

Ethernet-Switching- Configuration - MS400995M

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1. Configuring Interfaces

1.1. Overview

```
A# show interfaces gigabitEthernet 0/1
Index(dec):1 (hex):1
GigabitEthernet 0/1 is administratively down, line protocol is DOWN
Hardware is GigabitEthernet, address is 00d0.f865.de9b (bia 00d0.f865.de9b)
Interface address is: no ip address
MTU 1500 bytes, BW 1000000 Kbit
Encapsulation protocol is Bridge, loopback not set
Carrier delay is 2 sec
Rxload is 1/255, Txload is 1/255
Queue    Transmitted packets    Transmitted bytes    Dropped packets
Dropped bytes
  0          0          0          0
0
  1          0          0          0
0
  2          0          0          0
0
  3          0          0          0
0
  4          0          0          0
0
  5          0          0          0
0
  6          0          0          0
0
  7          4          440         0
0
```

```

Switchport attributes:
  interface's description:""
  lastchange time:0 Day:20 Hour:15 Minute:22 Second
  Priority is 0
    admin speed is AUTO, oper speed is Unknown
  flow control admin status is OFF, flow control oper status is Unknown
  admin negotiation mode is OFF, oper negotiation state is ON
  Storm Control: Broadcast is OFF, Multicast is OFF, Unicast is OFF
Port-type: access
  Vlan id: 1
10 seconds input rate 0 bits/sec, 0 packets/sec
10 seconds output rate 0 bits/sec, 0 packets/sec
  4 packets input, 408 bytes, 0 no buffer, 0 dropped
  Received 0 broadcasts, 0 runts, 0 giants
  0 input errors, 0 CRC, 0 frame, 0 overrun, 0 abort
  4 packets output, 408 bytes, 0 underruns, 0 dropped
0 output errors, 0 collisions, 0 interface resets
A# show interfaces vlan 1
Index(dec):4097 (hex):1001
VLAN 1 is UP, line protocol is DOWN
Hardware is VLAN, address is 00d0.f822.33af (bia 00d0.f822.33af)
Interface address is: 192.168.1.1/24
ARP type: ARPA, ARP Timeout: 3600 seconds
MTU 1500 bytes, BW 1000000 Kbit
Encapsulation protocol is Ethernet-II, loopback not set
  Carrier delay is 2 sec
Rxload is 0/255, Txload is 0/255

```

Interfaces are important in implementing data switching on network devices. The device supports two types of interfaces: physical ports and logical interfaces. A physical port is a hardware port on a device, such as the 100M Ethernet interface and gigabit Ethernet interface. A logical interface is not a hardware port on the device. A logical interface, such as the loopback interface and tunnel interface, can be associated with a physical port or independent of any physical port. For network protocols, physical ports and logical interfaces serve the same function.

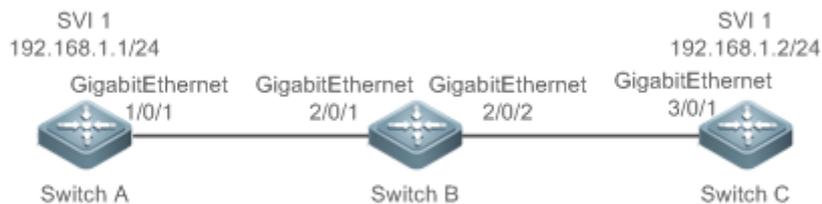
1.2. Applications

Application	Description
L2 Data Switching Through the Physical Ethernet Interface	Implement Layer-2 (L2) data communication of network devices through the physical L2 Ethernet interface.

L3 Routing Through the Physical Ethernet Interface	Implement Layer-3 (L3) data communication of network devices through the physical L3 Ethernet interface.
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1.2.1. L2 Data Switching Through the Physical Ethernet Interface

Scenario

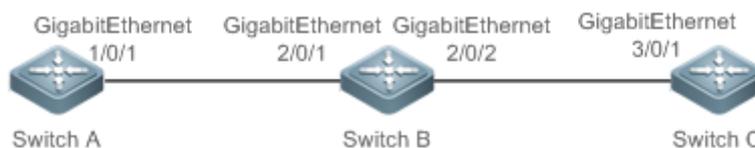


Deployment

- Connect Switch A to Switch B through physical ports GigabitEthernet 1/0/1 and GigabitEthernet 2/0/1.
- Connect Switch B to Switch C through physical ports GigabitEthernet 2/0/2 and GigabitEthernet 3/0/1.
- Configure GigabitEthernet 1/0/1, GigabitEthernet 2/0/1, GigabitEthernet 2/0/2, and GigabitEthernet 3/0/1 as Trunk ports.
- Create a switch virtual interface (SVI), SVI 1, on Switch A and Switch C respectively, and configure IP addresses from a network segment for the two SVIs. The IP address of SVI 1 on Switch A is 192.168.1.1/24, and the IP address of SVI 1 on Switch C is 192.168.1.2/24.
- Run the ping 192.168.1.2 command on Switch A and the ping 192.168.1.1 command on Switch C to implement data switching through Switch B.

1.2.2. L3 Routing Through the Physical Ethernet Interface

Scenario



Deployment

- Connect Switch A to Switch B through physical ports GigabitEthernet 1/0/1 and GigabitEthernet 2/0/1.
- Connect Switch B to Switch C through physical ports GigabitEthernet 2/0/2 and GigabitEthernet 3/0/1.
- Configure GigabitEthernet 1/0/1, GigabitEthernet 2/0/1, GigabitEthernet 2/0/2, and GigabitEthernet 3/0/1 as L3 routed ports.

- Configure IP addresses from a network segment for GigabitEthernet 1/0/1 and GigabitEthernet 2/0/1. The IP address of GigabitEthernet 1/0/1 is 192.168.1.1/24, and the IP address of GigabitEthernet 2/0/1 is 192.168.1.2/24.
- Configure IP addresses from a network segment for GigabitEthernet 2/0/2 and GigabitEthernet 3/0/1. The IP address of GigabitEthernet 2/0/2 is 192.168.2.1/24, and the IP address of GigabitEthernet 3/0/1 is 192.168.2.2/24.
- Configure a static route entry on Switch C so that Switch C can directly access the network segment 192.168.1.0/24.
- Run the ping 192.168.2.2 command on Switch A and the ping 192.168.1.1 command on Switch C to implement L3 routing through Switch B.

1.3. Features

Basic Concepts

→ Interface Classification

Interfaces on the device fall into three categories:

- L2 interface (Switch or bridge mode)
- L3 interface (supported by L3 devices)

1. Common L2 interfaces are classified into the following types:

- Switch port
- L2 aggregate port (AP)

2. Common L3 interfaces are classified into the following types:

- Routed port
- L3 AP port
- SVI
- Loopback interface
- Tunnel interface

→ Switch Port

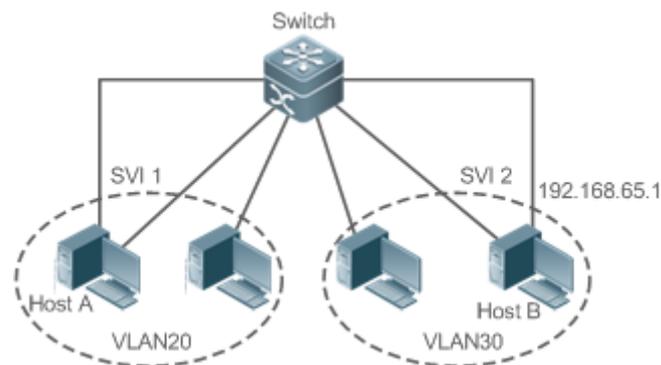
A switch port is an individual physical port on the device, and implements only the L2 switching function. The switch port is used to manage physical ports and L2 protocols related to physical ports.

→ L2 AP Port

An AP port is formed by aggregating multiple physical ports. Multiple physical links can be bound together to form a simple logical link. This logical link is called an AP port. For L2 switching, an AP port is equivalent to a switch port that combines bandwidths of multiple ports, thus expanding the link bandwidth. Frames sent over the L2 AP port are balanced among the L2 AP member ports. If one member link fails, the L2 AP port automatically transfers the traffic on the faulty link to other member links, improving reliability of connections.

→ SVI

The SVI can be used as the management interface of the local device, through which the administrator can manage the device. You can also create an SVI as a gateway interface, which is mapped to the virtual interface of each VLAN to implement routing across VLANs among L3 devices. You can run the `interface vlan` command to create an SVI and assign an IP address to this interface to set up a route between VLANs. As shown in Figure 1 3, hosts in VLAN 20 can directly communicate with each other without participation of L3 devices. If Host A in VLAN 20 wants to communicate with Host B in VLAN 30, SVI 1 of VLAN 20 and SVI 2 of VLAN 30 must be used.



→ Routed Port

A physical port on a L3 device can be configured as a routed port, which functions as the gateway interface for L3 switching. A routed port is not related with a specific VLAN. Instead, it is just an access port. The routed port cannot be used for L2 switching. You can run the `no switchport` command to change a switch port to a routed port and assign an IP address to this port to set up a route. Note that you must delete all L2 features of a switch port before running the `no switchport` command.



If a port is a L2 AP member port or a DOT1X port that is not authenticated, you cannot run the `switchport` or `no switchport` command to configure the switch port or routed port.

→ L3 AP Port

Like the L2 AP port, a L3 AP port is a logical port that aggregates multiple physical member ports. The aggregated ports must be the L3 ports of the same type. The AP port functions as a gateway interface for L3 switching. Multiple physical links are combined into one logical link, expanding the bandwidth of a link. Frames sent over the L3 AP port are balanced among the L3 AP member ports. If one member link fails, the L3 AP port automatically transfers the traffic on the faulty link to other member links, improving reliability of connections.

A L3 AP port cannot be used for L2 switching. You can run the `no switchport` command to change a L2 AP port that does not contain any member port into a L3 AP port, add multiple routed ports to this L3 AP port, and then assign an IP address to this L3 AP port to set up a route.

→ Loopback Interface

The loopback interface is a local L3 logical interface simulated by the software that is always UP. Packets sent to the loopback interface are processed on the device locally, including the route information. The IP address of the loopback interface can be used as the device ID of the Open Shortest Path First (OSPF) routing protocol, or as the source address used by Border Gateway Protocol (BGP) to set up a TCP connection. The procedure for configuring a loopback interface is similar to that for configuring an Ethernet interface, and you can treat the loopback interface as a virtual Ethernet interface.

→ Tunnel Interface

The Tunnel interface implements the tunnel function. Over the Tunnel interface, transmission protocols (e.g., IP) can be used to transmit packets of any protocol. Like other logical interfaces, the tunnel interface is also a virtual interface of the system. Instead of specifying any transmission protocol or load protocol, the tunnel interface provides a standard point-to-point (P2P) transmission mode. Therefore, a tunnel interface must be configured for every individual link.

Overview

Feature	Description
Interface Configuration Commands	You can configure interface-related attributes in interface configuration mode. If you enter interface configuration mode of a non-existing logical interface, the interface will be created.
Interface Description and Administrative Status	You can configure a name for an interface to identify the interface and help you remember the functions of the interface. You can also configure the administrative status of the interface.

Feature	Description
MTU	You can configure the maximum transmission unit (MTU) of a port to limit the length of a frame that can be received or sent over this port.
Bandwidth	You can configure the bandwidth of an interface.
Load Interval	You can specify the interval for load calculation of an interface.
Carrier Delay	You can configure the carrier delay of an interface to adjust the delay after which the status of an interface changes from Down to Up or from Up to Down.

Link Trap Policy	You can enable or disable the link trap function on an interface.
Interface Index Persistence	You can enable the interface index persistence function so that the interface index remains unchanged after the device is restarted.
Routed Port	You can configure a physical port on a L3 device as a routed port, which functions as the gateway interface for L3 switching.
L3 AP Port	You can configure an AP port on a L3 device as a L3 AP port, which functions as the gateway interface for L3 switching.
Interface Speed, Duplex Mode, Flow Control Mode, and Auto Negotiation Mode	You can configure the speed, duplex mode, flow control mode, and auto negotiation mode of an interface.
Automatic Module Detection	If the interface speed is set to auto, the interface speed can be automatically adjusted based on the type of the inserted module.
Protected Port	You can configure some ports as protected ports to disable communication between these ports. You can also disable routing between protected ports.
Port Errdisable Recovery	After a port is shut down due to a violation, you can run the errdisable recovery command in global configuration mode to recover all the ports in errdisable state and enable these ports.
Port Flapping Protection	You can configure the port flapping protection function so that the system can automatically shut down a port when flapping occurs on the port.

1.3.1. Interface Configuration Commands

Run the interface command in global configuration mode to enter interface configuration mode. You can configure interface-related attributes in interface configuration mode. Working Principle Run the interface command in global configuration mode to enter interface configuration mode. If you enter interface configuration mode of a non-existing logical interface, the interface will be created. You can also run the interface range or interface range macro command in global configuration mode to configure the range (IDs) of interfaces. Interfaces defined in the same range must be of the same type and have the same features.

You can run the no interface command in global configuration mode to delete a specified logical interface.

→ Interface Numbering Rules

In stand-alone mode, the ID of a physical port consists of two parts: slot ID and port ID on the slot. For example, if the slot ID of the port is 2, and port ID on the slot is 3, the interface ID is 2/3. In VSU or stack mode, the ID of a physical port consists of three parts: device ID, slot ID, and port ID on the slot. For example, if the device ID is 1, slot ID of the port is 2, and port ID on the slot is 3, the interface ID is 1/2/3.

The device ID ranges from 1 to the maximum number of supported member devices.

The slot number rules are as follows: The static slot ID is 0, whereas the ID of a dynamic slot (pluggable module or line card) ranges from 1 to the number of slots. Assume that you are facing the device panel. Dynamic slot are numbered from 1 sequentially from front to rear, from left to right, and from top to bottom.

The ID of a port on the slot ranges from 1 to the number of ports on the slot, and is numbered sequentially from left to right.

You can select fiber or copper as the medium of a combo port. Regardless of the medium selected, the combo port uses the same port ID.

The ID of an AP port ranges from 1 to the number of AP ports supported by the device.

The ID of an SVI is the VID of the VLAN corresponding to this SVI.

→ Configuring Interfaces Within a Range

You can run the interface range command in global configuration mode to configure multiple interfaces at a time. Attributes configured in interface configuration mode apply to all these interfaces.

The interface range command can be used to specify several interface ranges.

The macro parameter is used to configure the macro corresponding to a range. For details, see "Configuring Macros of Interface Ranges."

Ranges can be separated by commas (,).

The types of interfaces within all ranges specified in a command must be the same.

Pay attention to the format of the range parameter when you run the interface range command.

The following interface range formats are valid:

- FastEthernet device/slot/{first port} - {last port};
- GigabitEthernet device/slot/{first port} - {last port};
- TenGigabitEthernet device/slot/{first port} - {last port};
- FortyGigabitEthernet device/slot/{first port} - {last port};
- AggregatePort Aggregate-port ID (The AP ID ranges from 1 to the maximum number of AP ports supported by the device.)

- vlan vlan-ID-vlan-ID (The VLAN ID ranges from 1 to 4,094.)
- Loopback loopback-ID (The loopback ID ranges from 1 to 2,147,483,647.)
- Tunnel tunnel-ID (The tunnel ID ranges from 0 to the maximum number of tunnel interfaces supported by the device minus 1.)

Interfaces in an interface range must be of the same type, namely, FastEthernet, GigabitEthernet, AggregatePort, or SVI.

→ Configuring Macros of Interface Ranges

You can define some macros to replace the interface ranges. Before using the macro parameter in the interface range command, you must first run the define interface-range command in global configuration mode to define these macros.

Run the no define interface-range macro_name command in global configuration mode to delete the configured macros.

1.3.2. Interface Description and Administrative Status

You can configure a name for an interface to identify the interface and help you remember the functions of the interface.

You can enter interface configuration mode to enable or disable an interface.

Working Principle

→ Interface Description

You can configure the name of an interface based on the purpose of the interface. For example, if you want to assign GigabitEthernet 1/1 for exclusive use by user A, you can describe the interface as "Port for User A."

→ Interface Administrative Status

You can configure the administrative status of an interface to disable the interface as required. If the interface is disabled, no frame will be received or sent on this interface, and the interface will lose all its functions. You can enable a disabled interface by configuring the administrative status of the interface. Two types of interface administrative status are defined: Up and Down. The administrative status of an interface is Down when the interface is disabled, and Up when the interface is enabled.

1.3.3. MTU

You can configure the MTU of a port to limit the length of a frame that can be received or sent over this port.

Working Principle

When a large amount of data is exchanged over a port, frames greater than the standard Ethernet frame may exist. This type of frame is called jumbo frame. The MTU is the length of the valid data segment in a frame. It does not include the Ethernet encapsulation overhead.

If a port receives or sends a frame with a length greater than the MTU, this frame will be discarded.

1.3.4. Bandwidth

Working Principle

The bandwidth command can be configured so that some routing protocols (for example, OSPF) can calculate the route metric and the Resource Reservation Protocol (RSVP) can calculate the reserved bandwidth. Modifying the interface bandwidth will not affect the data transmission rate of the physical port.



The bandwidth command is a routing parameter, and does not affect the bandwidth of a physical link.

1.3.5. Load Interval

Working Principle

You can run the load-interval command to specify the interval for load calculation of an interface. Generally, the interval is 10s.

1.3.6. Carrier Delay

Working Principle

The carrier delay refers to the delay after which the data carrier detect (DCD) signal changes from Down to Up or from Up to Down. If the DCD status changes during the delay, the system will ignore this change to avoid negotiation at the upper data link layer. If this parameter is set to a great value, nearly every DCD change is not detected. On the contrary, if the parameter is set to 0, every DCD signal change will be detected, resulting in poor stability.



If the DCD carrier is interrupted for a long time, the carrier delay should be set to a smaller value to accelerate convergence of the topology or route. On the contrary, if the DCD carrier interruption time is shorter than the topology or route convergence time, the carrier delay should be set to a greater value to avoid topology or route flapping.

1.3.7. Link Trap Policy

You can enable or disable the link trap function on an interface.

Working Principle

When the link trap function on an interface is enabled, the Simple Network Management Protocol (SNMP) sends link traps when the link status changes on the interface.

1.3.8. Interface Index Persistence

Like the interface name, the interface index also identifies an interface. When an interface is created, the system automatically assigns a unique index to the interface. The index of an interface may change after the device is restarted. You can enable the interface index persis-

tence function so that the interface index remains unchanged after the device is restarted.

Working Principle

After interface index persistence is enabled, the interface index remains unchanged after the device is restarted.

1.3.9. Routed Port

Working Principle

A physical port on a L3 device can be configured as a routed port, which functions as the gateway interface for L3 switching. The routed port cannot be used for L2 switching. You can run the no switchport command to change a switch port to a routed port and assign an IP address to this port to set up a route. Note that you must delete all L2 features of a switch port before running the no switchport command.

1.3.10. L3 AP Port

Working Principle

Like a L3 routed port, you can run the no switchport command to change a L2 AP port into a L3 AP port on a L3 device, and then assign an IP address to this AP port to set up a route. Note that you must delete all L2 features of the AP port before running the no switchport command.



A L2 AP port with one or more member ports cannot be configured as a L3 AP port. Similarly, a L3 AP port with one or more member ports cannot be changed to a L2 AP port.

1.3.11. Interface Speed, Duplex Mode, Flow Control Mode, and Auto Negotiation Mode

You can configure the interface speed, duplex mode, flow control mode, and auto negotiation mode of an Ethernet physical port or AP port.

Working Principle

→ Speed

Generally, the speed of an Ethernet physical port is determined through negotiation with the peer device. The negotiated speed can be any speed within the interface capability. You can also configure any speed within the interface capability for the Ethernet physical port.

When you configure the speed of an AP port, the configuration takes effect on all of its member ports. (All these member ports are Ethernet physical ports.)

→ Duplex Mode

- The duplex mode of an Ethernet physical port or AP port can be configured as follows:
- Set the duplex mode of the interface to full-duplex so that the interface can receive packets while sending packets.

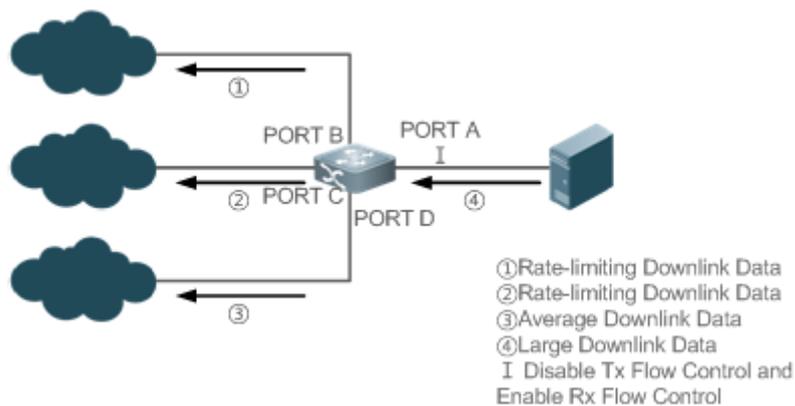
- Set the duplex mode of the interface to half-duplex so that the interface can receive or send packets at a time.
- Set the duplex mode of the interface to auto-negotiation so that the duplex mode of the interface is determined through auto negotiation between the local interface and peer interface.
- When you configure the duplex mode of an AP port, the configuration takes effect on all of its member ports. (All these member ports are Ethernet physical ports.)

→ Flow Control

Two flow control modes are defined for an interface:

- Symmetric flow control mode: Generally, after flow control is enabled on an interface, the interface processes the received flow control frames, and sends the flow control frames when congestion occurs on the interface. The received and sent flow control frames are processed in the same way. This is called symmetric flow control mode.
- Asymmetric flow control mode: In some cases, an interface on a device is expected to process the received flow control frames to ensure that no packet is discarded due to congestion, and not to send the flow control frames to avoid decreasing the network speed. In this case, you need to configure asymmetric flow control mode to separate the procedure for receiving flow control frames from the procedure for sending flow control frames.
- When you configure the flow control mode of an AP port, the configuration takes effect on all of its member ports. (All these member ports are Ethernet physical ports.)

As shown in Figure 1 4, Port A of the device is an uplink port, and Ports B, C and D are downlink ports. Assume that Port A is enabled with the functions of sending and receiving flow control frames. Port B and Port C are connected to different slow networks. If a large amount of data is sent on Port B and Port C, Port B and Port C will be congested, and consequently congestion occurs in the inbound direction of Port A. Therefore, Port A sends flow control frames. When the uplink device responds to the flow control frames, it reduces the data flow sent to Port A, which indirectly slows down the network speed on Port D. At this time, you can disable the function of sending flow control frames on Port A to ensure the bandwidth usage of the entire network.



→ Auto Negotiation Mode

- The auto negotiation mode of an interface can be On or Off. The auto negotiation state of an interface is not completely equivalent to the auto negotiation mode. The auto negotia-

tion state of an interface is jointly determined by the interface speed, duplex mode, flow control mode, and auto negotiation mode.

- When you configure the auto negotiation mode of an AP port, the configuration takes effect on all of its member ports. (All these member ports are Ethernet physical ports.) NOTE: Generally, if one of the interface speed, duplex mode, and flow control mode is set to auto, or the auto negotiation mode of an interface is On, the auto negotiation state of the interface is On, that is, the auto negotiation function of the interface is enabled. If none of the interface speed, duplex mode, and flow control mode is set to auto, and the auto negotiation mode of an interface is Off, the auto negotiation state of the interface is Off, that is, the auto negotiation function of the interface is disabled.



For a 100M fiber port, the auto negotiation function is always disabled, that is, the auto negotiation state of a 100M fiber port is always Off. For a Gigabit copper port, the auto negotiation function is always enabled, that is, the auto negotiation state of a Gigabit copper port is always On.

1.3.12. Automatic Module Detection

If the interface speed is set to auto, the interface speed can be automatically adjusted based on the type of the inserted module.

Working Principle

Currently, the automatic module detection function can be used to detect only the SFP and SFP+ modules. The SFP is a Gigabit module, whereas SFP+ is a 10 Gigabit module. If the inserted module is SFP, the interface works in Gigabit mode. If the inserted module is SFP+, the interface works in 10 Gigabit mode.



The automatic module detection function takes effect only when the interface speed is set to auto.

1.3.13. Protected Port

In some application environments, it is required that communication be disabled between some ports. For this purpose, you can configure some ports as protected ports. You can also disable routing between protected ports.

Working Principle

→ Protected Port

After ports are configured as protected ports, protected ports cannot communicate with each other, but can communicate with non-protected ports.

Protected ports work in either of the two modes. In the first mode, L2 switching is blocked but routing is allowed between protected ports. In the second mode, both L2 switching and routing are blocked between protected ports. If a protected port supports both modes, the first mode is used by default.

When two protected port are configured as a pair of mirroring ports, frames sent or received by the source port can be mirrored to the destination port.

Currently, only an Ethernet physical port or AP port can be configured as a protected port. When an AP port is configured as a protected port, all of its member ports are configured as protected ports.

→ Blocking L3 Routing Between Protected Ports

By default, L3 routing between protected ports is not blocked. In this case, you can run the protected-ports route-deny command to block routing between protected ports.

1.3.14. Port Errdisable Recovery

Some protocols support the port errdisable recovery function to ensure security and stability of the network. For example, in the port security protocol, when you enable port security and configure the maximum number of security addresses on the port, a port violation event is generated if the number of addresses learned on this port exceeds the maximum number of security addresses. Other protocols, such as the Spanning Tree Protocol (STP), DOT1X, and REUP, support the similar functions, and a violating port will be automatically shut down to ensure security.

Working Principle

When a port is disabled because it is set to the errdisable state by the REUP link state tracking group function, the port can be restored only by REUP at a scheduled time or by running the REUP errdisable recovery command in global configuration mode. In other scenarios, you can run the errdisable recovery command in global configuration mode to recovery all the ports in errdisable state and enable these ports. You can manually recover a port, or automatically recover a port at a scheduled time. On some models, you can run the shutdown or no shutdown command to recover all the ports in errdisable state and enable these ports

1.3.15. Split and Combination of the 40G Port

Working Principle

The 40G Ethernet port is a high-bandwidth port. It is mainly used on devices at the convergence layer or core layer to increase the port bandwidth. 40G port split means that a 40G port is split into four 10G ports. At this time, the 40G port becomes unavailable, and the four 10G ports forward data independently. 40G port combination means that four 10G ports are combined into a 40G port. At this time, the four 10G ports become unavailable, and only the 40G port forwards data. You can flexibly adjust the bandwidth by combining or splitting ports.

