the WiNet network.
3. Create a WiNet group and add the members to the group.
4. Upgrade the configuration file on all members in the WiNet group.
5. Save configuration file **startup.cfg** on the FTP server.

Figure 3 Network diagram



Procedure

1. Configure TC 1:

   # Configure VLAN-interface 1.

   ```
   <TC1> system-view
   [TC1] interface vlan-interface 1
   [TC1-Vlan-interface1] ip address 192.168.2.3 24
   [TC1-Vlan-interface1] quit
   ```

   # Enable HTTP and HTTPS.

   ```
   [TC1] ip http enable
   [TC1] ip https enable
   ```

   # Enable the Telnet service.

   ```
   [TC1] telnet server enable
   ```

   # Enable NETCONF over SOAP over HTTP.

   ```
   [TC1] netconf soap http enable
   ```

   # Enable LLDP globally.

   ```
   [TC1] lldp global enable
   ```

Create a user named **admin**.

```
[TC1] local-user admin
```

Lower password complexity requirements. For more information about these commands, see password control commands in *Security Command Reference*.

```
[TC1-luser-manage-admin] password-control length 4
[TC1-luser-manage-admin] password-control composition type-number 1 type-length 1
[TC1-luser-manage-admin] undo password-control complexity user-name check
```

Set the username and password to **admin**, add the **telnet**, **http**, and **https** service types, and authorize the user to use the **network-admin** user role.

```
[TC1-luser-manage-admin] password simple admin
[TC1-luser-manage-admin] service-type telnet http https
[TC1-luser-manage-admin] authorization-attribute user-role network-admin
[TC1-luser-manage-admin] quit
```

Set scheme authentication for VTY user lines 0 to 63.

```
[TC1] line vty 0 63
[TC1-line-vty0-63] authentication-mode scheme
[TC1-line-vty0-63] quit
```

Enable WiNet and set the device role to **tc**.

```
[TC1] winet tc enable
```

2. Configure TC 2 and TC 3 in the same way TC 1 is configured. (Details not shown.)

3. Configure the TM:

Configure GigabitEthernet 1/0/1.

```
<TM> system-view
[TM] interface gigabitethernet 1/0/1
[TM-GigabitEthernet1/0/1] port link-mode route
[TM-GigabitEthernet1/0/1] ip address 192.168.52.2 24
[TM-GigabitEthernet1/0/1] quit
```

Configure VLAN-interface 1.

```
[TM] interface vlan-interface 1
[TM-Vlan-interface1] ip address 192.168.2.2 24
[TM-Vlan-interface1] quit
```

Enable HTTP and HTTPS.

```
[TM] ip http enable
[TM] ip https enable
```

Enable the Telnet service.

```
[TM] telnet server enable
```

Enable NETCONF over SOAP over HTTP.

```
[TM] netconf soap http enable
```

Enable LLDP globally.

```
[TM] lldp global enable
```

Create a user. Set the username to **admin** and the password to **hello12345**, add the **telnet**, **http**, and **https** service types, and authorize the user to use the **network-admin** user role.

```
[TM] local-user admin
[TM-luser-manage-admin] password simple hello12345
[TM-luser-manage-admin] service-type telnet http https
[TM-luser-manage-admin] authorization-attribute user-role network-admin
[TM-luser-manage-admin] quit
```

Set scheme authentication for VTY user lines 0 to 63.

```
[TM] line vty 0 63
[TM-line-vty0-63] authentication-mode scheme
[TM-line-vty0-63] quit
```

Enable WiNet, set the device role to commander, and set the username to **admin** and the password (plaintext) to **hello12345**.

```
[TM] winet tm username admin password simple hello12345 enable
```

Specify GigabitEthernet 1/0/1 as the outgoing interface.

```
[TM] interface gigabitethernet 1/0/1
[TM-GigabitEthernet1/0/1] winet outbound
[TM-GigabitEthernet1/0/1] quit
```

Set the file server IP address, username, and plaintext password to 192.168.2.1, **admin**, and **hello12345**, respectively.

```
[TM] winet ftp-server 192.168.2.1 username admin password simple hello12345
```

Create WiNet group **S1** and enter its view.

```
[TM] winet group S1
```

Create an IP address match criterion to add all members in the specified network segment to WiNet group **S1**.

```
[TM-winet-group-S1] match ip-address 192.168.2.0 24
```

Specify the upgrade configuration file **startup.cfg** for WiNet group **S1**.

```
[TM-winet-group-S1] startup-configuration startup.cfg
[TM-winet-group-S1] quit
```

Upgrade the configuration file on all members in WiNet group **S1**.

```
[TM] winet upgrade startup-configuration group S1 file startup.cfg
```

Verifying the configuration

Display brief information about all members after the WiNet network is established.

```
[TM] display winet tc
TCID DeviceType Sysname  IpAddress       MacAddress     Status   Version
1    WS5820     TC1      192.168.2.3     201c-e7c3-0300 Normal   COMWAREV700R001
2    WS5820     TC2      192.168.2.4     201c-e7c3-0301 Normal   COMWAREV700R001
3    WS5820     TC3      192.168.2.5     201c-e7c3-0302 Normal   COMWAREV700R001
```

Display the configuration file upgrade status on the members.

```
<TM> display winet upgrade status
ID    IpAddress        MacAddress      Status      UpdateTime        UpdateFile
1     192.168.2.3      201c-e7c3-0300  Finished    Immediately       startup.cfg
2     192.168.2.4      201c-e7c3-0301  Finished    Immediately       startup.cfg
3     192.168.2.5      201c-e7c3-0302  Finished    Immediately       startup.cfg
```

Contents

Configuring EPA

About EPA

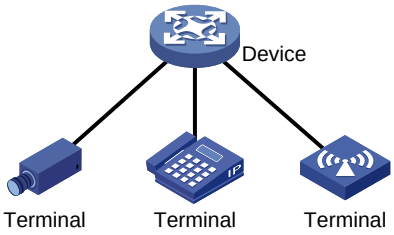
Endpoint Analysis (EPA) allows you to monitor associations and disassociations of endpoints (for example, cameras and IP phones) connecting to an H3C device.

Application scenarios

Non-SmartMC (or Non-WiNet) networking

As shown in Figure 1, the device configured with EPA monitors associations and disassociations of endpoints connecting to it. The device can be a standalone device or an IRF fabric. For an IRF fabric, EPA monitors endpoints connecting to all members. The collected association and disassociation information will be reported to the master device for processing.

Figure 1 Non-SmartMC (or Non-WiNet) networking

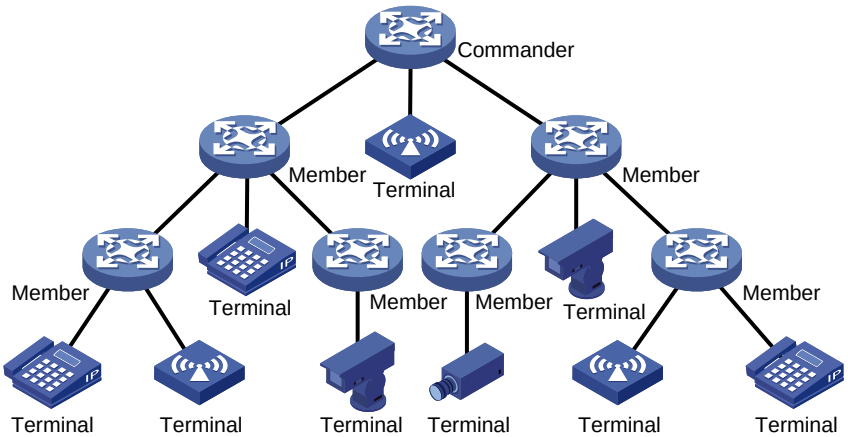


SmartMC (or WiNet) networking

In a SmartMC (or WiNet) network as shown in Figure 2, EPA settings are configured only on the commander. The members report association and disassociation information about their associated endpoints to the commander. The commander records such information about all associated endpoints in the network, and deploys EPA settings to the members.

You can view EPA information in the entire network on the commander.

Figure 2 SmartMC (or WiNet) networking



Working mechanism

EPA monitors endpoint associations and disassociations by monitoring the generation and aging of MAC address entries learned by devices. A device configured with EPA can monitor only endpoints in the same subnet as the endpoint access port on the device.

For more information about MAC address entries, see *Layer 2—LAN Switching Configuration Guide*.

Collecting endpoint association information

If a device configured with EPA learns a new MAC address entry, it compares the MAC address and VLAN ID with the configured EPA monitor rules.

- If a match is found, the device determines that a monitored endpoint came online.
  - In a non-SmartMC (or non-WiNet) network, the device records the endpoint association event locally.
  - In a SmartMC (or WiNet) network, if the device is the commander, it records the endpoint association event locally. If the device is a member, it reports the event to the commander.
- If no match is found, the device determines that the endpoint is not a monitored endpoint and does not record the endpoint association event.

Collecting endpoint disassociation information

When the MAC address entry of an endpoint ages out, the device determines that the endpoint went offline.

- In a non-SmartMC (or non-WiNet) network, the device records the endpoint disassociation event locally for 7 days.
- In a SmartMC (or WiNet) network, the commander records the endpoint disassociation event for 7 days.

Synchronizing information in a SmartMC (or WiNet) network

In a SmartMC (or WiNet) network, endpoint monitor rules are configured on the commander and deployed to all members by the commander. The rules take effect on both the commander and members. If a member detects an association or disassociation event of a monitored endpoint, it reports the event to the commander for statistics collection and analysis.

You can view endpoint associations and disassociations that occurred in the entire network from the commander. For more information about SmartMC (or WiNet), see "Configuring SmartMC (or WiNet)."

Restrictions: Software version compatibility with EPA

This feature is supported only in Release 6328 and later.

Restrictions and guidelines: EPA configuration

Do not use the **`mac-address dynamic`** command to configure dynamic MAC address entries for monitored endpoints. If you do so, the system might fail to identify endpoint association events.

When you configure endpoint monitor rules, follow these restrictions and guidelines:

- To configure multiple rules to monitor an endpoint in different VLANs, make sure the specified VLAN ranges in these rules do not overlap with each other.

- As a best practice to ensure the optimal EPA performance, specify the VLANs in which an endpoint will be monitored.
- If you configure a rule to monitor an endpoint in all VLANs, make sure the endpoint will not come online from over 10 VLANs.
- You can configure a maximum of 1024 monitor rules. As a best practice to ensure the optimal EPA performance, do not configure over 512 monitor rules.
- You can specify a rule ID when creating a monitor rule. If you do not specify the ID, the system assigns the smallest available ID to the rule.
- You cannot execute the **epa monitor-rule** command multiple times to edit an existing rule. To edit an existing rule, use the **undo epa monitor-rule** command to delete the rule and then create the rule again.

When you configure EPA in a SmartMC (or WiNet) network, follow these restrictions and guidelines:

- Make sure all devices in the network support EPA.
- You can configure endpoint monitor rules only on the commander.
- Configure the same aging time for MAC address entries on all devices in the SmartMC (or WiNet) network. Otherwise, endpoint association and disassociation analysis on the commander might be inaccurate. For more information about MAC address entries, see *Layer 2—LAN Switching Configuration Guide*.
- To view endpoint association and disassociation events in a SmartMC (or WiNet) network, execute the **display epa monitor-information** command on the commander instead of a member. If you execute the command on a member, the command displays only association events of endpoints connecting to the member.

Configuring EPA

1. Enter system view.

   system-view
2. Create an endpoint monitor rule.

   epa monitor-rule [*monitor-rule-id*] **mac** *mac-address* [**mask** *mac-mask*] [**vlan** *vlan-id*]

   By default, no endpoint monitor rules exist.

Disabling EPA logging

About this task

By default, the EPA module logs endpoint associations and disassociations. If a monitored endpoint comes online or goes offline frequently, the device will generate a large number of log entries. In this case, to avoid affecting device performance, disable EPA logging as a best practice.

Procedure

1. Enter system view.

   system-view
2. Disable EPA logging.

   epa online-offline-log disable

   By default, EPA logging is enabled.

Display and maintenance commands for EPA

Execute **display** commands in any view.

Task	Command
Display endpoint association and disassociation information detected by EPA.	**display epa monitor-information** [**online** | **offline**] [**device** *device-id* | **mac** *mac-address* [**vlan** *vlan-id*]]

Telemetry Configuration Guide

This command reference is applicable to the following switches and software versions:

H3C S5120V2-LI switch series (Release 6308P01 and later)
H3C S3100V3-SI switch series (Release 6309P01 and later)
H3C S5110V2 switch series (Release 6310 and later)
H3C S5110V2-SI switch series (Release 6310 and later)
H3C S5000V3-EI switch series (Release 6310 and later)
H3C S5000V5-EI switch series (Release 6319P01 and later)
H3C S5000E-X switch series (Release 6310 and later)
H3C S5130S-LI switch series (Release 6310 and later)
H3C MS4320V2 switch series (Release 6308P01 and later)
H3C MS4320 switch series (Release 6308P01 and later)
H3C MS4300V2 switch series (Release 6308P01 and later)
H3C MS4200 switch series (Release 6310 and later)
H3C WS5810-WiNet switch series (Release 6308P01 and later)
H3C WS5820-WiNet switch series (Release 6308P01 and later)
H3C WAS6000 switch series (Release 6308P01 and later)
H3C S5000X-EI switch series (Release 6329 and later)
H3C MS4320V3 switch series (Release 6329 and later)
H3C S5120V3-SI switch series (Release 6329 and later)
H3C S5120V3-LI switch series (Release 6329 and later)

New H3C Technologies Co., Ltd.
http://www.h3c.com

Software version: Release 63xx
Document version: 6W105-20230524

Preface

This configuration guide describes gRPC feature and configuration tasks.

This preface includes the following topics about the documentation:

Audience

This documentation is intended for:

- Network planners.
- Field technical support and servicing engineers.
- Network administrators.

Conventions

The following information describes the conventions used in the documentation.

Command conventions

Convention	Description
Boldface	**Bold** text represents commands and keywords that you enter literally as shown.
Italic	*Italic* text represents arguments that you replace with actual values.
[ ]	Square brackets enclose syntax choices (keywords or arguments) that are optional.
{ x | y | ... }	Braces enclose a set of required syntax choices separated by vertical bars, from which you select one.
[x | y | ...]	Square brackets enclose a set of optional syntax choices separated by vertical bars, from which you select one or none.
{ x | y | ... } *	Asterisk marked braces enclose a set of required syntax choices separated by vertical bars, from which you select a minimum of one.
[x | y | ...] *	Asterisk marked square brackets enclose optional syntax choices separated by vertical bars, from which you select one choice, multiple choices, or none.
&<1-n>	The argument or keyword and argument combination before the ampersand (&) sign can be entered 1 to n times.
#	A line that starts with a pound (#) sign is comments.

GUI conventions

Convention	Description
Boldface	Window names, button names, field names, and menu items are in Boldface. For example, the **New User** window opens; click **OK**.
>	Multi-level menus are separated by angle brackets. For example, **File** > **Create** > **Folder**.

Symbols

Convention	Description
WARNING!	An alert that calls attention to important information that if not understood or followed can result in personal injury.
CAUTION:	An alert that calls attention to important information that if not understood or followed can result in data loss, data corruption, or damage to hardware or software.
IMPORTANT:	An alert that calls attention to essential information.
NOTE:	An alert that contains additional or supplementary information.
TIP:	An alert that provides helpful information.

Network topology icons

Convention	Description
	Represents a generic network device, such as a router, switch, or firewall.
	Represents a routing-capable device, such as a router or Layer 3 switch.
	Represents a generic switch, such as a Layer 2 or Layer 3 switch, or a router that supports Layer 2 forwarding and other Layer 2 features.
	Represents an access controller, a unified wired-WLAN module, or the access controller engine on a unified wired-WLAN switch.
	Represents an access point.
	Represents a wireless terminator unit.
	Represents a wireless terminator.
	Represents a mesh access point.
	Represents omnidirectional signals.
	Represents directional signals.
	Represents a security product, such as a firewall, UTM, multiservice security gateway, or load balancing device.
	Represents a security module, such as a firewall, load balancing, NetStream, SSL VPN, IPS, or ACG module.

Examples provided in this document

Examples in this document might use devices that differ from your device in hardware model, configuration, or software version. It is normal that the port numbers, sample output, screenshots, and other information in the examples differ from what you have on your device.

Documentation feedback

You can e-mail your comments about product documentation to info@h3c.com.

We appreciate your comments.

Contents

Configuring gRPC

About gRPC

gRPC is an open source remote procedure call (RPC) system initially developed at Google. It uses HTTP 2.0 for transport and provides network device configuration and management methods that support multiple programming languages.

gRPC protocol stack layers

Table 1 describes the gRPC protocol stack layers.

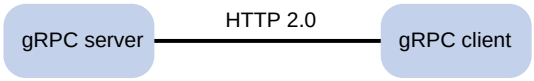
Table 1 gRPC protocol stack layers

Layer	Description
Content layer	Defines the data of the service module. Two peers must notify each other of the data models that they are using.
Protocol buffer encoding layer	Encodes data by using the protocol buffer code format.
gRPC layer	Defines the protocol interaction format for remote procedure calls.
HTTP 2.0 layer	Carries gRPC.
TCP layer	Provides connection-oriented reliable data links.

Network architecture

As shown in Figure 1, the gRPC network uses the client/server model. It uses HTTP 2.0 for packet transport.

Figure 1 gRPC network architecture



The gRPC network uses the following mechanism:

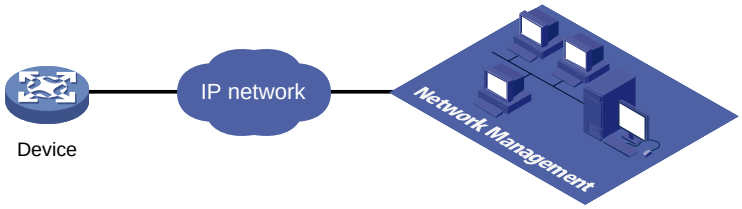
1. The gRPC server listens to connection requests from clients at the gRPC service port.
2. A user runs the gRPC client application to log in to the gRPC server, and uses methods provided in the .proto file to send requests.
3. The gRPC server responds to requests from the gRPC client.