1.3.16. Port Flapping Protection

When flapping occurs on a port, a lot of hardware interruptions occur, consuming a lot of CPU resources. On the other hand, frequent port flapping damages the port. You can configure the flapping protection function to protect ports.

Working Principle

By default, the port flapping protection function is enabled. You can disable this function as required.

There are two kinds of port oscillation protection mechanism:

- When flapping occurs on a port, the port detects flapping every 2s or 10s. If flapping occurs six times within 2s on a port, the device displays a prompt. If 10 prompts are displayed continuously, that is, port flapping is detected continuously within 20s, the port is disabled. If flapping occurs 10 times within 10s on a port, the device displays a prompt without disabling the port.
- Flapping detection is enabled every 30s. A section of flapping includes at least 60 flappings within 30s. Then, a syslog will be printed after three consecutive sections of flapping occur. If flapping protection is enabled, the port will be shut down. If not, the port will not be shut down.

1.3.17. Syslog

You can enable or disable the syslog function to determine whether to display information about the interface changes or exceptions.

Working Principle

You can enable or disable the syslog function as required. By default, this function is enabled. When an interface becomes abnormal, for example, the interface status changes, or the interface receives error frames, or flapping occurs, the system displays prompts to notify users.

1.3.18. Interface FEC Mode

Working Principle

Forward Error Correction (FEC) is an error code correction method employing the following working principle: The sender adds a redundancy error-correcting code to the data for sending. The receiver performs error detection on the data based on the error-correcting code. If an error is found, the receiver corrects the error. FEC improves signal quality but also causes signal delay. Users can enable or disable this function according to the actual situation.

Different types of ports support different FEC modes. A 25 Gbps port supports the BASE-R mode, while a 100 Gbps port supports the RS mode.

Related Configuration

→ Configuring Interface FEC Mode

By default, FEC mode is related with the port type and depends on the product model. And whether the FEC mode is enabled or disabled on a port is determined by the inserted optical module and rate.

Run the fec mode {rs | base-r | none | auto} command in interface mode to configure the FEC mode on an interface.



There are three FEC modes: RS, Base-R, and auto modes. Different types of port support different FEC modes.



For S6120 products, the MGMT interface information can be displayed by the show interface mgmt command instead of the show mgmt virtual command.

1.4. Configuration

Configuration	Description and Command
Performing Basic Configurations	(Optional) It is used to manage interface configurations, for example, creating/deleting an interface, or configuring the interface description.
interface	Creates an interface and enters configuration mode of the created interface or a specified interface.
interface range	Enters an interface range, creates these interfaces (if not created), and enters interface configuration mode.
define interface-range	Creates a macro to specify an interface range.
snmp-server if-index persist	Enables the interface index persistence function so that the interface index remains unchanged after the device is restarted.
description	Configures the interface description of up to 80 characters in interface configuration mode.
snmp trap link-status	Configures whether to send the link traps of the interface.
shutdown	Shuts down an interface in interface configuration mode.
split interface	Splits a 40G port in global configuration mode.
physical-port dither protect	Configures the port flapping protection function in global configuration mode.
logging [link-updown error-frame link-dither res-lack-frame]	Configures the syslog function on an interface in global configuration mode.

Configuring Interface Attributes	(Optional) It is used to configure interface attributes	
	bandwidth	Configures the bandwidth of an interface in interface configuration mode.
	carrier-delay	Configures the carrier delay of an interface in interface configuration mode.
	load-interval	Configures the interval for load calculation of an interface.
	duplex	Configures the duplex mode of an interface.
	mtu	Configures the MTU of an interface.
	negotiation mode	Configures the auto negotiation mode of an interface.
	speed	Configures the speed of an interface.

Configuring Interface Attributes	port speed-mode	Configure the speed mode for 25G port.
	switchport	Configures an interface as a L2 interface in interface configuration mode. (Run the no switchport command to configure an interface as a L3 interface.)
	switchport protected	Configures a port as a protected port.
	protected-ports route-deny	Blocks L3 routing between protected ports in global configuration mode.
	errdisable recovery	Recovers a port in errdisable state in global configuration mode.
	fiber antifake ignore	Disables the optical module antifake detection function in global configuration mode.
	fiber antifake enable	Enables the optical module antifake detection function in global configuration mode.
	fec mode	Configures interface FEC mode.

1.4.1. Performing Basic Configurations

[Configuration Effect](#)

- Create a specified logical interface and enter configuration mode of this interface, or enter configuration mode of an existing physical or logical interface.
- Create multiple specified logical interfaces and enter interface configuration mode, or enter configuration mode of multiple existing physical or logical interfaces.
- The interface indexes remain unchanged after the device is restarted.
- Configure the interface description so that users can directly learn information about the interface.
- Enable or disable the link trap function of an interface.
- Enable or disable an interface.
- Split a 40G port or combine four 10G ports into a 40G port.

[Notes](#)

- The no form of the command can be used to delete a specified logical interface or logical interfaces in a specified range, but cannot be used to delete a physical port or physical ports in a specified range.
- The default form of the command can be used in interface configuration mode to restore default settings of a specified physical or logical interface, or interfaces in a specified range.

Configuration Steps

→ Configuring a Specified Interface

- Optional.
- Run this command to create a logical interface or enter configuration mode of a physical port or an existing logical interface.

Command	interface interface-type interface-number
Parameter Description	interface-type interface-number: Indicates the type and number of the interface. The interface can be an Ethernet physical port, AP port, SVI, or loopback interface.
Defaults	N/A
Command Mode	Global configuration mode
Usage Guide	<ul style="list-style-type: none"> • If a logical interface is not created yet, run this command to create this interface and enter configuration mode of this interface. • For a physical port or an existing logical interface, run this command to enter configuration mode of this interface. • Use the no form of the command to delete a specified logical interface. • Use the default form of the command to restore default settings of the interface in interface configuration mode.

→ Configuring Interfaces Within a Range

- Optional.
- Run this command to create multiple logical interfaces or enter configuration mode of multiple physical port or existing logical interfaces.

Command	interface range { port-range macro macro_name }
Parameter Description	port-range: Indicates the type and ID range of interfaces. These interfaces can be Ethernet physical ports, AP ports, SVIs, or loopback interfaces. macro_name: Indicates the name of the interface range macro.
Defaults	N/A

Command Mode	Global configuration mode
Usage Guide	<ul style="list-style-type: none"> • If logical interfaces are not created yet, run this command to create these interfaces and enter interface configuration mode. • For multiple physical ports or existing logical interfaces, run this command to enter interface configuration mode. • Use the default form of the command to restore default settings of these interfaces in interface configuration mode. • Before using a macro, run the define interface-range command to define the interface range as a macro name in global configuration mode, and then run the interface range macro macro_name command to apply the macro.

→ Configuring Interface Index Persistence

- Optional.
- Run this command when the interface indexes must remain unchanged after the device is restarted.

Command	snmp-server if-index persist
Parameter Description	N/A
Defaults	By default, interface index persistence is disabled.
Command Mode	Global configuration mode
Usage Guide	After this command is executed, current indexes of all interfaces will be saved, and the indexes remain unchanged after the device is restarted. You can use the no or default form of the command to disable the interface index persistence function.

→ Configuring the Description of an Interface

- Optional.
- Run this command to configure the description of an interface.

Command	description string
Parameter Description	string: Indicates a string of up to 80 characters.

Defaults	By default, no description is configured.
Command Mode	Interface configuration mode
Usage Guide	This command is used to configure the description of an interface. You can use the no or default form of the command to delete the description of an interface.-

→ Configuring the Link Trap Function of an Interface

- Optional.
- Run this command to obtain the link traps through SNMP.

Command	snmp trap link-status
Parameter Description	N/A
Defaults	By default, the link trap function is enabled.
Command Mode	Interface configuration mode
Usage Guide	This command is used to configure the link trap function on an interface. When this function is enabled, the SNMP sends link traps when the link status changes on the interface. You can use the no or default form of the command to disable the link trap function.

→ Configuring the Administrative Status of an Interface

- Optional.
- Run this command to enable or disable an interface.
- An interface cannot send or receive packets after it is disabled.

Command	shutdown
Parameter Description	N/A
Defaults	By default, the administrative status of an interface is Up.
Command Mode	Interface configuration mode

Usage Guide	You can run the shutdown command to disable an interface, or the no shutdown command to enable an interface. In some cases, for example, when an interface is in errdisable state, you cannot run the no shutdown command on an interface. You can use the no or default form of the command to enable the interface.
-------------	---

→ Splitting a 40G Port or Combining Four 10G Ports into a 40G Port

- Optional.
- Run this command to split or combine a 40G.

Command	[no] split interface interface-type interface-number
Parameter Description	interface-type interface-number: Indicates the type and number of a port. The port must be a 40G port.
Defaults	By default, the ports are combined.
Command Mode	Global configuration mode
Usage Guide	You can run the split command to split a 40G port, or the no split command to combine the split 40G port. After this command is configured, you generally need to restart the line card or the entire device so that the configuration can take effect.

→ Configuring Port Flapping Protection

- Optional.
- Run this command to protect the port against flapping.

Command	physical-port dither protect
Parameter Description	N/A
Defaults	By default, port flapping protection is enabled.
Command Mode	Global configuration mode
Usage Guide	N/A

→ Configuring Port Flapping Protection

- Optional.

- Run this command to protect the port against flapping.

Command	port dither protect
Parameter Description	N/A
Defaults	By default, port flapping protection is enabled.
Command Mode	Global configuration mode
Usage Guide	N/A

→ Configuring the Syslog Function

- Optional.
- Run this command to enable or disable the syslog function on an interface.

Command	
Parameter Description	link-updown: prints the status change information. error-frame: prints the error frame information. link-dither: prints the port flapping information. res-lack-frame: prints the error frame information received by an interface due to lack of resource.
Defaults	By default, the syslog function is enabled on an interface.
Command Mode	Global configuration mode
Usage Guide	N/A

Verification

→ Configuring a Specified Interface

- Run the interface command. If you can enter interface configuration mode, the configuration is successful.
- For a logical interface, after the no interface command is executed, run the show running or show interfaces command to check whether the logical interface exists. If not, the logical interface is deleted.
- After the default interface command is executed, run the show running command to check whether the default settings of the corresponding interface are restored. If yes, the operation is successful.

→ Configuring Interfaces Within a Range

- Run the interface range command. If you can enter interface configuration mode, the configuration is successful.
- After the default interface range command is executed, run the show running command to check whether the default settings of the corresponding interfaces are restored. If yes, the operation is successful.

→ Configuring Interface Index Persistence

- After the snmp-server if-index persist command is executed, run the write command to save the configuration, restart the device, and run the show interface command to check the interface index. If the index of an interface remains the same after the restart, interface index persistence is enabled.

→ Configuring the Link Trap Function of an Interface

- Remove and then insert the network cable on a physical port, and enable the SNMP server. If the SNMP server receives link traps, the link trap function is enabled.
- Run the no form of the snmp trap link-status command. Remove and then insert the network cable on a physical port. If the SNMP server does not receive link traps, the link trap function is disabled.

→ Configuring the Administrative Status of an Interface

- Insert the network cable on a physical port, enable the port, and run the shutdown command on this port. If the syslog is displayed on the Console indicating that the state of the port changes to Down, and the indicator on the port is off, the port is disabled. Run the show interfaces command, and verify that the interface state changes to Administratively Down. Then, run the no shutdown command to enable the port. If the syslog is displayed on the Console indicating that the state of the port changes to Up, and the indicator on the port is on, the port is enabled.

→ Splitting or Combining a 40G Port

- Run the split command on a 40G port in global configuration mode. Verify that the related syslog is displayed on the Console. Run the write command to save the configuration, and restart the device or line card according to the method described in the syslog. The four 10G ports can be configured as L2 or L3 ports, but the split 40G port cannot be configured as a L2 or L3 port.
- Run the no split command on a split 40G port. Verify that the related syslog is displayed on the Console. Run the write command to save the configuration, and restart the device or line card according to the method described in the syslog. The four 10G ports cannot be configured as L2 or L3 ports, but the combined 40G port can be configured as a L2 or L3 port.

→ Configuring Port Flapping Protection

- Run the physical-port dither protect command in global configuration mode. Frequently remove and insert the network cable on a physical port to simulate port flapping. Verify that a syslog indicating port flapping is displayed on the Console. After such a syslog is displayed for several times, the system prompts that the port will be shut down.

→ Configuring the Syslog Function

- Run the logging link-updown command in global configuration mode to display the interface status information. Remove and then insert the network cable on a physical port. The interface state will change twice. Verify that the information is displayed on the Console, indicating that the interface state changes from Up to Down, and then from Down to Up. Run the no logging link-updown command. Remove and then insert the network cable. Verify that the related information is no longer displayed on the Console. This indicates that the syslog function is normal.

Configuration Example

→ Configuring Basic Attributes of Interfaces

<p>Scenario Figure 1-5</p>	
<p>Configuration Steps</p>	<ul style="list-style-type: none"> • Connect two devices through the switch ports. • Configure an SVI respectively on two devices, and assign IP addresses from a network segment to the two SVIs. • Enable interface index persistence on the two devices. • Enable the link trap function on the two devices. • Configure the interface administrative status on the two devices.
<p>A</p>	<pre> A# configure terminal A(config)# snmp-server if-index persist A(config)# interface vlan 1 A(config-if-VLAN 1)# ip address 192.168.1.1 255.255.255.0 A(config-if-VLAN 1)# exit A(config)# interface gigabitethernet 0/1 A(config-if-GigabitEthernet 0/1)# snmp trap link-status A(config-if-GigabitEthernet 0/1)# shutdown A(config-if-GigabitEthernet 0/1)# end A# write </pre>

<p>B</p>	<pre> B# configure terminal B(config)# snmp-server if-index persist B(config)# interface vlan 1 B(config-if-VLAN 1)# ip address 192.168.1.2 255.255.255.0 B(config-if-VLAN 1)# exit B(config)# interface gigabitEthernet 0/1 B(config-if-GigabitEthernet 0/1)# snmp trap link-status B(config-if-GigabitEthernet 0/1)# shutdown B(config-if-GigabitEthernet 0/1)# end B# write </pre>
<p>Verification</p>	<p>Perform verification on Switch A and Switch B as follows:</p> <ul style="list-style-type: none"> • Run the shutdown command on port GigabitEthernet 0/1, and check whether GigabitEthernet 0/1 and SVI 1 are Down. • Run the shutdown command on port GigabitEthernet 0/1, and check whether a trap indicating that this interface is Down is sent. • Restart the device, and check whether the index of GigabitEthernet 0/1 is the same as that before the restart.

A

```

A# show interfaces gigabitEthernet 0/1
Index(dec):1 (hex):1
GigabitEthernet 0/1 is administratively down, line protocol is DOWN
Hardware is GigabitEthernet, address is 00d0.f865.de9b (bia 00d0.f865.de9b)
Interface address is: no ip address
MTU 1500 bytes, BW 1000000 Kbit
Encapsulation protocol is Bridge, loopback not set
Carrier delay is 2 sec
Rxload is 1/255, Txload is 1/255
Queue    Transmitted packets    Transmitted bytes    Dropped packets
Dropped bytes
  0          0          0          0
0
  1          0          0          0
0
  2          0          0          0
0
  3          0          0          0
0
  4          0          0          0
0
  5          0          0          0
0
  6          0          0          0
0
  7          4          440         0
0
Switchport attributes:
  interface's description:""
  lastchange time:0 Day:20 Hour:15 Minute:22 Second
  Priority is 0
    admin speed is AUTO, oper speed is Unknown
  flow control admin status is OFF, flow control oper status is Unknown
  admin negotiation mode is OFF, oper negotiation state is ON
  Storm Control: Broadcast is OFF, Multicast is OFF, Unicast is OFF
Port-type: access
  Vlan id: 1
10 seconds input rate 0 bits/sec, 0 packets/sec
10 seconds output rate 0 bits/sec, 0 packets/sec
  4 packets input, 408 bytes, 0 no buffer, 0 dropped
  Received 0 broadcasts, 0 runts, 0 giants
  0 input errors, 0 CRC, 0 frame, 0 overrun, 0 abort
  4 packets output, 408 bytes, 0 underruns, 0 dropped
0 output errors, 0 collisions, 0 interface resets
A# show interfaces vlan 1
Index(dec):4097 (hex):1001
VLAN 1 is UP, line protocol is DOWN
Hardware is VLAN, address is 00d0.f822.33af (bia 00d0.f822.33af)
    
```

```
Interface address is: 192.168.1.1/24
ARP type: ARPA, ARP Timeout: 3600 seconds
MTU 1500 bytes, BW 1000000 Kbit
Encapsulation protocol is Ethernet-II, loopback not set
  Carrier delay is 2 sec
Rxload is 0/255, Txload is 0/255
```

B

```

B# show interfaces gigabitEthernet 0/1
Index(dec):1 (hex):1
GigabitEthernet 0/1 is administratively down, line protocol is DOWN
Hardware is GigabitEthernet
Interface address is: no ip address, address is 00d0.f865.de9b (bia 00d0.f865.de9b)
MTU 1500 bytes, BW 1000000 Kbit
Encapsulation protocol is Bridge, loopback not set
    Carrier delay is 2 sec
Rxload is 1/255, Txload is 1/255
Queue    Transmitted packets    Transmitted bytes    Dropped packets
Dropped bytes
    0                0                0                0
0
    1                0                0                0
0
    2                0                0                0
0
    3                0                0                0
0
    4                0                0                0
0
    5                0                0                0
0
    6                0                0                0
0
    7                4                440              0
0
Switchport attributes:
    interface's description:""
    lastchange time:0 Day:20 Hour:15 Minute:22 Second
    Priority is 0
    admin duplex mode is AUTO, oper duplex is Unknown
    admin speed is AUTO, oper speed is Unknown
    flow control admin status is OFF, flow control oper status is Unknown
    admin negotiation mode is OFF, oper negotiation state is ON
    Storm Control: Broadcast is OFF, Multicast is OFF, Unicast is OFF
Port-type: access
    Vlan id: 1
10 seconds input rate 0 bits/sec, 0 packets/sec
10 seconds output rate 0 bits/sec, 0 packets/sec
    4 packets input, 408 bytes, 0 no buffer, 0 dropped
    Received 0 broadcasts, 0 runts, 0 giants
    0 input errors, 0 CRC, 0 frame, 0 overrun, 0 abort
    4 packets output, 408 bytes, 0 underruns, 0 dropped
0 output errors, 0 collisions, 0 interface resets
B# show interfaces vlan 1
Index(dec):4097 (hex):1001
VLAN 1 is UP, line protocol is DOWN
    
```

```
Hardware is VLAN, address is 00d0.f822.33af (bia 00d0.f822.33af)
Interface address is: 192.168.1.2/24
ARP type: ARPA, ARP Timeout: 3600 seconds
MTU 1500 bytes, BW 1000000 Kbit
Encapsulation protocol is Ethernet-II, loopback not set
Carrier delay is 2 sec
Rxload is 0/255, Txload is 0/255
```

1.4.2. Configuring Interface Attributes

Configuration Effect

- Enable the device to connect and communicate with other devices through the switch port or routed port.
- Adjust various interface attributes on the device.

Configuration Steps

→ Configuring a Routed Port

- Optional.
- Run this command to configure a port as a L3 routed port.
- After a port is configured as a L3 routed port, L2 protocols running on the port do not take effect.
- This command is applicable to a L2 switch port.

Command	no switchport
Parameter Description	N/A
Defaults	By default, an Ethernet physical port is a L2 switch port.
Command Mode	Interface configuration mode
Usage Guide	On a L3 device, you can run this command to configure a L2 switch port as a L3 routed port. You can run the switchport command to change a L3 routed port into a L2 switch port.

→ Configuring a L3 AP Port

- Optional.
- Run the no switchport command in interface configuration mode to configure a L2 AP port as a L3 AP port. Run the switchport command to configure a L3 AP port as a L2 AP port.
- After a port is configured as a L3 routed port, L2 protocols running on the port do not take

effect.

- This command is applicable to a L2 AP port.

Command	no switchport
Parameter Description	N/A
Defaults	By default, an AP port is a L2 AP port.
Command Mode	Interface configuration mode
Usage Guide	After entering configuration mode of a L2 AP port on a L3 device, you can run this command to configure a L2 AP port as a L3 AP port. After entering configuration mode of a L3 AP port, you can run the switchport command to change a L3 AP port into a L2 AP port.

→ Configuring the Speed of an Interface

- Optional.
- Port flapping may occur if the configured speed of a port changes.
- This command is applicable to an Ethernet physical port or AP port.

Command	speed [1000 40G auto]
Parameter Description	1000: Indicates that the speed of the interface is 1000 Mbps. 40G: Indicates that the speed of the interface is 40 Gbps. auto: Indicates that the speed of the interface automatically adapts to the actual condition.
Defaults	By default, the speed of an interface is auto.
Command Mode	Interface configuration mode
Usage Guide	<p>If an interface is an AP member port, the speed of this interface is determined by the speed of the AP port. When the interface exits the AP port, it uses its own speed configuration. You can run show interfaces to display the speed configurations. The speed options available to an interface vary with the type of the interface. For example, you cannot set the speed of an SFP interface to 10 Mbps.</p> <div style="display: flex; align-items: center; margin-top: 10px;">  <div style="border-left: 1px solid black; padding-left: 10px;"> <p>The speed of a 40G physical port can only be set to 40 Gbps or auto.</p> </div> </div>

Command	port speed-mode [10G 25G]
Parameter Description	10G: Indicates that the speed of the interface is 10 Gbps. 25G: Indicates that the speed of the interface is 25 Gbps.
Defaults	The speed of the interface is 25G by default.
Command Mode	Interface configuration mode
Usage Guide	<p>Only 25 Gbps ports support this speed mode. A same speed mode must be configured on four consecutive 25 Gbps ports.</p> <p> Only 25 Gbps ports with the same speed mode are allowed to join the same aggregation group.</p> <p> Running the default interface command does not clear the speed mode configuration on 25 Gbps ports.</p>

→ Configuring the Duplex Mode of an Interface

- Optional.
- Port flapping may occur if the configured duplex mode of a port changes.
- This command is applicable to an Ethernet physical port or AP port.

Command	duplex { auto full half }
Parameter Description	auto: Indicates automatic switching between full duplex and half duplex. full: Indicates full duplex. half: Indicates half duplex.
Defaults	By default, the duplex mode of an interface is auto.
Command Mode	Interface configuration mode
Usage Guide	The duplex mode of an interface is related to the interface type. You can run show interfaces to display the configurations of the duplex mode.

→ Configuring the Flow Control Mode of an Interface

- Optional.
- Generally, the flow control mode of an interface is off by default. For some products, the flow control mode is on by default.
- After flow control is enabled on an interface, the flow control frames will be sent or received

to adjust the data volume when congestion occurs on the interface.

- Port flapping may occur if the configured flow control mode of a port changes.
- This command is applicable to an Ethernet physical port or AP port.

Command	Command flowcontrol { auto off on }
Parameter Description	auto: Indicates automatic flow control. off: Indicates that flow control is disabled. on: Indicates that flow control is enabled.
Defaults	By default, flow control is disabled on an interface.
Command Mode	Interface configuration mode
Usage Guide	Run the show interfaces command to check whether the configuration takes effect.

→ Configuring the Auto Negotiation Mode of an Interface

- Optional.
- Port flapping may occur if the configured auto negotiation mode of a port changes.
- This command is applicable to an Ethernet physical port or AP port.

Command	negotiation mode { on off }
Parameter Description	on: Indicates that the auto negotiation mode is on. off: Indicates that the auto negotiation mode is off.
Defaults	By default, the auto negotiation mode is off.
Command Mode	Interface configuration mode
Usage Guide	N/A

→ Configuring the MTU of an Interface

- Optional.
- You can configure the MTU of a port to limit the length of a frame that can be received or sent over this port.
- This command is applicable to an Ethernet physical port or SVI.

Command	mtu num
---------	---------

Parameter Description	num: 64–9216
Defaults	By default, the MTU of an interface is 1500 bytes.
Command Mode	Interface configuration mode
Usage Guide	This command is used to configure the interface MTU, that is, the maximum length of a data frame at the link layer. Currently, you can configure MTU for only a physical port or an AP port that contains one or more member ports.

→ Configuring the Bandwidth of an Interface

- Optional.
- Generally, the bandwidth of an interface is the same as the speed of the interface.

Command	bandwidth kilobits
Parameter Description	kilobits: The value ranges from 1 to 2,147,483,647. The unit is kilo bits.
Defaults	Generally, the bandwidth of an interface matches the type of the interface. For example, the default bandwidth of a gigabit Ethernet physical port is 1,000,000, and that of a 10G Ethernet physical port is 10,000,000.
Command Mode	Interface configuration mode
Usage Guide	N/A

→ Configuring the Carrier Delay of an Interface

- Optional.
- If the configured carrier delay is long, it takes a long time to change the protocol status when the physical status of an interface changes. If the carrier delay is set to 0, the protocol status changes immediately after the physical status of an interface changes.

Command	carrier-delay {[milliseconds] num up [milliseconds] num down [milliseconds] num}
---------	--

Parameter Description	num: The value ranges from 0 to 60. The unit is second. milliseconds: Indicates the carrier delay. The value ranges from 0 to 60,000. The unit is millisecond. up: Indicates the delay after which the state of the DCD changes from Down to Up. down: Indicates the delay after which the state of the DCD changes from Up to Down.
Defaults	By default, the carrier delay of an interface is 2s.
Command Mode	Interface configuration mode
Usage Guide	If millisecond is used as the unit, the configured carrier delay must be an integer multiple of 100 milliseconds.

→ Configuring the Load Interval of an Interface

- Optional.
- The configured load interval affects computation of the average packet rate on an interface. If the configured load interval is short, the average packet rate can accurately reflect the changes of the real-time traffic.

Command	load-interval seconds
Parameter Description	seconds: The value ranges from 5 to 600. The unit is second.
Defaults	By default, the load interval of an interface is 10s.
Command Mode	Interface configuration mode
Usage Guide	N/A

→ Configuring a Protected Port

- Optional.
- L2 packets cannot be forwarded between protected ports.
- This command is applicable to an Ethernet physical port or AP port.

Command	switchport protected
Parameter Description	N/A
Defaults	By default, no protected port is configured.

Command Mode	Interface configuration mode
Usage Guide	N/A

→ Blocking L3 Routing Between Protected Ports

- Optional.
- After this command is configured, L3 routing between protected ports are blocked.