The device can act as the gRPC server or client.

Telemetry technology based on gRPC

Telemetry is a remote data collection technology for monitoring device performance and operating status. H3C telemetry technology uses gRPC to push data from the device to the collectors on the NMSs. As shown in Figure 2, after a gRPC connection is established between the device and NMSs, the NMSs can subscribe to data of modules on the device.

Figure 2 Telemetry technology based on gRPC



Telemetry modes

The device supports the following telemetry modes:

- **Dial-in mode**—The device acts as a gRPC server and the collectors act as gRPC clients. A collector initiates a gRPC connection to the device to subscribe to device data.

  Dial-in mode applies to small networks where collectors need to deploy configurations to devices.
- **Dial-out mode**—The device acts as a gRPC client and the collectors act as gRPC servers. The device initiates a gRPC connection to the collectors and pushes subscribed device data to the collectors.

  Dial-out mode applies to larger networks where devices need to push device data to collectors.

Protocols

RFC 7540, *Hypertext Transfer Protocol version 2 (HTTP/2)*

FIPS compliance

The device supports the FIPS mode that complies with NIST FIPS 140-2 requirements. Support for features, commands, and parameters might differ in FIPS mode and non-FIPS mode. For more information about FIPS mode, see *Security Configuration Guide*.

gRPC is not supported in FIPS mode.

Prerequisites for gRPC

Before you can configure gRPC, you must install a gRPC feature software image compatible with the device software version. For information about the installation procedure, see software upgrade in *Fundamentals Configuration Guide*.

Configuring the gRPC dial-in mode

gRPC dial-in mode configuration tasks at a glance

To configure the gRPC dial-in mode, perform the following tasks:

1. Configuring the gRPC service
2. Configuring a gRPC user

Configuring the gRPC service

Restrictions and guidelines

If the gRPC service fails to be enabled, use the **display tcp** or **display ipv6 tcp** command to verify whether the gRPC service port number has been used by another feature. If yes, specify a free port as the gRPC service port number and try to enable the gRPC service again. For more information about the **display tcp** and **display ipv6 tcp** commands, see *Layer 3—IP Services Command Reference*.

Procedure

1. Enter system view.

   system-view

2. (Optional.) Set the gRPC service port number.

   grpc port *port-number*

   By default, the gRPC service port number is 50051.

   Changing the gRPC service port number when the gRPC service is enabled reboots the gRPC service and closes gRPC connections to gRPC clients. The gRPC clients must re-initiate the connections.

3. Enable the gRPC service.

   grpc enable

   By default, the gRPC service is disabled.

4. (Optional.) Set the gRPC session idle timeout timer.

   grpc idle-timeout *minutes*

   By default, the gRPC session idle timeout timer is 5 minutes.

Configuring a gRPC user

About gRPC users

For gRPC clients to establish gRPC sessions with the device, you must configure local users for the gRPC clients.

Procedure

1. Enter system view.

   system-view

2. Add a local user with the device management right.

   local-user *user-name* [**class manage**]

3. Configure a password for the user.

   password [{ **hash** | **simple** } *password*]

   By default, no password is configured for a local user. A non-password-protected user can pass authentication after providing the correct username and passing attribute checks.

4. Assign user role network-admin to the user.

   authorization-attribute user-role *user-role*

   By default, a local user is assigned the network-operator role.

5. Authorize the user to use the HTTPS service.

   service-type https

   By default, no service types are authorized to a local user.

For more information about the **local-user**, **password**, **authorization-attribute**, and **service-type** commands, see AAA configuration in *Security Command Reference*.

Configuring the gRPC dial-out mode

gRPC dial-out mode configuration tasks at a glance

To configure the gRPC dial-out mode, perform the following tasks:

1. Enabling the gRPC service
2. Configuring sensors
3. Configuring collectors
4. Configuring a subscription

Enabling the gRPC service

1. Enter system view.
   system-view
2. Enable the gRPC service.
   grpc enable
   By default, the gRPC service is disabled.

Configuring sensors

About sensors

The device uses sensors to sample data. A sensor path indicates a data source.

Supported data sampling types include:

- **Event-triggered sampling**—Sensors in a sensor group sample data when certain events occur. For sensor paths of this data sampling type, see *NETCONF XML API Event Reference* for the module.
- **Periodic sampling**—Sensors in a sensor group sample data at intervals. For sensor paths of this data sampling type, see the NETCONF XML API references for the module except for *NETCONF XML API Event Reference*.

Procedure

1. Enter system view.
   system-view
2. Enter telemetry view.
   telemetry
3. Create a sensor group and enter sensor group view.
   sensor-group *group-name*
4. Specify a sensor path.
   sensor path *path*
   To specify multiple sensor paths, execute this command multiple times.

Configuring collectors

About collectors

Collectors are used to receive sampled data from network devices. For the device to communicate with collectors, you must create a destination group and add collectors to the destination group.

You can add collectors to a destination group by their IP addresses. As from Release 6343P08, you can also add collectors to a destination group also by their domain names. When you specify collectors by their domain names, use the following restrictions and guidelines:

- You must configure DNS to make sure the device can translate the domain names of the collectors to IP addresses. For more information about DNS, see *Layer 3—IP Services Configuration Guide*.
- To view domain name and IP address mappings, use the **display dns host** command. If a domain name maps to multiple IP addresses, the device pushes data to the first reachable IP address.

Restrictions and guidelines

As a best practice, configure a maximum of five destination groups. If you configure too many destination groups, system performance might degrade.

Procedure

1. Enter system view.

   system-view

2. Enter telemetry view.

   telemetry

3. Create a destination group and enter destination group view.

   destination-group *group-name*

4. Specify a collector.

   IPv4:

   ipv4-address *ipv4-address* [**port** *port-number*]

   IPv6:

   ipv6-address *ipv6-address* [**port** *port-number*]

   To add multiple collectors, repeat this command. A collector is uniquely identified by a three-tuple of IP address, port number, and VPN instance name. One collector must have a different IP address, port number, or VPN instance name than the other collectors in the destination group.

5. Add a collector to the destination group by its domain name.

   IPv4:

   domain-name *domain-name* [**port** *port-number*] [**vpn-instance** *vpn-instance-name*]

   This command is supported only in Release 6343P08 and later.

   IPv6:

   ipv6 domain-name *domain-name* [**port** *port-number*] [**vpn-instance** *vpn-instance-name*]

   This command is supported only in Release 6343P08 and later.

   To add multiple collectors, repeat this command. A collector is uniquely identified by a three-tuple of domain name, port number, and VPN instance name. One collector must have a different domain name, port number, or VPN instance name than the other collectors in the destination group.

Configuring a subscription

About configuring a subscription

A subscription binds sensor groups to destination groups. Then, the device pushes data from the specified sensors to the collectors.

Procedure

1. Enter system view.

   system-view
2. Enter telemetry view.

   telemetry
3. Create a subscription and enter subscription view.

   subscription *subscription-name*
4. (Optional.) Specify the source IP address for packets sent to collectors.

   source-address { *ipv4-address* | **interface** *interface-type interface-number* | **ipv6** *ipv6-address* }

   By default, the device uses the primary IPv4 address of the output interface for the route to the collectors as the source address.

   Changing the source IP address for packets sent to collectors causes the device to re-establish the connection to the gRPC server.
5. Specify a sensor group.

   sensor-group *group-name* [**sample-interval** *interval*]

   Specify the **sample-interval** *interval* option for periodic sensor paths and only for periodic sensor paths.

   - If you specify the option for event-triggered sensor paths, the sensor paths do not take effect.
   - If you do not specify the option for periodic sensor paths, the device does not sample or push data.
6. Specify a destination group.

   destination-group *group-name*

Display and maintenance commands for gRPC

Execute **display** commands in any view.

Task	Command
Display gRPC information.	**display grpc** [**verbose**] The **verbose** keyword is supported only in Release 6343P08 and later.

gRPC configuration examples

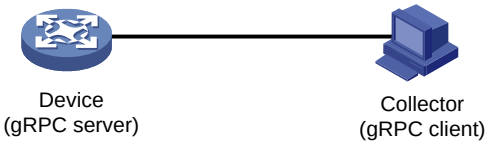
These configuration examples describe only CLI configuration tasks on the device. The collectors need to run an extra application. For information about collector-side application development, see "Developing the collector-side application."

Example: Configuring the gRPC dial-in mode

Network configuration

As shown in Figure 3, configure the gRPC dial-in mode on the device so the device acts as the gRPC server and the gRPC client can subscribe to LLDP events on the device.

Figure 3 Network diagram



Prerequisites

Before you can configure gRPC, you must install a gRPC feature software image compatible with the device software version. For more information about the installation procedure, see software upgrade configuration in *Fundamentals Configuration Guide*.

To install a gRPC feature software image:

1. Download the gRPC feature software image compatible with the device software version from the H3C website to the root directory of the flash memory on the device. On an IRF fabric, use FTP or TFTP commands to transfer the image file to the root directory of the default file system on the master device. (Details not shown.)
2. Install the feature software image on the device and commit the software change. On an IRF fabric, install the image on each member device. For example, install the image on the member device with an IRF member ID of 1 for the slot number.

```
<Device> install activate feature flash:/grpc-01.bin slot 1
Verifying the file flash:/grpc-01.bin on slot 1....Done.
Identifying the upgrade methods....Done.
Upgrade summary according to following table:
flash:/grpc-01.bin
  Running Version             New Version
  None                        Demo 01
  Slot                        Upgrade Way
  1                           Service Upgrade
Upgrading software images to compatible versions. Continue? [Y/N]:y
This operation might take several minutes, please wait...................Done.
<Device> install commit
This operation will take several minutes, please wait.....................Done.
```

3. Log in to the device or the IRF fabric again.

Procedure

1. Assign IP addresses to interfaces on the gRPC server and client and configure routes. Make sure the server and client can reach each other.
2. Configure the device as the gRPC server:

   # Enable the gRPC service.

```
<Device> system-view
[Device] grpc enable
```

   # Create a local user named **test**. Set the password to **test**, and assign user role network-admin and the HTTPS service to the user.

```
[Device] local-user test
```

```
[Device-luser-manage-test] password simple test
[Device-luser-manage-test] authorization-attribute user-role network-admin
[Device-luser-manage-test] service-type https
[Device-luser-manage-test] quit
```

3. Configure the gRPC client.
   a. Prepare a PC and install the gRPC environment on the PC. For more information, see the user guide for the gRPC environment.
   b. Obtain the H3C proto definition file and uses the protocol buffer compiler to generate code of a specific language, for example, Java, Python, C/C++, or Go.
   c. Create a client application to call the generated code.
   d. Start the application to log in to the gRPC server.

Verifying the configuration

When an LLDP event occurs on the gRPC server, verify that the gRPC client receives the event.

Example: Configuring the gRPC dial-out mode

Network configuration

As shown in Figure 4, the device is connected to a collector. The collector uses port 50050.

Configure gRPC dial-out mode on the device so the device pushes the device capability information of its interface module to the collector at 10-second intervals.

Figure 4 Network diagram

Prerequisites

Before you can configure gRPC, you must install a gRPC feature software image compatible with the device software version. For more information about the installation procedure, see software upgrade configuration in *Fundamentals Configuration Guide*.

To install a gRPC feature software image:

1. Download the gRPC feature software image compatible with the device software version from the H3C website to the root directory of the flash memory on the device. On an IRF fabric, use FTP or TFTP commands to transfer the image file or patch to the root directory of the default file system on the master device. (Details not shown.)
2. Install the feature software image on the device and commit the software change. On an IRF fabric, install the image on each member device. For example, install the image on the member device with an IRF member ID of 1 for the slot number.

```
<Device> install activate feature flash:/grpc-01.bin slot 1
Verifying the file flash:/grpc-01.bin on slot 1....Done.
Identifying the upgrade methods....Done.
Upgrade summary according to following table:
flash:/grpc-01.bin
  Running Version             New Version
  None                        Demo 01
  Slot                        Upgrade Way
```

```
  1                           Service Upgrade
Upgrading software images to compatible versions. Continue? [Y/N]:y
This operation might take several minutes, please wait...................Done.
<Device> install commit
This operation will take several minutes, please wait.....................Done.
```

3. Log in to the device or the IRF fabric again.

Procedure

Configure IP addresses as required so the device and the collector can reach each other. (Details not shown.)

Enable the gRPC service.

```
<Device> system-view
[Device] grpc enable
```

Create a sensor group named **test**, and add sensor path **ifmgr/devicecapabilities/**.

```
[Device] telemetry
[Device-telemetry] sensor-group test
[Device-telemetry-sensor-group-test] sensor path ifmgr/devicecapabilities/
[Device-telemetry-sensor-group-test] quit
```

Create a destination group named **collector1**. Specify a collector that uses IPv4 address 192.168.2.1 and port number 50050.

```
[Device-telemetry] destination-group collector1
[Device-telemetry-destination-group-collector1] ipv4-address 192.168.2.1 port 50050
[Device-telemetry-destination-group-collector1] quit
```

Configure a subscription named **A** to bind sensor group **test** with destination group **collector1**. Set the sampling interval to 10 seconds.

```
[Device-telemetry] subscription A
[Device-telemetry-subscription-A] sensor-group test sample-interval 10
[Device-telemetry-subscription-A] destination-group collector1
[Device-telemetry-subscription-A] quit
```

Verifying the configuration

Verify that the collector receives the device capability information of the interface module from the device at 10-second intervals. (Details not shown.)

Protocol buffer code

Protocol buffer code format

Google Protocol Buffers provide a flexible mechanism for serializing structured data. Different from XML code and JSON code, the protocol buffer code is binary and provides higher performance.

Table 2 compares a protocol buffer code format example and the corresponding JSON code format example.

Table 2 Protocol buffer and JSON code format examples

Protocol buffer code format example	Corresponding JSON code format example

{
1:“H3C”
2:“H3C”
3:“H3C Simware”
4:“Syslog/LogBuffer”
5:"notification": {
"Syslog": {
"LogBuffer": {
"BufferSize": 512,
"BufferSizeLimit": 1024,
"DroppedLogsCount": 0,
"LogsCount": 100,
"LogsCountPerSeverity": {
"Alert": 0,
"Critical": 1,
"Debug": 0,
"Emergency": 0,
"Error": 3,
"Informational": 80,
"Notice": 15,
"Warning": 1
},
"OverwrittenLogsCount": 0,
"State": "enable"
}
},
"Timestamp": "1527206160022"
}
}
	{
	"producerName": "H3C",
	"deviceName": "H3C",
	"deviceModel": "H3C Simware",
	"sensorPath": "Syslog/LogBuffer",
	"jsonData": {
	"notification": {
	"Syslog": {
	"LogBuffer": {
	"BufferSize": 512,
	"BufferSizeLimit": 1024,
	"DroppedLogsCount": 0,
	"LogsCount": 100,
	"LogsCountPerSeverity": {
	"Alert": 0,
	"Critical": 1,
	"Debug": 0,
	"Emergency": 0,
	"Error": 3,
	"Informational": 80,
	"Notice": 15,
	"Warning": 1
	},
	"OverwrittenLogsCount": 0,
	"State": "enable"
	}
	},
	"Timestamp": "1527206160022"
	}
	}
	}

Proto definition files

You can define data structures in a proto definition file. Then, you can compile the file with utility protoc to generate code in a programing language such as Java and C++. Using the generated code, you can develop an application for a collector to communicate with the device.

H3C provides proto definition files for both dial-in mode and dial-out mode.

Proto definition files in dial-in mode

Public proto definition files

The **grpc_service.proto** file defines the public RPC methods in dial-in mode, for example, login method and logout method.

The following are the contents of the **grpc_service.proto** file:

```
syntax = "proto2";
package grpc_service;
message GetJsonReply {   // Reply to the Get method
    required string result = 1;
}
message SubscribeReply { // Subscription result
    required string result = 1;
}
message ConfigReply {    // Configuration result
    required string result = 1;
}
message ReportEvent {    // Subscribed event
    required string token_id = 1;    // Login token_id
    required string stream_name = 2; // Event stream name
    required string event_name = 3;  // Event name
    required string json_text = 4;   // Subscription result, a JSON string
}
message GetReportRequest{ // Obtains the event subscription result
    required string token_id = 1; // Returns the token_id upon a successful login
}
message LoginRequest {  // Login request parameters
    required string user_name = 1; // Username
    required string password = 2; // Password
}
message LoginReply {  // Reply to a login request
    required string token_id = 1; // Returns the token_id upon a successful login
}
message LogoutRequest { // Logout parameter
    required string token_id = 1; // token_id
}
message LogoutReply { // Reply to a logout request
    required string result = 1; // Logout result
}
message SubscribeRequest { // Event stream name
    required string stream_name = 1;
```

```
}
service GrpcService {    // gRPC methods
    rpc Login (LoginRequest) returns (LoginReply) {}      // Login method
    rpc Logout (LogoutRequest) returns (LogoutReply) {}   // Logout method
    rpc SubscribeByStreamName (SubscribeRequest) returns (SubscribeReply) {} // Event
subscription method
    rpc GetEventReport (GetReportRequest) returns (stream ReportEvent) {} // Method for
obtaining the subscribed event
}
```

Proto definition files for service modules

The dial-in mode supports proto definition files for the following service modules: Device, Ifmgr, IPFW, LLDP, and Syslog.

The following are the contents of the **Device.proto** file, which defines the RPC methods for the Device module:

```
syntax = "proto2";
import "grpc_service.proto";
package  device;
message DeviceBase { // Structure for obtaining basic device information
    optional string HostName = 1;    // Device name
    optional string HostOid = 2;     // sysoid
    optional uint32 MaxChassisNum = 3;    //Maximum number of chassis
    optional uint32 MaxSlotNum = 4;  // Maximum number of slots
    optional string HostDescription = 5; // Device description
}
message DevicePhysicalEntities { // Structure for obtaining physical entity information
of the device
    message Entity {
        optional uint32 PhysicalIndex = 1;    // Entity index
        optional string VendorType = 2;       // Vendor type
        optional uint32 EntityClass = 3;      // Entity class
        optional string SoftwareRev = 4;      // Software version
        optional string SerialNumber = 5;     // Serial number
        optional string Model = 6;            // Model
    }
    repeated Entity entity = 1;
}
service DeviceService { // RPC methods
    rpc GetJsonDeviceBase(DeviceBase) returns (grpc_service.GetJsonReply) {} // Method
for obtaining basic device information
    rpc GetJsonDevicePhysicalEntities(DevicePhysicalEntities) returns
(grpc_service.GetJsonReply) {}   // Method for obtaining physical entity information of
the device
}
```

Proto definition file in dial-out mode

The **grpc_dialout.proto** file defines the public RPC methods in dial-out mode. The following are the contents of the file:

```
syntax = "proto2";
```

```
package grpc_dialout;
message DeviceInfo{  // Pushed device information
    required string producerName = 1; // Vendor name
    required string deviceName = 2; // Device name
    required string deviceModel = 3; // Device model
    optional string deviceIpAddr = 4; // Device IP
    optional string eventType = 5; // Type of the sensor path
    optional string deviceSerialNumber = 6; // Serial number of the device
    optional string deviceMac= 7; // Bridge MAC address of the device
}
message DialoutMsg{   // Format of the pushed data
    required DeviceInfo deviceMsg = 1; // Device information described by DeviceInfo
    required string sensorPath = 2; // Sensor path, which corresponds to xpath in NETCONF
    required string jsonData = 3; // Sampled data, a JSON string
}
message DialoutResponse{  // Response from the collector. Reserved. The value is not
processed.
    required string response = 1;
}
service gRPCDialout {  // Data push method
    rpc Dialout(stream DialoutMsg) returns (DialoutResponse);
}
```

Obtaining proto definition files

Contact the technical support.

Example: Developing a gRPC collector-side application

Use a language (for example, C++) to develop a gRPC collector-side application on Linux to enable a collector to collect device data.

Prerequisites

1. Obtain H3C proto definition files.
   - For dial-in mode, obtain the **grpc_service.proto** file and proto definition files for service modules.
   - For dial-out mode, obtain the **grpc_dialout.proto** file.
2. Obtain utility protoc from https://github.com/google/protobuf/releases.
3. Obtain the protobuf plug-in for C++ (**protobuf-cpp**) from https://github.com/google/protobuf/releases.

Generating the C++ code for the proto definition files

Dial-in mode

Copy the required proto definition files to the current directory, for example, **grpc_service.proto** and **BufferMonitor.proto**.

```
$protoc --plugin=./grpc_cpp_plugin  --grpc_out=. --cpp_out=. *.proto
```

Dial-out mode

Copy proto definition file **grpc_dialout.proto** to the current directory.

```
$ protoc --plugin=./grpc_cpp_plugin  --grpc_out=.  --cpp_out=. *.proto
```

Developing the collector-side application

Dial-in mode

In dial-in mode, the application needs to provide the code to be run on the gRPC client.

The C++ code generated from the proto definition files already encapsulates the service classes, which are GrpcService and BufferMonitorService in this example. For the gRPC client to initiate RPC requests, you only need to call the RPC method in the application.

The application performs the following operations:

- Log in to obtain the token_id.
- Prepare parameters for the RPC method, use the service classes generated from the proto definition files to call the RPC method, and resolve the returned result.
- Log out.

To develop the collector-side application in dial-in mode:

1. Create a GrpcServiceTest class.

   # In the class, use the GrpcService::Stub class generated from grpc_service.proto. Implement login and logout with the Login and Logout methods generated from grpc_service.proto.

   ```
   class GrpcServiceTest
   {
   public:
       /* Constructor functions */
       GrpcServiceTest(std::shared_ptr<Channel> channel):
   GrpcServiceStub(GrpcService::NewStub(channel))  {}

       /* Member functions */
       int Login(const std::string& username, const std::string& password);
       void Logout();
       void listen();

       /* Member variable */
       std::string token;

   private:
       std::unique_ptr<GrpcService::Stub> GrpcServiceStub;  // Use the
   GrpcService::Stub class generated from grpc_service.proto.
   };
   ```

2. Customize the Login method.

Call the Login method of the GrpcService::Stub class to allow a user who provides the correct the username and password to log in.

```
int GrpcServiceTest::Login(const std::string& username, const std::string& password)
{
    LoginRequest request;   // Username and password.
    request.set_user_name(username);
    request.set_password(password);

LoginReply reply;
ClientContext context;

    // Call the Login method.
    Status status = GrpcServiceStub->Login(&context, request, &reply);
    if (status.ok())
    {
        std::cout << "login ok!" << std::endl;
        std::cout <<"token id is :" << reply.token_id() << std::endl;
        token = reply.token_id();  // The login succeeds. The token is obtained.
        return 0;
    }
    else{
        std::cout << status.error_code() << ": " << status.error_message()
                  << ". Login failed!" << std::endl;
        return -1;
    }
}
```

3. Initiate an RPC request to the device. In this example, the application subscribes to interface packet drop events.

```
rpc SubscribePortQueDropEvent(PortQueDropEvent) returns
(grpc_service.SubscribeReply) {}
```

4. Create the BufMon_GrpcClient class to encapsulate the RPC method.

Use the BufferMonitorService::Stub class generated from BufferMonitor.proto to call the RPC method.

```
class BufMon_GrpcClient
{
public:
    BufMon_GrpcClient(std::shared_ptr<Channel> channel):
mStub(BufferMonitorService::NewStub(channel))
    {
    }

    std::string BufMon_Sub_AllEvent(std::string token);
    std::string BufMon_Sub_BoardEvent(std::string token);
    std::string BufMon_Sub_PortOverrunEvent(std::string token);
    std::string BufMon_Sub_PortDropEvent(std::string token);

    /* Get entries */
    std::string BufMon_Sub_GetStatistics(std::string token);
    std::string BufMon_Sub_GetGlobalCfg(std::string token);
```

```
    std::string BufMon_Sub_GetBoardCfg(std::string token);
    std::string BufMon_Sub_GetNodeQueCfg(std::string token);
    std::string BufMon_Sub_GetPortQueCfg(std::string token);

private:
    std::unique_ptr<BufferMonitorService::Stub> mStub; // Use the class generated
from BufferMonitor.proto.
};
```

5. Use std::string BufMon_Sub_PortDropEvent(std::string token) to implement interface packet drop event subscription.

```
std::string BufMon_GrpcClient::BufMon_Sub_PortDropEvent(std::string token)
{
    std::cout << "-------BufMon_Sub_PortDropEvent-------- " << std::endl;

    PortQueDropEvent stNodeEvent;
    PortQueDropEvent_PortQueDrop* pstParam = stNodeEvent.add_portquedrop();

    UINT uiIfIndex = 0;
    UINT uiQueIdx = 0;
    UINT uiAlarmType = 0;

    std::cout<<"Please input interface queue info : ifIndex queIdx alarmtype " <<
std::endl;
    cout<<"alarmtype : 1 for ingress; 2 for egress; 3 for port headroom"<<endl;

    std::cin>>uiIfIndex>>uiQueIdx>>uiAlarmType; // Set the subscription parameters
and interface index.
    pstParam->set_ifindex(uiIfIndex);
    pstParam->set_queindex(uiQueIdx);
    pstParam->set_alarmtype(uiAlarmType);

    ClientContext context;

    /* Token needs to be added to context */ // Set the token_id to be returned after
a successful login
    std::string key = "token_id";
    std::string value = token;
    context.AddMetadata(key, value);

    SubscribeReply reply;
    Status status = mStub->SubscribePortQueDropEvent(&context,stNodeEvent,&reply);
// Call the RPC method.

    return reply.result();
}
```

6. Use a loop to listen to event reports.

Implement this method in the GrpcServiceTest class.

```
void GrpcServiceTest::listen()
{
```

```
    GetReportRequest reportRequest;
    ClientContext context;
    ReportEvent reportedEvent;

   /* Add the token to the request */
   reportRequest.set_token_id(token);

    std::unique_ptr< ClientReader< ReportEvent>>
reader(GrpcServiceStub->GetEventReport(&context, reportRequest)); // Use
GetEventReport (which is generated from grpc_service.proto) to obtain event
information.

    std::string streamName;
    std::string eventName;
    std::string jsonText;
   std::string token;

    JsonFormatTool jsonTool;

   std::cout << "Listen to server for Event" << std::endl;

    while(reader->Read(&reportedEvent) ) // Read the received event report.
    {
        streamName = reportedEvent.stream_name();
        eventName = reportedEvent.event_name();
        jsonText = reportedEvent.json_text();
        token = reportedEvent.token_id();

       std::cout << "/**********************EVENT COME************************/"
<< std::endl;
        std::cout << "TOKEN: " << token << std::endl;
        std::cout << "StreamName: "<< streamName << std::endl;
        std::cout << "EventName: " << eventName << std::endl;
        std::cout << "JsonText without format: " << std::endl << jsonText << std::endl;
        std::cout << std::endl;
        std::cout << "JsonText Formated: " << jsonTool.formatJson(jsonText) <<
std::endl;
        std::cout << std::endl;
    }

    Status status = reader->Finish();
    std::cout << "Status Message:" << status.error_message() << "ERROR code :" <<
status.error_code();
}  // Login and RPC request finished.
```

7. To log out, call the Logout method. (Details not shown.)

Dial-out mode

In dial-out mode, the application needs to provide the gRPC server code so the collector can receive and resolve data obtained from the device.

The application performs the following operations:

- Inherit the automatically generated GRPCDialout::Service class, overload the automatically generated RPC Dialout service, and resolve the fields.
- Register the RPC service with the specified listening port.

To develop the collector-side application in dial-out mode:

1. Inherit and overload RPC service Dialout.

Create class DialoutTest and inherit GRPCDialout::Service.

```
class DialoutTest final : public GRPCDialout::Service { // Overload the automatically generated abstract class.
    Status Dialout(ServerContext* context, ServerReader< DialoutMsg>* reader, DialoutResponse* response) override; // Implement RPC method Dialout.
};
```

2. Register the DialoutTest service as a gRPC service and specify the listening port.

```
using grpc::Server;
using grpc::ServerBuilder;
std::string server_address("0.0.0.0:60057"); // Specify the address and port to listen to.
DialoutTest dialout_test; // Define the object declared in step 1.
ServerBuilder builder;
builder.AddListeningPort(server_address, grpc::InsecureServerCredentials());// Add the listening port.
builder.RegisterService(&dialout_test); // Register the service.
std::unique_ptr<Server> server(builder.BuildAndStart()); // Start the service.
server->Wait();
```

3. Implement the Dialout method and data resolution.

```
Status DialoutTest::Dialout(ServerContext* context, ServerReader< DialoutMsg>* reader, DialoutResponse* response)
{
        DialoutMsg msg;

        while( reader->Read(&msg))
        {
            const DeviceInfo &device_msg = msg.devicemsg();
            std::cout<< "Producer-Name: " << device_msg.producername() << std::endl;
            std::cout<< "Device-Name: " << device_msg.devicename() << std::endl;
            std::cout<< "Device-Model: " << device_msg.devicemodel() << std::endl;
            std::cout<<"Sensor-Path: " << msg.sensorpath()<<std::endl;
            std::cout<<"Json-Data: " << msg.jsondata()<<std::endl;
            std::cout<<std::endl;
        }
        response->set_response("test");

        return Status::OK;
}
```

4. After obtaining the DialoutMsg object (generated from the proto definition file) through the Read method, you can call the method to obtain the field values.

OpenFlow Configuration Guide

This command reference is applicable to the following switches and software versions:

H3C S5120V2-LI switch series (Release 6308P01 and later)
H3C S3100V3-SI switch series (Release 6309P01 and later)
H3C S5110V2 switch series (Release 6310 and later)
H3C S5110V2-SI switch series (Release 6310 and later)
H3C S5000V3-EI switch series (Release 6310 and later)
H3C S5000V5-EI switch series (Release 6319P01 and later)
H3C S5000E-X switch series (Release 6310 and later)
H3C S5130S-LI switch series (Release 6310 and later)
H3C MS4320V2 switch series (Release 6308P01 and later)
H3C MS4320 switch series (Release 6308P01 and later)
H3C MS4300V2 switch series (Release 6308P01 and later)
H3C MS4200 switch series (Release 6310 and later)
H3C WS5810-WiNet switch series (Release 6308P01 and later)
H3C WS5820-WiNet switch series (Release 6308P01 and later)
H3C WAS6000 switch series (Release 6308P01 and later)
H3C S5000X-EI switch series (Release 6329 and later)
H3C MS4320V3 switch series (Release 6329 and later)
H3C S5120V3-SI switch series (Release 6329 and later)
H3C S5120V3-LI switch series (Release 6329 and later)

New H3C Technologies Co., Ltd.
http://www.h3c.com

Software version: Release 63xx
Document version: 6W105-20230524

Preface

This configuration guide describes OpenFlow fundamentals and configuration procedures.

This preface includes the following topics about the documentation:

Audience

This documentation is intended for:

- Network planners.
- Field technical support and servicing engineers.
- Network administrators.

Conventions

The following information describes the conventions used in the documentation.

Command conventions

Convention	Description
Boldface	**Bold** text represents commands and keywords that you enter literally as shown.
Italic	*Italic* text represents arguments that you replace with actual values.
[ ]	Square brackets enclose syntax choices (keywords or arguments) that are optional.
{ x | y | ... }	Braces enclose a set of required syntax choices separated by vertical bars, from which you select one.
[x | y | ...]	Square brackets enclose a set of optional syntax choices separated by vertical bars, from which you select one or none.
{ x | y | ... } *	Asterisk marked braces enclose a set of required syntax choices separated by vertical bars, from which you select a minimum of one.
[x | y | ...] *	Asterisk marked square brackets enclose optional syntax choices separated by vertical bars, from which you select one choice, multiple choices, or none.
&<1-n>	The argument or keyword and argument combination before the ampersand (&) sign can be entered 1 to n times.
#	A line that starts with a pound (#) sign is comments.

GUI conventions

Convention	Description
Boldface	Window names, button names, field names, and menu items are in Boldface. For example, the **New User** window opens; click **OK**.
>	Multi-level menus are separated by angle brackets. For example, **File** > **Create** > **Folder**.

Symbols

Convention	Description
WARNING!	An alert that calls attention to important information that if not understood or followed can result in personal injury.
CAUTION:	An alert that calls attention to important information that if not understood or followed can result in data loss, data corruption, or damage to hardware or software.
IMPORTANT:	An alert that calls attention to essential information.
NOTE:	An alert that contains additional or supplementary information.
TIP:	An alert that provides helpful information.

Network topology icons

Convention	Description
	Represents a generic network device, such as a router, switch, or firewall.
	Represents a routing-capable device, such as a router or Layer 3 switch.
	Represents a generic switch, such as a Layer 2 or Layer 3 switch, or a router that supports Layer 2 forwarding and other Layer 2 features.
	Represents an access controller, a unified wired-WLAN module, or the access controller engine on a unified wired-WLAN switch.
	Represents an access point.
	Represents a wireless terminator unit.
	Represents a wireless terminator.
	Represents a mesh access point.
	Represents omnidirectional signals.
	Represents directional signals.
	Represents a security product, such as a firewall, UTM, multiservice security gateway, or load balancing device.
	Represents a security module, such as a firewall, load balancing, NetStream, SSL VPN, IPS, or ACG module.

Examples provided in this document

Examples in this document might use devices that differ from your device in hardware model, configuration, or software version. It is normal that the port numbers, sample output, screenshots, and other information in the examples differ from what you have on your device.

Documentation feedback

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We appreciate your comments.

Contents

Configuring OpenFlow

About OpenFlow

OpenFlow is the communications interface defined between the control and forwarding layers of a Software-Defined Networking architecture. With OpenFlow, you can perform centralized data forwarding management for physical and virtual devices through controllers.

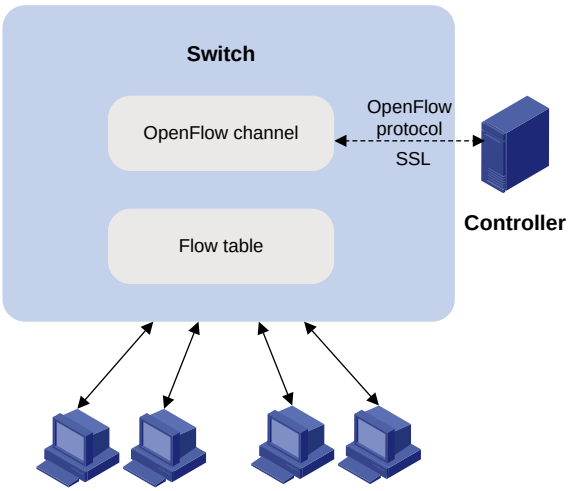
OpenFlow network components

OpenFlow separates the data forwarding and routing decision functions. It keeps the flow-based forwarding function and employs a separate controller to make routing decisions. An OpenFlow switch communicates with the controller through an OpenFlow channel. An OpenFlow channel can be encrypted by using TLS or run directly over TCP. An OpenFlow switch exchanges control messages with the controller through an OpenFlow channel to perform the following operations:

- Receive flow table entries or data from the controller.
- Report information to the controller.

Unless otherwise stated, a switch refers to an OpenFlow switch throughout this document.

Figure 1 OpenFlow network diagram



OpenFlow switch

OpenFlow switches include the following types:

- **OpenFlow-only**—Supports only OpenFlow operation.
- **OpenFlow-hybrid**—Supports both OpenFlow operation and traditional Ethernet switching operation.

OpenFlow port

OpenFlow supports the following types of ports:

- **Physical port**—Corresponds to a hardware interface, such as an Ethernet interface. A physical port can be either an ingress port or an output port.

- **Logical port**—Does not correspond to a hardware interface and might be defined by non-OpenFlow methods. For example, aggregate interfaces are logical ports. A logical port can be either an ingress port or an output port.
- **Reserved port**—Defined by OpenFlow to specify forwarding actions. Reserved ports include the following types:
  - **All**—All ports that can be used to forward a packet.
  - **Controller**—OpenFlow controller.
  - **In port**—Packet ingress port.
  - **Any**—Generic port description.
  - **Local**—Local CPU.
  - **Normal**—Normal forwarding process.
  - **Flood**—Flooding.