Command	protected-ports route-deny
Parameter Description	N/A
Defaults	By default, the function of blocking L3 routing between protected ports is disabled.
Command Mode	Global configuration mode
Usage Guide	By default, L3 routing between protected ports is not blocked. In this case, you can run this command to block routing between protected ports.

→ Configuring Port Errdisable Recovery

- Optional.
- By default, a port will be disabled and will not be recovered after a violation occurs. After port errdisable recovery is configured, a port in errdisable state will be recovered and enabled.

Command	errdisable recovery [interval time]
Parameter Description	time: Indicates the automatic recovery time. The value ranges from 30 to 86,400. The unit is second.
Defaults	By default, port errdisable recovery is disabled.
Command Mode	Global configuration mode
Usage Guide	By default, a port in errdisable state is not recovered. You can recover the port manually or run this command to automatically recover the port.

→ Optical Module Antifake Detection

- (Optional) Run this command to enable optical module antifake detection.
- Optical module antifake detection is disabled by default, and the system does not display any alarm if a non-Ruijie optical module is inserted. After this function is enabled, the system will display alarms for several times if a non-Ruijie optical module is inserted.

Command	fiber antifake { ignore enable }
Parameter Description	ignore: Disables the optical module antifake detection function in global configuration mode. enable: Enables the optical module antifake detection function in global configuration mode.
Defaults	By default, optical module antifake detection is disabled.
Command Mode	Global configuration mode
Usage Guide	You can run the fiber antifake enable command to enable optical module antifake detection.

→ Configuring Interface FEC Mode

- Optional.
- By default, FEC mode is related with the port type and depends on the product model.

Command	fec mode {rs base-r none auto}
Parameter Description	rs: Enables FEC mode by rs. base-r: Enables FEC mode by base-r. none: Disables FEC function. auto: Whether the FEC mode is enabled or disabled is determined by the inserted optical module.
Command Mode	Interface configuration mode
Usage Guide	When one end runs FEC function, the other end should enable it, too. On the premise of not affecting the negotiation status of the two ends, we suggest you NOT to: * enable FEC function on the QSFP28-100G-LR4 optical module, on which FEC function is disabled by default. * disable FEC function on QSFP28 modules (except QSFP28-100G-LR4), on which FEC function is enabled by default.

Verification

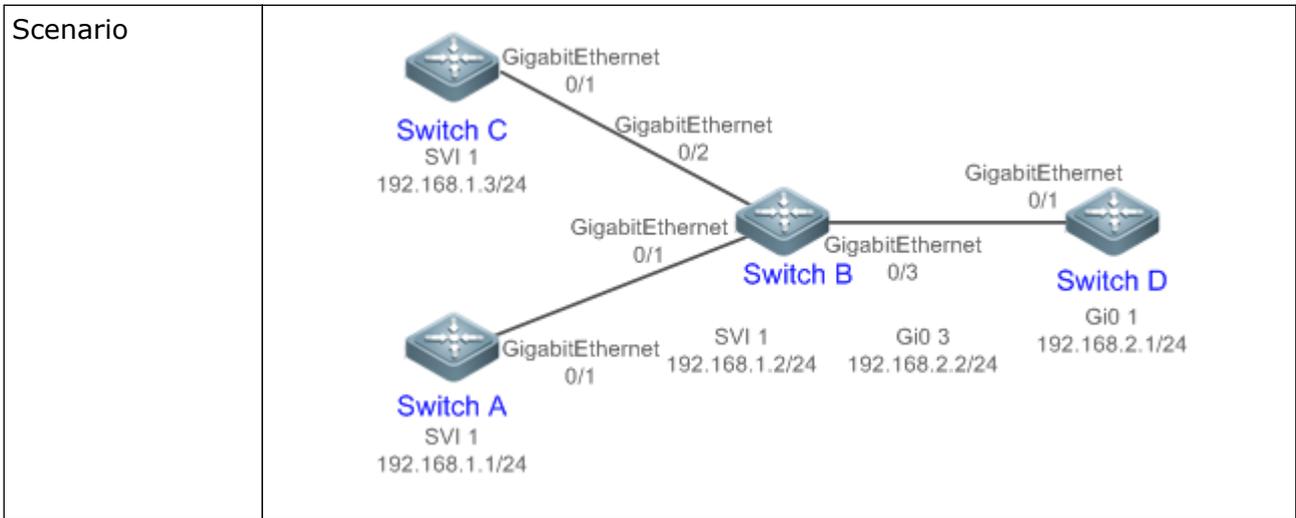
- Run the show interfaces command to display the attribute configurations of interfaces.

Command	show interfaces [interface-type interface-number] [description switchport trunk]
Parameter Description	<p>interface-type interface-number: Indicates the type and number of the interface.</p> <p>description: Indicates the interface description, including the link status.</p> <p>switchport: Indicates the L2 interface information. This parameter is effective only for a L2 interface.</p> <p>trunk: Indicates the Trunk port information. This parameter is effective for a physical port or an AP port.</p>
Command Mode	Privileged EXEC mode
Usage Guide	Use this command without any parameter to display the basic interface information.
	<pre> SwitchA#show interfaces GigabitEthernet 0/1 Index(dec):1 (hex):1 GigabitEthernet 0/1 is DOWN, line protocol is DOWN Hardware is Broadcom 5464 GigabitEthernet, address is 00d0.f865.de9b (bia 00d0.f865.de9b) Interface address is: no ip address Interface IPv6 address is: No IPv6 address MTU 1500 bytes, BW 1000000 Kbit Encapsulation protocol is Ethernet-II, loopback not set Carrier delay is 2 sec Ethernet attributes: Last link state change time: 2012-12-22 14:00:48 Time duration since last link state change: 3 days, 2 hours, 50 minutes, 50 seconds Priority is 0 Admin duplex mode is AUTO, oper duplex is Unknown Admin speed is AUTO, oper speed is Unknown Flow receive control admin status is OFF,flow send control admin status is OFF Flow receive control oper status is Unknown,flow send control oper status is Unknown Storm Control: Broadcast is OFF, Multicast is OFF, Unicast is OFF </pre>

	<pre> Bridge attributes: Port-type: trunk Native vlan:1 Allowed vlan lists:1-4094 //Allowed VLAN list of the Trunk port Active vlan lists:1, 3-4 //Active VLAN list (indicating that only VLAN 1, VLAN 3, and VLAN 4 are created on the device) Rxload is 1/255,Txload is 1/255 5 minutes input rate 0 bits/sec, 0 packets/sec 5 minutes output rate 0 bits/sec, 0 packets/sec 0 packets input, 0 bytes, 0 no buffer, 0 dropped Received 0 broadcasts, 0 runts, 0 giants 0 input errors, 0 CRC, 0 frame, 0 overrun, 0 abort 0 packets output, 0 bytes, 0 underruns, 0 dropped 0 output errors, 0 collisions, 0 interface resets </pre>
--	--

Configuration Example

→ Configuring Interface Attributes



Configuration Steps	<ul style="list-style-type: none"> • On Switch A, configure GigabitEthernet 0/1 as an access mode, and the default VLAN ID is 1. Configure SVI 1, assign an IP address to SVI 1, and set up a route to Switch D. • On Switch B, configure GigabitEthernet 0/1 and GigabitEthernet 0/2 as Trunk ports, and the default VLAN ID is 1. Configure SVI 1, and assign an IP address to SVI 1. Configure GigabitEthernet 0/3 as a routed port, and assign an IP address from another network segment to this port. • On Switch C, configure GigabitEthernet 0/1 as an Access port, and the default VLAN ID is 1. Configure SVI 1, and assign an IP address to SVI 1. • On Switch D, configure GigabitEthernet 0/1 as a routed port, assign an IP address to this port, and set up a route to Switch A.
A	<pre> A# configure terminal A(config)# interface GigabitEthernet 0/1 A(config-if-GigabitEthernet 0/1)# switchport mode access A(config-if-GigabitEthernet 0/1)# switchport access vlan 1 A(config-if-GigabitEthernet 0/1)# exit A(config)# interface vlan 1 A(config-if-VLAN 1)# ip address 192.168.1.1 255.255.255.0 A(config-if-VLAN 1)# exit A(config)# ip route 192.168.2.0 255.255.255.0 VLAN 1 192.168.1.2 </pre>
B	<pre> B# configure terminal B(config)# interface GigabitEthernet 0/1 B(config-if-GigabitEthernet 0/1)# switchport mode trunk B(config-if-GigabitEthernet 0/1)# exit B(config)# interface GigabitEthernet 0/2 B(config-if-GigabitEthernet 0/2)# switchport mode trunk B(config-if-GigabitEthernet 0/2)# exit B(config)# interface vlan 1 B(config-if-VLAN 1)# ip address 192.168.1.2 255.255.255.0 B(config-if-VLAN 1)# exit B(config)# interface GigabitEthernet 0/3 B(config-if-GigabitEthernet 0/3)# no switchport B(config-if-GigabitEthernet 0/3)# ip address 192.168.2.2 255.255.255.0 B(config-if-GigabitEthernet 0/3)# exit </pre>

<p>C</p>	<pre> C# configure terminal C(config)# interface GigabitEthernet 0/1 C(config-if-GigabitEthernet 0/1)# port-group 1 C(config-if-GigabitEthernet 0/1)# exit C(config)# interface aggregateport 1 C(config-if-AggregatePort 1)# switchport mode access C(config-if-AggregatePort 1)# switchport access vlan 1 C(config-if-AggregatePort 1)# exit C(config)# interface vlan 1 C(config-if-VLAN 1)# ip address 192.168.1.3 255.255.255.0 C(config-if-VLAN 1)# exit </pre>
<p>D</p>	<pre> D# configure terminal D(config)# interface GigabitEthernet 0/1 D(config-if-GigabitEthernet 0/1)# no switchport D(config-if-GigabitEthernet 0/1)# ip address 192.168.2.1 255.255.255.0 D(config-if-GigabitEthernet 0/1)# exit A(config)# ip route 192.168.1.0 255.255.255.0 GigabitEthernet 0/1 192.168.2.2 </pre>
<p>Verification</p>	<p>Perform verification on Switch A, Switch B, Switch C, and Switch D as follows:</p> <ul style="list-style-type: none"> • On Switch A, ping the IP addresses of interfaces of the other three switches. Verify that you can access the other three switches on Switch A.. • Verify that switch B and Switch D can be pinged mutually. • Verify that the interface status is correct.

A

```
A# show interfaces gigabitEthernet 0/1
Index(dec):1 (hex):1
GigabitEthernet 0/1 is UP, line protocol is UP
Hardware is GigabitEthernet, address is 00d0.f865.de90 (bia
00d0.f865.de90)
Interface address is: no ip address
MTU 1500 bytes, BW 100000 Kbit
Encapsulation protocol is Ethernet-II, loopback not set
Carrier delay is 2 sec
Ethernet attributes:
  Last link state change time: 2012-12-22 14:00:48
  Time duration since last link state change: 3 days, 2 hours,
50 minutes, 50 seconds
  Priority is 0
  Admin duplex mode is AUTO, oper duplex is Full
  Admin speed is AUTO, oper speed is 100M
  Flow control admin status is OFF, flow control oper status is
OFF
  Admin negotiation mode is OFF, oper negotiation state is ON
  Storm Control: Broadcast is OFF, Multicast is OFF, Unicast is
OFF
Bridge attributes:
Port-type: access
  Vlan id: 1
Rxload is 1/255, Txload is 1/255
10 seconds input rate 0 bits/sec, 0 packets/sec
10 seconds output rate 67 bits/sec, 0 packets/sec
  362 packets input, 87760 bytes, 0 no buffer, 0 dropped
  Received 0 broadcasts, 0 runts, 0 giants
  0 input errors, 0 CRC, 0 frame, 0 overrun, 0 abort
  363 packets output, 82260 bytes, 0 underruns, 0 dropped
  0 output errors, 0 collisions, 0 interface resets
```

B

```
B# show interfaces gigabitEthernet 0/1
Index(dec):1 (hex):1
GigabitEthernet 0/1 is UP, line protocol is UP
Hardware is GigabitEthernet, address is 00d0.f865.de91 (bia
00d0.f865.de91)
Interface address is: no ip address
MTU 1500 bytes, BW 100000 Kbit
Encapsulation protocol is Ethernet-II, loopback not set
Carrier delay is 2 sec
Ethernet attributes:
  Last link state change time: 2012-12-22 14:00:48
  Time duration since last link state change: 3 days, 2 hours,
50 minutes, 50 seconds
  Priority is 0
Admin duplex mode is AUTO, oper duplex is Full
Admin speed is AUTO, oper speed is 100M
Flow control admin status is OFF, flow control oper status is
OFF
Admin negotiation mode is OFF, oper negotiation state is ON
Storm Control: Broadcast is OFF, Multicast is OFF, Unicast is
OFF
Bridge attributes:
  Port-type: trunk
  Native vlan: 1
  Allowed vlan lists: 1-4094
  Active vlan lists: 1
Rxload is 1/255, Txload is 1/255
10 seconds input rate 0 bits/sec, 0 packets/sec
10 seconds output rate 67 bits/sec, 0 packets/sec
  362 packets input, 87760 bytes, 0 no buffer, 0 dropped
  Received 0 broadcasts, 0 runts, 0 giants
  0 input errors, 0 CRC, 0 frame, 0 overrun, 0 abort
  363 packets output, 82260 bytes, 0 underruns, 0 dropped
  0 output errors, 0 collisions, 0 interface resets
```

C

```
C# show interfaces gigabitEthernet 0/1
Index(dec):1 (hex):1
GigabitEthernet 0/1 is UP, line protocol is UP
Hardware is GigabitEthernet, address is 00d0.f865.de92 (bia
00d0.f865.de92)
Interface address is: no ip address
MTU 1500 bytes, BW 100000 Kbit
Encapsulation protocol is Ethernet-II, loopback not set
Carrier delay is 2 sec
Ethernet attributes:
  Last link state change time: 2012-12-22 14:00:48
  Time duration since last link state change: 3 days, 2 hours,
50 minutes, 50 seconds
  Priority is 0
Admin duplex mode is AUTO, oper duplex is Full
Admin speed is AUTO, oper speed is 100M
Flow control admin status is OFF, flow control oper status is
OFF
Admin negotiation mode is OFF, oper negotiation state is ON
Storm Control: Broadcast is OFF, Multicast is OFF, Unicast is
OFF
Rxload is 1/255, Txload is 1/255
10 seconds input rate 0 bits/sec, 0 packets/sec
10 seconds output rate 67 bits/sec, 0 packets/sec
  362 packets input, 87760 bytes, 0 no buffer, 0 dropped
  Received 0 broadcasts, 0 runts, 0 giants
  0 input errors, 0 CRC, 0 frame, 0 overrun, 0 abort
  363 packets output, 82260 bytes, 0 underruns, 0 dropped
  0 output errors, 0 collisions, 0 interface resets
```

D	<pre> D# show interfaces gigabitEthernet 0/1 Index(dec):1 (hex):1 GigabitEthernet 0/1 is UP, line protocol is UP Hardware is GigabitEthernet, address is 00d0.f865.de93 (bia 00d0.f865.de93) Interface address is: 192.168.2.1/24 MTU 1500 bytes, BW 100000 Kbit Encapsulation protocol is Ethernet-II, loopback not set Carrier delay is 2 sec Ethernet attributes: Last link state change time: 2012-12-22 14:00:48 Time duration since last link state change: 3 days, 2 hours, 50 minutes, 50 seconds Priority is 0 Admin duplex mode is AUTO, oper duplex is Full Admin speed is AUTO, oper speed is 100M Flow control admin status is OFF, flow control oper status is OFF Admin negotiation mode is OFF, oper negotiation state is ON Storm Control: Broadcast is OFF, Multicast is OFF, Unicast is OFF Rxload is 1/255, Txload is 1/255 10 seconds input rate 0 bits/sec, 0 packets/sec 10 seconds output rate 67 bits/sec, 0 packets/sec 362 packets input, 87760 bytes, 0 no buffer, 0 dropped Received 0 broadcasts, 0 runts, 0 giants 0 input errors, 0 CRC, 0 frame, 0 overrun, 0 abort 363 packets output, 82260 bytes, 0 underruns, 0 dropped 0 output errors, 0 collisions, 0 interface resets </pre>
---	---

1.5. Monitoring

Clearing



Running the clear commands may lose vital information and thus interrupt services.

Description	Command
Clears the counters of a specified interface.	clear counters [interface-type interface-number]

Resets the interface hardware.	clear interface interface-type interface-number
--------------------------------	---

Displaying

→ Displaying Interface Configurations and Status

Description	Command
Displays all the status and configuration information of a specified interface.	show interfaces [interface-type interface-number]
Displays the interface status.	show interfaces [interface-type interface-number] status
Displays the interface errdisable status.	show interfaces [interface-type interface-number] status err-disable
Displays the link status change time and count of a specified port.	show interfaces [interface-type interface-number] link-state-change statistics
Displays the administrative and operational states of switch ports (non-routed ports).	show interfaces [interface-type interface-number] switchport
Displays the description and status of a specified interface.	show interfaces [interface-type interface-number] description [up down]
Displays the counters of a specified port, among which the displayed speed may have an error of $\pm 0.5\%$.	show interfaces [interface-type interface-number] counters [up down]
Displays the number of packets increased in a load interval.	show interfaces [interface-type interface-number] counters increment [up down]
Displays statistics about error packets.	show interfaces [interface-type interface-number] counters errors [up down]
Displays the packet sending/receiving rate of an interface.	show interfaces [interface-type interface-number] counters rate [up down]
Displays a summary of interface information.	show interfaces [interface-type interface-number] counters summary [up down]
Displays the discarded packet statistics over an interface.	show interfaces [interface-type interface-number] counters drops [up down]

Displays the bandwidth usage of an interface.	show interfaces [interface-type interface-number] usage [up down]
---	---

→ Displaying Optical Module Information

Description	Command
Displays basic information about the optical module of a specified interface.	show interfaces [interface-type interface-number] transceiver
Displays the fault alarms of the optical module on a specified interface. If no fault occurs, "None" is displayed.	show interfaces [interface-type interface-number] transceiver alarm
Displays the optical module diagnosis values of a specified interface.	show interfaces [interface-type interface-number] transceiver diagnosis
Displays the 40G interface splitting and combining information.	show split summary

2. Configuring MAC Address

2.1. Overview

A MAC address table contains the MAC addresses, interface numbers and VLAN IDs of the devices connected to the local device.

When a device forwards a packet, it finds an output port from its MAC address table according to the destination MAC address and the VLAN ID of the packet.

After that, the packet is unicast, multicast or broadcast.



This document covers dynamic MAC addresses, static MAC addresses and filtered MAC addresses. For the management of multicast MAC addresses, please see Configuring IGMP Snooping Configuration.

Protocols and Standards

- IEEE 802.3: Carrier sense multiple access with collision detection (CSMA/CD) access method and physical layer specifications
- IEEE 802.1Q: Virtual Bridged Local Area Networks

2.2. Applications

Application	Description
MAC Address Learning	Forward unicast packets through MAC addresses learning.
MAC Address Change Notification	Monitor change of the devices connected to a network device through MAC address change notification.

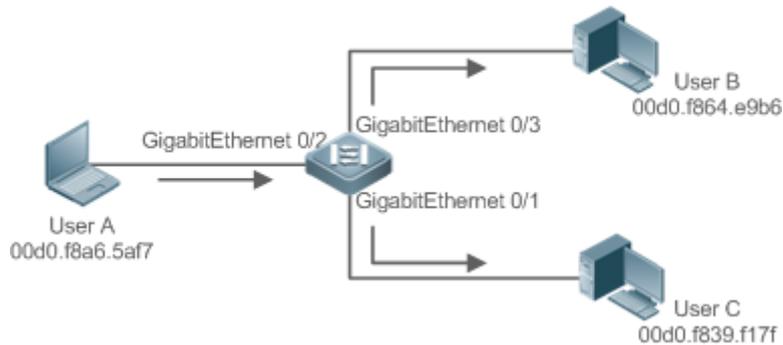
2.2.1. MAC Address Learning

Scenario

Usually a device maintains a MAC address table by learning MAC addresses dynamically. The operating principle is described as follows:

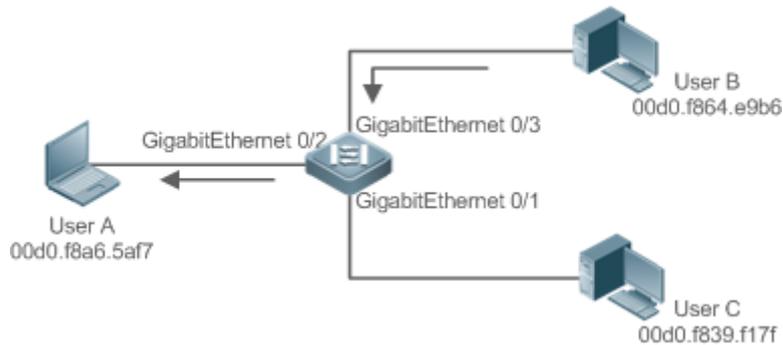
As shown in the following figure, the MAC address table of the switch is empty. When User A communicates with User B, it sends a packet to the port GigabitEthernet 0/2 of the switch, and the switch learns the MAC address of User A and stores it in the table.

As the table does not contain the MAC address of User B, the switch broadcasts the packet to the ports of all connected devices except User A, including User B and User C.



Status	VLAN	MAC address	Interface
Dynamic	1	00d0.f8a6.5af7	GigabitEthernet 0/2

When User B receives the packet, it sends a reply packet to User A through port GigabitEthernet 0/3 on the switch. As the MAC address of User A is already in the MAC address table, the switch send the reply unicast packet to port GigabitEthernet 0/2 port and learns the MAC address of User B. User C does not receive the reply packet from User B to User A.



Status	VLAN	MAC address	Interface
Dynamic	1	00d0.f8a6.5af7	GigabitEthernet 0/2
Dynamic	1	00d0.f8a4.e9b6	GigabitEthernet 0/3

Through the interaction between User A and User B, the switch learns the MAC addresses of User A and User B. After that, packets between User A and User B will be exchanged via unicast without being received by User C.

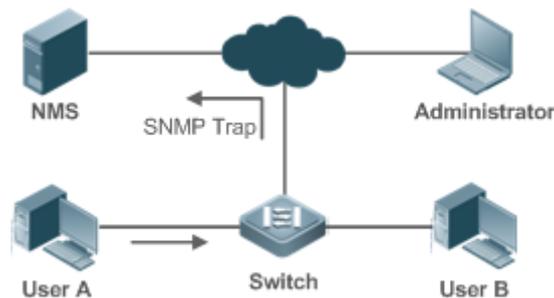
Deployment

- With MAC address learning, a layer-2 switch forwards packets through unicast, reducing broadcast packets and network load.

2.2.2. MAC Address Change Notification

MAC address change notification provides a mechanism for the network management system (NMS) to monitor the change of devices connected to a network device.

Scenario



After MAC address change notification is enabled on a device, the device generates a notification message when the device learns a new MAC address or finishes aging a learned MAC address, and sends the message in an SNMP Trap message to a specified NMS.

A notification of adding a MAC address indicates that a new user accesses the network, and that of deleting a MAC address indicates that a user sends no packets within an aging time and usually the user exits the network.

When a network device is connected to a number of devices, a lot of MAC address changes may occur in a short time, resulting in an increase in traffic. To reduce traffic, you may configure an interval for sending MAC address change notifications. When the interval expires, all notifications generated during the interval are encapsulated into a message.

±When a notification is generated, it is stored in the table of historical MAC address change notifications. The administrator may know recent MAC address changes by checking the table of notification history even without NMS.



A MAC address change notification is generated only for a dynamic MAC address.

Deployment

- Enable MAC address change notification on a layer-2 switch to monitor the change of devices connected to a network device.

2.3. Features

Basic Concepts

→ Dynamic MAC Address

A dynamic MAC address is a MAC address entry generated through the process of MAC address learning by a device.

→ Address Aging

A device only learns a limited number of MAC addresses, and inactive entries are deleted through address aging.

A device starts aging a MAC address when it learns it. If the device receives no packet containing the source MAC address, it will delete the MAC address from the MAC address table when the time expires.

→ Forwarding via Unicast

If a device finds in its MAC address table an entry containing the MAC address and the VLAN ID of a packet and the output port is unique, it will send the packet through the port directly.

→ Forwarding via Broadcast

If a device receives a packet containing the destination address ffff.ffff.ffff or an unidentified destination address, it will send the packet through all the ports in the VLAN where the packet is from, except the input port.

Overview

Feature	Description
Dynamic Address Limit for VLAN	Limit the number of dynamic MAC addresses in a VLAN.
Dynamic Address Limit for Interface	Limit the number of dynamic MAC addresses on an interface.

2.3.1. Dynamic Address Limit for VLAN

Working Principle

The MAC address table with a limited capacity is shared by all VLANs. Configure the maximum number of dynamic MAC addresses for each VLAN to prevent one single VLAN from exhausting the MAC address table space.

A VLAN can only learn a limited number of dynamic MAC addresses after the limit is configured. The packets exceeding the limit are forwarded. User can configure the maximum MAC addresses learned by a VLAN. After the maximum number exceeds the limit, the VLAN will stop learning MAC address, and packets will be discarded.



If the number of learned MAC addresses is greater than the limit, a device will stop learning the MAC addresses from the VLAN and will not start learning again until the number drops below the limit after address aging.



The MAC addresses copied to a specific VLAN are not subject to the limit.

2.3.2. Dynamic Address Limit for Interface

Working Principle

An interface can only learn a limited number of dynamic MAC addresses after the limit is configured. The packets exceeding the limit are forwarded.

User can configure the maximum MAC addresses learned by a VLAN. After the maximum number exceeds the limit, the VLAN will stop learning MAC address, and packets will be discarded.



If the number of learned MAC addresses is greater than the limit, a device will stop learning the MAC addresses from the interface and will not start learning again until the number drops below the limit after address aging.

2.4. Configuration

Configuration	Description and Command	
Configuring Dynamic MAC Address	(Optional) It is used to enable MAC address learning.	
	mac-address-learning	Configures MAC address learning globally or on an interface.
	mac-address-table aging-time	Configures an aging time for a dynamic MAC address.
Configuring a Static MAC Address	(Optional) It is used to bind the MAC address of a device with a port of a switch.	
	mac-address-table static	Configures a static MAC address.
Configuring a MAC Address for Packet Filtering	(Optional) It is used to filter packets.	
	mac-address-table filtering	Configures a MAC address for packet filtering.
Configuring MAC Address Change Notification	(Optional) It is used to monitor change of devices connected to a network device.	
	mac-address-table notification	Configures MAC address change notification globally.
	snmp trap mac-notification	Configures MAC address change notification on an interface.