  Except the **Any** type, all reserved ports can be used as output ports. Only the **Controller** and **Local** types can be used as ingress ports.

OpenFlow instance

Unless otherwise stated, an OpenFlow switch refers to an OpenFlow instance throughout this document.

You can configure one or more OpenFlow instances on the same device. A controller considers each OpenFlow instance as a separate OpenFlow switch and deploys forwarding instructions to it.

OpenFlow instance mode

An OpenFlow instance is associated with VLANs. The flow entries take effect only on packets within VLANs associated with the OpenFlow instance.

Activation and reactivation

The configurations for an OpenFlow instance take effect only after the OpenFlow instance is activated.

The controller can deploy flow entries to an OpenFlow instance only after the OpenFlow instance reports the following device information to the controller:

- Capabilities supported by OpenFlow.
- Information about ports that belong to the OpenFlow instance.

An activated OpenFlow instance must be reactivated when any of the OpenFlow instance configurations are changed.

After reactivation, the OpenFlow instance is disconnected from all controllers and then reconnected to them.

OpenFlow instance port

An OpenFlow switch sends information about the following ports to the controller:

- Physical ports.
- Logical ports.
- Reserved ports of the **Local** type.

In loosen mode, a port belongs to the OpenFlow instance when VLANs associated with the OpenFlow instance overlap with the port's allowed VLANs. Otherwise, a port belongs to an OpenFlow instance only when VLANs associated with the OpenFlow instance are within the port's allowed VLAN list.

OpenFlow flow table

An OpenFlow switch matches packets with one or more flow tables. A flow table contains flow entries, and packets are matched based on the matching precedence of flow entries.

Flow table types

OpenFlow flow tables include the following types:

- **MAC-IP**—Combines the MAC address table and FIB table.

  A MAC-IP flow table provides the following match fields:

  - Destination MAC address.
  - VLAN.
  - Destination IP address.

  A MAC-IP flow table provides the following actions:

  - Modifying the destination MAC address.
  - Modifying the source MAC address.
  - Modifying the VLAN.
  - Specifying the output port.

  For more information, see "Appendix B MAC-IP flow table."
- **Extensibility**—Uses ACLs to match packets.

Flow entry

A flow entry contains the following fields:

- **Match fields**—Matching rules of the flow entry. These contain the ingress port, packet headers, and metadata specified by the previous table.
- **Priority**—Matching precedence of the flow entry. When a packet is matched with the flow table, only the highest priority flow entry that matches the packet is selected.
- **Counters**—Counts of the packets and bytes that match the flow entry.
- **Instructions**—Used to modify the action set or pipeline processing. Instructions include the following types:
  - **Meter**—Directs the packets to the specified meter to rate limit the packets.
  - **Apply-Actions**—Applies the specified actions in the action list immediately.
  - **Clear-Actions**—Clears all actions in the action set immediately.
  - **Write-Actions**—Modifies all actions in the action set immediately.
  - **Goto-Table**—Indicates the next flow table in the processing pipeline.

  Actions are executed in one of the following ways:

  - **Action Set**—When the instruction set of a flow entry does not contain a **Goto-Table** instruction, pipeline processing stops. Then, the actions in the action set are executed in the order specified by the instruction list. An action set contains a maximum of one action of each type.
  - **Action List**—The actions in the action list are executed immediately in the order specified by the action list. The effect of those actions is cumulative.

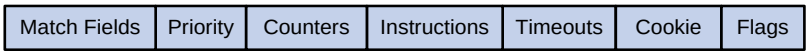
  Actions include the following types:

  - **(Required.) Output**—The Output action forwards a packet to the specified OpenFlow port. OpenFlow switches must support forwarding packets to physical ports, logical ports, and reserved ports.
  - **(Required.) Drop**—No explicit action exists to represent drops. Packets whose action sets have no output actions are dropped. Typically, packets are dropped due to empty instruction sets, empty action sets, or the executing a Clear-Actions instruction.

- **(Required.) Group**—Process the packet through the specified group. The exact interpretation depends on group type.
- **(Optional.) Set-Queue**—The Set-Queue action sets the queue ID for a packet. When the packet is forwarded to a port by the output action, the packet is assigned to the queue attached to this port for scheduling and forwarding. The forwarding behavior is dictated by the configuration of the queue and provides basic QoS support.
- **(Optional.) Set-Field**—The Set-Field actions are identified by their field type and modify the values of corresponding header fields in the packet. Set-Field actions are always applied to the outermost header. For example, a Set VLAN ID action always sets the ID of the outermost VLAN tag.

- **Timeouts**—Maximum amount of idle time or hard time for the flow entry.
  - **idle time**—The flow entry is removed when it has matched no packets during the idle time.
  - **hard time**—The flow entry is removed when the hard time timeout is exceeded, regardless of whether or not it has matched packets.
- **Cookie**—Custom data specified by the controller. The data are not used for processing packets, and might be used by the controller for matching flow entries.
- **Flags**—Flag for modifying the flow entry management method. For example, the OFPFF_SEND_FLOW_REM flag triggers the switch to send Flow-Removed messages for the flow entry to the controller.

Figure 2 Flow entry components



OpenFlow pipeline

The OpenFlow pipeline processing defines how packets interact with flow tables contained by a switch.

The flow tables of an OpenFlow switch are sequentially numbered, starting at 0. The packet is first matched with flow entries of the first flow table, which is flow table 0. A flow entry can only direct a packet to a flow table number that is greater than its own flow table number.

When a packet matches a flow entry, the OpenFlow switch updates the action set for the packet and passes the packet to the next flow table. In the last flow table, the OpenFlow switch executes all actions to modify packet contents and specify the output port for packet forwarding. If the instruction set of a flow table contains an action list, the OpenFlow switch immediately executes the actions for a copy of the packet in this table.

Figure 3 OpenFlow forwarding workflow

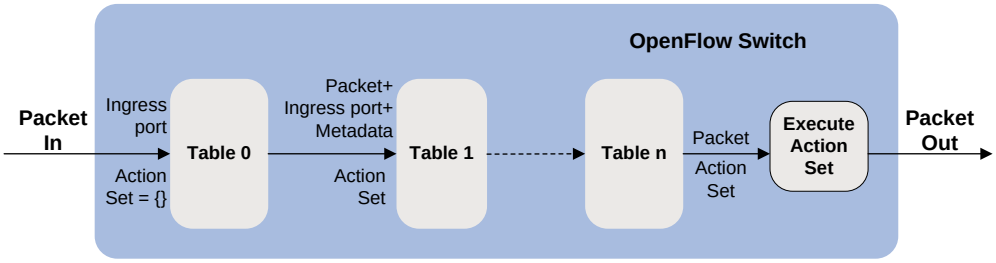


Table-miss flow entry

Every flow table must support a table-miss flow entry to process table misses. The table-miss flow entry specifies how to process packets that were not matched by other flow entries in the flow table.

The table-miss flow entry wildcards all match fields (all fields omitted) and has the lowest priority 0.

The table-miss flow entry behaves in most ways like any other flow entry.

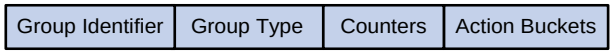
Group table

The ability for a flow entry to point to a group enables OpenFlow to represent additional methods of forwarding. A group table contains group entries.

A group entry contains the following fields:

- **Group Identifier**—A 32 bit unsigned integer uniquely identifying the group.
- **Group Type**—Type of the group. **All** means executing all buckets in the group. This group is used for multicast or broadcast forwarding.
- **Counters**—Updated when packets are processed by a group.
- **Action Buckets**—An ordered list of action buckets, where each action bucket contains a set of actions to execute and associated parameters.

Figure 4 Group entry components



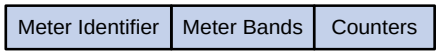
Meter table

Meters enable OpenFlow to implement various simple QoS operations, such as rate-limiting. A meter table contains meter entries.

A meter entry contains the following fields:

- **Meter Identifier**—A 32 bit unsigned integer uniquely identifying the meter.
- **Meter Bands**—Each meter can have one or more meter bands. Each band specifies the rate at which the band applies and the way packets should be processed. If the current rate of packets exceeds the rate of multiple bands, the band with the highest configured rate is used.
- **Counters**—Updated when packets are processed by a meter.

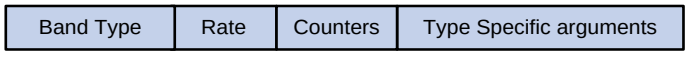
Figure 5 Meter entry components



A meter band contains the following fields:

- **Band Type**—(Optional.) Packet processing methods. Options are:
  - **Drop**—Discards the packet when the rate of the packet exceeds the band rate.
  - **DSCP Remark**—Remarks the DSCP field in the IP header of the packet.
- **Rate**—Defines the lowest rate at which the band can apply.
- **Counters**—Updated when packets are processed by a band.
- **Type Specific Arguments**—Some band types have specific arguments.

Figure 6 Band components



OpenFlow channel

The OpenFlow channel is the interface that connects each OpenFlow switch to a controller. The controller uses the OpenFlow channel to exchange control messages with the switch to perform the following operations:

- Configure and manage the switch.
- Receive events from the switch.
- Send packets out the switch.

The OpenFlow channel is usually encrypted by using TLS. Also, an OpenFlow channel can be run directly over TCP.

The OpenFlow protocol supports the following message types: controller-to-switch, asynchronous, and symmetric. Each message type has its own subtypes.

Controller-to-switch messages

Controller-to-switch messages are initiated by the controller and used to directly manage or inspect the state of the switch. Controller-to-switch messages might or might not require a response from the switch.

The controller-to-switch messages include the following subtypes:

- **Features**—The controller requests the basic capabilities of a switch by sending a features request. The switch must respond with a features reply that specifies the basic capabilities of the switch.
- **Configuration**—The controller sets and queries configuration parameters in the switch. The switch only responds to a query from the controller.
- **Modify-State**—The controller sends Modify-State messages to manage state on the switches. Their primary purpose is to add, delete, and modify flow or group entries in the OpenFlow tables and to set switch port properties.
- **Read-State**—The controller sends Read-State messages to collect various information from the switch, such as current configuration and statistics.
- **Packet-out**—These are used by the controller to send packets out of the specified port on the switch, or to forward packets received through packet-in messages. Packet-out messages must contain a full packet or a buffer ID representing a packet stored in the switch. The message must also contain a list of actions to be applied in the order they are specified. An empty action list drops the packet.
- **Barrier**—Barrier messages are used to confirm the completion of the previous operations. The controller send s Barrier request. The switch must send a Barrier reply when all the previous operations are complete.
- **Role-Request**—Role-Request messages are used by the controller to set the role of its OpenFlow channel, or query that role. It is typically used when the switch connects to multiple controllers.
- **Asynchronous-Configuration**—These are used by the controller to set an additional filter on the asynchronous messages that it wants to receive, or to query that filter. It is typically used when the switch connects to multiple controllers.

Asynchronous messages

Switches send asynchronous messages to controllers to inform a packet arrival or switch state change. For example, when a flow entry is removed due to timeout, the switch sends a flow-removed message to inform the controller.

The asynchronous messages include the following subtypes:

- **Packet-In**—Transfer the control of a packet to the controller. For all packets forwarded to the Controller reserved port using a flow entry or the table-miss flow entry, a packet-in event is always sent to controllers. Other processing, such as TTL checking, can also generate packet-in events to send packets to the controller. The packet-in events can include the full packet or can be configured to buffer packets in the switch. If the packet-in event is configured to buffer packets, the packet-in events contain only some fraction of the packet header and a buffer ID. The controller processes the full packet or the combination of the packet header and the buffer ID. Then, the controller sends a packet-out message to direct the switch to process the packet.

- **Flow-Removed**—Inform the controller about the removal of a flow entry from a flow table. These are generated due to a controller flow delete request or the switch flow expiry process when one of the flow timeouts is exceeded.
- **Port-status**—Inform the controller of a state or setting change on a port.
- **Error**—Inform the controller of a problem or error.

Symmetric messages

Symmetric messages are sent without solicitation, in either direction.

The symmetric messages contain the following subtypes:

- **Hello**—Hello messages are exchanged between the switch and controller upon connection startup.
- **Echo**—Echo request or reply messages can be sent from either the switch or the controller, and must return an echo reply. They are mainly used to verify the liveness of a controller-switch connection, and might also be used to measure its latency or bandwidth.
- **Experimenter**—This is a staging area for features meant for future OpenFlow revisions.

OpenFlow timers

An OpenFlow switch supports the following timers:

- **Connection detection interval**—Interval at which the OpenFlow switch sends an Echo Request message to a controller. When the OpenFlow switch receives no Echo Reply message within three intervals, the OpenFlow switch is disconnected from the controller.
- **Reconnection interval**—Interval for the OpenFlow switch to wait before it attempts to reconnect to a controller.

OpenFlow controller

Controller roles

A switch can establish connections with multiple controllers. When OpenFlow operation is initiated, a switch is simultaneously connected to multiple controllers in Equal state. A controller can request its role to be changed at any time. The controller role contains the following types:

- **Equal**—In this role, the controller has full access to the switch and is equal to other controllers in the same role. By default, the controller receives all switch asynchronous messages such as packet-in and flow-removed messages. The controller can send controller-to-switch messages to modify the state of the switch.
- **Master**—This role is similar to the Equal role and has full access to the switch. The difference is that up to one controller in this role is allowed for a switch.
- **Slave**—In this role, the controller has read-only access to the switch.

  The controller cannot send controller-to-switch messages to perform the following operations:

  - Deploy flow entries, group entries, and meter entries.
  - Modify the port and switch configurations.
  - Send packet-out messages.

  By default, the controller does not receive switch asynchronous messages except Port-status messages. The controller can send Asynchronous-Configuration messages to set the asynchronous message types it wants to receive.

Controller connection modes

An OpenFlow instance can connect to one or more controllers, depending on the controller connection mode the OpenFlow instance uses:

- **Single**—The OpenFlow instance connects to only one controller at a time. When communication with the current controller fails, the OpenFlow instance uses another controller.

- **Multiple**—The OpenFlow instance can simultaneously connect to multiple controllers. When communication with any controller fails, the OpenFlow instance attempts to reconnect to the controller after a reconnection interval.

Main and auxiliary connections

The OpenFlow channel can have one main connection and multiple auxiliary connections.

- **Main connection**—Processes control messages to complete operations such as deploying entries, obtaining data, and sending information. The main connection must be a reliable TCP or SSL connection.
- **Auxiliary connection**—Improves the communication performance between the controller and OpenFlow switches. An auxiliary connection can have the different destination IP address and port number than the main connection.

Connection interruption mode

When an OpenFlow switch is disconnected from all controllers, the OpenFlow switch is set to either of the following modes:

- **Secure**—The OpenFlow switch forwards traffic based on flow tables and does not remove unexpired flow entries. If the output action in a matching flow entry is to forward traffic to a controller, the traffic is discarded. This is the default forwarding mode.
- **Smart**—The OpenFlow switch forwards traffic based on flow tables and does not remove unexpired flow entries. If the output action in a matching flow entry is to forward traffic to a controller, the traffic is forwarded in normal process.
- **Standalone**—The OpenFlow switch uses the normal forwarding process.

The OpenFlow switch forwards traffic based on flow tables when it reconnects to a controller successfully.

Protocols and standards

OpenFlow Switch Specification Version 1.3.3

OpenFlow tasks at a glance

To configure OpenFlow, perform the following tasks:

1. Configuring OpenFlow instances
   a. Creating an OpenFlow instance
   b. Configuring the OpenFlow instance mode
   c. (Optional.) Configuring inband management VLANs
   d. (Optional.) Configuring flow tables and flow entries for an OpenFlow instance
   e. (Optional.) Setting the controller connection mode
   f. (Optional.) Preventing an OpenFlow instance from reporting the specified types of ports to controllers
   g. Activating or reactivating an OpenFlow instance
   h. (Optional.) Configuring OpenFlow instance attributes
2. Configuring controllers for an OpenFlow switch
3. (Optional.) Configuring an OpenFlow instance to act as an SSL server to listen to controllers
4. (Optional.) Refreshing all Layer 3 flow entries in the MAC-IP flow tables for an OpenFlow instance
5. (Optional.) Shutting down an interface by OpenFlow

Configuring OpenFlow instances

Creating an OpenFlow instance

1. Enter system view.

   system-view

2. Create an OpenFlow instance and enter its view.

   openflow instance *instance-id*

3. (Optional) Set the datapath ID.

   datapath-id *id*

   By default, the datapath ID of an OpenFlow instance contains the instance ID and the bridge MAC address of the device. The upper 16 bits are the instance ID and the lower 48 bits are the bridge MAC address of the device.

   The datapath ID uniquely identifies an OpenFlow switch (OpenFlow instance). Do not set the same datapath ID for different OpenFlow switches.

4. Set a DSCP value for OpenFlow packets.

   tcp dscp *dscp-value*

   By default, no DSCP value is set for OpenFlow packets.

Configuring the OpenFlow instance mode

Restrictions and guidelines

When you associate an OpenFlow instance with VLANs, follow these guidelines:

- For VLAN traffic to be processed correctly, associate different OpenFlow instances with different VLANs.
- When you activate an OpenFlow instance that is associated with nonexistent VLANs, the system automatically creates the VLANs.
- Do not associate VLANs permitted on a port with different OpenFlow instances. Otherwise, port modification messages of different OpenFlow instances deployed from different controllers overwrite each other.
- Do not configure BFD MAD on the VLAN interface for a VLAN that is associated with an OpenFlow instance. For more information about BFD MAD, see *Virtual Technologies Configuration Guide*.

Enabling the VLAN mode for an OpenFlow instance

1. Enter system view.

   system-view

2. Enter OpenFlow instance view.

   openflow instance *instance-id*

3. Configure the OpenFlow instance mode.

   classification vlan *vlan-id* [**mask** *vlan-mask*] [**loosen**]

   By default, the OpenFlow instance mode is not configured.

Configuring inband management VLANs

About inband management VLANs

Traffic in the inband management VLANs are forwarded in the normal forwarding process instead of the OpenFlow forwarding process. Inband management VLANs are used by an OpenFlow instance to establish OpenFlow channels to controllers.

Restrictions and guidelines

The ports that are assigned only to inband management VLANs are not OpenFlow ports.

Inband management VLANs configure for an OpenFlow instance in VLAN mode must be within the list of the VLANs associated with the OpenFlow instance.

If an OpenFlow instance in global or VLAN mode connects to a controller through a non-management Ethernet interface, configure the VLAN to which the interface belongs as an inband management VLAN.

Procedure

1. Enter system view.

   system-view
2. Enter OpenFlow instance view.

   openflow instance *instance-id*
3. Configure inband management VLANs for the OpenFlow instance.

   in-band management vlan *vlan-id-list*

   By default, no inband management VLANs are configured for an OpenFlow instance.

Configuring flow tables and flow entries for an OpenFlow instance

Restrictions and guidelines

The extensibility flow table ID must be greater than the MAC-IP flow table ID.

Procedure

1. Enter system view.

   system-view
2. Enter OpenFlow instance view.

   openflow instance *instance-id*
3. Configure flow tables for the OpenFlow instance.

   flow-table { **extensibility** *extensibility-table-id* | **mac-ip** *mac-ip-table-id* }*

   By default, an OpenFlow instance contains one extensibility flow table with an ID of 0.
4. Set the maximum number of flow entries that each extensibility flow table supports.

   flow-entry max-limit *limit-value*

   The default setting is 65535.

   When the maximum number is reached, the OpenFlow instance does not accept new flow entries for that table and sends a deployment failure notification to the controller.
5. Configure the OpenFlow instance to allow dynamic ARP entries to overwrite OpenFlow ARP entries.

   precedence dynamic arp

By default, an OpenFlow instance does not allow dynamic ARP entries to overwrite OpenFlow ARP entries.

Only MAC-IP flow tables support this feature.

6. Allow the deployed flow tables to include link aggregation member ports.

   permit-port-type member-port

   By default, the deployed flow tables cannot include link aggregation member ports.

7. Configure the default action of table-miss flow entries to forward packets to the normal pipeline.

   default table-miss permit

   By default, the default action of table-miss flow entries is to drop packets.

Setting the controller connection mode

Procedure

1. Enter system view.

   system-view

2. Enter OpenFlow instance view.

   openflow instance *instance-id*

3. Set the controller connection mode.

   controller mode { **multiple** | **single** }

   By default, the **multiple** mode is used.

Preventing an OpenFlow instance from reporting the specified types of ports to controllers

About port type reporting prevention

Perform this task to prevent an OpenFlow instance from reporting controllers information about the following types of interfaces that belong to the OpenFlow instance:

- VLAN interface.

Procedure

1. Enter system view.

   system-view

2. Enter OpenFlow instance view

   openflow instance *instance-id*

3. Prevent an OpenFlow instance from reporting the specified types of ports to controllers.

   forbidden port { **l3-physical-interface** | **vlan-interface** | **vsi-interface** } *

   By default, no port types are prevented from being reported to the controllers. All ports that belong to an OpenFlow instance are reported to the controllers.

   The **l3-physical-interface** and **vsi-interface** keywords are not supported in the current software version.

Activating or reactivating an OpenFlow instance

1. Enter system view.

   system-view

2. Enter OpenFlow instance view.

   openflow instance *instance-id*

3. Activate or reactivate the OpenFlow instance.

   active instance

   By default, an OpenFlow instance is not activated.

Configuring OpenFlow instance attributes

Restrictions and guidelines

The OpenFlow instance attribute configurations of an OpenFlow instance can take effect without activation for the OpenFlow instance.

Procedure

1. Enter system view.

   system-view

2. Enter OpenFlow instance view.

   openflow instance *instance-id*

3. Configure a description for the OpenFlow instance.

   description *text*

   By default, an OpenFlow instance does not have a description.

4. Set OpenFlow timers.
   - Set the connection detection interval.

     controller echo-request interval *interval*

     The default setting is 5 seconds.
   - Set the reconnection interval.

     controller connect interval *interval*

     The default setting is 60 seconds.

5. Configure MAC address-related features.
   - Forbid MAC address learning for VLANs associated with the OpenFlow instance.

     mac-learning forbidden

     By default, MAC address learning is allowed for VLANs associated with an OpenFlow instance.

     The configuration does not take effect on inband management VLANs.
   - Configure the OpenFlow instance to support matching the dynamic MAC addresses in the query and deletion flow entry instructions sent from controllers.

     mac-ip dynamic-mac aware

     By default, an OpenFlow instance ignores dynamic MAC addresses in the query and deletion flow entry instructions sent from controllers.

     Only MAC-IP flow tables support this feature.

6. Prevent the OpenFlow instance from reporting ARP packets to the specified controllers.

   forbidden packet-in arp controller *controller-id-list*

   By default, no controllers to which ARP packets are forbidden to be reported are configured.

   This feature forbids an OpenFlow instance to report ARP packets to the specified controllers to prevent the controllers from being affected by a large number of packets.

7. Disable logging for successful flow table modifications.

   flow-log disable

By default, logging for successful flow table modifications is enabled.

8. Enable loop guard for the OpenFlow instance.

   loop-protection enable

   By default, loop guard is disabled for an OpenFlow instance.

   After an OpenFlow instance is deactivated, you can enable loop guard for the OpenFlow instance to avoid loops. This feature enables the deactivated OpenFlow instance to create a flow entry for dropping all traffic in these VLANs.

Configuring controllers for an OpenFlow switch

Restrictions and guidelines

Make sure the configuration of an auxiliary connection does not conflict with the configuration of the main connection. Otherwise, the auxiliary connection cannot be established.

Procedure

1. Enter system view.

   system-view

2. Enter OpenFlow instance view.

   openflow instance *instance-id*

3. Specify a controller and configure the main connection to the controller.

   controller *controller-id* **address** { **ip** *ipv4-address* | **ipv6** *ipv6-address* } [**port** *port-number*] [**local address** { **ip** *local-ipv4-address* | **ipv6** *local-ipv6-address* } [**port** *local-port- number*]] [**ssl** *ssl-policy-name*]

   By default, an OpenFlow instance does not have a main connection to a controller.

   The source IP address must be the IP address of a port belonging to an OpenFlow instance. Otherwise, the OpenFlow switch might fail to establish a connection with the controller.

4. (Optional) Specify a controller and configure an auxiliary connection to the controller.

   controller *id* **auxiliary** *auxiliary-id* **transport** { **tcp** | **udp** | **ssl** *ssl-policy-name* } [**address** { **ip** *ipv4-address* | **ipv6** *ipv6-address* }] [**port** *port-number*]

   By default, an OpenFlow instance does not have auxiliary connections to a controller.

   If no destination IP address and port number are specified, the auxiliary connection uses the destination IP address and port number configured for the main connection.

5. (Optional) Set the connection interruption mode.

   fail-open mode { **secure** | **smart** | **standalone** }

   By default, the **secure** mode is used.

6. (Optional) Enable OpenFlow connection backup.

   tcp-connection backup

   By default, OpenFlow connection backup is enabled.

   This feature prevents connection interruption when an active/standby switchover occurs.

   This feature is available only on an IRF fabric with two member devices.

   This feature is available for only OpenFlow connections established over TCP.

Configuring an OpenFlow instance to act as an SSL server to listen to controllers

About configuring SSL server for an OpenFlow instance

Typically, an OpenFlow instance actively connects to the controller acting as a TCP/SSL client. After the SSL server is enabled for an OpenFlow instance, the controller acts as the SSL client and actively connects to the OpenFlow instance. For more information about SSL, see *Security Configuration Guide*.

Restrictions and guidelines

This feature can take effect without activation for an OpenFlow instance.

To re-configure the SSL server, first execute the **undo** form of the command to delete the existing SSL server configuration.

Procedure

1. Enter system view.
   system-view
2. Enter OpenFlow instance view.
   openflow instance *instance-id*
3. Configure an OpenFlow instance to act as an SSL server to listen to controllers.
   listening port *port-number* **ssl** *ssl-policy-name*
   By default, an OpenFlow instance is not configured to acts as an SSL server listen to controllers.

Refreshing all Layer 3 flow entries in the MAC-IP flow tables for an OpenFlow instance

About refreshing all Layer 3 flow entries in the MAC-IP flow tables

Perform this task to obtain all Layer 3 flow entries in the MAC-IP flow tables from the controller again if the Layer 3 flow entries have been overwritten.

Restrictions and guidelines

1. Enter system view.
   system-view
2. Enter OpenFlow instance view.
   openflow instance *instance-id*
3. Refresh all Layer 3 flow entries in the MAC-IP flow tables.
   refresh ip-flow

Shutting down an interface by OpenFlow

About interface shutdown

After an interface is shut down by OpenFlow, the **Current state** field displays **OFP DOWN** in the **display interface** command output.

You can use the **undo openflow shutdown** command to bring up an interface shut down by OpenFlow. The interface can also be brought up by port modification messages from controllers.

Procedure

1. Enter system view.
   system-view
2. Enter interface view.
   interface *interface-type interface-number*
3. Shut down an interface by OpenFlow.
   openflow shutdown
   By default, an interface is not shut down by OpenFlow.

Display and maintenance commands for OpenFlow

Execute **display** commands in any view.

Task	Command
Display the detailed information for an OpenFlow instance.	**display openflow instance** [*instance-id*]
Display controller information for an OpenFlow instance.	**display openflow instance** *instance-id* { **controller** [*controller-id*] | **listened** }
Display auxiliary connection information.	**display openflow instance** *instance-id* **auxiliary** [*controller-id* [**auxiliary** *auxiliary-id*]]
Display flow table entries for an OpenFlow instance.	**display openflow instance** *instance-id* **flow-table** [*table-id*]
Display group table information for an OpenFlow instance.	**display openflow instance** *instance-id* **group** [*group-id*]
Display meter table information for an OpenFlow instance.	**display openflow instance** *instance-id* **meter** [*meter-id*]
Display summary OpenFlow instance information.	**display openflow summary**
Clear statistics on packets that a controller sends and receives for an OpenFlow instance.	**reset openflow instance** *instance-id* { **controller** [*controller-id*] | **listened** } **statistics**

OpenFlow configuration examples

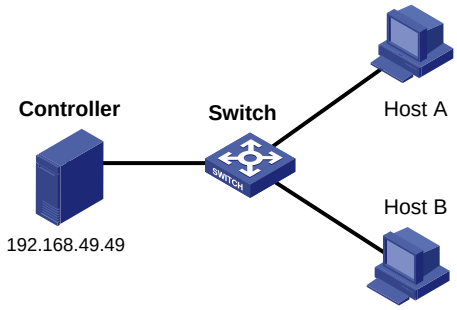
Example: Configuring OpenFlow in VLAN mode

Network configuration

As shown in Figure 7, an OpenFlow switch communicates with the controller. Perform the following tasks on the OpenFlow switch:

- Create OpenFlow instance 1, associate VLANs 4092 and 4094 with the OpenFlow instance, and activate the OpenFlow instance.
- Configure the IP address for controller 1 to have the controller manage the OpenFlow switch.

Figure 7 Network diagram



Procedure

Create VLANs 4092 and 4094.

```
<Switch> system-view
[Switch] vlan 4092
[Switch-vlan4092] quit
[Switch] vlan 4094
[Switch-vlan4094] quit
```

Create OpenFlow instance 1 and associate VLANs with it.

```
[Switch] openflow instance 1
[Switch-of-inst-1] classification vlan 4092 mask 4093
```

Specify controller 1 for OpenFlow instance 1 and activate the instance.

```
[Switch-of-inst-1] controller 1 address ip 192.168.49.49
[Switch-of-inst-1] active instance
[Switch-of-inst-1] quit
```

Verifying the configuration

View detailed information about the OpenFlow instance.

```
[Switch] display openflow instance 1
Instance 1 information:

Configuration information:
 Description   : --
 Active status : Active
 Inactive configuration:
  None
 Active configuration:
```

```
  Classification VLAN, total VLANs(2)
   4092, 4094
  In-band management VLAN, total VLANs(0)
   Empty VLAN
  Connect mode: Multiple
  Mac-address learning: Enabled
  Flow table:
   Table ID(type): 0(Extensibility), count: 0
  Flow-entry max-limit: 65535
  Datapath ID: 0x0064001122000101
  Default table-miss: Permit
  Forbidden port: VLAN interface
  Qinq Network: Disabled
  TCP connection backup: Enabled
Port information:
 GigabitEthernet1/0/3
Active channel information:
 Controller 1 IP address: 192.168.49.49 port: 6633
```

Appendix A Application restrictions

Flow entry restrictions

Matching restrictions

VLAN matching

Table 1 describes the VLAN matching restrictions when an OpenFlow instance is associated with VLANs.

Table 1 VLAN matching

VLAN	Mask	Matching packets
-	-	All packets in the VLANs that are associated with the OpenFlow instance.
0	-	Packets without a VLAN tag. The PVID of the ingress port must be associated with the OpenFlow instance.
0	Value	Unsupported.
Valid VLAN	-/value	Unsupported.
0x1000	-/value (except 0x1000)	Unsupported.
0x1000	0x1000	Packets with a VLAN tag. The VLAN ID of the VLAN tag must be associated with the OpenFlow instance.
Valid VLAN | 0x1000	-/value	Matching packets by the combination of the VLAN ID and VLAN mask. The VLANs obtained through the combination of the VLAN ID and VLAN mask must be associated with the OpenFlow instance.
Other	Other	Unsupported.

Protocol packet matching

If protocols are enabled, protocol packets (except LLDP frames) are processed by the corresponding protocols instead of the OpenFlow protocol.

For more information about LLDP frame matching, see "LLDP frame matching."

Metadata matching

Metadata passes matching information between flow tables. The controller deploys metadata matching entries only to non-first flow tables. If the controller deploys a metadata matching entry to the first flow table, the switch returns an unsupported flow error.

Instruction restrictions

Table 2 Instruction restrictions

Instruction type	Restrictions
Clear-Actions	The Clear-Actions instruction has the following restrictions: • For the single flow table, the flow entries of the table cannot include this instruction and other instructions at the same time. • For multiple flow tables of the pipeline, only the flow entries of the first flow table can include this instruction and other instructions at the same time.
Apply-Actions	The action list of the Apply-Actions instruction cannot include multiple Output actions. When the action list includes only one Output action, the switch processes the action list as described in "Restrictions for merging the action list into the action set."
Write-Metadata/mask	The flow entries of the last table of the pipeline cannot include this instruction. Otherwise, the switch returns an unsupported flow error.
Goto-Table	

Restrictions for merging the action list into the action set

The switch follows the following restrictions to merge the action list into the action set.

Non-output actions

When the action set and the action list do not contain the Output or Group action, the following rules apply:

- If actions in the action set do not conflict with actions in the action list, the switch merges the action list into the action set.
- If actions in the action set conflict with actions in the action list, actions in the action list are replaced with actions in the action set.

Output actions

When the action set and the action list contain the Output action or the Group action, the following rules apply:

- If both the action list and the action set contain an Output action, the Output action in the action list takes precedence. The Output action in the action list does not modify the packet. The Output action in the action set is executed at the last step of the pipeline processing to modify the packet.
- If either the action list or the action set contains an Output action, the port specified by the Output action is treated as the output port. The actions are executed in the order defined by the action set rules.
- If the action list contains an Output action and the action set contains a Group action, the following rules apply:
  - The Output action does not modify the packet.

- The Group action is executed.

Packet-out messages restrictions

Ingress port

The ingress port must be a physical or logical port when one of the following reserved ports is the output port in a packet-out message:

- Normal.
- Local.
- In Port.
- Controller.

Buffer ID co-existing with packet

If a packet-out message contains both the packet and the buffer ID representing the packet stored in the switch, the switch processes only the buffered packet. The switch ignores the packet in the message.

Packets without a VLAN tag

If the packet contained in a packet-out message has no VLAN tag, the switch performs the following operations:

- Tags the packet with the PVID of the ingress port.
- Forwards the packet within the VLAN.

The switch processes the packet as follows when the ingress port is a reserved port:

- If the output port is a physical or logical port, the switch tags the packet with the PVID of the output port and forwards the packet within the VLAN.
- If the output port is the Flood or All reserved port, the switch processes the packet as described in "Output port."

Output port

If the output port in a packet-out message is the Flood or All reserved port, the switch processes the packet contained in the packet-out message as follows:

- When the output port is the Flood reserved port:
  - If the packet has a VLAN tag, the switch broadcasts the packet within the VLAN.
  - If the packet has no VLAN tag and the ingress port is a physical or logical port, the switch tags the packet with the PVID of the ingress port. The switch then forwards the packet within the VLAN.
  - If the packet has no VLAN tag and the ingress port is the Controller reserved port, the switch forwards the packet out all OpenFlow ports.
- When the output port is the All reserved port:
  - If the packet has a VLAN tag, the switch broadcasts the packet within the VLAN.
  - If the packet has no VLAN tag, the switch forwards the packet out of all OpenFlow ports regardless of the ingress port type.

Packet-in messages restrictions

Processing VLAN tags

When sending a packet-in message to the controller, the switch processes the VLAN tag of the packet contained in the packet-out message as follows:

- If the VLAN tag of the packet is the same as the PVID of the ingress port, the switch removes the VLAN tag.
- If the VLAN tag of the packet is different from the PVID of the ingress port, the switch does not remove the VLAN tag.

Packet buffer

If a packet-in message is sent to controller due to no matching flow entry, the switch supports buffering the packet contained in the packet-in message. The buffer size is 1K packets.

If a packet-in message is sent to controller for other reasons, the switch does not support buffering the packet contained in the packet-in message. The switch must send the full packet to the controller, and the cookie field of the packet is set to 0xFFFFFFFFFFFFFFFF.

LLDP frame matching

LLDP is used to perform topology discovery in an OpenFlow network. LLDP must be enabled globally on a device. A switch sends a LLDP frame to the controller through the packet-in message when the following conditions exist:

- The port that receives the LLDP frame from the controller belongs to OpenFlow instances.
- The flow tables in the OpenFlow instance have a flow entry that matches the LLDP frame (the output port is the Controller reserved port).

Flow table modification messages restrictions

The flow table modification messages have the following restrictions for the table-miss flow entry and common flow entries.

Table-miss flow entry

The controller deploys the table-miss flow entry (the action is Drop) to an OpenFlow instance after the OpenFlow instance is activated.