Configuring Maximum Number of MAC Addresses Learned by a VLAN	(Optional) It is used to configure the maximum number of MAC addresses learned by a VLAN/port.	
	max-dynamic-mac-count count	Configures the maximum number of MAC addresses learned by a VLAN/port.
	max-dynamic-mac-count exceed-action forward discard	Indicates that packets are forwarded or discarded when the number of learned MAC addresses exceeds the limit.

2.4.1. Configuring Dynamic MAC Address

Configuration Effect

Learn MAC addresses dynamically and forward packets via unicast.

Configuration Steps

- Configuring Global MAC Address Learning
- Optional.
- You can perform this configuration to disable global MAC address learning.
- Configuration:

Command	mac-address-learning { enable disable }
Parameter Description	enable: Enables global MAC address learning. disable: Disable global MAC address learning.
Defaults	Global MAC address learning is enabled by default.
Command Mode	Global configuration mode
Usage Guide	N/A



By default, global MAC address learning is enabled. When global MAC address learning is enabled, the MAC address learning configuration on an interface takes effect; when the function is disabled, MAC addresses cannot be learned globally.

→ Configuring MAC Address Learning on Interface

- Optional.
- You can perform this configuration to disable MAC address learning on an interface.

- Configuration:

Command	mac-address-learning
Parameter Description	N/A
Defaults	MAC address learning is enabled by default.
Command Mode	Interface configuration mode
Usage Guide	Perform this configuration on a layer-2 interface, for example, a switch port or an AP port.



By default, MAC address learning is enabled. If DOT1X, IP SOURCE GUARD, or a port security function is configured on a port, MAC address learning cannot be enabled. Access control cannot be enabled on a port with MAC address learning disabled.

- Configuring an Aging Time for a Dynamic MAC Address
- Optional.
- Configure an aging time for dynamic MAC addresses.
- Configuration:

Command	mac-address-table aging-time value
Parameter Description	value: Indicates the aging time. The value is either 0 or in the range from 10 to 1000,000.
Defaults	The default is 300s.
Command Mode	Global configuration mode
Usage Guide	If the value is set to 0, MAC address aging is disabled and learned MAC addresses will not be aged.



The actual aging time may be different from the configured value, but it is not more than two times of the configured value.

Verification

- Check whether a device learns dynamic MAC addresses.
- Run the show mac-address-table dynamic command to display dynamic MAC addresses.

- Run the show mac-address-table aging-time command to display the aging time for dynamic MAC addresses.

Command	show mac-address-table dynamic [address mac-address] [interface interface-id] [vlan vlan-id]									
Parameter Description	address mac-address: Displays the information of a specific dynamic MAC address. interface interface-id: Specifies a physical interface or an AP port. vlan vlan-id: Displays the dynamic MAC addresses in a specific VLAN.									
Command Mode	Privileged EXEC mode/Global configuration mode/Interface configuration mode									
Usage Guide	N/A									
	<pre>Switch# show mac-address-table dynamic Vlan MAC Address Type Interface ----- - 1 0000.0000.0001 DYNAMIC GigabitEthernet 1/1 1 0001.960c.a740 DYNAMIC GigabitEthernet 1/1 1 0007.95c7.dff9 DYNAMIC GigabitEthernet 1/1 1 0007.95cf.eee0 DYNAMIC GigabitEthernet 1/1 1 0007.95cf.f41f DYNAMIC GigabitEthernet 1/1 1 0009.b715.d400 DYNAMIC GigabitEthernet 1/1 1 0050.bade.63c4 DYNAMIC GigabitEthernet 1/1</pre> <table border="1"> <thead> <tr> <th>Field</th> <th>Description</th> </tr> </thead> <tbody> <tr> <td>Vlan</td> <td>Indicates the VLAN where the MAC address resides. MAC Address Indicates a MAC Address.</td> </tr> <tr> <td>Type</td> <td>Indicates a MAC address type.</td> </tr> <tr> <td>Interface</td> <td>Indicates the interface where the MAC address resides.</td> </tr> </tbody> </table>		Field	Description	Vlan	Indicates the VLAN where the MAC address resides. MAC Address Indicates a MAC Address.	Type	Indicates a MAC address type.	Interface	Indicates the interface where the MAC address resides.
Field	Description									
Vlan	Indicates the VLAN where the MAC address resides. MAC Address Indicates a MAC Address.									
Type	Indicates a MAC address type.									
Interface	Indicates the interface where the MAC address resides.									

Command	show mac-address-table aging-time
Parameter Description	N/A

Command Mode	Privileged EXEC mode/Global configuration mode/Interface configuration mode
Usage Guide	N/A
	<pre>Switch# show mac-address-table aging-time Aging time: 300</pre>

Configuration Example

→ Configuring Dynamic MAC Address

Scenario	
Configuration Steps	<ul style="list-style-type: none"> • Enable MAC address learning on an interface. • Configure the aging time for dynamic MAC addresses to 180s. • Delete all dynamic MAC addresses in VLAN 1 on port GigabitEthernet 0/1.
	<pre>Switch# configure terminal Switch(config-if-GigabitEthernet 0/1)# mac-address-learning Switch(config-if-GigabitEthernet 0/1)# exit Switch(config)# mac aging-time 180 Switch# clear mac-address-table dynamic interface GigabitEthernet 0/1 vlan 1</pre>
Verification	<ul style="list-style-type: none"> • Check MAC address learning on an interface. • Display the aging time for dynamic MAC addresses. • Display all dynamic MAC addresses in VLAN 1 on port GigabitEthernet 0/1.

```
Switch# show mac-address-learning
GigabitEthernet 0/1      learning ability: enable
Switch# show mac aging-time
Aging time      : 180 seconds
Switch# show mac-address-table dynamic interface GigabitEthernet
0/1 vlan 1
Vlan            MAC Address                Type      Interface
-----
1               00d0.f800.1001          STATIC    GigabitEthernet 1/1
```

Common Errors

Configure MAC address learning on an interface before configuring the interface as a layer-2 interface, for example, a switch port or an AP port.

2.4.2. Configuring a Static MAC Address

Configuration Effect

- Bind the MAC address of a network device with a port of a switch.

Configuration Steps

→ Configuring a Static MAC address

- Optional.
- Bind the MAC address of a network device with a port of a switch.
- Configuration:

Command	mac-address-table static mac-address vlan vlan-id interface interface-id
Parameter Description	Parameter Description address mac-address: Specifies a MAC address. vlan vlan-id: Specifies a VLAN where the MAC address resides. interface interface-id: Specifies a physical interface or an AP port.
Defaults	By default, no static MAC address is configured.
Command Mode	Global configuration mode
Usage Guide	When the switch receives a packet containing the specified MAC address on the specified VLAN, the packet is forwarded to the bound interface.

Verification

- Run the show mac-address-table static command to check whether the configuration takes effect.

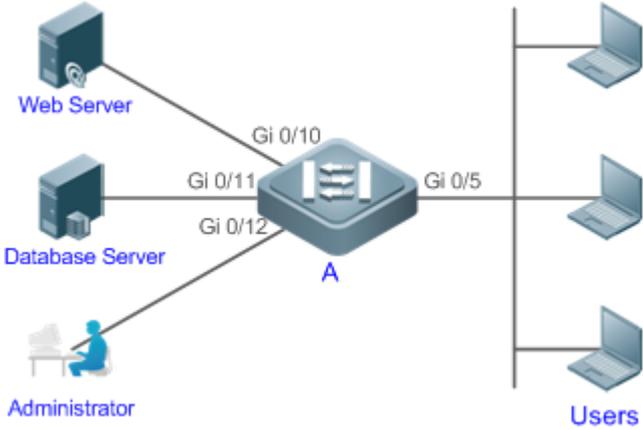
Command	show mac-address-table static [address mac-address] [interface interface-id] [vlan vlan-id]
Parameter Description	address mac-address: Specifies a MAC address. interface interface-id: Specifies a physical interface or an AP port. vlan vlan-id: Specifies a VLAN where the MAC address resides.
Command Mode	Privileged EXEC mode/Global configuration mode /Interface configuration mode
Usage Guide	N/A
	<pre>Switch# show mac-address-table static Vlan MAC Address Type Interface ----- - 1 00d0.f800.1001 STATIC GigabitEthernet 1/1 1 00d0.f800.1002 STATIC GigabitEthernet 1/1 1 00d0.f800.1003 STATIC GigabitEthernet 1/1</pre>

Configuration Example

→ Configuring a Static MAC address

In the above example, the relationship of MAC addresses, VLAN and interfaces is shown in the following table.

Role	MAC Address	VLAN ID	Interface ID
Web Server	00d0.3232.0001	VLAN2	Gi0/10
Database Server	00d0.3232.0002	VLAN2	Gi0/11
Administrator	00d0.3232.1000	VLAN2	Gi0/12

<p>Scenario</p>	
<p>Configuration Steps</p>	<ul style="list-style-type: none"> • Specify destination MAC addresses (mac-address). • Specify the VLAN (vlan-id) where the MAC addresses reside. • Specify interface IDs (interface-id).
<p>A</p>	<pre> A# configure terminal A(config)# mac-address-table static 00d0.f800.3232.0001 vlan 2 interface gigabitEthernet 0/10 A(config)# mac-address-table static 00d0.f800.3232.0002 vlan 2 interface gigabitEthernet 0/11 A(config)# mac-address-table static 00d0.f800.3232.1000 vlan 2 interface gigabitEthernet 0/12 </pre>
<p>Verification</p>	<p>Display the static MAC address configuration on a switch.</p>
<p>A</p>	<pre> A# show mac-address-table static Vlan MAC Address Type Interface ----- 2 00d0.f800.3232.0001 STATIC GigabitEthernet 0/10 2 00d0.f800.3232.0002 STATIC GigabitEthernet 0/11 2 00d0.f800.3232.1000 STATIC GigabitEthernet 0/12 </pre>

Common Errors

- Configure a static MAC address before configuring the specific port as a layer-2 interface, for example, a switch port or an AP port.

2.4.3. Configuring a MAC Address for Packet Filtering

Configuration Effect

- If a device receives packets containing a source MAC address or destination MAC address specified as the filtered MAC address, the packets are discarded.

Configuration Steps

→ Configuring a MAC Address for Packet Filtering

- Optional.
- Perform this configuration to filter packets.
- Configuration:

Command	mac-address-table filtering mac-address vlan vlan-id
Parameter Description	address mac-address: Specifies a MAC address. vlan vlan-id: Specifies a VLAN where the MAC address resides.
Defaults	By default, no filtered MAC address is configured.
Command Mode	Global configuration mode
Usage Guide	If a device receives packets containing a source MAC address or destination MAC address specified as the filtered MAC address, the packets are discarded.

Verification

→ Run the show mac-address-table filter command to display the filtered MAC address.

Command	show mac-address-table filter [address mac-address] [vlan vlan-id]
Parameter Description	address mac-address: Specifies a MAC address. vlan vlan-id: Specifies a VLAN where the MAC address resides.
Command Mode	Privileged EXEC mode/Global configuration mode /Interface configuration mode
Usage Guide	N/A

	<pre>Switch# show mac-address-table filtering Vlan MAC Address Type Interface ----- 1 0000.2222.2222 FILTER</pre>
--	--

Configuration Example

→ Configuring a MAC Address for Packet Filtering

Configuration Steps	<ul style="list-style-type: none"> • Specify a destination MAC address (mac-address) for filtering. • Specify a VLAN where the MAC addresses resides.
	<pre>Switch# configure terminal Switch(config)# mac-address-table static 00d0.f800.3232.0001 vlan 1</pre>
Verification	Display the filtered MAC address configuration.
	<pre>Switch# show mac-address-table filter Vlan MAC Address Type Interface ----- 1 00d0.f800.3232.0001 FILTER</pre>

2.4.4. Configuring MAC Address Change Notification

Configuration Effect

- Monitor change of devices connected to a network device.

Configuration Steps

→ Configuring NMS

- Optional.
- Perform this configuration to enable an NMS to receive MAC address change notifications.

- Configuration:

Command	snmp-server host host-addr traps [version { 1 2c 3 [auth noauth priv] }] community-string
Parameter Description	<p>host host-addr: Specifies the IP address of a receiver.</p> <ul style="list-style-type: none"> • version { 1 2c 3 [auth noauth priv] }: Specifies the version of SNMP TRAP messages. You can also specify authentication and a security level for packets of Version 3. <p>community-string: Indicates an authentication name.</p>
Defaults	By default, the function is disabled.
Command Mode	Global configuration mode
Usage Guide	N/A

→ Enabling SNMP Trap

- Optional.
- Perform this configuration to send SNMP Trap messages.
- Configuration:

Command	snmp-server enable traps
Parameter Description	N/A
Defaults	By default, the function is disabled.
Command Mode	Global configuration mode
Usage Guide	N/A

→ Configuring Global MAC Address Change Notification

- Optional.
- If MAC address change notification is disabled globally, it is disabled on all interfaces.

- Configuration:

Command	mac-address-table notification
Parameter Description	N/A
Defaults	By default, MAC address change notification is disabled globally.
Command Mode	Global configuration mode
Usage Guide	N/A

→ Configuring MAC Address Change Notification On Interface

- Optional.
- Perform this configuration to enable MAC address change notification on an interface.
- Configuration:

Command	snmp trap mac-notification { added removed }
Parameter Description	added: Generates a notification when an MAC address is added. removed: Generates a notification when an MAC address is deleted.
Defaults	By default, MAC address change notification is disabled on an interface.
Command Mode	Interface configuration mode
Usage Guide	N/A

→ Configuring Interval for Generating MAC Address Change Notifications and Volume of Notification History

- Optional.
- Perform this configuration to modify the interval for generating MAC address change notifications and the volume of notification history.

- Configuration:

Command	mac-address-table notification { interval value history-size value }
Parameter Description	interval value: (Optional) Indicates the interval for generating MAC address change notifications. The value ranges from 1 to 3600 seconds,. history-size value: Indicates the maximum number of entries in the table of notification history. The value ranges from 1 to 200.
Defaults	The default interval is 1 second. The default maximum amount of notifications is 50.
Command Mode	Global configuration mode
Usage Guide	N/A

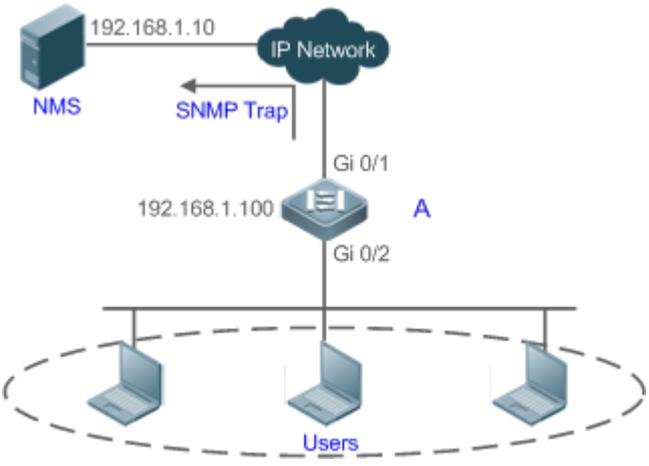
Verification

- Run the show mac-address-table notification command to check whether the NMS receives MAC address change notifications.

Command	show mac-address-table notification [interface [interface-id] history]
Parameter Description	Interface: Displays the configuration of MAC address change notification on all interfaces. interface-id: Displays the configuration of MAC address change notification on a specified interface. history: Displays the history of MAC address change notifications.
Command Mode	Privileged EXEC mode/Global configuration mode /Interface configuration mode
Usage Guide	N/A

Usage Guide	<p>Display the configuration of global MAC address change notification.</p> <div style="border: 1px solid #ccc; padding: 10px; margin: 10px 0;"> <pre>Switch#show mac-address-table notification MAC Notification Feature : Enabled Interval(Sec): 300 Maximum History Size : 50 Current History Size : 0</pre> </div> <table border="1" data-bbox="416 701 1436 1160"> <thead> <tr> <th data-bbox="416 701 924 779">Field</th> <th data-bbox="932 701 1436 779">Description</th> </tr> </thead> <tbody> <tr> <td data-bbox="416 779 924 898">Interval(Sec)</td> <td data-bbox="932 779 1436 898">Indicates the interval for generating MAC address change notifications.</td> </tr> <tr> <td data-bbox="416 898 924 1046">Maximum History Size</td> <td data-bbox="932 898 1436 1046">Indicates the maximum number of entries in the table of notification history.</td> </tr> <tr> <td data-bbox="416 1046 924 1160">Current History Size</td> <td data-bbox="932 1046 1436 1160">Indicates the current notification entry number.</td> </tr> </tbody> </table>		Field	Description	Interval(Sec)	Indicates the interval for generating MAC address change notifications.	Maximum History Size	Indicates the maximum number of entries in the table of notification history.	Current History Size	Indicates the current notification entry number.
Field	Description									
Interval(Sec)	Indicates the interval for generating MAC address change notifications.									
Maximum History Size	Indicates the maximum number of entries in the table of notification history.									
Current History Size	Indicates the current notification entry number.									

Configuration Example

<p>Scenario</p>	 <p>The figure shows an intranet of an enterprise. Users are connected to A via port Gi0/2.</p> <p>The Perform the configuration to achieve the following effects:</p> <ul style="list-style-type: none"> • When port Gi0/2 learns a new MAC address or finishes aging a learned MAC address, a MAC address change notification is generated. • Meanwhile, A sends the MAC address change notification in an SNMP Trap message to a specified NMS. • In a scenario where A is connected to a number of Users, the configuration can prevent MAC address change notification burst in a short time so as to reduce the network flow.
<p>Configuration Steps</p>	<ul style="list-style-type: none"> • Enable global MAC address change notification on A, and configure MAC address change notification on port Gi0/2. • Configure the IP address of the NMS host, and enable A with SNMP Trap. A communicates with the NMS via routing. • Configure the interval for sending MAC address change notifications to 300 seconds (1 second by default).

<p>A</p>	<pre>Switch# configure terminal Switch(config)# mac-address-table notification Switch(config)# interface gigabitEthernet 0/2 Switch(config-if-GigabitEthernet 0/2)# snmp trap mac-notification added Switch(config-if-GigabitEthernet 0/2)# snmp trap mac-notification removed Switch(config-if-GigabitEthernet 0/2)# exit Switch(config)# snmp-server host 192.168.1.10 traps version 2c comefrom2 Switch(config)# snmp-server enable traps Switch(config)# mac-address-table notification interval 300</pre>
<p>Verification</p>	<ul style="list-style-type: none"> • Check t whether MAC address change notification is enabled globally . • Check whether MAC address change notification is enabled on the interface. • Display the MAC addresses of interfaces, and run the clear mac-address-table dynamic command to simulate aging dynamic MAC addresses. • Check whether global MAC address change notification is enabled globally. • Display the history of MAC address change notifications.

```

A
Switch# show mac-address-table notification
MAC Notification Feature : Enabled
Interval(Sec): 300
Maximum History Size : 50
Current History Size : 0
Switch# show mac-address-table notification interface
GigabitEthernet 0/2
Interface                MAC Added Trap          MAC Removed Trap
-----                -
GigabitEthernet 0/2      Enabled                  Enabled
Switch# show mac-address-table interface GigabitEthernet 0/2
Vlan          MAC Address          Type          Interface
-----
1             00d0.3232.0001      DYNAMIC      GigabitEthernet 0/2
Switch# show mac-address-table notification
MAC Notification Feature : Enabled
Interval(Sec): 300
Maximum History Size : 50
Current History Size : 1
Switch# show mac-address-table notification history
History Index : 0
Entry Timestamp: 221683
MAC Changed Message :
Operation:DEL Vlan:1 MAC Addr: 00d0.3232.0003 GigabitEthernet 0/2
    
```

2.4.5. Configuring the Maximum Number of MAC Addresses Learned by a Port

Configuration Effect

→ Only a limited number of dynamic MAC addresses can be learned by a port.

Notes

None

Configuration Steps

→ Configuring the Maximum Number of MAC Addresses Learned by a Port

- Optional
- Perform this operation on the switch.

Command	max-dynamic-mac-count count
Parameter Description	count: Indicates the maximum number of MAC addresses learned by a port.
Defaults	By default, the number of MAC addresses learned by a port is not limited. After the number of MAC addresses learned by a port is limited and after the maximum number of MAC addresses exceeds the limit, packets from source MAC addresses are forwarded by default.
Command Mode	Interface configuration mode
Usage Guide	

2.4.6. Configuring the Maximum Number of MAC Addresses Learned by a VLAN

Configuration Effect

- Only a limited number of dynamic MAC addresses can be learned by a VLAN.

Notes

None

Configuration Steps

→ Configuring the Maximum Number of MAC Addresses Learned by a VLAN

- Optional
- Perform this operation on the switch.

Command	max-dynamic-mac-count exceed-action forward discard
Parameter Description	forward/discard: Indicates that packets are forwarded or discarded when the number of MAC addresses learned by a VLAN exceeds the limit.
Defaults	By default, the number of MAC addresses learned by a VLAN is not limited. After the number of MAC addresses learned by a VLAN is limited and after the maximum number of MAC addresses exceeds the limit, packets from source MAC addresses are forwarded by default.
Command Mode	VLAN configuration mode
Usage Guide	N/A

Verification

- Run show run to query the configuration result.

Configuration Example

→ Configuring the Maximum Number of MAC Addresses Learned by a Port

Configuration Steps	<ul style="list-style-type: none"> • Configure the maximum number of MAC addresses learned by a port.
	<ul style="list-style-type: none"> • Configure the maximum number of MAC addresses learned by a port and the countermeasure for the case that the number of MAC addresses exceeds the limit. <pre>Switch(config)# interface GigabitEthernet 1/1 Switch(config-if-GigabitEthernet 1/1)# max-dynamic-mac-count 100</pre>
Verification	Run show running on the switch to query the configuration.

Common Errors

None

2.5. Monitoring

Clearing



Running the clear commands may lose vital information and interrupt services.

Description	Command
Clears dynamic MAC addresses.	clear mac-address-table dynamic [address mac-address] [interface interface-id] [vlan vlan-id]

Displaying

Description	Command
Displays the MAC address table.	show mac-address-table { dynamic static filter } [address mac-address] [interface interface-id] [vlan vlan-id]

Displays the aging time for dynamic MAC addresses.	show mac-address-table aging-time
Displays the maximum number of dynamic MAC addresses.	show mac-address-table max-dynamic-mac-count
Displays the configuration and history of MAC address change notifications.	show mac-address-table notification [interface [interface-id] history]

Debugging



System resources are occupied when debugging information is output. Therefore, disable debugging immediately after use.

Description	Command
Debugs MAC address operation.	debug bridge mac

3. Configuring Aggregated Port

3.1. Overview

An aggregated port (AP) is used to bundle multiple physical links into one logical link to increase the link bandwidth and improve connection reliability.

An AP port supports load balancing, namely, distributes load evenly among member links. Besides, an AP port realizes link backup. When a member link of the AP port is disconnected, the load carried by the link is automatically allocated to other functional member links. A member link does not forward broadcast or multicast packets to other member links.

For example, the link between two devices supports a maximum bandwidth of 1,000 Mbps. When the service traffic carried by the link exceeds 1,000 Mbps, the traffic in excess will be discarded. Port aggregation can be used to solve the problem. For example, you can connect the two devices with network cables and combine multiple links to form a logical link capable of multiples of 1,000 Mbps.

For example, there are two devices connected by a network cable. When the link between the two ports of the devices is disconnected, the services carried by the link will be interrupted. After the connected ports are aggregated, the services will not be affected as long as one link remains connected.

Protocols and Standards

- IEEE 802.3ad

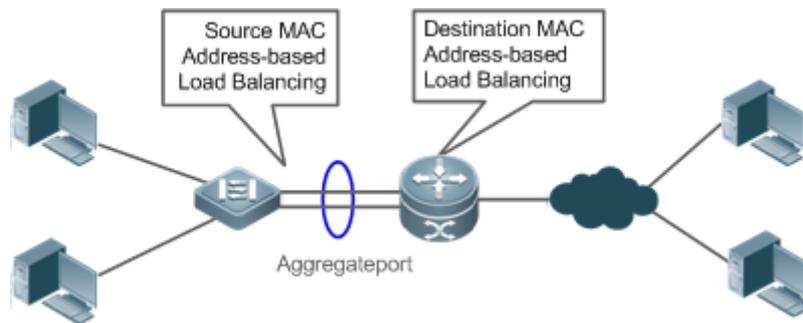
3.2. Applications

Applications	Description
AP Link Aggregation and Load Balancing	A large number of packets are transmitted between an aggregation device and a core device, which requires a greater bandwidth. To meet this requirement, you can bundle the physical links between the devices into one logical link to increase the link bandwidth, and configure a proper load balancing algorithm to distribute the work load evenly to each physical link, thus improving bandwidth utilization.

3.2.1. AP Link Aggregation and Load Balancing

Scenario

In Figure 3-1, the switch communicates with the router through an AP port. All the devices on the intranet (such as the two PCs on the left) use the router as a gateway. All the devices on the extranet (such as the two PCs on the right) send packets to the internet devices through the router, with the gateway's MAC address as its source MAC address. To distribute the load between the router and other hosts to other links, configure destination MAC address-based load balancing. On the switch, configure source MAC address-based load balancing.



Deployment

- Configure the directly connected ports between the switch and router as a static AP port or a Link Aggregation Control Protocol (LACP) AP port.
- On the switch, configure a source MAC address-based load balancing algorithm.
- On the router, configure a destination MAC address-based load balancing algorithm.

3.3. Features

Basic Concepts

→ Static AP

The static AP mode is an aggregation mode in which physical ports are directly added to an AP aggregation group through manual configuration to allow the physical ports to forward packets when the ports are proper in link state and protocol state. An AP port in static AP mode is called a static AP, and its member ports are called static AP member ports.

→ LACP

LACP is a protocol about dynamic link aggregation. It exchanges information with the connected device through LACP data units (LACPDUs). An AP port in LACP mode is called an LACP AP port, and its member ports are called LACP AP member ports.

→ AP Member Port Mode

There are three aggregation modes available, namely, active, passive, and static.

AP member ports in active mode initiate LACP negotiation. AP member ports in passive mode only respond to received LACPDUs. AP member ports in static mode do not send LACPDUs for negotiation. The following table lists the requirements for peer port mode.