The controller cannot query the table-miss flow entry through Multipart messages.

The controller cannot modify the table-miss flow entry through the Modify request. The controller can only modify the table-miss flow entry through the Add request.

The controller can modify or delete the table-miss flow entry only through the strict version of the Modify or Delete request. The controller cannot modify or remove the table-miss flow entry through the non-strict version of the Modify or Delete request despite that the match fields are wildcarded.

The controller deploys a table-miss flow entry (the action is Drop) to an OpenFlow instance after the current table-miss flow entry is deleted.

Common flow entries

The controller cannot modify or remove all common flow entries through the non-strict version of the Modify or Delete request despite that the match fields are wildcarded.

Appendix B MAC-IP flow table

Capabilities supported by the MAC-IP flow table

The controller must include the required match fields and actions and can include the optional match fields and actions in the flow entries deployed to the MAC-IP flow table. If the controller does not include the optional match fields and actions in the flow entries, the switch adds them to the flow entries by default.

The Layer 2 flow entries are implemented by using MAC address entries. Table 3 describes the capabilities supported by Layer 2 flow entries.

Table 3 Capabilities supported by Layer 2 flow entries

Item	Capabilities
Required match fields	The MAC-IP flow table must support the following match fields: • VLAN ID. • Unicast destination MAC address.
Optional match fields	N/A
Required actions	Specifying the output port.

The Layer 3 flow entries are implemented by using routing entries. Table 4 describes the capabilities supported by Layer 3 flow entries.

Table 4 Capabilities supported by Layer 3 flow entries

Item	Capabilities
Required match fields	The MAC-IP flow table must support the following match fields: • VLAN ID. • Unicast destination IP address. • Unicast destination MAC address, which must be the MAC address of the VLAN interface for the VLAN that is matched.
Optional match fields	N/A
Required actions	Specifying the output port.

MAC-IP flow table restrictions

Controller must follow the restrictions in the following tables to deploy flow entries for MAC-IP flow table. Otherwise, forwarding failure might occur.

Table 5 Restrictions for deploying Layer 2 flow entries for the MAC-IP flow table

Item	Restrictions
Match fields	The destination MAC address cannot be the MAC address of the switch to which the flow entry is deployed.
Actions	The output port must belong to the VLAN that is matched.

Table 6 Restrictions for deploying Layer 3 flow entries for the MAC-IP flow table

Item	Restrictions
Match fields	The VLAN interface of the VLAN that is matched is in up state. The destination MAC address is the MAC address of the VLAN interface for the VLAN that is matched. The destination IP address cannot be the IP address of the switch to which the flow entry is deployed.
Actions	The specified output port must belong to the destination VLAN. The destination MAC address cannot be the MAC address of the switch to which the flow entry is deployed. If the switch modifies the source MAC address, the source MAC address must be the MAC address of the VLAN interface for the VLAN to which the output port

Item	Restrictions
	belongs.

To deploy a Layer 3 flow entry, make sure the following requirements are met:

- The VLAN interface of the matched VLAN is in up state.
- The switch sends the controller a packet that indicates the VLAN interface acts as an OpenFlow port. The link state and the MAC address of the VLAN interface are also included in the packet.

The switch reports the VLAN interface deletion to the controller and the controller removes the corresponding Layer 3 flow entry.

The controller ensures the correctness of Layer 3 flow entries. The switch does not check for the restrictions for Lay 3 flow entries.

Table-miss flow entry of MAC-IP flow tables

The table-miss flow entry of a MAC-IP flow table supports the following output actions:

- **Goto-Table**—Direct the packet to the next table.
- **Drop**—Drop the packet.
- **Controller**—Send the packet to the controller.
- **Normal**—Forward the packet to the normal pipeline.

Dynamic aware

On an OpenFlow switch that supports MAC-IP flow tables, you can configure OpenFlow to support querying and deleting dynamic MAC address flow entries.

The controller can query and delete dynamic MAC address flow entries by specifying a VLAN, a MAC address, or the combination of a MAC address and a VLAN.

MAC-IP flow table cooperating with extensibility flow table

Metadata/mask

The MAC-IP flow table supports the Write Metadata/mask instruction and the extensibility flow table supports metadata/mask matching. The MAC-IP flow table can cooperate with an extensibility flow table to perform the pipeline process of multiple tables by using metadata/mask.

Each metadata mask bit has a different meaning. The corresponding metadata bit being set indicates that the metadata mask bit is matched. When the corresponding metadata bit is not set, the metadata mask bit is wildcarded.

Table 7 Metadata mask meanings

Metadata mask bit	Meaning	Metadata
Bit 0	Destination MAC address	• **1**—Set. Matches the destination MAC address. • **0**—Not set. Does not match the destination MAC address.
Bit 1	Source MAC address	• **1**—Set. Matches the source MAC address. • **0**—Not set. Does not match the source MAC address.
Bit 2	Destination IP address	• **1**—Set. Matches the destination IP address. • **0**—Not set. Does not match the destination IP address.

Metadata mask bit	Meaning	Metadata
Others	Reserved	Reserved.

Matching restrictions

When the output action in an extensibility flow table is not Normal, the following rules apply:

- The MAC-IP flow table does not take effect.
- All actions are executed according to the extensibility flow table.

When the output action in an extensibility flow table is Normal, the following rules apply:

- The output action is executed according to the MAC-IP flow table.
- The other actions are executed according to the extensibility flow table.

H3C Network Technology Acronyms

A B C D E F G H I K L M N O P Q R S T U V W X Z

10GE	Ten-GigabitEthernet
1DM	One-way Delay Measurement
3DES	Triple Data Encryption Standard
6PE	IPv6 Provider Edge
A	Return
AAA	Authentication, Authorization and Accounting
AAL	ATM Adaptation Layer
AAL5	ATM Adaptation Layer 5
ABR	Area Border Router
AC	Access Controller
AC	Access Circuit
AC	Attachment Circuit
AC	Access Category
AC Name	Access Concentrator Name
ACA	Acquire Change Authorization
ACCM	Async-Control-Character-Map
ACFC	Address-and-Control-Field-Compression
ACFP	Application Control Forwarding Protocol
Ack	Acknowledgment
ACL	Access Control List
ACR	Adaptive Clock Recovery
ACS	Auto-Configuration Server
ACS	AS Control Server
ACSEI	ACFP Client and Server Exchange Information
Active-Stateful PCC	Active-Stateful Path Computation Client
Active-Stateful PCE	Active-Stateful Path Computation Element
AD	Active Directory
ADM	ATM Direct Mapping
ADP	Add Diagnostic Parameter
ADPCM	Adaptive Differential Pulse Code Modulation
ADR	Adaptive Date Rate
ADSL	Asymmetric Digital Subscriber Line
ADVPN	Auto Discovery Virtual Private Network
AER	AS Edge Router
AES	Advanced Encryption Standard

AF	Assured Forwarding
AFI	Address Family Identifier
AFI	Authority and Format Identifier
AFT	Address Family Translation
AFTR	Address Family Transition Router
AH	Authentication Header
AIFSN	Arbitration Inter Frame Spacing Number
AIGP	Accumulated Interior Gateway Protocol Metric
AIS	Alarm Indication Signal
AIW	APPN Implementers Workshop
AKM	Authentication and Key Management
ALG	Application Level Gateway
AM	Analog Modem
AMB	Active Main Board
AMI	Alternate Mark Inversion
A-MPDU	Aggregate MAC Protocol Data Unit
A-MSDU	Aggregate MAC Service Data Unit
ANCP	Access Node Control Protocol
ANI	Adaptive Noise Immunity
ANSI	American National Standards Institute
AP	Access Point
AP	Agreement Protocol
APD	Avalanche Photo Diode
APDB	Access Point Information Database
APoT	AP of things
APP	Application Protocol
APPN	Advanced Peer-to-Peer Networking
APR	Application Recognition
ARP	Address Resolution Protocol
ARQ	Automatic Repeat Request
AS	Autonomous System
ASBR	Autonomous System Boundary Router
ASM	Any-Source Multicast
ASPF	Application Specific Packet Filter
ASPF	Advanced Stateful Packet Filter
AT	AppleTalk
ATD	Attribute Discovery
ATM	Asynchronous Transfer Mode
AU	Administration Unit
AUG	Administration Unit Group

AU-PTR	Administration Unit Pointer
AVF	Active Virtual Forwarder
AVF	Appointed VLAN-x Forwarder
AVP	Attribute Value Pair
B	Return
B4	Basic Bridging BroadBand
B8ZS	Bipolar 8-zero substitution
BA	Block Acknowledgment
BAS	Broadband Access Server
BB_Credit	Buffer-to-Buffer Credit
BC	Boundary Clock
BC	Bandwidth Constraint
BCB	Backbone Core Bridge
BCMP	Broadband-access-network Cluster Management Protocol
BDF	Backup DF
BDI	Backward Defect Indication
BDR	Backup Designated Router
BE	Best Effort
BEB	Backbone Edge Bridge
BECN	Backward Explicit Congestion Notification
BF	Build Fabric
BFD	Bidirectional Forwarding Detection
BGP	Border Gateway Protocol
BGP-EPE	BGP Egress Peer Engineering
BIDIR-PIM	Bidirectional Protocol Independent Multicast
BIMS	Branch Intelligent Management System
BIP	Bit-Interleaved Parity
BIP	Broadcast Integrity Protocol
BITS	Building Integrated Timing Supply System
BLE	Bluetooth Low Energy
B-MAC	Backbone MAC
BMC	Best Master Clock
BMP	BGP Monitoring Protocol
BOOTP	Bootstrap Protocol
BPDU	Bridge Protocol Data Unit
BQ	Bandwidth Queuing
BRAS	Broadband Remote Access Server
BRI	Basic Rate Interface
BRPC	Backward-Recursive PCE-Based Computation

BSB	Blockade State Block
BSM	Bootstrap Message
BSMF	Bootstrap Message Fragment
BSR	Bootstrap Router
BSS	Basic Service Set
BSV	BRI S/T Voice
BT	BitTorrent
B-VLAN	Backbone VLAN
C	Return
CA	Certificate Authority
CA	Connectivity Association
CAC	Connect Admission Control
CAMS	Comprehensive Access Management Server
CAPWAP	Controlling and Provisioning of Wireless Access Point
CAR	Committed Access Rate
CARP	Cache Array Routing Protocol
CB	Controlling Bridge
CB	Customer Bridge
CBQ	Class Based Queuing
CBR	Constant Bit Rate
CBS	Committed Burst Size
C-BSR	Candidate-BSR
CBT	Core-Based Tree
CBTS	Class-of-service Based Tunnel Selection
CBWFQ	Class Based Weighted Fair Queuing
CC	Continuity Check
CC	Call Control
CC	Control Channel
CC	Challenge Collapsar
CC	Common Criteria
CCA	Clear Channel Assessment
CCC	Circuit Cross Connect
CCF	Congestion Controlled Flow
CCM	Continuity Check Message
CD	Computed Distance
C-DCC	Circular DCC
CDCP	S-Channel Discovery and Configuration Protocol
CDP	Cisco Discovery Protocol
CDR	Call Detail Record

CDV	Cell Delay Variation
CE	Customer Edge
CED	Called Station Identifier
CEDCNG	Called Station Identifier
CEE	Converged Enhanced Ethernet
CEM	Circuit Emulation
CEM Class	Circuit Emulation Class
CESoPSN	Circuit Emulation Services over PSN
CFD	Connectivity Fault Detection
CFI	Canonical Format Indicator
CFM	Connectivity Fault Management
CGN	Carrier Grade NAT
CHAP	Challenge Handshake Authentication Protocol
CID	Calling Identity Delivery
CIDR	Classless Inter-Domain Routing
CIR	Committed Information Rate
CIR ALLOW	Committed Information Rate ALLOW
CIST	Common and Internal Spanning Tree
CLC	Channel Link Control
CLI	Command Line Interface
CLI	Calling Line Identification
CLNP	Connection-Less Network Protocol
CLP	Cell Loss Priority
CMC	Call Management Center
CNAME	Canonical Name
CND	Congestion Notification Domain
CNG	Comfortable Noise Generation
CNG	Calling Tone
CNGCED	Calling Tone
CNM	Congestion Notification Message
CNPV	Congestion Notification Priority Value
CO	Central Office
COPS	Common Open Policy Service
CoS	Class of Service
CP	Congestion Point
CP	Control Plane
CPE	Customer Premises Equipment
CPOS	Channelized POS
CPS	Certification Practice Statement
CPTone	Call Progress Tone

CQ	Custom Queuing
CR	Constraint-based Routing
CR	Core Router
CRC	Cyclic Redundancy Check
CRC	Cyclic Redundancy Code
CRC4	Cyclic Redundancy Check 4
CRL	Certificate Revocation List
CRLDP	Constraint-based Routed Label Distribution Protocol
CRLSP	Constraint-based Routed Label Switched Paths
C-RP	Candidate-RP
CS	Class Selector
CSMA/CD	Carrier Sense Multiple Access/Collision Detect
CSNP	Complete Sequence Number PDU
CSP	Port Extender Control and Status Protocol
CSPF	Constraint-based Shortest Path First
CST	Common Spanning Tree
CSV	Comma Separated Value
CT	Class Type
CTR	Counter mode
CTS	Clear to Send
CUG	Closed User Group
CV	Connectivity Verification
CWMP	CPE WAN Management Protocol
D	Return
DAC	Data Analysis Center
DAC	Digital to Analog Converter
DAD	Duplicate Address Detection
DAE	Dynamic Authorization Extensions
DAR	Deeper Application Recognition
Data-MDT	Data-Multicast Distribution Tree
DBA	Dynamic Bandwidth Allocation
DCBX	Data Center Bridging Exchange Protocol
DCC	Dial Control Center
DCD	Data Carrier Detection
DCE	Data Center Ethernet
DCE	Data Circuit-terminating Equipment
DCF	Distributed Coordination Function
DCN	Data Communication Network
DCR	Differential Clock Recovery

DD	Database Description
DDN	Digital Data Network
DDNS	Dynamic Domain Name System
DDoS	Distributed Denial of Service
DDR	Dial-on-Demand Routing
DDT	Delegated Database Tree
DE	Discard Eligibility
DED	Designated Edge Device
Default-MDT	Default-Multicast Distribution Tree
DER	Distinguished Encoding Rules
DF	Designated Forwarder
DGAF	Downstream Group-Addressed Forwarding
DH	Diffie-Hellman
DHCP	Dynamic Host Configuration Protocol
DHCPv6	Dynamic Host Configuration Protocol for IPv6
DID	Direct Inward Dialing
DID	Device ID
DiffServ	Differentiated Service
DIS	Designated IS
DLCI	Data Link Connection Identifier
DLDP	Device Link Detection Protocol
DLSw	Data Link Switching
DM	Diagnostic and Monitoring
DM	Delay Measurement
DMC	Device Management Controller
DMM	Delay Measurement Message
DMR	Delay Measurement Reply
DMZ	Demilitarized Zone
DN	Distinguished Name
DN	Directory Number
DNAT	Destination Network Address Translation
DND	Do-not Disturb
DNS	Domain Name System
DNSSL	DNS Search List
DNU	Do Not Use for synchronization
DoD	Downstream On Demand
DoS	Denial of Service
DP	Drop Profile
DP	Data Plane
DPD	Dead Peer Detection

DPI	Deep Packet Inspection
DR	Designated Router
DR device	Distributed Relay device
DRB	Designated Routing Bridge
DRCP	Distributed Relay Control Protocol
DRCPDU	Distributed Relay Control Protocol Data Unit
DRE	Data Redundancy Elimination
DRNI	Distributed Resilient Network Interconnect
DRS	DPI Report Statistics
DS	Differentiated Services
DSA	Digital Signature Algorithm
DSCP	Differentiated Services Code Point
DSL	Digital Subscriber Line
DS-Lite	Dual Stack Lite
DSU	Data Service Unit
DTD	Document Type Definition
DTE	Data Terminal Equipment
DTIM	Delivery Traffic Indication Message
DTLS	Datagram Transport Layer Security
DTMF	Dual Tone Multi-Frequency
DU	Downstream Unsolicited
DUAL	Diffusing Update Algorithm
DUID	DHCP Unique Identifier
DUID-LL	DUID Based on Link-layer Address
D-V	Distance Vector
DVMRP	Distance Vector Multicast Routing Protocol
DVPN	Dynamic Virtual Private Network
DWDM	Dense Wavelength Division Multiplexing
E	Return
E2ETC	End-to-End Transparent Clock
EAA	Embedded Automation Architecture
EACL	Enhanced ACL
EAD	Endpoint Admission Defense
EAIS	Ethernet Alarm Indication Signal
EAN	Ethernet Access Node
EAP	Extensible Authentication Protocol
EAPOL	Extensible Authentication Protocol over LAN
EAPOL KCK	EAPOL-Key Confirmation Key
EAPOL KEK	EAPOL-Key Encryption Key

EAP-TLS	Extensible Authentication Protocol -Transport Layer Security
EBS	Excess Burst Size
ECDSA	Elliptic Curve Digital Signature Algorithm
ECID	E-channel Identifier
ECM	Encapsulated Control Message
ECM	Error Correction Mode
ECN	Explicit Congestion Notification
ECP	Edge Control Protocol
ECT	Equal Cost Tree
ECWmax	Exponent form of CWmax
ECWmin	Exponent form of CWmin
ED	Edge Device
EDCA	Enhanced Distributed Channel Access
EDSG	Enhanced Dynamic Service Gateway
EEE	Energy Efficient Ethernet
EF	Expedited Forwarding
EFM	Ethernet First Mile
EGP	Exterior Gateway Protocol
EID	Endpoint Identifier
EIGRP	Enhanced Interior Gateway Routing Protocol
EIRP	Effective Isotropic Radiated Power
EM	Event Monitor
EMO	Endpoint Mobile Office
EMR	Ensure Minimum Rate
ENDC	EVI Neighbor Discovery Client
ENDC	Enhanced Neighbor Discovery Client
End-Of-RIB	End of Routing-Information-Base
ENDP	Enhanced Neighbor Discovery Protocol
ENDP	EVI Neighbor Discovery Protocol
ENDS	Enhanced Neighbor Discovery Server
ENDS	EVI Neighbor Discovery Server
eNodeB	evolved Node B
ENUM	Telephone Number Mapping
EOAM	Ethernet Operation, Administration and Maintenance
EoPW	Ethernet over Pseudo Wire
EPC	External Path Computation
EPC	Evolved Packet Core
EPON	Ethernet Passive Optical Network
EPS	Endpoints Profiling System
ER	Edge Relay