Port Mode	Peer Port Mode
Active mode	Active or passive mode
Passive mode	Active mode

Static Mode	Static Mode
-------------	-------------

→ AP Member Port State

There are two kinds of AP member port state available:

- When a member port is Down, the port cannot forward packets. The Down state is displayed.
- When a member port is Up and the link protocol is ready, the port can forward packets. The Up state is displayed.

There are three kinds of LACP member port state:

- When the link of a port is Down, the port cannot forward packets. The Down state is displayed.
- When the link of a port is Up and the port is added to an aggregation group, the bndl state is displayed.
- When the link of a port is Up but the port is suspended because the peer end is not enabled with LACP or the attributes of the ports are inconsistent with those of the master port, the susp state is displayed. (The port in susp state does not forward packets.)



Only full-duplex ports are capable of LACP aggregation.



LACP aggregation can be implemented only when the rates, flow control approaches, medium types, and Layer-2/3 attributes of member ports are consistent.



If you modify the preceding attributes of a member port in the aggregation group, LACP aggregation will fail.



The ports which are prohibited from joining or exiting an AP port cannot be added to or removed from a static AP port or an LACP AP port.

→ AP Capacity Mode

The maximum number of member ports is fixed, which is equal to the maximum number of AP ports multiplied by the maximum number of member ports supported by a single AP port. If you want to increase the maximum number of AP ports, the maximum number of member ports supported by a single AP port must be reduced, and vice versa. This concerns the AP capacity mode concept. Some devices support the configuration of the AP capacity mode. For example, if the system supports 16,384 member ports, you can select the 1024 x 16, 512 x 32, and other AP capacity modes (Maximum number of AP ports multiplied by the maximum number of member ports supported by a single AP port).

→ LACP System ID

One device can be configured with only one LACP aggregation system. The system is identified by a system ID and each system has a priority, which is a configurable value. The system ID

consists of the LACP system priority and MAC address of the device. A lower system priority indicates a higher priority of the system ID. If the system priorities are the same, a smaller MAC address of the device indicates a higher priority of the system ID. The system with an ID of a higher priority determines the port state. The port state of a system with an ID of a lower priority keeps consistent with that of a higher priority.

→ LACP Port ID

Each port has an independent LACP port priority, which is a configurable value. The port ID consists of the LACP port priority and port number. A smaller port priority indicates a higher priority of the port ID. If the port priorities are the same, a smaller port number indicates a higher priority of the port ID.

→ LACP Master Port

When dynamic member ports are Up, LACP selects one of those ports to be the master port based on the rates and duplex modes, ID priorities of the ports in the aggregation group, and the bundling state of the member ports in the Up state. Only the ports that have the same attributes as the master port are in Bundle state and participate in data forwarding. When the attributes of ports are changed, LACP reselects a master port. When the new master port is not in Bundle state, LACP disaggregates the member ports and performs aggregation again.

→ Preferred AP Member Port

The preferred AP member port feature is used when an AP port is connected to a server with two systems. An AP member port is selected as the preferred port which will forward specified packets (packets of the management VLAN) to the server. These packets will not be distributed to other member ports by load balancing. This ensures the communication with the server.



Configure the port connected to the management network interface card (NIC) of the server as the preferred AP member port.

Some Linux servers have two systems. For example, an HP server has a master system and remote management system. The master system is a Linux system. The remote management system with Integrated Lights-Out (iLO) provides remote management at the hardware-level. iLO can manage the server remotely even when the master system is restarted. The master system has two NICs bundled into an AP port for service processing. The management system uses one of the two NICs for remote management. Because services are separated by different VLANs, the VLAN used by the management system is called a management VLAN. The port of a device connected to a server with two NICs is an AP port. The packets of the management VLAN must be sent by the member port connected to the NICs of the server to ensure the communication with the remote management system. You can configure a preferred AP member port to send the packets of the management VLAN.



For a server with two NICs bundled through LACP, if LACP is not running when the master system is restarted, LACP negotiation fails and the AP port is Down. At that time, the preferred AP member port is downgraded into a static member port and it is bound to the AP port for communication with the remote management system of the server. The preferred AP member port will be enabled with LACP again for negotiation after the Linux system is restarted and LACP runs normally.

→ LACP Independent Ports In normal cases, LACP independent ports are used for interworking between access switches and servers with two NICs. If the OS is not pre-installed when a server with two NICs starts, the OS needs to be installed via the remote PXE OS installation device. Before the OS is installed, the server with two NICs cannot perform LACP negotiation with the access device, and only one NIC can work. In this case, the port on the access device must be able to change to a common Ethernet physical port automatically to ensure normal communication between the server and the remote PXE OS installation device. After the OS is installed and both NICs can run the LACP, the port on the access device must be able to enable the LACP again for negotiation.



LACP independent ports can work only at layer 2. After an LACP independent port is enabled, if the LACP independent port does not receive LACP packets, it automatically changes to a common Ethernet port, which automatically copies the rate, duplex mode, flow control, and VLAN configuration from the AP port to ensure port forwarding capabilities.



An LACP independent port automatically changes to a common Ethernet port only if it does not receive LACP packets within 90s. After the port receives LACP packets, it changes to an LACP member port again.

Overview

Overview	Description
Link Aggregation	Aggregates physical links statically or dynamically to realize bandwidth extension and link backup.
Load Balancing	Balances the load within an aggregation group flexibly by using different load balancing methods.

3.3.1. Link Aggregation

Working Principle

There are two kinds of AP link aggregation. One is static AP, and the other is dynamic aggregation through LACP.

- Static AP

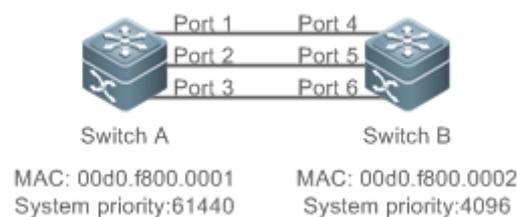
The static AP configuration is simple. Run a command to add the specified physical port to the AP port. After joining the aggregation group, a member port can receive and transmit data and participate in load balancing within the group.

- Dynamic AP (LACP)

An LACP-enabled port sends LACPDU to advertise its system priority, system MAC address, port priority, port number, and operation key. When receiving the LACPDU from the peer end, the device compares the system priorities of both ends based on the system ID in the packet. The end with a higher system ID priority sets the ports in the aggregation group to Bundle state based on the port ID priorities in a descending order, and sends an updated LACPDU.

When receiving the LACPDU, the peer end sets corresponding ports to Bundle state so that both ends maintain consistency when a port exits or joins the aggregation group. The physical link can forward packets only after the ports at both ends are bundled dynamically.

After link aggregation, the LACP member ports periodically exchange LACPDUs. When a port does not receive an LACPDU in the specified time, a timeout occurs and the links are unbundled. In this case, the member ports cannot forward packets. There are two timeout modes: long timeout and short timeout. In long timeout mode, a port sends a packet every 30s. If it does not receive a packet from the peer end in 90s, a timeout occurs. In short timeout mode, a port sends a packet every 1s. If it does not receive a packet from the peer end in 3s, a timeout occurs.



In Figure 3-2, Switch A is connected to Switch B through three ports. Set the system priorities of Switch A and Switch B to 61440 and 4096 respectively. Enable LACP on the Ports 1–6, set the aggregation mode to the active mode, and set the port priority to the default value 32768. When receiving an LACPDU from Switch A, Switch B finds that it has a higher system ID priority than Switch A (the system priority of Switch B is higher than that of Switch A). Switch B sets Port 4, Port 5, and Port 6 to Bundle state based on the order of port ID priorities (or in an ascending order of port numbers if the port priorities are the same). When receiving an updated LACPDU from Switch B, Switch A finds that Switch B has a higher system ID priority and has set Port 4, Port 5, and Port 6 to Bundle state. Then Switch A also sets Port 1, Port 2, and Port 3 to Bundle state.

3.3.2. Load Balancing

Working Principle

AP ports segregate packet flows by using load balancing algorithms based on packet features, such as the source and destination MAC addresses, source and destination IP addresses, and Layer-4 source and destination port numbers. The packet flow with the consistent feature is transmitted by one member link, and different packet flows are evenly distributed to member links. For example, in source MAC address-based load balancing, packets are distributed to the member links based on the source MAC addresses of the packets. Packets with different source MAC addresses are evenly distributed to member links. Packets with the identical source MAC address are forwarded by one member link.

Currently, there are several AP load balancing modes as follows:

- Source MAC address or destination MAC address
- Source MAC address + destination MAC address
- Source IP address or destination IP address
- Source IP address + destination IP address

- Layer-4 source port number or Layer-4 destination port number
- Layer-4 source port number + Layer-4 destination port number
- Source IP address + Layer-4 source port number
- Source IP address + Layer-4 destination port number
- Destination IP address + Layer-4 source port number
- Destination IP address + Layer-4 destination port number
- Source IP address + Layer-4 source port number + Layer-4 destination port number
- Destination IP address + Layer-4 source port number + Layer-4 destination port number
- Source IP address + destination IP address + Layer-4 source port number
- Source IP address + destination IP address + Layer-4 destination port number
- Source IP address + destination IP address + Layer-4 source port number + Layer-4 destination port number
- Panel port for incoming packets
- Aggregation member port polling
- Enhanced mode



Load balancing based on IP addresses or port numbers is applicable only to Layer-3 packets. When a device enabled with this load balancing method receives Layer-2 packets, it automatically switches to the default load balancing method.



All the load balancing methods use a load algorithm (hash algorithm) to calculate the member links based on the input parameters of the methods. The input parameters include the source MAC address, destination MAC address, source MAC address + destination MAC address, source IP address, destination IP address, source IP address + destination IP addresses, source IP address + destination IP address + Layer-4 port number and so on. The algorithm ensures that packets with different input parameters are evenly distributed to member links. It does not indicate that these packets are always distributed to different member links. For example, in IP address-based load balancing, two packets with different link source and destination IP addresses may be distributed to the same member link through calculation.

→ Enhanced Load Balancing

Enhanced load balancing allows the combination of multiple fields in different types of packets. These fields include src-mac, dst-mac, and vlan in Layer-2 packets, src-ip, dst-ip, protocol, l4-src-port, l4-dst-port, and vlan in IPv4 packets, src-ip, dst-ip, protocol, l4-src-port, l4-dst-port, and vlan in IPv6 packets.



All the load balancing methods are applicable to Layer-2 and Layer-3 AP ports. You need to configure proper load distribution methods based on different network environments to fully utilize network bandwidth.



Perform enhanced load balancing based on the src-mac, dst-mac, and vlan fields in Layer-2 packets, and the src-ip field in IPv4 packets. If the incoming packet is an IPv4 packet with an ever-changing source MAC address, the enhanced balancing algorithm does not take effect, because the device will perform load balancing only based on the src-ip field in the IPv4 packet after finding that it is an IPv4 packet.

→ Hash Load Balancing Control

Hash load balancing enables users to control load balancing flexibly in different scenarios. Currently, the following hash load functions are available:

- Hash disturbance factor: Traffic over AP ports is hashed for balancing. For two devices of the same type, the same path will be calculated for load balancing for the same stream. When the ECMP is deployed, the same stream of the two devices may be balanced to the same destination device, resulting in hash polarization. The hash disturbance factor is used to affect the load balancing algorithm. Different disturbance factors are configured for different devices to ensure that different paths are provided for the same stream.
- Hash synchronization: To ensure network security, a firewall cluster is deployed between the internal and external networks for traffic cleaning. This requires that both the uplink and downlink traffic of a session is transmitted to the same device in the firewall cluster for processing. The source and destination IP addresses contained in the uplink and downlink streams of a session are reversed. The uplink and downlink streams will be directed to different firewalls in the firewall cluster based on the traditional hash algorithm. The hash synchronization function ensures that uplink and downlink streams of a session be transmitted over the same path.

3.3.3. Member Port BFD Detection

Working Principle

Bidirectional Forwarding Detection (BFD) is a protocol that delivers fast detection of path failures. According to RFC7130, LACP takes 3s to detect link failures even in short timeout mode. The packets distributed to the faulty link during the 3-second period will be lost. BFD delivers faster failure detection. You can configure BFD on member ports to detect link failure and switch load to other member links in case of a link failure. When BFD detects that the path on a member port fails, the packets will not be distributed to the member port.

After BFD is enabled on an AP port, BFD sessions are set up on its member ports in forwarding state independently.

3.4. Configuration

Configuration	Description and Command	
Configuring Static AP Ports	(Mandatory) It is used to configure link aggregation manually.	
	interface aggregateport	Creates an Ethernet AP port.
	port-group	Configures static AP member ports.
Configuring LACP AP Ports	(Mandatory) It is used to configure link aggregation dynamically.	
	port-group mode	Configures LACP member ports.
	lACP system-priority	Configures the LACP system priority.
	lACP port-priority	Configures the port priority.
Enabling LinkTrap	(Optional) It is used to enable LinkTrap.	
	snmp trap link-status	Enables LinkTrap advertisement for an AP port.
	aggregateport member linktrap	Enables LinkTrap t for AP member ports.

Configuring a Load Balancing Mode	(Optional) It is used to configure a load balancing mode for an aggregated link.	
	aggregateport load-balance	Configures a load balancing algorithm for an AP port or AP member ports.
	(Optional) It is used to configure the profile of enhanced load balancing.	
	load-balance-profile	Renames the profile of enhanced load balancing.
	l2 field	Configures a load balancing mode for Layer-2 packets.
	ipv4 field	Configures a load balancing mode for IPv4 packets.
	ipv6 field	Configures a load balancing mode for IPv6 packets.
	(Optional) It is used to control load balancing policy.	
	hash-disturb { string { [seed seed_value] [offset offset] □ }	Configures hash disturbance factor.
	hash-symmetrical [ipv4 ipv6]	Configures hash synchronization.
Configuring an AP Capacity Mode	(Optional) It is used to configure the AP capacity mode.	
	aggregateport capacity mode	Configures an AP capacity mode in global configuration mode.
Enabling BFD for AP Member Ports	(Optional) It is used to enable BFD for AP member ports.	
	aggregate bfd-detect ipv4	Enables IPv4 BFD for AP member ports.
Configuring a Preferred AP Member Port	(Optional) It is used to configure an AP member port as the preferred port.	
	aggregateport primary-port	Configures an AP member port as the preferred port.

Enabling the LACP Independent Port Function	lacp individual-port enable	Enables the LACP independent port function.
---	-----------------------------	---

3.4.1. Configuring Static AP Ports

Configuration Effect

- Configure multiple physical ports as AP member ports to realize link aggregation.
- The bandwidth of the aggregation link is equal to the sum of the member link bandwidths.
- When a member link of the AP port is disconnected, the load carried by the link is automatically allocated to other functional member links.

Notes

- Only physical ports can be added to an AP port.
- The ports of different media types or port modes cannot be added to the same AP port.
- Layer-2 ports can be added to only a Layer-2 AP port, and Layer-3 ports can be added to only a Layer-3 AP port. The Layer-2/3 attributes of an AP port that contains member ports cannot be modified.
- After a port is added to an AP port, the attributes of the port are replaced by those of the AP port.
- After a port is removed from an AP port, the attributes of the port are restored.



After a port is added to an AP port, the attributes of the port are consistent with those of the AP port. Therefore, do not perform configuration on the AP member ports or apply configuration to a specific AP member port. However, some configurations (the shutdown and no shutdown commands) can be configured on AP member ports. When you use AP member ports, check whether the function that you want to configure can take effect on a specific AP member port, and perform this configuration properly.

Configuration Steps

→ Creating an Ethernet AP Port

- Mandatory.
- Perform this configuration on an AP-enabled device.

Command	interface aggregateport ap-number
Parameter Description	ap-number: Indicates the number of an AP port.

Defaults	By default, no AP port is created.
Command Mode	Global configuration mode
Usage Guide	To create an Ethernet AP port, run <code>interfaces aggregateport</code> in global configuration mode. To delete the specified Ethernet AP port, run <code>no interfaces aggregateport ap-number</code> in global configuration mode.



Run `port-group` to add a physical port to a static AP port in interface configuration mode. If the AP port does not exist, it will be created automatically.



Run `port-group mode` to add a physical port to an LACP AP port in interface configuration mode. If the AP port does not exist, it will be created automatically.



The AP feature must be configured on the devices at both ends of a link and the AP mode must be the same (static AP or LACP AP).

→ Configuring Static AP Member Ports

- Mandatory.
- Perform this configuration on AP-enabled devices.

Command	<code>port-group ap-number</code>
Parameter Description	<code>port-group ap-number</code> : Indicates the number of an AP port.
Defaults	By default, no ports are added to any static AP port.
Command Mode	Interface configuration mode of the specified Ethernet port
Usage Guide	To add member ports to an AP port, run <code>port-group</code> in interface configuration mode. To remove member ports from an AP port, run <code>no port-group</code> in interface configuration mode.



The static AP member ports configured on the devices at both ends of a link must be consistent.



After a member port exits the AP port, the default settings of the member port are restored. Different functions deal with the default settings of the member ports differently. It is recommended that you check and confirm the port settings after a member port exits an AP port.



After a member port exits an AP port, the port is disabled by using the shutdown command to avoid loops. After you confirm that the topology is normal, run no shutdown in interface configuration mode to enable the port again.

→ Converting Layer-2 APs to Layer-3 APs

- *Optional.
- When you need to enable Layer-3 routing on an AP port, for example, to configure IP addresses or static route entries, convert the Layer-2 AP port to a Layer-3 AP port and enable routing on the Layer-3 AP port.
- Perform this configuration on AP-enabled devices that support Layer-2 and Layer-3 features, such as Layer-3 switches.

Command	no switchport
Parameter Description	N/A
Defaults	By default, the AP ports are Layer-2 AP ports.
Command Mode	Interface configuration mode of the specified AP port
Usage Guide	The Layer-3 AP feature is supported by only Layer-3 devices.



The AP port created on a Layer-3 device that does not support Layer-2 feature is a Layer-3 AP port. Otherwise, the AP port is a Layer-2 AP port.

→ Creating an Ethernet AP Subinterface

- Optional.
- On a device that supports subinterface configuration, run interface aggregateport sub-ap-number to create a subinterface.
- Perform this configuration on AP-enabled devices that support Layer-2 and Layer-3 features, such as Layer-3 switches.

Command	interface aggregateport sub-ap-number
Parameter Description	sub-ap-number: Indicates the number of an AP subinterface.
Defaults	By default, no subinterfaces are created.
Command Mode	Interface configuration mode of the specified AP port

Usage Guide	You need to convert the master port of the AP port to a Layer-3 port before creating a subinterface.
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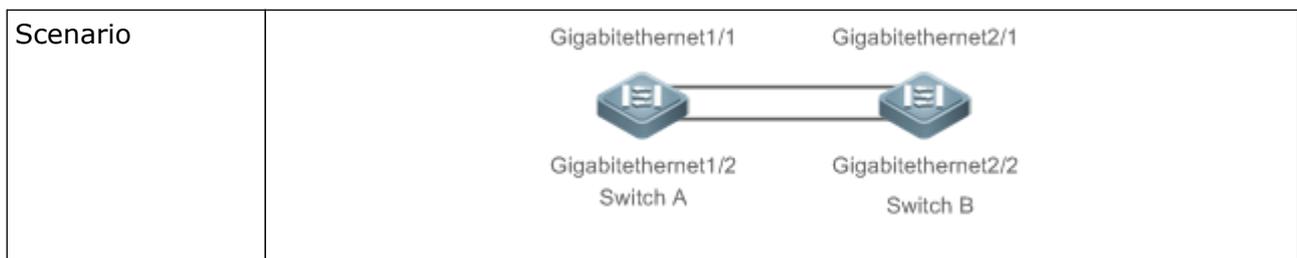
Verification

- Run show running to display the configuration.
- Run show aggregateport summary to display the AP configuration.

Command	show aggregateport aggregate-port-number [load-balance summary]
Parameter Description	aggregate-port-number: Indicates the number of an AP port. load-balance: Displays the load balancing algorithm. summary: Displays the summary of each link.
Command Mode	Any mode
Usage Guide	The information on all AP ports is displayed if you do not specify the AP port number.
	<pre> Switch# show aggregateport 1 summary AggregatePort MaxPorts SwitchPort Mode Load balance Ports ----- Ag1 8 Enabled ACCESS dst-mac Gi0/2 </pre>

Configuration Example

→ Configuring an Ethernet Static AP Port



Configuration Steps	<ul style="list-style-type: none"> • Add the GigabitEthernet 1/1 and GigabitEthernet 1/2 ports on Switch A to static AP port 3. • Add the GigabitEthernet 2/1 and GigabitEthernet 2/2 ports on Switch B to static AP port 3.
Switch A	<pre>SwitchA# configure terminal SwitchA(config)# interface range GigabitEthernet 1/1-2 SwitchA(config-if-range)# port-group 3</pre>
Switch B	<pre>SwitchB# configure terminal SwitchB(config)# interface range GigabitEthernet 2/1-2 SwitchB(config-if-range)# port-group 3</pre>
Verification	<ul style="list-style-type: none"> • Run show aggregateport summary to check whether AP port 3 contains member ports GigabitEthernet 1/1 and GigabitEthernet 1/2.
Switch A	<pre>SwitchA# show aggregateport summary AggregatePort MaxPorts SwitchPort Mode Ports ----- ----- Ag3 8 Enabled ACCESS Gi1/1,Gi1/2</pre>
Switch B	<pre>SwitchB# show aggregateport summary AggregatePort MaxPorts SwitchPort Mode Ports ----- ----- Ag3 8 Enabled ACCESS Gi2/1,Gi2/2</pre>

3.4.2. Configuring LACP AP Ports

Configuration Effect

- Connected devices perform autonegotiation through LACP to realize dynamic link aggregation.

- The bandwidth of the aggregation link is equal to the sum of the member link bandwidths.
- When a member link of the AP port is disconnected, the load carried by the link is automatically allocated to other functional member links.
- It takes LACP 90s to detect a link failure in long timeout mode and 3s in short timeout mode.

Notes

- After a port exits an LACP AP port, the default settings of the port may be restored. Different functions deal with the default settings of the member ports differently. It is recommended that you check and confirm the port settings after a member port exits an LACP AP port.
- Changing the LACP system priority may cause LACP member ports to be disaggregated and aggregated again.
- Changing the priority of an LACP member port may cause the other member ports to be disaggregated and aggregated again.

Configuration Steps

→ Configuring LACP Member Ports * Mandatory. * Perform this configuration on LACP-enabled devices.

Command	port-group key-number mode { active passive }
Parameter Description	Key-number: Indicates the management key of an AP port. In other words, it is the LACP AP port number. The maximum value is subject to the number of AP ports supported by the device. active: Indicates that ports are added to a dynamic AP port actively. passive: Indicates that ports are added to a dynamic AP port passively.
Defaults	By default, no physical ports are added to any LACP AP port.
Command Mode	Interface configuration mode of the specified physical port
Usage Guide	Use this command in interface configuration mode to add member ports to an LACP AP port.



The LACP member port configuration at both ends of a link must be consistent.

→ Configuring the LACP System Priority

- Optional.
- Perform this configuration when you need to adjust the system ID priority. A smaller value indicates a higher system ID priority. The device with a higher system ID priority selects an AP port.

- Perform this configuration on LACP-enabled devices.

Command	lacp system-priority system-priority
Parameter Description	system-priority: Indicates the LACP system priority. The value ranges from 0 to 65535.
Defaults	By default, the LACP system priority is 32768.
Command Mode	Global configuration mode
Usage Guide	Use this command in global configuration mode to configure the LACP system priority. All the dynamic member links share one LACP system priority. Changing the LACP system priority will affect all member links. To restore the default settings, run no lacp system-priority in interface configuration mode.

→ Configuring the Priority of an LACP Member Port

- Optional.
- Perform this configuration when you need to specify the port ID priority. A smaller value indicates a higher port ID priority. The port with the highest port ID priority will be selected as the master port.
- Perform this configuration on LACP-enabled devices.

Command	lacp port-priority port-priority
Parameter Description	port-priority: Indicates the priority of an LACP member port. The value ranges from 0 to 65535.
Defaults	By default, the priority of an LACP member port is 32768.
Command Mode	Interface configuration mode of the specified physical port
Usage Guide	Use this command in global configuration mode to configure the priority of an LACP member port. To restore the settings, run no lacp port-priority in interface configuration mode.

→ Configuring the Timeout Mode of LACP Member Ports

- Optional.
- When you need to implement real-time link failure detection, configure the short timeout mode. It takes LACP 90s to detect a link failure in long timeout mode and 3s in short timeout mode.

- Perform this configuration on LACP-enabled devices, such as switches.

Command	lacp short-timeout
Parameter Description	N/A
Defaults	By default, the timeout mode of LACP member ports is long timeout.
Command Mode	Interface configuration mode
Usage Guide	The timeout mode is supported only by physical ports. To restore the default settings, run no lacp short-timeout in interface configuration mode.

Verification

- Run show running to display the configuration.
- Run show lacp summary to display LACP link state.

Command	show lacp summary [key-number]
Parameter Description	key-name: Indicates the number of an LACP AP port.
Command Mode	Any mode
Usage Guide	The information on all LACP AP ports is displayed if you do not specify key-name.

```

Switch(config)# show lacp summary 3
System Id:32768, 00d0.f8fb.0002
Flags: S - Device is requesting Slow LACPDUs
F - Device is requesting Fast LACPDUs.
A - Device is in active mode.      P - Device is in passive
mode.
Aggregated port 3:
Local information:
LACP port      Oper  Port  Port
Port  Flags  State  Priority  Key  Number
State
-----
--
Gi0/1  SA    bndl  4096    0x3  0x1
0x3d
Gi0/2  SA    bndl  4096    0x3  0x2
0x3d
Gi0/3  SA    bndl  4096    0x3  0x3
0x3d
Partner information:
Port          LACP port  Oper  Port  Port
State        Flags  Priority  Dev ID  Key  Number
-----
---
Gi0/1  SA    61440  00d0.f800.0001  0x3  0x1
0x3d
Gi0/2  SA    61440  00d0.f800.0001  0x3  0x2
0x3d
Gi0/3  SA    61440  00d0.f800.0001  0x3  0x3
0x3d
    
```

Configuration Example

→ Configuring LACP

<p>Scenario</p>	
<p>Configuration Steps</p>	<ul style="list-style-type: none"> • On Switch A, set the LACP system priority to 4096. • Enable dynamic link aggregation on the GigabitEthernet1/1 and GigabitEthernet1/2 ports on Switch A and add the ports to LACP AP port 3. • On Switch B, set the LACP system priority to 61440. • Enable dynamic link aggregation on the GigabitEthernet2/1 and GigabitEthernet2/2 ports on Switch B and add the ports to LACP AP port 3.
<p>Switch A</p>	<pre>SwitchA# configure terminal SwitchA(config)# lacp system-priority 4096 SwitchA(config)# interface range GigabitEthernet 1/1-2 SwitchA(config-if-range)# port-group 3 mode active SwitchA(config-if-range)# end</pre>
<p>Switch B</p>	<pre>SwitchB# configure terminal SwitchB(config)# lacp system-priority 61440 SwitchB(config)# interface range GigabitEthernet 2/1-2 SwitchB(config-if-range)# port-group 3 mode active SwitchB(config-if-range)# end</pre>
<p>Verification</p>	<ul style="list-style-type: none"> • Run show lacp summary 3 to check whether LACP AP port 3 contains member ports GigabitEthernet2/1 and GigabitEthernet2/2.