ERPS	Ethernet Ring Protection Switching
ERSPAN	Encapsulated Remote Switch Port Analyzer
ERT	Export Route-target
ES	End System
ES	Ethernet Segment
ESF	Extended Super Frame
ESI	Ethernet Segment Identifier
ESMC	Ethernet Synchronous Message Channel
ESN	Extended Sequence Number
ESP	Encapsulating Security Payload
ESS	Extended Service Set
ESS	Exchange Switch Support
ETR	Egress Tunnel Router
ETS	Enhanced Transmission Selection
ETSI	European Telecommunications Standards Institute
EUI	Extended Unique Identifier
EUI-64	64-bit Extended Unique Identifier
EVB	Edge Virtual Bridging
Event MIB	Event Management Information Base
EVFP	Exchange Virtual Fabrics Parameter
EVI	Ethernet Virtual Interconnect
EVPN	Ethernet Virtual Private Network
Extended-MAM	Extended Maximum Allocation Model
F	Return
FA	Foreign Agent
FA	Foreign-AC
FAC	Feature Access Code
FAS	Frame Alignment Signal
FC	Forwarding Class
FC	Fibre Channel
FC	Feasibility Condition
FCF	FCoE Forwarder
FCM	Fast Connect Modem
FCoE	Fibre Channel over Ethernet
FCPS	FC Port Security
FCS	Fabric Configuration Server
FCS	Frame Check Sequence
FD	Feasible Distance
FDB	Forwarding Database

FDMI	Fabric Device Management Interface
FE	Fast Ethernet
FEAC	Far End Alarm and Control signal
FEC	Forward Error Correction
FEC	Forwarding Equivalence Class
FECN	Forward Explicit Congestion Notification
FEP	Front End Processor
FF	Fixed-Filter
FFD	Fast Failure Detection
FFT	Fast Fourier Transform
FG	Forwarding Group
FHR	First Hop Router
FIB	Forwarding Information Base
FIFO	First In First Out
FIFO	First In First Out Queuing
FIP	FCoE Initialization Protocol
FIP Snooping	FCoE Initialization Protocol Snooping
FIPS	Federal Information Processing Standards
Flowspec	Flow Specification
FNG	Fault Notification Generator
FP	Forwarding Profile
FPGA	Field Programmable Gate Array
FPMA	Fabric Provided MAC Address
FQ	Fair Queuing
FQDN	Fully Qualified Domain Name
FR	Frame Relay
FRR	Fast Reroute
FRTP	Frame Relay Traffic Policing
FRTS	Frame Relay Traffic Shaping
FRU	Field Replaceable Unit
FS	Forced Switch
FS	Feasible Successor
FSK	Frequency Shift Keying
FSPF	Fabric Shortest Path First
FT	Fault Tolerance
FT	Fast BSS Transition
FTN	FEC to NHLFE map
FTP	File Transfer Protocol
FXO	Foreign Exchange Office
FXS	Foreign Exchange Station

G	Return
GAL	G-ACh Label
GARP	Generic Attribute Registration Protocol
GAS	Generic Advertisement Service
GDOI	Group Domain of Interpretation
GE	Gigabit Ethernet
GI	Guard Interval
GK	GateKeeper
GLB	Global Load Balance
GM	Group Member
GM	Grandmaster Clock
GMK	Group Master Key
GNE	Gateway Network Element
GNS	Get Nearest Server
GOLD	Generic OnLine Diagnostics
GPS	Global Positioning System
GR	Graceful Restart
GRE	Generic Routing Encapsulation
Group Domain VPN	Group Domain Virtual Private Network
gRPC	Google Remote Procedure Call
GSMPv3	General Switch Management Protocol Version 3
GTC	Generic Token Card
GTK	Group Temporal Key
GTP	GPRS Tunneling Protocol
GTP-U	GPRS Tunneling Protocol User
GTS	Generic Traffic Shaping
GTSM	Generalized TTL Security Mechanism
GVRP	GARP VLAN Registration Protocol
GW	Gateway
GWMP	Gateway Message Protocol
H	Return
HA	Home-AC
HA	High Availability
HA	Home Agent
HABP	HW Bypass Protocol
HBA	Host Bus Adapter
HDB3	High-density bipolar 3
HDLC	High-level Data Link Control
HDSL	High-speed Digital Subscriber Line

HESSID	Homogenous Extended Service Set IDentifier
HGMP	HW Group Management Protocol
HGMPv2	HW Group Management Protocol version 2
HMAC	Hash-based Message Authentication Code
HoPE	Hierarchy of PE
HoVPN	Hierarchy of VPN
HQoS	Hierarchical Quality of Service
HS	High-performance Switch
HTTP	Hypertext Transfer Protocol
HTTPS	Hypertext Transfer Protocol Secure
H-VPLS	Hierarchical VPLS
HWTACACS	HW Terminal Access Controller Access Control System
I	Return
IA	Identity Association
IACTP	Inter Access Controller Tunneling Protocol
IAD	Integrated Access Device
IANA	Internet Assigned Numbers Authority
IBGP	Internal Border Gateway Protocol
ICANN	Internet Corporation for Assigned Names and Numbers
ICMP	Internet Control Message Protocol
ICMPv6	Internet Control Message Protocol for IPv6
ICP	IMA Control Protocol
ICPIF	Calculated Planning Impairment Factor
ICRQ	Incoming Call Request
IDN	Integrated Digital Network
IDS	Intrusion Detection System
IE	Information Element
IE	Interconnect Element
IEEE	Institute of Electrical and Electronics Engineers
IETF	Internet Engineering Task Force
IGMP	Internet Group Management Protocol
IGMP Snooping	Internet Group Management Protocol Snooping
IGP	Interior Gateway Protocol
IGTK	Integrity Group Temporal Key
IIH	Intermediate System-to-Intermediate System Hello
IKE	Internet Key Exchange
IKEv2	Internet Key Exchange Version 2
ILM	Incoming Label Map
ILS	Internet Locator Service

IM	Instant Messaging
IMA	Inverse Multiplexing for ATM
IMAP	Internet Mail Access Protocol
iMC	Intelligent Management Center
IMSI	International Mobile Subscriber Identification Number
InARP	Inverse Address Resolution Protocol
IND	Inverse Neighbor Discovery
INT	In-band Network Telemetry
IntServ	Integrated Service
IPC	Inter-process Communication
IPE	Image Package Envelope
IPHC	IP Header Compression
IPL	Intra-Portal Link
IPN	IGTK Packet Number
IPng	IP Next Generation
IPoA	IP over ATM
IPoEoA	IP over Ethernet over ATM
IPP	Intra-Portal Port
IPS	Intrusion Prevention System
IPsec	IP Security
IPTA	IP Terminal Access
IPv6	Internet Protocol version 6
IPv6 MBGP	IPv6 Multicast BGP
IPv6 ND	IPv6 Neighbor Discovery
IPv6 PIM	IPv6 Protocol Independent Multicast
IPv6 PIM Snooping	IPv6 Protocol Independent Multicast Snooping
IPX	Internetwork Packet Exchange
IRB	Integrated Bridging and Routing
IRB	Integrated Routing and Bridging
IRB	Integrated Routing Bridging and Bridging Routing
IRDP	ICMP Router Discovery Protocol
IRF	Intelligent Resilient Framework
IS	Intermediate System
ISAKMP	Internet Security Association and Key Management Protocol
ISATAP	Intra-Site Automatic Tunnel Addressing Protocol
ISDN	Integrated Services Digital Network
I-SID	Backbone Service Instance Identifier
IS-IS	Intermediate System-to-Intermediate System
ISO	International Organization for Standardization
ISP	Internet Service Provider

ISPF	Incremental Shortest Path First
ISSU	In-Service Software Upgrade
IST	Internal Spanning Tree
ITA	Intelligent Target Accounting
ITR	Ingress Tunnel Router
ITSP	Internet Telephone Service Provider
ITU	International Telecommunication Union
ITU-T	International Telecommunication Union Telecommunication
IV	Initialization Vector
IVR	Interactive Voice Response
K	Return
KAT	Known-Answer Test
KCK	EAPOL-Key Confirmation Key
KEK	Key Encrytion Key
KEK	EAPOL-Key Encryption Key
KS	Key Server
L	Return
L2F	Layer 2 Forwarding
L2PT	Layer 2 Protocol Tunneling
L2TP	Layer 2 Tunneling Protocol
L2VPN	Layer 2 Virtual Private Network
L3VNI	Layer 3 VNI
L3VPN	Layer 3 Virtual Private Network
LAC	L2TP Access Concentrator
LACP	Link Aggregation Control Protocol
LACPDU	Link Aggregation Control Protocol Data Unit
LAN	Local Area Network
LB	Loopback
LB	Label Base
LB	Load Balance
LBM	Loopback Message
LBR	Loopback Reply
LC	Logic Channel
LCFO	Loop Current Feed Open
LCI	Logic Channel Identifier
LCP	Link Control Protocol
LDAP	Lightweight Directory Access Protocol
LDN	Local Dialing Number
LDP	Label Distribution Protocol

LDP ID	LDP Identifier
LDPC	Low-Density Parity Check
LER	Label Edge Router
LFI	Link Fragmentation and Interleaving
LFIB	Label Forwarding Information Base
LGS	Loop-start & Ground-start Signaling
LHR	Last-Hop Router
LI	Leap Indicator
LLC	Logical Link Control
LLDP	Link Layer Discovery Protocol
LLDPDU	Link Layer Discovery Protocol Data Unit
LLDP-MED	Link Layer Discovery Protocol Media Endpoint Discovery
LLID	Logical Link ID
LLQ	Low Latency Queuing
LM	Loss Measurement
LMI	Local Management Interface
LMM	Loss Measurement Message
LMR	Loss Measurement Reply
LNS	L2TP Network Server
LO	Label-block Offset
LOCV	Loss of Connectivity Verification defect
LOID	Logical ONU Identifier
LoRaWAN	Long Range Wide Area Network
LOS	Loss of Signal
LPU	Line Processing Unit
LPU Port	Line Processing Unit Port
LQR	Link Quality Reports
LR	Line Rate
LR	Label Range
LS	Link State
LSA	Link State Acknowledgment
LSA	Link State Advertisement
LSAck	Link State Acknowledgment
LSDB	Link State Database
LSDB	Link State DataBase
LSN	Large-scale NAT
LSP	Label Switched Path
LSP	Link State PDU
LSPDU	Link State Protocol Data Unit
LSR	Link State Request

LSR	Link State Record
LSR	Label Switching Router
LSU	Link State Update
LT	Linktrace
LTM	Linktrace Message
LTR	Linktrace Reply
LTS	L2TP Tunnel Switch
LVF	Listening Virtual Forwarder
LZ	Lempel-Ziv compression
M	Return
M flag	Managed Address Configuration Flag
MA	Mobility Agent
MA	Maintenance Association
MAC	Message Authentication Code
MAC	Media Access Control
MACsec	Media Access Control Security
MAD	Multi-Active Detection
MAM	Maximum Allocation Model
MAN	Metropolitan Area Network
MAP	Mesh Access Point
MBGP	Multicast BGP
MBS	Maximum Burst Size
MC	Mobility Controller
MCC	Mobile Country Code
MCE	Multi-VPN-Instance Customer Edge
MCS	Modulation and Coding Scheme
MCU	Multipoint Control Unit
MD	Maintenance Domain
MD	Multicast Domain
MDC	Multitenant Device Context
MDI	Medium Dependent Interface
MDL	Maintenance Data Link
mDNS	Multicast DNS
MDT	Multicast Distribution Tree
ME	Maintenance Entity
MEC	Multi-access Edge Computing
MED	Multi-Exit Discriminator
MEG	Maintenance Entity Group
MEP	Maintenance association End Point

MEP	MEG End Point
MFAS	Multiframe FAS
MFC	Multi-Frequency Compelled
MFF	MAC-Forced Forwarding
MFR	Multilink Frame Relay
MGCP	Media Gateway Control Protocol
mGRE	Multipoint Generic Routing Encapsulation
MIB	Management Information Base
MIC	Message Integrity Check
MIMO	Multiple Input, Multiple Output
MIP	Maintenance association Intermediate Point
MIP	Mobile IP
MKA	MACsec Key Agreement
MKD	Mesh Key Distributor
MKI	Master Key Identifier
MLD	Multicast Listener Discovery Protocol
MLD Snooping	Multicast Listener Discovery Snooping
MLSP	Mobile Link Switch Protocol
MME	Management MIC IE
MNC	Mobile Network Code
MoH	Music on Hold
MOS	Mean Opinion Scores
MOTD	Message of The Day
MP	Maintenance Point
MP	Mesh Point
MP	Merge Point
MP_REACH_NLRI	Multiprotocol Reachable NLRI
MP_UNREACH_NLRI	Multiprotocol Unreachable NLRI
MP-BGP	Multiprotocol Border Gateway Protocol
MPCP	Multipoint Control Protocol
MPDU	MAC Protocol Data Unit
MPE	Middle-Level PE
MPLS	Multiprotocol Label Switching
MPLS SR	Segment Routing with MPLS
MPLS TE	Multiprotocol Label Switching Traffic Engineering
MPLS VPN	MPLS Virtual Private Network
MPLS-TP	MPLS Transport Profile
MPP	Mesh Portal Point
MQC	Model QoS Command
MR	Map Resolver

MR	Merge Request
MRIB	Multicast Routing Information Base
MRP	Multiple Registration Protocol
MRPDU	MRP Protocol Data Unit
MRRA	Merge Request Resource Allocation
MRU	Maximum-Receive-Unit
MS	Manual Switch
MS	Map Server
MSCHAP	Microsoft Challenge Handshake Authentication Protocol
MSDP	Multicast Source Discovery Protocol
MSDU	MAC Service Data Unit
MSK	Multicast Session Key
MSOH	Multiplex Section Overhead
MSS	Maximum Segment Size
MSTI	Multiple Spanning Tree Instance
MSTP	Multiple Spanning Tree Protocol
MT	Multicast Tunnel
MTI	Multicast Tunnel Interface
MTP	Maintain Probe
MTR	Multi-Topology Routing
MTU	Maximum Transmission Unit
MTU-s	Multi-Tenant Unit switch
MU	Mobile Unit
MVPN	Multicast Virtual Private Network
MVRP	Multiple VLAN Registration Protocol
MVXLAN	Multicast VXLAN
MWI	Message Waiting Indication
MX	Mail Exchanger
N	Return
NA	Neighbor Advertisement
NAI	Network Access Identifier
NAPT	Network Address Port Translation
NAPT-PT	Network Address Port Translation-Protocol Translation
NAS	Network Access Service
NAS	Network Access Server
NAS-ID	Network Access Server Identifier
NAS-Port-ID	Network Access Server Port Identifier
NAS-VLAN-ID	Network Access Server VLAN Identifier
NAT	Network Address Translation

NAT-PT	Network Address Translation-Protocol Translation
NBAR	Network Based Application Recognition
NBMA	Non-Broadcast Multi-Access
NCP	Network Control Protocol
ND	Neighbor Discovery
NDA	NetStream Data Analyzer
NDE	NetStream Data Exporter
NDP	Neighbor Discovery Protocol
NDPP	Network Device Protection Profile
NE	Network Element
NEMO	Network Mobility
NET	Network Entity Title
NetBIOS	Network Basic Input/Output System
NETCONF	Network Configuration Protocol
NFAS	non–FAS
NFV	Network Function Virtualisation
NHLFE	Next Hop Label Forwarding Entry
NHRP	Next Hop Resolution Protocol
NI	National ISDN
NIB	Nexthop Information Base
NII	Network International Identifier
NIST	National Institute of Standards and Technology
NIT	Not Initial Terminal
NLB	Network Load Balancing
NLBS	Network Load Balancing Service
NLPID	Network Layer Protocol Identifier
NLRI	Network Layer Reachability Information
NM	Network Management
NMFAS	Non-Multiframe FAS
NMS	Network Management Station
NMS	Network Management System
NMS	Network Management Server
NNI	Network-to-Network Interface
NO-PAT	Not Port Address Translation
NPDU	Network Protocol Data Unit
NPE	Network Provider Edge
NPTv6	IPv6-to-IPv6 Network Prefix Translation
NPV	N_Port Virtualization
NQA	Network Quality Analyzer
NR	No Request

nrt-VBR	non-real-time Variable Bit Rate
NS	Neighbor Solicitation
NS	Name Server
NSAP	Network Service Access Point
NSC	NetStream Collector
NSF	Non-Standard Facilities
NSR	Nonstop Routing
NSS	Number of Spatial Streams
NTDP	Neighbor Topology Discover Protocol
NTE	Named Telephone Event
NTP	Network Time Protocol
NTT	Nippon Telegraph and Telephone Corpration
NVC	Network Virtualization Controller
NVE	Network Virtualization Edge
NVGRE	Network Virtualization using Generic Routing Encapsulation
O	Return
O Flag	Other Stateful Configuration Flag
OAA	Open Application Architecture
OAMPDU	OAM Protocol Data Unit
OAP	Open Application Platform
OC	Optical Carrier
OC	Ordinary Clock
ODAP	On-Demand Address Pool
ODF	Optical Distribution Frame
ODN	Optical Distribution Network
ODU	Optical Data Unit
OEM	Original Equipment Manufacturer
OFDM	Orthogonal Frequency Division Multiplexing
OI	Organization Identifier
OID	Object Identifier
OLT	Optical Line Terminal
ONU	Optical Network Unit
OOB	Out-of-Band
OPU	Optical Payload Unit
ORF	Outbound Route Filtering
OSI	Open System Interconnection
OSPF	Open Shortest Path First
OSU	Online Sign Up
OTN	Optical Transport Network