Switch A	<pre> SwitchA# show LACP summary 3 System Id:32768, 00d0.f8fb.0001 Flags: S - Device is requesting Slow LACPDUs F - Device is requesting Fast LACPDUs. A - Device is in active mode. P - Device is in passive mode. Aggregated port 3: Local information: LACP port Oper Port Port Port Flags State Priority Key Number State ----- ---- Gi1/1 SA bndl 32768 0x3 0x1 0x3d Gi1/2 SA bndl 32768 0x3 0x2 0x3d Partner information: LACP port Oper Port Port Port Flags Priority Dev ID Key Number State ----- --- Gi2/1 SA 32768 00d0.f800.0002 0x3 0x1 0x3d Gi2/2 SA 32768 00d0.f800.0002 0x3 0x2 0x3d </pre>
----------	--

```

Switch B

SwitchB# show LACP summary 3
System Id:32768, 00d0.f8fb.0002
Flags: S - Device is requesting Slow LACPDUs
F - Device is requesting Fast LACPDUs.
A - Device is in active mode.      P - Device is in passive
mode.
Aggregated port 3:
Local information:
LACP port      Oper  Port      Port
Port  Flags  State  Priority  Key  Number
State
-----
----
Gi2/1  SA    bndl    32768    0x3    0x1
0x3d
Gi2/2  SA    bndl    32768    0x3    0x2
0x3d
Partner information:
LACP port      Oper  Port  Port
Port  Flags  Priority  Dev ID  Key  Number
State
-----
---
Gi1/1  SA    32768    00d0.f800.0001  0x3    0x1
0x3d
Gi1/2  SA    32768    00d0.f800.0001  0x3    0x2
0x3d
    
```

3.4.3. Enabling LinkTrap

Configuration Effect

Enable the system with LinkTrap to send LinkTrap messages when aggregation links are changed.

Configuration Steps

→ Enabling LinkTrap for an AP Port

- Optional.
- Enable LinkTrap in interface configuration mode. By default, LinkTrap is enabled. LinkTrap messages are sent when the link state or protocol state of the AP port is changed.
- Perform this configuration on AP-enabled devices.

Command	snmp trap link-status
Parameter Description	N/A
Defaults	By default, LinkTrap is enabled.
Command Mode	Interface configuration mode of the specified AP port
Usage Guide	Use this command in interface configuration mode to enable LinkTrap for the specified AP port. After LinkTrap is enabled, LinkTrap messages are sent when the link state of the AP port is changed. Otherwise, LinkTrap messages are not sent. By default, LinkTrap is enabled. To disable LinkTrap for an AP port, run no snmp trap link-status in interface configuration mode. LinkTrap cannot be enabled for a specific AP member port. To enable LinkTrap for all AP member ports, run aggregateport member link-trap in global configuration mode.

→ Enabling LinkTrap for AP Member Ports

- Optional.
- By default, LinkTrap is disabled for AP member ports.
- Perform this configuration on AP-enabled devices.

Command	aggregateport member linktrap
Parameter Description	N/A
Defaults	By default, LinkTrap is disabled for AP member ports.
Command Mode	Global configuration mode
Usage Guide	Use this command in global configuration mode to enable LinkTrap for all AP member ports. By default, LinkTrap messages are not sent when the link state of AP member ports is changed. To disable LinkTrap for all AP member ports, run no aggregateport member linktrap in global configuration mode.

Verification

- Run show running to display the configuration.
- After LinkTrap is enabled, you can monitor this feature on AP ports or their member ports by using the MIB software.

Configuration Example

→ Enabling LinkTrap for AP Member Ports

<p>Scenario</p>	
<p>Configuration Steps</p>	<ul style="list-style-type: none"> • Add the GigabitEthernet 1/1 and GigabitEthernet 1/2 ports on Switch A to static AP port 3. • Add the GigabitEthernet 2/1 and GigabitEthernet 2/2 ports on Switch B to static AP port 3. • On Switch A, disable LinkTrap for AP port 3 and enable LinkTrap for its member ports. • On Switch B, disable LinkTrap for AP port 3 and enable LinkTrap its AP member ports.
<p>Switch A</p>	<pre>SwitchA# configure terminal SwitchA(config)# interface range GigabitEthernet 1/1-2 SwitchA(config-if-range)# port-group 3 SwitchA(config-if-range)# exit SwitchA(config)# aggregateport member linktrap SwitchA(config)# interface Aggregateport 3 SwitchA(config-if-AggregatePort 3)# no snmp trap link-status</pre>
<p>Switch B</p>	<pre>SwitchB# configure terminal SwitchB(config)# interface range GigabitEthernet 2/1-2 SwitchB(config-if-range)# port-group 3 SwitchB(config-if-range)# exit SwitchB(config)# aggregateport member linktrap SwitchB(config)# interface Aggregateport 3 SwitchB(config-if-AggregatePort 3)# no snmp trap link-status</pre>
<p>Verification</p>	<ul style="list-style-type: none"> • Run show running to check whether LinkTrap is enabled for AP port 3 and its member ports.

Switch A	<pre>SwitchA# show run include AggregatePort 3 Building configuration... Current configuration: 54 bytes interface AggregatePort 3 no snmp trap link-status SwitchA# show run include AggregatePort aggregateport member linktrap</pre>
Switch B	<pre>SwitchB# show run include AggregatePort 3 Building configuration... Current configuration: 54 bytes interface AggregatePort 3 no snmp trap link-status SwitchB# show run include AggregatePort aggregateport member linktrap</pre>

3.4.4. Configuring a Load Balancing Mode

Configuration Effect

The system distributes incoming packets among member links by using the specified load balancing algorithm. The packet flow with the consistent feature is transmitted by one member link, whereas different packet flows are evenly distributed to various links. A device enabled with enhanced load balancing first determines the type of packets to be transmitted and performs load balancing based on the specified fields in the packets. For example, the AP port performs source IP-based load balancing on the packets containing an ever-changing source IPv4 address.

- In enhanced load balancing mode, configure the hash disturbance factor to ensure that same packets from two devices of the same type will be balanced to different links.
- In enhanced load balancing mode, enable hash synchronization to ensure that uplink and downlink packets of the same type will be transmitted over the same link. For example, in load balancing based on the source and destination IP addresses, enable hash synchronization for IPv4 packets to ensure that the uplink and downlink IPv4 packets will be transmitted over the same path.

Notes

- Different disturbance factors may lead to the same disturbance effect.
- Enable or disable hash synchronization for IPv4 and IPv6 as required.
- The flexible hash function can be configured in global configuration mode or interface configuration mode of a specific AP port.

Configuration Steps

→ Configuring the Global Load Balancing Algorithm of an AP port

- (Optional) Perform this configuration when you need to optimize load balancing.
- Perform this configuration on AP-enabled devices.

Command	aggregateport load-balance { dst-mac src-mac src-dst-mac dst-ip src-ip src-dst-ip src-dst-ip-l4port enhanced profile profile-name }
Parameter Description	<p>dst-mac: Indicates that load is distributed based on the destination MAC addresses of incoming packets.</p> <p>src-mac: Indicates that load is distributed based on the source MAC addresses of incoming packets.</p> <p>src-dst-ip: Indicates that load is distributed based on source and destination IP addresses of incoming packets.</p> <p>dst-ip: Indicates that load is distributed based on the destination IP addresses of incoming packets.</p> <p>src-ip: Indicates that load is distributed based on the source IP addresses of incoming packets.</p> <p>src-dst-mac: Indicates that load is distributed based on source and destination MAC addresses of incoming packets.</p> <p>src-dst-ip-l4port (Not supported in interface configuration mode): Indicates that load is distributed based on source IP and destination IP addresses as well as Layer-4 source and destination port numbers.</p> <p>enhanced profile profile-name: Indicates the name of the enhanced load balancing profile.</p>
Defaults	Load balancing can be based on source and destination MAC addresses (applicable to switches), source and destination IP addresses (applicable to gateways), or the profile of enhanced load balancing (applicable to switches with CB line cards).
Command Mode	Global configuration mode
Usage Guide	<p>To restore the default settings, run no aggregateport load-balance in global configuration mode. You can run aggregateport load-balance in interface configuration mode of an AP port on devices that support load balancing configuration on a specific AP port. The configuration in interface configuration mode prevails. To disable the load balancing algorithm, run no aggregateport load-balance in interface configuration mode of the AP port. After that, the load balancing algorithm configured in global configuration mode takes effect.</p> <div style="display: flex; align-items: center; margin-top: 20px;">  <p>You can run aggregateport load-balance in interface configuration mode of an AP port on devices that support load balancing configuration on a specific AP port.</p> </div>

→ Renaming the Profile of Enhanced Load Balancing

- By default, if a device supports enhanced load balancing, the system creates a profile named default for enhanced load balancing. Perform this configuration when you need to rename the profile or restore the default settings. In other cases, the configuration is optional.
- Perform this configuration on devices that support enhanced load balancing, such as aggregation switches and core switches.

Command	load-balance-profile profile-name
Parameter Description	profile-name: Indicates the profile name, which contains up to 31 characters.
Defaults	The default profile name is default.
Command Mode	Global configuration mode
Usage Guide	To enter default profile mode, run load-balance-profile default. To rename the enhanced load balancing profile, run load-balance-profile profile-name. To restore the default profile name, run default load-balance-profile in global configuration mode. To restore the default load balancing settings, run default load-balance-profile profile-name in global configuration mode. Only one profile is supported globally. Please do not delete the profile. To display the enhanced load balancing profile, run show load-balance-profile.

→ Configuring the Layer-2 Packet Load Balancing Mode

- (Optional) Perform this configuration to specify the Layer-2 packet load balancing mode.
- Perform this configuration on devices that support enhanced load balancing, such as aggregation switches and core switches.

Command	l2 field { [src-mac] [dst-mac] [vlan] }
Parameter Description	src-mac: Indicates that load is distributed based on the source MAC addresses of incoming Layer-2 packets. dst-mac: Indicates that load is distributed based on the destination MAC addresses of incoming Layer-2 packets. vlan: Indicates that load is distributed based on the VLAN IDs of incoming Layer-2 packets.
Defaults	By default, the load balancing mode of Layer-2 packets varies with the product.
Command Mode	Profile configuration mode

Usage Guide	To restore the default settings, run no l2 field in profile configuration mode.
Command	ipv4 field { [src-ip] [dst-ip] [protocol] [l4-src-port] [l4-dst-port] [vlan] [src-port] }
Parameter Description	<p>src-ip: Indicates that load is distributed based on the source IP addresses of incoming IPv4 packets.</p> <p>dst-ip: Indicates that load is distributed based on the destination IP addresses of incoming IPv4 packets.</p> <p>protocol: Indicates that load is distributed based on the protocol types of incoming IPv4 packets.</p> <p>l4-src-port: Indicates that load is distributed based on the Layer-4 source port numbers of incoming IPv4 packets.</p> <p>l4-dst-port: Indicates that load is distributed based on the Layer-4 destination port numbers of incoming IPv4 packets.</p> <p>vlan: Indicates that load is distributed based on the VLAN IDs of incoming IPv4 packets.</p> <p>src-port: Indicates that load is distributed based on the panel port of incoming IPv4 packets.</p>
Defaults	By default, the load balancing mode of IPv4 packets varies with the product.
Command Mode	Profile configuration mode
Usage Guide	To restore the default settings, run no ipv4 field in profile configuration mode.

→ Configuring the IPv6 Packet Load Balancing Mode

- Optional.
- Perform this configuration to specify the IPv6 packet load balancing mode.
- Perform this configuration on devices that support IPv6 packet load balancing, such as aggregation switches and core switches.

Command	ipv6 field { [src-ip] [dst-ip] [protocol] [l4-src-port] [l4-dst-port] [vlan] [src-port] }
Parameter Description	src-ip: Indicates that load is distributed based on the source IP addresses of incoming IPv6 packets. dst-ip: Indicates that load is distributed based on the destination IP addresses of incoming IPv6 packets. protocol: Indicates that load is distributed based on the protocol types of incoming IPv6 packets. l4-src-port: Indicates that load is distributed based on the Layer-4 source port numbers of incoming IPv6 packets. l4-dst-port: Indicates that load is distributed based on the Layer-4 destination port numbers of incoming IPv6 packets. vlan: Indicates that load is distributed based on the VLAN IDs of incoming IPv6 packets. src-port: Indicates that load is distributed based on the source port of incoming IPv6 packets.
Defaults	By default, the load balancing mode of IPv6 packets varies with the product.
Command Mode	Profile configuration mode
Usage Guide	To restore the default settings, run no ipv6 field in profile configuration mode.

→ Configuring the Hash Disturbance Factor

- Optional
- Perform this operation to balance packets of the same type over the AP port for devices of the same type.

Command	hash-disturb { string { [seed seed_value] [offset offset] □ }
Parameter Description	string: Indicates the character string used to calculate the hash disturbance factor. seed_value: Indicates the seed value of HASH disturbance. offset: Indicates the offset value of HASH disturbance.
Defaults	By default, no hash disturbance factor is set.
Command Mode	Profile configuration mode
Usage Guide	To restore the default settings, run no hash-disturb in profile configuration mode.

→ Enabling or Disabling Hash Synchronization

- Optional
- Perform this operation to ensure that uplink and downlink streams of the same packet type are transmitted over the same path.

Command	hash-symmetrical {ipv4 ipv6 }
Parameter Description	ipv4: Indicates that hash synchronization is enabled for IPv4 packets. ipv6: Indicates that hash synchronization is enabled for IPv6 packets.
Defaults	Set it as required.
Command Mode	Profile configuration mode
Usage Guide	When hash synchronization is enabled for IPv4, IPv6, and FCoE packets as required, if uplink and downlink streams of the same packet type do not need to be transmitted over the same path, run the no form of this command in profile configuration mode.

Verification

- Run show running to display the configuration.
- Run show aggregateport load-balance to display the load balancing configuration. If a device supports load balancing configuration on a specific AP port, run show aggregateport summary to display the configuration.
- Run show load-balance-profile to display the enhanced load balancing profile.

Command	show aggregateport aggregate-port-number [load-balance summary]
Parameter Description	aggregate-port-number: Indicates the number of an AP port. load-balance: Displays the load balancing algorithm. summary: Displays the summary of each link.
Command Mode	Any mode
Usage Guide	The information on All AP ports is displayed if you do not specify the AP port number.

	<pre>Switch# show aggregateport 1 summary AggregatePort MaxPorts SwitchPort Mode Load balance Ports ----- ----- Ag1 8 Enabled ACCESS dst-mac Gi0/2</pre>
--	---

Command	show load-balance-profile [profile-name]
Parameter Description	profile-name: Indicates the profile name.
Command Mode	Any mode
Usage Guide	All enhanced profiles are displayed if you do not specify the profile number.
	<pre>Switch# show load-balance-profile module0 Load-balance-profile: module0 Packet Hash Field: IPv4: src-ip dst-ip IPv6: src-ip dst-ip L2 : src-mac dst-mac vlan</pre>

Configuration Example

→ Configuring a Load Balancing Mode

Scenario	<pre> graph LR S1[Switch A] --- S2[Switch B] S1 --- P1[GigabitEthernet1/1] S1 --- P2[GigabitEthernet1/2] S2 --- P3[GigabitEthernet2/1] S2 --- P4[GigabitEthernet2/2] </pre>
----------	---

Configuration Steps	<ul style="list-style-type: none"> • Add the GigabitEthernet 1/1 and GigabitEthernet 1/2 ports on Switch A to static AP port 3. • Add the GigabitEthernet 2/1 and GigabitEthernet 2/2 ports on Switch B to static AP port 3. • On Switch A, configure source MAC address-based load balancing for AP port 3 in global configuration mode. • On Switch B, configure destination MAC address-based load balancing for AP port 3 in global configuration mode.
Switch A	<pre>SwitchA# configure terminal SwitchA(config)# interface range GigabitEthernet 1/1-2 SwitchA(config-if-range)# port-group 3 SwitchA(config-if-range)# exit SwitchA(config)# aggregateport load-balance src-mac</pre>
Switch B	<pre>SwitchB# configure terminal SwitchB(config)# interface range GigabitEthernet 2/1-2 SwitchB(config-if-range)# port-group 3 SwitchB(config-if-range)# exit SwitchB(config)# aggregateport load-balance dst-mac</pre>
Verification	<ul style="list-style-type: none"> • Run show aggregateport load-balance to check the load balancing algorithm configuration.
Switch A	<pre>SwitchA# show aggregatePort load-balance Load-balance : Source MAC</pre>
Switch B	<pre>SwitchB# show aggregatePort load-balance Load-balance : Destination MAC</pre>

→ Configuring Hash Load Balancing Control

<p>Scenario</p>	
<p>Configuration Steps</p>	<ul style="list-style-type: none"> • Add the GigabitEthernet 1/1 and GigabitEthernet 1/2 ports on Switch A to static AP port 3. • Add the GigabitEthernet 2/1 and GigabitEthernet 2/2 ports on Switch B to static AP port 3. • On Switch A, configure the hash disturbance factor A. • On Switch B, configure the hash disturbance factor B.
<p>Switch A</p>	<pre>SwitchA# configure terminal SwitchA(config)# interface range GigabitEthernet 1/1-2 SwitchA(config-if-range)# port-group 3 SwitchA(config-if-range)# exit SwitchA(config)#load-balance-profile SwitchA(config-load-balance-profile)#hash-disturb A SwitchA(config-load-balance-profile)#exit</pre>
<p>Switch B</p>	<pre>SwitchB# configure terminal SwitchB(config)# interface range GigabitEthernet 2/1-2 SwitchB(config-if-range)# port-group 3 SwitchB(config-if-range)# exit SwitchB(config)#load-balance-profile SwitchA(config-load-balance-profile)#hash-disturb B SwitchB(config-load-balance-profile)#exit</pre>
<p>Verification</p>	<ul style="list-style-type: none"> • Run show running to check whether the configuration is correct.

Common Errors

A user enables hash synchronization for IPv4, and IPv6 packets. However, no configuration is displayed when the user runs show running. This is because hash synchronization for IPv4,

IPv6, and FCoE packets is enabled by default. After the user disables the function, the configuration is displayed.

3.4.5. Configuring an AP Capacity Mode

Configuration Effect

- Change the maximum number of configurable AP ports and the maximum number of member ports in each AP port.

Notes * The system has a default AP capacity mode. You can run show aggregateport capacity to display the current capacity mode. * If the current configuration (maximum number of AP ports or the number of member ports in each AP port) exceeds the capacity to be configured, the capacity mode configuration will fail.

Configuration Steps

→ Configuring an AP Capacity Mode

- (Optional) Perform this configuration to change the AP capacity.
- Perform this configuration on devices that support AP capacity change, such as core switches.

Command	aggregateport capacity mode capacity-mode
Parameter Description	capacity-mode: Indicates a capacity mode.
Defaults	By default, AP capacity modes vary with devices. For example, 256 x 16 indicates that the device has a maximum of 256 AP ports and 16 member ports in each AP port.
Command Mode	Global configuration mode
Usage Guide	The system provides several capacity modes for devices that support capacity mode configuration. To restore the default settings, run no aggregateport capacity mode in global configuration mode.

Verification

- Run show running to display the configuration.
- Run show aggregateport capacity to display the current AP capacity mode and AP capacity usage.

Command	show aggregateport capacity
Parameter Description	N/A
Command Mode	Any mode
Usage Guide	N/A
	<pre>Switch# show aggregateport capacity AggregatePort Capacity Information: Configuration Capacity Mode: 128*16. Effective Capacity Mode : 256*8. Available Capacity : 128*8. Total Number: 128, Used: 1, Available: 127.</pre>

Configuration Example

→ Configuring an AP Capacity Mode

Scenario	<pre> graph LR S1[Switch A] --- S2[Switch B] S1 --- P1[GigabitEthernet1/1] S1 --- P2[GigabitEthernet1/2] S2 --- P3[GigabitEthernet2/1] S2 --- P4[GigabitEthernet2/2] </pre>
Configuration Steps	<ul style="list-style-type: none"> • Add the GigabitEthernet 1/1 and GigabitEthernet 1/2 ports on Switch A to static AP port 3. • Add the GigabitEthernet 2/1 and GigabitEthernet 2/2 ports on Switch B to static AP port 3. • On Switch A, configure the 128 x128 AP capacity mode. • On Switch B, configure the 256 x 64 AP capacity mode.

Switch A	<pre>SwitchA# configure terminal SwitchA(config)# interface range GigabitEthernet 1/1-2 SwitchA(config-if-range)# port-group 3 SwitchA(config-if-range)# exit SwitchA(config)# aggregateport capacity mode 128*128</pre>
Switch B	<pre>SwitchB# configure terminal SwitchB(config)# interface range GigabitEthernet 2/1-2 SwitchB(config-if-range)# port-group 3 SwitchB(config-if-range)# exit SwitchB(config)# aggregateport capacity mode 256*64</pre>
Verification	<ul style="list-style-type: none"> • Run show aggregateport capacity to check the AP capacity mode configuration.
Switch A	<pre>SwitchA# show aggregatePort capacity AggregatePort Capacity Information: Configuration Capacity Mode: 128*128. Effective Capacity Mode : 128*128. Available Capacity Mode : 128*128. Total Number : 128, Used: 1, Available: 127.</pre>
Switch B	<pre>SwitchB# show aggregatePort capacity AggregatePort Capacity Information: Configuration Capacity Mode: 256*64. Effective Capacity Mode : 256*64. Available Capacity Mode : 256*64. Total Number : 256, Used: 1, Available: 255.</pre>

3.4.6. Enabling BFD for AP Member Ports

Configuration Effect

- Enable BFD for all the member ports of a specified AP port.

- After BFD is enabled for an AP port, each member port performs BFD to determine whether the packets should be distributed to the member port to realize load balancing. When BFD detects a member port Down, the packets are not distributed to the port. When BFD detects that the member port is restored to Up, the packets are distributed to the port again.

Notes

- After BFD is enabled for an AP port, BFD sessions are set up. To make the sessions take effect, you need to configure BFD parameters. For details, see Configuring BFD.
- Enabling or disabling BFD for a single AP member port is not supported. You must enable or disable BFD for the entire AP group.
- Only member ports in the forwarding state are enabled with BFD. If a member port is not in the forwarding state because the link or LACP is down, the BFD session on the member port is automatically deleted.
- If only one member port is available (in the forwarding state), all packets are distributed to this port. In this case, BFD fails. When there are more than one available member port, BFD takes effect again.

Configuration Steps

→ Enabling BFD for AP Member Ports

- (Optional) Enable BFD when you need to detect path failure on member ports in milliseconds. Traffic on the faulty link will be switched to other member links in case of a link failure.
- Perform this configuration on devices that support AP-BFD correlation.

Command	aggregate bfd-detect ipv4 src_ip dst_ip
Parameter Description	ipv4: Enables IPv4 BFD if the AP port is configured with an IPv4 address. src_ip: Indicates the source IP address, that is, the IP address configured on the AP port. dst_ip: Indicates the destination IP address, that is, the IP address configured on the peer AP port.
Defaults	By default, BFD is disabled.
Command Mode	Interface configuration mode of the specified AP port
Usage Guide	<ol style="list-style-type: none"> 1. To make BFD sessions take effect, you need to configure BFD parameters. For details, see Configuring BFD. 2. Both IPv4 BFD and IPv6 BFD can be enabled for an AP port if both are supported. 3. After BFD is enabled for an AP port, BFD sessions are automatically set up on its member ports in the forwarding state.

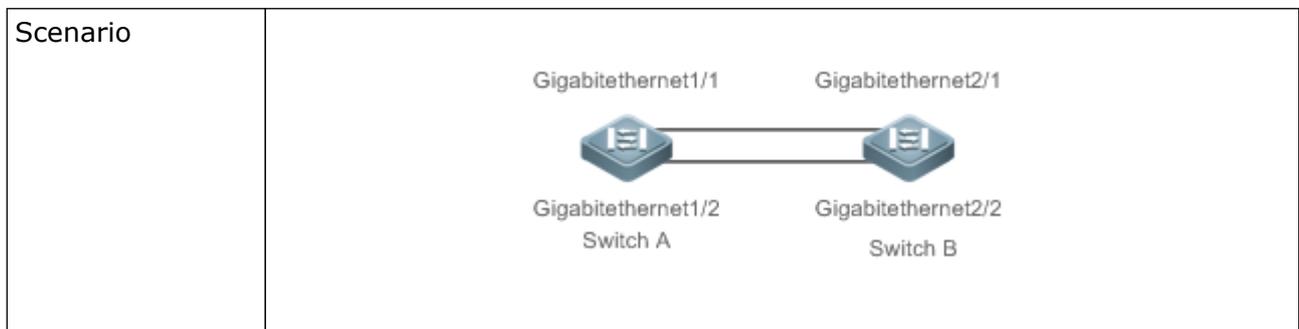
Verification

- Run show running to display the configuration.
- Run show interface aggregateport to display the BFD state of the AP member ports.