OTU	Optical Transmit Unit
OUI	Organizationally Unique Identifier
OVSDB	Open vSwitch Database
P	Return
P2MP	Point-to-MultiPoint
P2P	PW to PW
P2P	Peer-to-Peer
P2P	Point-to-Point
P2PTC	Peer-to-Peer Transparent Clock
PA	Provider Allocated
PADT	PPPoE Active Discovery Terminate
PAGP	Port Aggregation Protocol
PAM	Port to Application Map
PAM	Pulse Amplitude Modulation
PAN ID	Personal Area Network Identifier
PAP	Password Authentication Protocol
Passive-Stateful PCC	Passive-Stateful Path Computation Client
Passive-Stateful PCE	Passive-Stateful Path Computation Element
PAT	Port Address Translation
PBAR	Port Based Application Recognition
PBB	Provider Backbone Bridge
PBBN	Provider Backbone Bridge Network
PBN	Provider Bridge Network
PBR	Policy-based Routing
PBX	Private Branch Exchange
PCB	Protocol Control Block
PCC	Path Computation Client
PCE	Path Computation Element
PCEP	Path Computation Element Communication Protocol
PCM	Pulse Code Modulation
PCR	Peak Cell Rate
PD	Powered Device
PD	Prefix Delegation
PDH	Plesiochronous Digital Hierarchy
PDP	Policy Decision Point
PDU	Protocol Data Unit
PE	Provider Edge
PE-agg	PE Aggregation
PEAP	Protected Extensible Authentication Protocol

PEAP-GTC	Protected Extensible Authentication Protocol-Microsoft Generic Token Card
PEAP-MSCHAPv2	Protected Extensible Authentication Protocol-Microsoft Challenge Handshake Authentication Protocol v2
PEM	Privacy Enhanced Mail
PEM	Power Entry Module
PEP	Policy Enforcement Point
PFC	Power Free Connector
PFC	Priority-based Flow Control
PFC	Protocol-Field-Compression
PFS	Perfect Forward Secrecy
PHB	Per-hop Behavior
PHP	Penultimate Hop Popping
PI	Power Interface
PI	Provider Independent
PI	Progress Indicator
PIC	Prefix Independent Convergence
PIM	Protocol Independent Multicast
PIM Snooping	Protocol Independent Multicast Snooping
PIM-DM	Protocol Independent Multicast-Dense Mode
PIM-SM	Protocol Independent Multicast-Sparse Mode
PIM-SSM	Protocol Independent Multicast Source-Specific Multicast
PIN	Personal Identification Number
PIR	Peak Information Rate
PKCS	Public Key Cryptography Standards
PKI	Public Key Infrastructure
PLCP	Physical Layer Convergence Procedure
PLMN	Public Land Mobile Network
PLR	Point of Local Repair
PMK	Pairwise Master Key
PMTU	Path MTU
PoE	Power over Ethernet
POH	Path Overhead
POP3	Post Office Protocol - Version 3
POS	Passive Optical Splitter
POS	Point of Sale
PPP	Point-to-Point Protocol
PPPoA	PPP over ATM
PPPoE	Point-to-Point Protocol over Ethernet
PPPoEoA	PPPoE over ATM

PPTP	Point-to-Point Tunneling Protocol
PQ	Priority Queuing
PRBS	Pseudo Random Bit Sequence
PRC	Primary Reference Clock
PRI	Primary Rate Interface
PRL	Preferred Roaming List
PS	Protection Switching
PSB	Path State Block
PSC	Protection State Coordination
PSD	Power Spectral Density
PSE	Power Sourcing Equipment
PSK	Pre-Shared Key
PSN	Packet Switched Network
PSNP	Partial Sequence Number PDU
PSST	Principal Switch Selection Timer
PSTN	Public Switched Telephone Network
PTK	Pairwise Transient Key
PTP	Precision Time Protocol
PTR	Pointer Record
PTY	Pseudo-Terminals
PUK	PIN Unlocking Key
PVC	Permanent Virtual Circuit
PVC PQ	PVC Priority Queuing
PVID	Port VLAN ID
PVP	Permanent Virtual Path
PVST	Per-VLAN Spanning Tree
PW	Pseudowire
PW-ACH	PW Associated Channel Header
PWCT	Pairwise Conditional Test
PWE3	Pseudo Wire Emulation Edge-to-Edge
PXE	Preboot eXecution Environment
Q	Return
QCN	Quantized Congestion Notification
QL	Quality Level
QoS	Quality of Service
QPPB	QoS Policy Propagation Through the Border Gateway Protocol
R	Return
RA	Router Alert
RA	Router Advertisement

RA	Registration Authority
RADIUS	Remote Authentication Dial-In User Service
RAI	Remote Alarm Indication
RALM	RADIUS Authenticated Login Using MAC-address
R-APS	Ring Automatic Protection Switching
RAS	Registration, Admission, and Status
RB	Routing Bridge
RBAC	Role Based Access Control
RBM	Remote Backup Management
RCA	Release Change Authorization
RCF	Reconfigure Fabric
RCPI	Received Channel Power Indicator
RD	Routing Domain
RD	Reported Distance
RD	Route Distinguisher
RDI	Remote Defect Indication
RDM	Russian Dolls Model
RDP	Read Diagnostic Parameters
RED	Random Early Detection
RedisDBM	Redis Database Manager
REG	Registration Center
RFID	Radio Frequency Identification
RIB	Routing Information Base
RIP	Routing Information Protocol
RIP-2	Routing Information Protocol version 2
RIPng	RIP next generation
RIR	Resilient Intelligent Route
RLOC	Routing Locator
RLSN	Remote Link Status Notification
RMON	Remote Network Monitoring
ROA	Recognized operating Agency
Roam OI	Roam Organization Identifier
RP	Rendezvous Point
RP	Reflective Relay
RP	Reaction Point
RPA	Register Port Attributes
RPA	Rendezvous Point Address
RPC	Remote Procedure Call
RPF	Reverse Path Forwarding
RPI	Receive Power Indication

RPKI	Resource Public Key Infrastructure
RPL	Rendezvous Point Link
RPL	Ring Protection Link
RPR	Resilient Packet Ring
RPRT	Register Port
RPS	Redundant Power System
RP-Set	Rendezvous Point Set
RPT	Rendezvous Point Tree
RR	Route Reflector
RR	Reflective Relay
RR	Router Renumber
RRI	Reverse Route Injection
RRM	Radio Resource Management
RRPP	Rapid Ring Protection Protocol
RS	Router Solicitation
RSB	Reservation State Block
RSCN	Registered State Change Notification
RS-DCC	Resource-Shared DCC
RSH	Remote Shell
RSN	Robust Security Network
RSNA	Robust Security Network Association
RSNI	Received Signal to Noise Indicator
RSOH	Regenerator Section Overhead
RSSI	Received Signal Strength Indicator
RSSI	Received Signal Strength Indication
RSTP	Rapid Spanning Tree Protocol
RSVP	Resource Reservation Protocol
RT	Route Target
RTC	Remote Terminal Connection
RTCP	Real-Time Transport Control Protocol
RTM	Real-Time Event Manager
RTP	Reliable Transport Protocol
RTP	Real-Time Transport Protocol
RTPQ	Real-Time Transport Protocol Priority Queuing
RTS	Request to Send
RTSP	Real Time Streaming Protocol
RTT	Round-Trip Time
rt-VBR	Real-time Variable Bit Rate
RU	Rack Unit

S	Return
S/MIME	Secure/Multipurpose Internet Mail Extensions
SA	Security Association
SA	Source Active
SA Query	Security Association Query
SABM	Set Asynchronous Balanced Mode
SACK	Selective Acknowledgment
SAE	Simultaneous authentication of equals
SAFI	Subsequent Address Family Identifier
SAII	Source Attachment Individual Identifier
SAM	Security Accounting Management
SAN	Storage Area Networks
SAP	Service Advertising Protocol
SAToP	Structure-Agnostic TDM over Packet
SAVI	Source Address Validation Improvement
SB	Service Bridge
SBFD	Seamless BFD
SBM	Subnetwork Bandwidth Management
SCCP	Skinny Client Control Protocol
SCEP	Simple Certificate Enrollment Protocol
SCFF	Single Choke Fairness Frame
SCR	Sustainable Cell Rate
SCR	State Change Registration
SD	Signal Degrade
SDH	Synchronous Digital Hierarchy
SDLC	Synchronous Data Link Control
SDN	Software Defined Network
SDP	Session Description Protocol
SDSL	Symmetric Digital Subscriber Line
SDU	Service Data Unit
SE	Shared-Explicit
SEC	SDH Equipment Clock
SF	Super Frame
SF	Signal Fail
SFC	Stage Fabric Configuration Update
sFlow	Sampled Flow
SFM	Source-Filtered Multicast
SFP	Small Form-factor Pluggable
SFTP	Secure FTP

Short GI	Short Guard Interval
SIA	Stuck In Active
SID	Segment Identifier
SIP	Session Initiation Protocol
SIPS	SIP Secure
SLA	Service Level Agreement
SLAAC	Stateless Address Autoconfiguration
SLB	Server Load Balance
SLC	Service Logic Control
SLIP	Serial Line Internet Protocol
SLM	Single-ended Loss Measurement
SMA	State Machine based Anti-spoofing
SmartMC	Smart Management Center
SMET	Selective Multicast Ethernet Tag Route
S-MLAG	Simple Multichassis Link Aggregation
SMTP	Simple Mail Transfer Protocol
SN	Serial Number
SNA	System Network Architecture
SNAP	Subnet Access Protocol
SNAT	Source Network Address Translation
SNMP	Simple Network Management Protocol
SNMP-DCA	SNMP Data Collection Agent
SNP	Sequence Number PDU
SNPA	Subnetwork Point of Attachment
SNR	Signal-to-Noise Ratio
SNTP	Simple NTP
SOA	Start of Authority
SOAP	Simple Object Access Protocol
SOH	Section Overhead
SONET	Synchronous Optical Network
SoO	Site of Origin
SP	Strict Priority
SP	Service Provider
SP	Scheduler Policy
SPB	Shortest Path Bridging
SPBM	Shortest Path Bridging MAC Mode
SPBM	Shortest Path Bridging MAC
SPBN	Shortest Path Bridging Network
SPCS	Stored Program Control Switching System
SPE	Superstratum PE or Service Provider-end PE

SPF	Shortest Path First
SPI	Security Parameter Index
SPID	Service Profile Identification
SPM	Smart PoE Manager
SPSource ID	Shortest Path Source Identifier
SPT	Shortest Path Tree
SQL	Structured Query Language
SR	Segment Routing
Srefresh	Summary Refresh
SRGB	Segment Routing Global Block
SRLB	Segment Routing Local Block
SRLSP	Segment Routing Label Switched Path
SRMC	Segment Routing Mapping Client
SRMS	Segment Routing Mapping Server
SRST	Survivable Remote Site Telephony
sr-TCM	single rate TCM
SRTP	Secure Real-Time Transport Protocol
SRV	Service
SSA	SIP Stack Adapt
SSH	Secure Shell
SSID	Service Set Identifier
SSL	Secure Sockets Layer
SSM	Synchronization Status Message
SSM	Source-Specific Multicast
SSP	Switch-to-Switch Protocol
SSU-A	primary level SSU
SSU-B	second level SSU
ST	Shared Tree
Stateful PCE	Stateful Path Computation Element
Stateless PCC	Stateless Path Computation Client
Stateless PCE	Stateless Path Computation Element
STBC	Space-Time Block Coding
STP	Spanning Tree Protocol
STR	Switch Trace Route
SVC	Static Virtual Circuit
SVC	Switched Virtual Circuit
SVP	SpectraLink Voice Priority
T	Return
TA	Terminal Adapter

TACACS	Terminal Access Controller Access Control System
TACL	Temporary Access Control List
TAI	International Atomic Time
TAII	Target Attachment Individual Identifier
T-BC	Telecom Boundary Clock
TC	Topology Checksum
TC	Topology Change
TC	Topology client
TC	Traffic Class
TC	Transparent Clock
TCA	Topology Change Acknowledge
TCAM	Ternary Content Addressable Memory
TCI	Tag Control Information
Tcl	Tool Command Language
TCN BPDU	Topology Change Notification BPDU
TCP	Transmission Control Protocol
TCT-BC	Transparent Telecom Boundary Clock
TDM	Time Division Multiplexing
TDMA	Time Division Multiple Access
TE	Traffic Engineering
TEDB	TE DataBase
TEI	Terminal Endpoint Identifier
TEID	Tunnel Endpoint Identifier
TEK	Tranfic Encrytion Key
TFO	Transport Flow Optimization
TFTP	Trivial File Transfer Protocol
TI-LFA FRR	Topology-Independent Loop-free Alternate Fast Reroute
TIM	Traffic Indication Map
TK	Temporal Key
TKIP	Temporal Key Integrity Protocol
TLS	Transport Layer Security
TLS	Transparent LAN Service
TLV	Type/Length/Value
TM	Topology Master
ToS	Type of Service
TP	Traffic Policing
TP	Topology Protection
TPA	Third-part Application
TPC	Transmit Power Control
TPDU	Transport Protocol Data Unit

TPID	Tag Protocol Identifier
TPMR	Two-Port MAC Relay
TQ	Time Quantum
TRILL	TRansparent Interconnection of Lots of Links
TRIP	Triggered RIP
tr-TCM	two-rate TCM
TS	Traffic Shaping
TSA	Tunnel Switching Aggregator
TST	Test
T-TC	Telecom Transparent Clock
TTI	Trail Trace Identifier
TTL	Time to Live
TTLS	Tunneled Transport Layer Security
TTLS-GTC	Tunneled Transport Layer Security-Microsoft Generic Token Card
TTLS-MSCHAPv2	Tunneled Transport Layer Security-Microsoft Challenge Handshake Authentication Protocol v2
T-TSC	Telecom Time Slave Clock
TTY	True Type Terminal
TU	Tributary Unit
TUG	Tributary Unit Group
TWAMP	Two-Way Active Measurement Protocol
TxBF	Tx Beamforming
TXOP Limit	Transmission Opportunity Limit
TXT	Text
U	Return
UA	Unnumbered Acknowledge
UA	User Agent
UAC	User Agent Client
U-APSD	Unscheduled Automatic Power-Save Delivery
UAS	User Agent Server
UBR	Unspecified Bit Rate
UCM	User Connection Management
UDLD	Uni-directional Link Direction
UDP	User Data Protocol
UE	User Equipment
UFC	Update Fabric Configuration
UIM	User Identity Module
UNI	User-to-Network Interface
UNI	User Network Interface

UPE	User facing-Provider Edge
UPE	Underlayer PE or User-end PE
URI	Uniform Resource Identifier
URL	Uniform Resource Locator
uRPF	Unicast Reverse Path Forwarding
USK	Unicast Session Key
USM	User-Based Security Model
UTC	Coordinated Universal Time
UTM	Unified Threat Management
V	Return
V2V	Video to Video
VA	Virtual Access
VACM	View-based Access Control Model
VAD	Voice Activity Detection
VAM	VPN Address Management
VBR-NRT	Variable Bit Rate-Non Real Time
VBR-RT	Variable Bit Rate-Real Time
VC	Virtual Circuit
VC	Virtual Container
VCC	Virtual Circuit Connection
VCCV	Virtual Circuit Connectivity Verification
VCF	Vertical Converged Framework
VCFC	VCF Controller
VCI	Virtual Channel Identifier
VCN	Virtual Circuit Number
VCPM	Voice Co-processing Module
VD	Virtual Device
VDP	VSI Discovery and Configuration Protocol
VDSL	Very high-speed Digital Subscriber Line
VE	Virtual Ethernet
VE-Bridge	Virtual Ethernet Bridge
VEth	Virtual Ethernet
VF Owner	Virtual Forwarder Owner
VFW	Virtual Firewall
VLAN	Virtual Local Area Network
VM	Virtual Machine
VMM	Virtual Machine Management
VN	Version Number
VNC	Virtual Network Computing

VNI	VXLAN Network Identifier
VoD	Video on Demand
VoIP	Voice over IP
VP	Virtual Path
VPC	Virtual Path Connection
VPC	Virtual Private Cloud
VPDN	Virtual Private Dial-up Network
VPI	Virtual Path Identifier
VPLS	Virtual Private LAN Service
VPM	Voice Processing Module
VPN	Virtual Private Network
VPWS	Virtual Private Wire Service
VR	Virtual Router
VRF	Virtual Routing and Forwarding
VRRP	Virtual Router Redundancy Protocol
VSAN	Virtual Storage Area Network
VSD	Virtual Security Domain
VSI	Virtual Switch Instance
VSI	Virtual Station Interface
VSID	Virtual Subnet Identifier
VSIP	Virtual Service IP
VSRP	Virtual Service Redundancy Protocol
vSwitch	Virtual Switch
VT	Virtual Template
VTEP	VXLAN Tunnel End Point
VTP	VLAN Trunking Protocol
VTY	Virtual Type Terminal
VXLAN	Virtual eXtensible LAN
VXLAN-DCI	VXLAN Data Center Interconnection
W	Return
WAAS	Wide Area Application Services
WAF	Web Application Firewall
WAI	WLAN Authentication Infrastructure
WAN	Wide Area Network
WAP	Wireless Application Protocol
WAPI	WLAN Authentication and Privacy Infrastructure
WASS	Wide Area Application Services
WDS	Wireless Distribution System
WEP	Wired Equivalent Privacy

WFQ	Weighted Fair Queuing
WHA	WLAN High Availability
WIDS	Wireless Intrusion Detection System
WiNet	Wisdom Network
WINS	Windows Internet Naming Service
WIPS	Wireless Intrusion Prevention System
WLAN	Wireless Local Area Network
WLAN RRM	Radio Resource Management
WMM	Wi-Fi Multimedia
WPA	Wi-Fi Protected Access
WPAD	Web Proxy Auto-Discovery
WPI	WLAN Privacy Infrastructure
WRED	Weighted Random Early Detection
WRR	Weighted Round Robin
WSA	Wireless Spectrum Analysis
WT	Wireless Terminator
WTU	Wireless Terminator Unit
WWN	World Wide Name
X	Return
XFP	10-Gigabit Small Form-factor Pluggable
XML	Extensible Markup Language
XSD	XML Schema Document
XSD	XML Schema Definition
Z	Return
ZBR	Zone Border Router