Command	show interface aggregateport ap-num
Parameter Description	ap-num: Indicates the number of an AP port.
Command Mode	Any mode
Usage Guide	N/A
	<pre> Switch# show interface aggregateport 11 ... Aggregate Port Informations: Aggregate Number: 11 Name: "AggregatePort 11" Members: (count=2) GigabitEthernet 0/1 Link Status: Up LACP Status: bndl BFD Status: UP GigabitEthernet 0/2 Link Status: Up LACP Status: susp BFD Status: Invalid ... </pre>

Configuration Example

→ Enabling IPv4 BFD for AP Member Ports



Configuration Steps	<ul style="list-style-type: none"> • Enable LACP for the GigabitEthernet 1/1 and GigabitEthernet 1/2 ports on Switch A and add the ports to LACP AP port 3. • Enable LACP for the GigabitEthernet 2/1 and GigabitEthernet 2/2 ports on Switch B and add the ports to LACP AP port 3. • Configure IP address 1.0.0.1 for AP port 3 on Switch A and enable IPv4 BFD. • Configure IP address 1.0.0.2 for AP port 3 on Switch B and enable IPv4 BFD.
Switch A	<pre>SwitchA# configure terminal SwitchA(config)# interface range GigabitEthernet 1/1-2 SwitchA(config-if-range)# no switchport SwitchA(config-if-range)# port-group 3 mode active SwitchA(config-if-range)# exit SwitchA(config)# interface aggregateport 3 SwitchA(config-if-Aggregateport 3)# ip address 1.0.0.1 255.255.255.0 SwitchA(config-if-Aggregateport 3)# aggregate bfd-detect ipv4 1.0.0.1 1.0.0.2 SwitchA(config-if-Aggregateport 3)# bfd interval 50 min_rx 50 multiplier 3</pre>
Switch B	<pre>SwitchB# configure terminal SwitchB(config)# interface range GigabitEthernet 1/1-2 SwitchB(config-if-range)# no switchport SwitchB(config-if-range)# port-group 3 mode active SwitchB(config-if-range)# exit SwitchB(config)# interface aggregateport 3 SwitchB(config-if-Aggregateport 3)# ip address 1.0.0.2 255.255.255.0 SwitchB(config-if-Aggregateport 3)# aggregate bfd-detect ipv4 1.0.0.2 1.0.0.1 SwitchB(config-if-Aggregateport 3)# bfd interval 50 min_rx 50 multiplier 3</pre>
Verification	<ul style="list-style-type: none"> • Run show run to check whether the configuration takes effect. • Run show interface aggregateport to display the BFD state of the AP member ports.

<p>Switch A</p>	<pre> SwitchA# show run include AggregatePort 3 Building configuration... Current configuration: 54 bytes interface AggregatePort 3 no switchport ip address 1.0.0.1 255.255.255.0 aggregate bfd-detect ipv4 1.0.0.1 1.0.0.2 bfd interval 50 min_rx 50 multiplier 3 SwitchA# show interface aggregateport 3 ... Aggregate Port Informations: Aggregate Number: 3 Name: "AggregatePort 3" Members: (count=2) GigabitEthernet 1/1 Link Status: Up LACP Status: bndl BFD Status: UP GigabitEthernet 1/2 Link Status: Up LACP Status: bndl BFD Status: UP ... </pre>
<p>Switch B</p>	<pre> SwitchB# show run include AggregatePort 3 Building configuration... Current configuration: 54 bytes interface AggregatePort 3 no switchport ip address 1.0.0.2 255.255.255.0 aggregate bfd-detect ipv4 1.0.0.2 1.0.0.1 bfd interval 50 min_rx 50 multiplier 3 SwitchB# show interface aggregateport 3 ... Aggregate Port Informations: Aggregate Number: 3 Name: "AggregatePort 3" Members: (count=2) GigabitEthernet 1/1 Link Status: Up LACP Status: bndl BFD Status: UP GigabitEthernet 1/2 Link Status: Up LACP Status: bndl BFD Status: UP ... </pre>

Common Errors

1. If BFD is enabled for an AP port without BFD parameters, BFD does not take effect.
2. After BFD is enabled for an AP port, the BFD neighbor must be a directly connected AP port enabled with BFD.

3.4.7. Configuring a Preferred AP Member Port

Configuration Effect

- Configure a member port as the preferred AP member port.
- After the preferred member port is configured, the management VLAN packets on the AP port are forwarded by this port.

Notes

- For details about management VLAN configuration, see Configuring MAC.
- Only one preferred member port can be configured for one AP port.
- After an LACP AP member port is configured as the preferred AP member port, if the LACP negotiation on all AP member ports fails, the preferred port is automatically downgraded to a static AP member port.

Configuration Steps

→ Configuring a Preferred AP Member Port

- (Optional) Perform this configuration to specify an AP member port dedicated to forwarding management VLAN packets.
- The configuration is applicable to dual-system servers. Configure the port connected to the management NIC of the server as the preferred AP member port.

Command	aggregateport primary-port
Parameter Description	N/A
Defaults	By default, No AP member port is a preferred port.
Command Mode	Interface configuration mode of an AP member port
Usage Guide	N/A

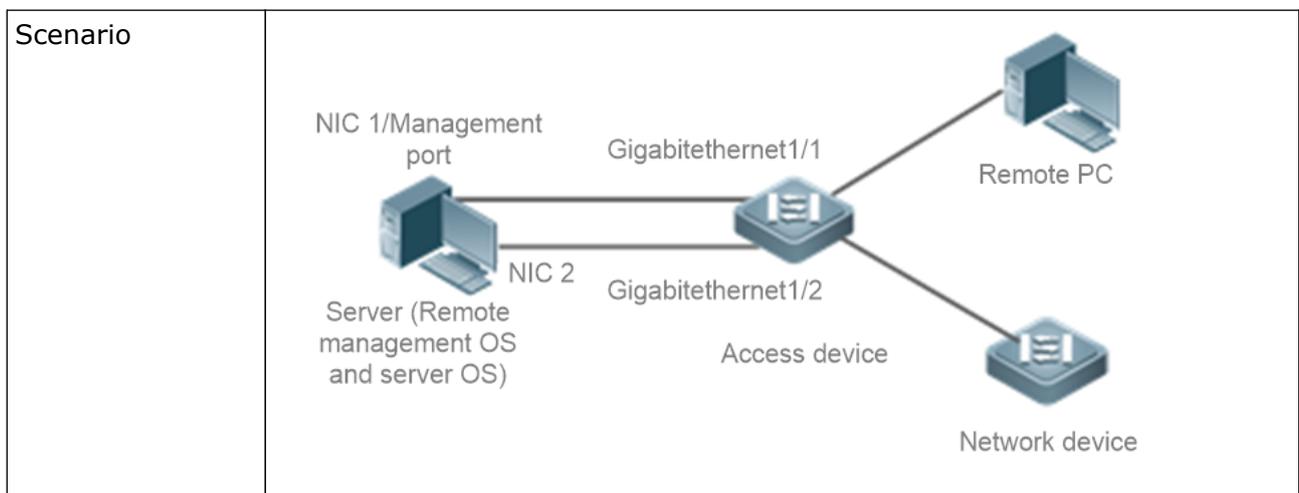
Verification

- Run show running to display the configuration.
- Run show interface aggregateport to display the preferred AP member port.

Command	show interface aggregateport ap-num
Parameter Description	ap-num: Indicates the number of an AP port.
Command Mode	Any mode
Usage Guide	N/A
	<pre> Switch# show interface aggregateport 11 ... Aggregate Port Informations: Aggregate Number: 11 Name: "AggregatePort 11" Members: (count=2) Primary Port: GigabitEthernet 0/1 GigabitEthernet 0/1 Link Status: Up LACP Status: bnd1 GigabitEthernet 0/2 Link Status: Up LACP Status: bnd1 ... </pre>

Configuration Example

→ Configuring Interworking Between the Access Device and a Server with Two NICs over a Preferred LACP AP Port



Description	<p>As shown in Figure 3-10, the server has two management systems: the remote management OS and server OS. The two OSs are independent. When the server OS restarts, access to the remote management OS is normal. The remote management OS is used to manage the server OS and uses NIC 1 as the communication port to access the access device (GigabitEthernet1/1 in Figure 3-10). It is allocated with a specific VLAN, for example, VLAN 10. The server OS is used to handle routine production services and uses NIC 1 and NIC 2 as the communication ports. LACP aggregation is enabled between NIC 1 and NIC 2. The server OS accesses the access device over the aggregate link. A VLAN except the management VLAN is allocated to the server OS. NIC 1 is used as the communication port for both the remote management OS and server OS. Based on the VLAN tag carried in packets, the server determines the destination of packets received from NIC 1.</p>
Configuration Steps	<ul style="list-style-type: none"> • Enable LACP for the GigabitEthernet 1/1 and GigabitEthernet 1/2 ports on the access device and add the ports to LACP AP port 3. • Configure GigabitEthernet 1/1 on the access device as the preferred port. • Configure VLAN 10 on the access device as the management VLAN.
Switch A	<p>Create LACP AP port 3 and add AP port 3 to the trunk.</p> <pre>SwitchA(config)# interface aggregateport 3 SwitchA(config-if-Aggregateport 3)# switchport mode trunk SwitchA(config-if-Aggregateport 3)# SwitchA# configure terminal SwitchA(config)# interface range GigabitEthernet 1/1-2 SwitchA(config-if-range)# port-group 3 mode active SwitchA(config-if-range)# exit</pre> <p>Configure VLAN 10 as the management VLAN.</p> <pre>SwitchA(config-if-GigabitEthernet 1/1)# exit SwitchA(config)# aggregateport-admin vlan 10</pre> <p>Configure GigabitEthernet 1/1 as the preferred port.</p> <pre>SwitchA(config)# interface gigabitEthernet 1/1 SwitchA(config-if-GigabitEthernet 1/1) aggregateport primary-port</pre>
Verification	<ul style="list-style-type: none"> • Run show run to check whether the configuration is correct. • Run show interface aggregateport to query the preferred AP port.

Switch A	<pre> SwitchA# show run include aggregateport-admin Building configuration... Current configuration: 54 bytes aggregateport-admin vlan 10 SwitchA# show run include GigabitEthernet 1/1 Building configuration... Current configuration: 54 bytes interface GigabitEthernet 1/1 aggregateport primary-port portgroup 3 mode active SwitchA# show interface aggregateport 3 ... Aggregate Port Informations: Aggregate Number: 3 Name: "AggregatePort 3" Members: (count=2) Primary Port: GigabitEthernet 1/1 GigabitEthernet 1/1 Link Status: Up LACP Status: bndl GigabitEthernet 1/2 Link Status: Up LACP Status: bndl ... </pre>
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→ Configuring Automatic Server Deployment over a Preferred LACP AP Port

Scenario	
Description	<p>As shown in Figure 3-11, the server has two NICs, and the two NICs connect to Switch A over the LACP AP port. The server can be automatically installed over NIC 1. After the server is installed, management data streams are sent over NIC 1 and NIC 2 for mutual backup and load balancing.</p>
Configuration Steps	<ul style="list-style-type: none"> • Enable LACP for the GigabitEthernet 1/1 and GigabitEthernet 1/2 ports on Switch A and add the ports to LACP AP port 3. • Configure GigabitEthernet 1/1 on Switch A as the preferred port.

Switch A	<pre> Create LACP AP port 3. SwitchA# configure terminal SwitchA(config)# interface range GigabitEthernet 1/1-2 SwitchA(config-if-range)# port-group 3 mode active SwitchA(config-if-range)# exit Configure GigabitEthernet 1/1 as the preferred port. SwitchA(config)# interface gigabitEthernet 1/1 SwitchA(config-if-GigabitEthernet 1/1) aggregateport primary-port </pre>
Verification	<ul style="list-style-type: none"> • Run show run to check whether the configuration is correct. • Run show interface aggregateport to query the preferred AP port.
Switch A	<pre> SwitchA# show run include GigabitEthernet 1/1 Building configuration... Current configuration: 54 bytes interface GigabitEthernet 1/1 aggregateport primary-port portgroup 3 mode active SwitchA# show interface aggregateport 3 ... Aggregate Port Informations: Aggregate Number: 3 Name: "AggregatePort 3" Members: (count=2) Primary Port: GigabitEthernet 1/1 GigabitEthernet 1/1 Link Status: Up LACP Status: bndl GigabitEthernet 1/2 Link Status: Up LACP Status: bndl ... </pre>

3.4.8. Enabling the LACP Independent Port Function

Configuration Effect

- After the independent LACP port function is enabled, an LACP member port automatically changes to a common physical port if the LACP member port does not receive LACP packets within 90s. The LACP member port state is changed to individual and the LACP member port can forward packets properly.
- After the LACP member port receives LACP packets, it changes to an LACP independent port again to perform LACP packet negotiation.

Notes

- After the LACP independent port function is enabled, an LACP member port will not change to a common physical port immediately. An LACP member port changes to a common physical port only if it does not receive LACP packets within 90s.

Configuration Steps

→ Enabling the LACP Independent Port Function

- Optional
- Perform this operation so that a member port of LACP aggregate group can forward packets normally when the LACP member port cannot perform LACP negotiation.

Command	lacp individual-port enable
Parameter Description	N/A
Defaults	By default, the LACP independent port function is disabled.
Command Mode	Interface configuration mode
Usage Guide	Usage Guide N/A

Verification

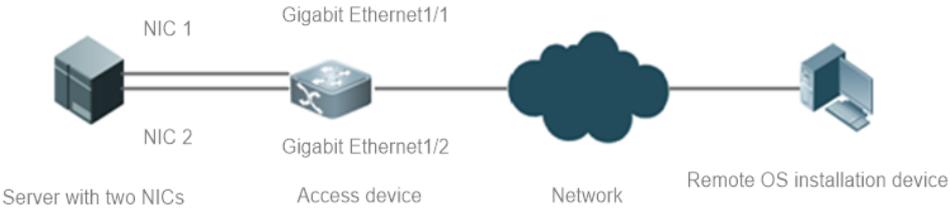
- Run show running to query the corresponding configuration.
- Run show interface aggregateport to query the AP member port status.

Command	show interface aggregateport ap-num
Parameter Description	ap-num: Indicates the AP number.
Command Mode	All modes
Usage Guide	N/A

<p>Command Presentation</p>	<pre>Switch# show interface aggregateport 3 ... Aggregate Port Informations: Aggregate Number: 3 Name: "AggregatePort 3" Members: (count=2) GigabitEthernet 0/1 Link Status: Up LACP Status: individual GigabitEthernet 0/2 Link Status: Up LACP Status: individual ...</pre>
-----------------------------	---

Configuration Example

→ Enabling the LACP Independent Port Function

<p>Scenario</p>	 <p>The diagram illustrates a network setup. On the left, a server is shown with two Network Interface Cards (NICs), labeled NIC 1 and NIC 2. These are connected to an access device (switch) via Gigabit Ethernet ports 1/1 and 1/2. The switch is connected to a central network cloud, which is then connected to a remote OS installation device on the right.</p>
<p>Description</p>	<p>As shown in Figure 3-12, the server uses NIC 1 and NIC 2 as the communication ports to access to the Gigabitethernet1/1 and Gigabitethernet1/2 ports of the access device. The Gigabitethernet1/1 and Gigabitethernet1/2 ports are added to the LACP aggregation group, for example, AP port 3. A specific VLAN, for example, VLAN 10 is allocated. The LACP independent port function is enabled for the Gigabitethernet1/1 and Gigabitethernet1/2 ports. When the OS is not installed on the server, LACP negotiation between the server and the access device fails. In this case, the Gigabitethernet1/1 and Gigabitethernet1/2 ports of the access device change to common physical ports and are allocated to VLAN 10 automatically. The server uses NIC 1 or NIC 2 to communicate with the remote OS installation device. After the OS is installed, the server connects to the access device in LACP mode.</p>

<p>Configuration Steps</p>	<ul style="list-style-type: none"> • Enable LACP for the GigabitEthernet 1/1 and GigabitEthernet 1/2 ports on the access device and add the ports to LACP AP port 3. • Enable the LACP independent port function for the GigabitEthernet 1/1 and GigabitEthernet 1/2 ports on the access device. • Allocate AP port 3 on the access device to VLAN 10.
<p>Switch A</p>	<pre> SwitchA# configure terminal SwitchA(config)# interface range GigabitEthernet 1/1-2 SwitchA(config-if-range)# port-group 3 mode active SwitchA(config-if-range)# lacp individual-port enable SwitchA(config-if-range)# exit SwitchA(config)# interface aggregateport 3 SwitchA(config-if-Aggregateport 3)#switch access vlan 10 SwitchA(config-if-Aggregateport 3)# </pre>
<p>Verification</p>	<ul style="list-style-type: none"> • Run show run to check whether the configuration is correct. • Run show lacp summery to query the status of each member port of the AP port.

```

Switch A

SwitchA# show lacp summary 3
System Id:32768, 00d0.f8fb.0001
Flags: S - Device is requesting Slow LACPDUs
F - Device is requesting Fast LACPDUs.
A - Device is in active mode.      P - Device is in passive
mode.
Aggregate port 3:
Local information:
LACP port      Oper   Port   Port
Port   Flags   State   Priority   Key   Number
State
-----
----
Gi1/1   SA     individual   32768     0x3   0x1
0x3d
Gi1/2   SA     individual   32768     0x3   0x2
0x3d
Partner information:
LACP port
Port   Flags   Priority   Dev ID   Oper   Port   Port
State   Key   Number
-----
---
Gi2/1   SA     32768     00d0.f800.0002   0x3   0x1
0x3d
Gi2/2   SA     32768     00d0.f800.0002   0x3   0x2
0x3d
    
```

3.5. Monitoring

Displaying

Description	Command
Displays the configuration of an enhanced load balancing profile.	show load-balance-profile [profile-name]
Displays the LACP aggregation state. You can display the information on a specified LACP AP port by specifying key-number.	show lacp summary [key-numebr]

Displays the summary or load balancing algorithm of an AP port.	show aggregateport [ap-number] { load-balance summary }
Displays the capacity mode and usage of an AP port.	show aggregateport capacity

Debugging



System resources are occupied when debugging information is output. Therefore, disable debugging immediately after use.

Description	Command
Debugs an AP port.	debug lsm ap
Debugs LACP.	debug lacp { packet event database ha realtime stm timer all }

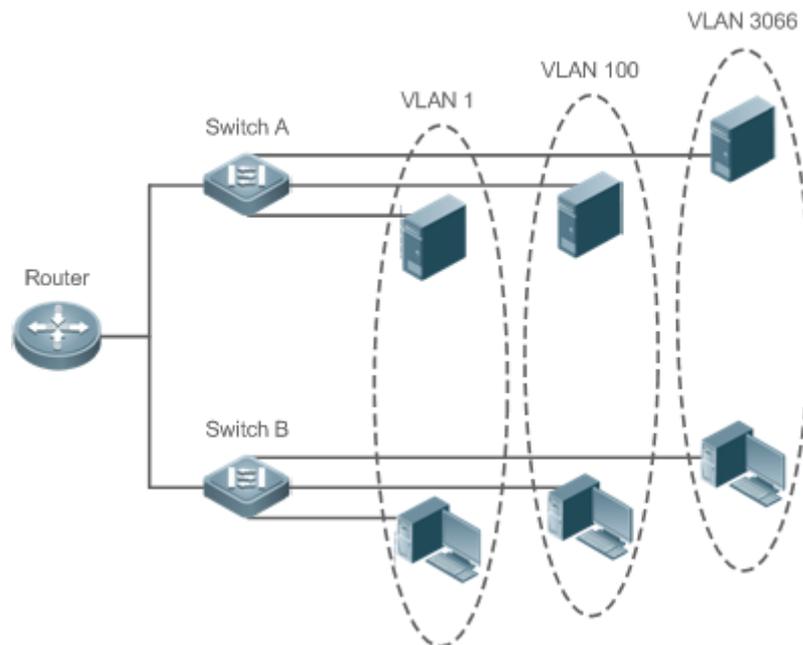
4. Configuring VLAN

4.1. Overview

A Virtual Local Area Network (VLAN) is a logical network created based on a physical network. A VLAN can be categorized into Layer-2 networks of the OSI model.

A VLAN has the same properties as a common LAN, except for physical location limitation. Uni-cast, broadcast and multicast frames of Layer 2 are forwarded and transmitted within a VLAN, keeping traffic segregated.

We may define a port as a member of a VLAN, and all terminals connected to this port are parts of a virtual network that supports multiple VLANs. You do not need to adjust the network physically when adding, removing and modifying users. Communication among VLANs is realized through Layer-3 devices, as shown in the following figure.



Protocols and Standards

- IEEE 802.1Q

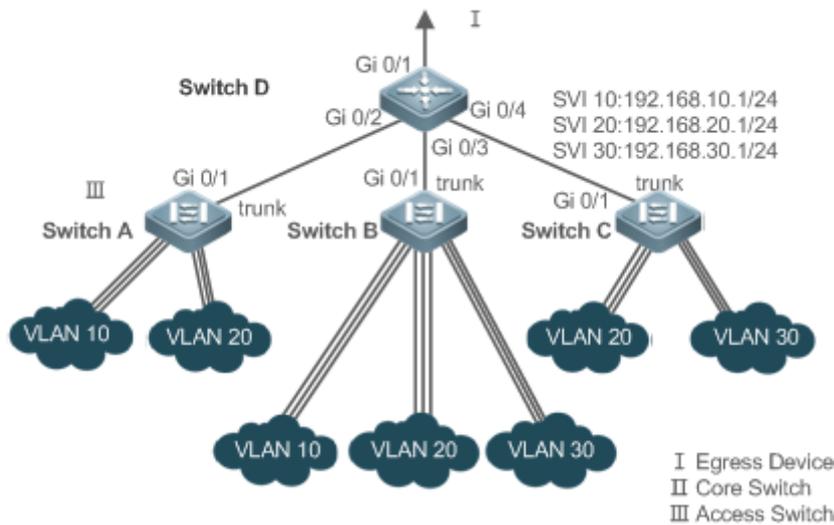
4.2. Applications

Application	Description
Isolating VLANs at Layer 2 and Interconnecting VLANs at Layer 3	An intranet is divided into multiple VLANs, realizing Layer-2 isolation and Layer-3 interconnection with each other through IP forwarding by core switches.

4.2.1. Isolating VLANs at Layer 2 and Interconnecting VLANs at Layer 3

Scenario

An intranet is divided into VLAN 10, VLAN 20 and VLAN 30, realizing Layer-2 isolation from each other. The three VLANs correspond respectively to the IP sub-networks 192.168.10.0/24, 192.168.20.0/24, and 192.168.30.0/24, realizing interconnection with each other through IP forwarding by Layer-3 core switches.



<p>Remarks:</p>	<p>Switch A, Switch B and Switch C are access switches. Configure three VLANs on a core switch and the port connected to the access switches as a Trunk port, and specify a list of allowed-VLANs to realize Layer-2 isolation; Configure three SVIs on the core switch, which are the gateway interfaces of the IP sub-networks corresponding to the three VLANs, and configure the IP addresses for these interfaces. Create VLANs respectively on the three access switches, assign Access ports for the VLANs, and specify Trunk ports of the core switch.</p>
-----------------	--

Deployment

- Divide an intranet into multiple VLANs to realize Layer-2 isolation among them.
- Configure SVIs on a Layer-3 switch to realize Layer-3 communication among VLANs.

4.3. Features

Basic Concepts

→ VLAN

A VLAN is a logical network created based on a physical network. A VLAN has the same properties as a common LAN, except for physical location limitation. Unicast, broadcast and multicast frames of Layer 2 are forwarded and transmitted within a VLAN, keeping traffic segregated.



The VLANs supported by this product comply with the IEEE802.1Q standard. A maximum of 4094 VLANs (VLAN ID 1-4094) are supported, among which VLAN 1 cannot be deleted.



The configurable VLAN IDs are from 1 to 4094.



In case of insufficient hardware resources, the system returns information on VLAN creation failure.

→ Port Mode

You can determine the frames allowed to pass a port and the VLANs which the port belongs to by configuring the port mode. See the following table for details.

Port Mode	Description
Access port	An Access port belongs to only one VLAN, which is specified manually.
Trunk port (802.1Q)	A Trunk port belongs to all the VLANs of an access switch by default, and it can forward the frames of all the VLANs or the frames of allowed-VLANs.
Uplink port	An Uplink port belongs to all the VLANs of an access switch by default, and it can forward the frames of all the VLANs and tag the native VLAN egress traffic.
Hybrid port	A Hybrid port belongs to all the VLANs of an access switch by default, and it can forward the frames of all the VLANs and send frames of VLANs untagged. It can also transmit frames of allowed-VLANs.
Servicechain Port	A service chain port does not learn MAC addresses and can forward packets from any VLAN by default. In addition, no other configuration is allowed.

Overview

Feature	Description
VLAN	VLAN helps realize Layer-2 isolation.

4.3.1. VLAN

Every VLAN has an independent broadcast domain, and different VLANs are isolated on Layer 2.

Working Principle

Every VLAN has an independent broadcast domain, and different VLANs are isolated on Layer 2. Layer-2 isolation: If no SVIs are configured for VLANs, VLANs are isolated on Layer 2. This means users in these VLANs cannot communicate with each other.

Layer-3 interconnection: If SVIs are configured on a Layer-3 switch for VLANs, these VLANs can communicate with each other on Layer 3.

4.4. Configuration

Configuration	Description and Command	
Configuring Basic VLAN	(Mandatory) It is used to create a VLAN.	
	vlan	Enters a VLAN ID.
	(Optional) It is used to configure an Access port to transmit the flows from a single VLAN.	
	switchport mode access	Defines a port as a Layer-2 Access port.
	switchport access vlan	Assigns a port to a VLAN.
	add interface	Adds one Access port or a group of such ports to the current VLAN.
	(Optional) It is used to rename a VLAN.	
	name	Names a VLAN.
Configuring a Trunk Port	(Mandatory) It is used to configure the port as a Trunk port.	
	switchport mode trunk	Defines a port as a Layer-2 Trunk port.
	(Optional) It is used to configure Trunk ports to transmit flows from multiple VLANs.	
	switchport trunk allowed vlan	Configures allowed-VLANs for a Trunk port.
	switchport trunk native vlan	Specifies a native VLAN for a Trunk port.

Configuring an Uplink Port	(Mandatory) It is used to configure the port as an Uplink port.	
	switchport mode uplink	Configures a port as an Uplink port.
	(Optional) It is used to restore the port mode.	
	no switchport mode	Restores the port mode.
Configuring a Hybrid Port	(Mandatory) It is used to configure a port as a Hybrid port.	
	switchport mode hybrid	Configures a port as a Hybrid port.
	(Optional) It is used to transmit the frames of multiple VLANs untagged.	
	no switchport mode	Restores the port mode.
	switchport hybrid allowed vlan	Configures allowed-VLANs for a Hybrid port.
	switchport hybrid native vlan	Configures a default VLAN for a Hybrid port.

4.4.1. Configuring Basic VLAN

[Configuration Effect](#)

- A VLAN is identified by a VLAN ID. You may add, delete, modify VLANs 2 to 4094, but VLAN 1 is created automatically and cannot be deleted. You may configure the port mode, and add or remove a VLAN.

[Notes](#)

- N/A

[Configuration Steps](#)

→ Creating and Modifying a VLAN

- Mandatory.
- In case of insufficient hardware resources, the system returns information on VLAN creation failure.
- Use the vlan vlan-id command to create a VLAN or enter VLAN mode.

- Configuration:

Command	vlan vlan-id
Parameter Description	vlan-id: indicates VLAN ID ranging from 1 to 4094.
Defaults	VLAN 1 is created automatically and is not deletable.
Command Mode	Global configuration mode
Usage Guide	If you enter a new VLAN ID, the corresponding VLAN will be created. If you enter an existing VLAN ID, the corresponding VLAN will be modified. You may use the no vlan vlan-id command to delete a VLAN. The undeletable VLANs include VLAN1, the VLANs configured with SVIs, and SubVLANs.

→ Renaming a VLAN

- Optional.
- You cannot rename a VLAN the same as the default name of another VLAN.
- Configuration:

Command	name vlan-name
Parameter Description	vlan-name: indicates a VLAN name.
Defaults	By default, the name of a VLAN is its VLAN ID. For example, the default name of the VLAN 4 is VLAN 0004.
Command Mode	VLAN configuration mode
Usage Guide	To restore the VLAN name to defaults, use the no name command.

→ Assigning Current Access port to a Specified VLAN

- Optional.
- Use the switchport mode access command to specify Layer-2 ports (switch ports) as Access ports.
- Use the switchport access vlan vlan-id command to add an Access port to a specific VLAN so that the flows from the VLAN can be transmitted through the port.
- Configuration:

Command	switchport mode access
Parameter Description	N/A
Defaults	A switch port is an Access port by default.
Command Mode	Interface configuration mode
Usage Guide	N/A

Command	switchport access vlan vlan-id
Parameter Description	vlan-id: indicates a VLAN ID.
Defaults	An Access port is added to VLAN 1 by default.
Command Mode	Interface configuration mode
Usage Guide	If a port is assigned to a non-existent VLAN, the VLAN will be created automatically.

→ Adding an Access Port to Current VLAN

- Optional.
- This command takes effect only on an Access port. After an Access port is added to a VLAN, the flows of the VLAN can be transmitted through the port.
- Configuration:

Command	add interface { interface-id range interface-range }
Parameter Description	interface-id: indicates a single port. interface-id: indicates multiple ports.
Defaults	By default, all Layer-2 Ethernet ports belong to VLAN 1.
Command Mode	VLAN configuration mode
Usage Guide	In VLAN configuration mode, add a specific Access port to a VLAN. This command takes the same effect as command switchport access vlan vlan-id.



For the two commands of adding a port to a VLAN, the command configured later will overwrite the other one.

Verification

- Send untagged packets to an Access port, and they are broadcast within the VLAN.
- Use commands show vlan and show interface switchport to check whether the configuration takes effect.

Command	show vlan [id vlan-id]
Parameter Description	vlan-id : indicates a VLAN ID.
Command Mode	Any mode
Usage Guide	N/A
Command Display	<pre>Switch(config-vlan)#show vlan id 20 VLAN Name Status Ports ----- - 20 VLAN0020 STATIC Gi0/1</pre>

Configuration Example

→ Configuring Basic VLAN and Access Port

Configuration Steps	<ul style="list-style-type: none"> • Create a VLAN and rename it. • Add an Access port to the VLAN. There are two approaches. One is:
---------------------	---

	<pre>Switch# configure terminal Switch(config)# vlan 888 Switch(config-vlan)# name test888 Switch(config-vlan)# exit Switch(config)# interface GigabitEthernet 0/3 Switch(config-if-GigabitEthernet 0/3)# switchport mode access Switch(config-if-GigabitEthernet 0/3)# switchport access vlan 20 The other approach is adding an Access port (GigabitEthernet 0/3) to VLAN20: Switch# configure terminal SwitchA(config)#vlan 20 SwitchA(config-vlan)#add interface GigabitEthernet 0/3</pre>
<p>Verification</p>	<p>Check whether the configuration is correct.</p>
	<pre>Check whether the configuration is correct. Switch(config-vlan)#show vlan VLAN Name Status Ports ----- 1 VLAN0001 STATIC 20 VLAN0020 STATIC Gi0/3 888 test888 STATIC Switch(config-vlan)# Switch# show interface GigabitEthernet 0/3 switchport Interface Switchport Mode Access Native Protected VLAN lists ----- GigabitEthernet 0/3 enabled ACCESS 20 1 Disabled ALL Switch# show run !</pre>

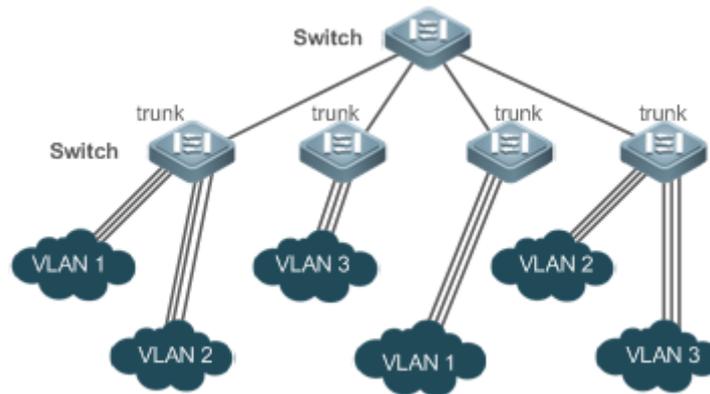
4.4.2. Configuring a Trunk Port

Configuration Effect

A Trunk is a point-to-point link connecting one Ethernet interface or multiple ones to other net-

work devices (for example, a router or switch) and it may transmit the flows from multiple VLANs.

The Trunk of the device adopts the 802.1Q encapsulation standard. The following figure displays a network adopting a Trunk connection.



You may configure an Ethernet port or Aggregate Port (See Configuring Aggregate Port for details) as a Trunk port.

You should specify a native VLAN for a Trunk port. The untagged packets received by and sent from the Trunk port are considered to belong to the native VLAN. The default VLAN ID (PVID in the IEEE 802.1Q) of this Trunk port is the native VLAN ID. Meanwhile, frames of the native VLAN sent via the Trunk are untagged. The default native VLAN of a Trunk port is VLAN 1.

When configuring a Trunk link, make sure the Trunk ports at the two ends of the link adopt the same native VLAN.

*Configuration Steps *

→ Configuring a Trunk Port

- Mandatory.
- Configure a Trunk port to transmit the flows from multiple VLANs.
- Configuration:

Command	switchport mode trunk
Parameter Description	N/A
Defaults	The default mode is Access, which can be modified to Trunk.
Command Mode	Interface configuration mode
Usage Guide	To restore all properties of a Trunk port to defaults, use the no switchport mode command.

→ Defining Allowed-VLANs for a Trunk Port

- Optional.
- By default, a trunk port transmits the flows from all the VLANs (1 to 4094). You may configure a list of allowed-VLANs to prohibit flows of some VLANs from passing through a Trunk port.
- Configuration:

Command	switchport trunk allowed vlan { all [add remove except only] } vlan-list
Parameter Description	The parameter vlan-list can be a VLAN or some VLANs, and the VLAN IDs are connected by "-" in order. For example: 10-20. all indicates allowed-VLANs include all VLANs; add indicates adding a specific VLAN to the list of allowed-VLANs; remove indicates removing a specific VLAN from the list of allowed-VLANs; except indicates adding all VLANs except those in the listed VLAN to the list of allowed-VLANs. only indicates adding the listed VLANs to the list of allowed-VLANs, and removing the other VLANs from the list.
Defaults	The Trunk port and the Uplink port belong to all VLANs.
Command Mode	Interface configuration mode
Usage Guide	To restore the configuration on a Trunk port to defaults (all), use the no switchport trunk allowed vlan command.

→ Configuring a Native VLAN

- Optional.
- A Trunk port receives and sends tagged or untagged 802.1Q frames. Untagged frames transmit the flows from the native VLAN. The default native VLAN is VLAN 1.
- If a frame carries the VLAN ID of a native VLAN, its tag will be stripped automatically when it passes a Trunk port.
- Configuration:

Command	switchport trunk native vlan vlan-id
Parameter Description	vlan-id: indicates a VLAN ID.
Defaults	The default VALN for a Trunk/Uplink port is VLAN 1.
Command Mode	Interface configuration mode

Usage Guide	To restore the native VLAN of a Trunk port back to defaults, use the no switchport trunk native vlan command.
-------------	---



When you set the native VLAN of a port to a non-existent VLAN, this VLAN will not be created automatically. Besides, the native VLAN can be out of the list of allowed-VLANs for this port. In this case, the flows from the native VLAN cannot pass through the port.

Verification

- Send tag packets to a Trunk port, and they are broadcast within the specified VLANs.
- Use commands show vlan and show interface switchport to check whether the configuration takes effect.

Command	show vlan [id vlan-id]
Parameter Description	vlan-id : indicates a VLAN ID.
Command Mode	Any mode
Usage Guide	N/A
Command Display	<pre>Switch(config-vlan)#show vlan id 20 VLAN Name Status Ports ----- 20 VLAN0020 STATIC Gi0/1</pre>

Configuration Example

→ Configuring Basic VLAN to Realize Layer-2 Isolation and Layer-3 Interconnection

<p>Scenario</p>	
<p>Configuration Steps</p>	<p>Networking Requirements: As shown in the figure above, an intranet is divided into VLAN 10, VLAN 20 and VLAN 30, realizing Layer-2 isolation from each other. The three VLANs correspond respectively to the IP sub-networks 192.168.10.0/24, 192.168.20.0/24, and 192.168.30.0/24, realizing interconnection with each other through IP forwarding by Layer-3 core switches. Key Points:</p> <p>The following example describes the configuration steps on a core switch and an access switch.</p> <ul style="list-style-type: none"> • Configure three VLANs on a core switch and the port connected to the access switches as a Trunk port, and specify a list of allowed-VLANs to realize Layer-2 isolation. • Configure three SVIs on the core switch, which are the gateway interfaces of the IP sub-networks corresponding to the three VLANs, and configure the IP addresses for these interfaces. • Create VLANs respectively on the three access switches, assign Access ports for the VLANs, and specify Trunk ports of the core switch. The following example describes the configuration steps on Switch A.

D

```
D#configure terminal
D(config)#vlan 10
D(config-vlan)#vlan 20
D(config-vlan)#vlan 30
D(config-vlan)#exit
D(config)#interface range GigabitEthernet 0/2-4
D(config-if-range)#switchport mode trunk
D(config-if-range)#exit
D(config)#interface GigabitEthernet 0/2
D(config-if-GigabitEthernet 0/2)#switchport trunk allowed vlan
remove 1-4094
D(config-if-GigabitEthernet 0/2)#switchport trunk allowed vlan
add 10,20
D(config-if-GigabitEthernet 0/2)#interface GigabitEthernet 0/3
D(config-if-GigabitEthernet 0/3)#switchport trunk allowed vlan
remove 1-4094
D(config-if-GigabitEthernet 0/3)#switchport trunk allowed vlan
add 10,20,30
D(config-if-GigabitEthernet 0/3)#interface GigabitEthernet 0/4
D(config-if-GigabitEthernet 0/4)#switchport trunk allowed vlan
remove 1-4094
D(config-if-GigabitEthernet 0/4)#switchport trunk allowed vlan
add 20,30
D#configure terminal
D(config)#interface vlan 10
D(config-if-VLAN 10)#ip address 192.168.10.1 255.255.255.0
D(config-if-VLAN 10)#interface vlan 20
D(config-if-VLAN 20)#ip address 192.168.20.1 255.255.255.0
D(config-if-VLAN 20)#interface vlan 30
D(config-if-VLAN 30)#ip address 192.168.30.1 255.255.255.0
D(config-if-VLAN 30)#exit
```

A	<pre>A#configure terminal A(config)#vlan 10 A(config-vlan)#vlan 20 A(config-vlan)#exit A(config)#interface range GigabitEthernet 0/2-12 A(config-if-range)#switchport mode access A(config-if-range)#switchport access vlan 10 A(config-if-range)#interface range GigabitEthernet 0/13-24 A(config-if-range)#switchport mode access A(config-if-range)#switchport access vlan 20 A(config-if-range)#exit A(config)#interface GigabitEthernet 0/1 A(config-if-GigabitEthernet 0/1)#switchport mode trunk</pre>
Verification	<p>Display the VLAN configuration on the core switch.</p> <ul style="list-style-type: none">• Display VLAN information including VLAN IDs, VLAN names, status and involved ports.• Display the status of ports Gi 0/2, Gi 0/3 and Gi 0/4.

D	<pre> D#show vlan VLAN Name Status Ports ----- 1 VLAN0001 STATIC Gi0/1, Gi0/5, Gi0/6, Gi0/7 Gi0/8, Gi0/9, Gi0/10, Gi0/11 Gi0/12, Gi0/13, Gi0/14, Gi0/15 Gi0/16, Gi0/17, Gi0/18, Gi0/19 Gi0/20, Gi0/21, Gi0/22, Gi0/23 Gi0/24 10 VLAN0010 STATIC Gi0/2, Gi0/3 20 VLAN0020 STATIC Gi0/2, Gi0/3, Gi0/4 30 VLAN0030 STATIC Gi0/3, Gi0/4 D#show interface GigabitEthernet 0/2 switchport Interface Switchport Mode Access Native Protected VLAN lists ----- GigabitEthernet 0/2 enabled TRUNK 1 1 Disabled 10,20 D#show interface GigabitEthernet 0/3 switchport Interface Switchport Mode Access Native Protected VLAN lists ----- GigabitEthernet 0/3 enabled TRUNK 1 1 Disabled 10,20,30 D#show interface GigabitEthernet 0/4 switchport Interface Switchport Mode Access Native Protected VLAN lists ----- GigabitEthernet 0/4 enabled TRUNK 1 1 Disabled 20,30 </pre>
---	--

4.4.3. Configuring an Uplink Port

Configuration Effect

- An Uplink port is usually used in QinQ (the IEEE 802.1ad standard) environment, and is similar to a Trunk port. Their difference is that an Uplink port only transmits tagged frames while a Trunk port sends untagged frames of the native VLAN.

Configuration Steps

→ Configuring an Uplink Port

- Mandatory.
- Configure an Uplink port to transmit the flows from multiple VLANS, but only tagged frames can be transmitted.
- Configuration:

Command	switchport mode uplink
Parameter Description	N/A
Defaults	The default mode is Access, which can be modified to Uplink.
Command Mode	Interface configuration mode
Usage Guide	To restore all properties of an Uplink port to defaults, use the no switchport mode command.

→ Defining Allowed-VLANs for a Trunk Port

- Optional.
- You may configure a list of allowed-VLANs to prohibit flows of some VLANs from passing through an Uplink port.
- Configuration:

Command	switchport trunk allowed vlan { all [add remove except only] } vlan-list
Parameter Description	The parameter vlan-list can be a VLAN or some VLANs, and the VLAN IDs are connected by "-" in order. For example: 10-20. all indicates allowed-VLANs include all VLANs; add indicates adding a specific VLAN to the list of allowed-VLANs; remove indicates removing a specific VLAN from the list of allowed-VLANs; except indicates adding all VLANs except those in the listed VLAN to the list of allowed-VLANs; and only indicates adding the listed VLANs to the list of allowed-VLANs, and removing the other VLANs from the list.
Command Mode	Interface configuration mode

Usage Guide	To restore the allowed-VLANs to defaults (all), use the no switchport trunk allowed vlan command.
-------------	---

→ Configuring a Native VLAN

- Optional.
- If a frame carries the VLAN ID of a native VLAN, its tag will not be stripped when it passes an Uplink port. This is contrary to a Trunk port.
- Configuration:

Command	switchport trunk native vlan vlan-id
Parameter Description	vlan-id: indicates a VLAN ID.
Command Mode	Interface configuration mode
Usage Guide	To restore the native VLAN of an Uplink to defaults, use the no switchport trunk native vlan command.

Verification

- Send tag packets to an Uplink port, and they are broadcast within the specified VLANs.
- Use commands show vlan and show interface switchport to check whether the configuration takes effect.

Command	show vlan [id vlan-id]
Parameter Description	vlan-id : indicates a VLAN ID.
Command Mode	Any mode
Usage Guide	N/A
Command Display	<pre>Switch(config-vlan)#show vlan id 20 VLAN Name Status Ports ----- 20 VLAN0020 STATIC Gi0/1</pre>

Configuration Example

→ Configuring an Uplink Port

<p>Configuration Steps</p>	<p>The following is an example of configuring Gi0/1 as an Uplink port.</p>
	<pre>Switch# configure terminal Switch(config)# interface gi 0/1 Switch(config-if-GigabitEthernet 0/1)# switchport mode uplink Switch(config-if-GigabitEthernet 0/1)# end</pre>
<p>Verification</p>	<p>Check whether the configuration is correct.</p>
	<pre>Switch# show interfaces GigabitEthernet 0/1 switchport Interface Switchport Mode Access Native Protected VLAN lists ----- GigabitEthernet 0/1 enabled UPLINK 1 1 disabled ALL</pre>

4.4.4. Configuring a Hybrid Port

Configuration Effect

- A Hybrid port is usually used in SHARE VLAN environment. By default, a Hybrid port is the same as a Trunk port. Their difference is that a Hybrid port can send the frames from the VLANs except the default VLAN in the untagged format.

Configuration Steps

→ Configuring a Hybrid Port

- Mandatory.
- Configure a Hybrid port to transmit the flows from multiple VLANs.

- Configuration:

Command	switchport mode hybrid
Parameter Description	N/A
Defaults	The default mode is Access, which can be modified to Hybrid.
Command Mode	Interface configuration mode
Usage Guide	To restore all properties of a Hybrid port to defaults, use the no switchport mode command.

→ Defining Allowed-VLANs for a Hybrid Port

- Optional.
- By default, a Hybrid port transmits the flows from all the VLANs (1 to 4094). You may configure a list of allowed-VLANs to prohibit flows of some VLANs from passing through a Hybrid port.
- Configuration:

Command	switchport hybrid allowed vlan [[add only] tagged [add] untagged remove] vlan_list
Parameter Description	vlan-id: indicates a VLAN ID.
Defaults	By default a Hybrid port belongs to all VLANs. The port is added to the default VLAN in untagged form and to the other VLANs in the tagged form.
Command Mode	Interface configuration mode
Interface configuration mode	N/A

→ Configuring a Native VLAN

- Optional.
- If a frame carries the VLAN ID of a native VLAN, its tag will be stripped automatically when it passes a Hybrid port.
- Configuration:

Command	switchport hybrid native vlan vlan_id
Parameter Description	vlan-id: indicates a VLAN ID.
Defaults	The default native VLAN is VLAN 1.
Command Mode	Interface configuration mode
Usage Guide	To restore the native VLAN of a Hybrid port to defaults, use the no switchport hybrid native vlan command.

Verification

- Send tagged packets to an Hybrid port, and they are broadcast within the specified VLANs.
- Use commands show vlan and show interface switchport to check whether the configuration takes effect.

Command	show vlan [id vlan-id]
Parameter Description	vlan-id : indicates a VLAN ID.
Command Mode	Any mode
Usage Guide	N/A
Command Display	<pre> Switch(config-vlan)#show vlan id 20 VLAN Name Status Ports ----- 20 VLAN0020 STATIC Gi0/1 </pre>

Configuration Example

→ Configuring a Hybrid Port

<p>Configuration Steps</p>	<p>The following is an example of configuring Gi0/1 as a Hybrid port.</p>
	<pre>Switch# configure terminal Switch(config)# interface gigabitEthernet 0/1 Switch(config-if-GigabitEthernet 0/1)# switchport mode hybrid Switch(config-if-GigabitEthernet 0/1)# switchport hybrid native vlan 3 Switch(config-if-GigabitEthernet 0/1)# switchport hybrid allowed vlan untagged 20-30 Switch(config-if-GigabitEthernet 0/1)# end</pre>
<p>Verification</p>	<p>Check whether the configuration is correct.</p>
	<pre>Switch(config-if-GigabitEthernet 0/1)#show run interface gigabitEthernet 0/1 Building configuration... Current configuration : 166 bytes interface GigabitEthernet 0/1 switchport switchport mode hybrid switchport hybrid native vlan 3 switchport hybrid allowed vlan add untagged 20-30</pre>

4.5. Monitoring

Displaying

Description	Command
Displays VLAN configuration.	show vlan
Displays configuration of switch ports.	show interface switchport

Debugging



System resources are occupied when debugging information is output. Disable the debugging switch immediately after use.

Description	Command
Debugs VLANs.	debug bridge vlan

5. Configuring Super VLAN

5.1. Overview

Super virtual local area network (VLAN) is an approach to dividing VLANs. Super VLAN is also called VLAN aggregation, and is a management technology tailored for IP address optimization.

Using super VLAN can greatly save IP addresses. Only one IP address needs to be assigned to the super VLAN that consists of multiple sub VLANs, which greatly saves IP addresses and facilitates network management.

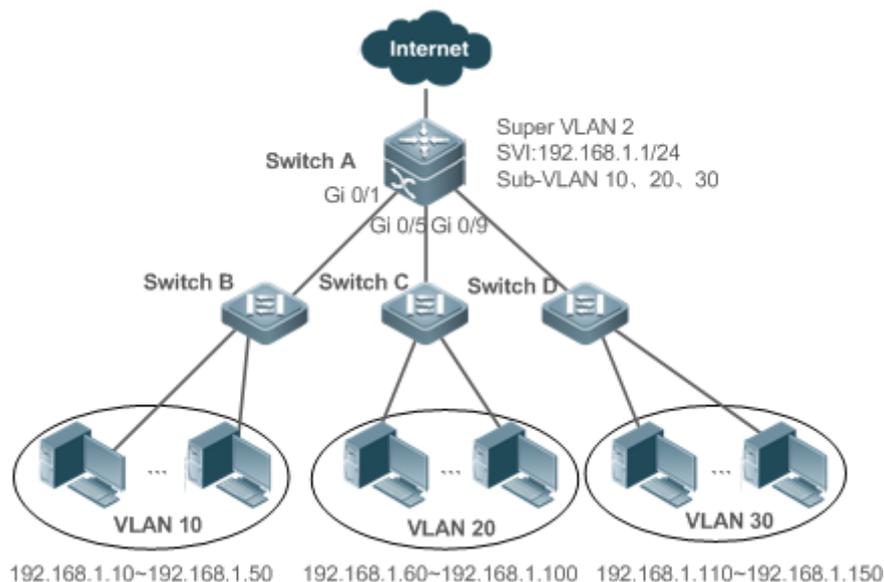
5.2. Application

Application	Description
Sharing One IP Gateway Among Multiple VLANs	VLANs are divided to implement layer-2 (L2) isolation of access users. All VLAN users share one IP gateway to implement layer-3 (L3) communication and communication with external networks.

5.2.1. Sharing One IP Gateway Among Multiple VLANs

Scenario

Multiple VLANs are isolated at L2 on a L3 device, but users of these VLANs can perform L3 communication with each other in the same network segment.



Remarks	<p>Switch A is a gateway or core switch. Switch B, Switch C, and Switch D are access switches. On Switch A, a super VLAN and multiple sub VLANs are configured, and a L3 interface and the IP address of the L3 interface are configured for the super VLAN. VLAN 10 is configured on Switch B, VLAN 20 is configured on Switch C, and VLAN 30 is configured on Switch D. Different departments of the company reside in different VLANs.</p>
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Deployment

On the intranet, use the super VLAN so that multiple sub VLANs can share one IP gateway and meanwhile VLANs are mutually isolated at L2.

Users in sub VLANs can perform L3 communication through the gateway of the super VLAN.

5.3. Features

Basic Concepts

→ Super VLAN

Super VLAN is also called VLAN aggregation, and is a management technology tailored for IP address optimization. It aggregates multiple VLANs to one IP network segment. No physical port can be added to a super VLAN. The switch virtual interface (SVI) is used to manage the cross-VLAN communication of sub VLANs. The super VLAN cannot be used as a common 802.1Q VLAN, but can be treated as the primary VLAN of sub VLANs.

→ Sub VLAN

A sub VLAN is an independent broadcast domain. Sub VLANs are mutually isolated at L2. Users of sub VLANs of the same or different super VLANs communicate with each other through the L3 SVIs of their own super VLANs.

→ ARP Proxy

A L3 SVI can be created only for a super VLAN. Users in a sub VLAN communicate with users in other sub VLANs of the same super VLAN or users in other network segments through the ARP proxy and the L3 SVI of the super VLAN. When a user of a sub VLAN sends an ARP request to a user of another sub VLAN, the gateway of the super VLAN uses its own MAC address to send or respond to the ARP requests. The process is called ARP proxy.

→ IP Address Range of the Sub VLAN

Based on the gateway IP address configured for the super VLAN, an IP address range can be configured for each sub VLAN.

Overview

Feature	Description
Super VLAN	Create a L3 interface as anSVI to allow all sub VLANs to share the same IP network segment through the ARP proxy.

5.3.1 Super VLAN

Users of all sub VLANs of a super VLAN can be allocated IP addresses in the same IP address range, and share the same IP gateway. Users can implement cross-VLAN communication through this gateway. It is unnecessary to allocate a gateway for every VLAN, which saves the IP addresses.

Working Principle

IP addresses in a network segment are allocated to different sub VLANs that belong to the same super VLAN. Each sub VLAN has an independent broadcast domain of the VLAN, and different sub VLANs are isolated from each other at L2. When users in sub VLANs need to perform L3 communication, the IP address of the SVI of the super VLAN is used as the gateway address. In this way, multiple VLANs share the same IP gateway, and it is unnecessary to configure a gateway for every VLAN. In addition, to implement L3 communication between sub VLANs and between sub VLANs and other network segments, the ARP proxy function is used to forward and process the ARP requests and responses.

L2 communication of sub VLANs: If the SVI is not configured for the super VLAN, sub VLANs of super VLAN are mutually isolated at L2, that is, users in different sub VLANs cannot communicate with each other. If the SVI is configured for the super VLAN, and the gateway of the super VLAN can function as the ARP proxy, users in different sub VLANs of the same super VLAN can communicate with each other. This is because IP addresses of users in different sub VLANs belong to the same network segment, and communication between these users is still treated as L2 communication.

L3 communication of sub VLANs: If users in sub VLANs of a super VLAN need to perform L3 communication across network segments, the gateway of this super VLAN functions as the ARP proxy to respond to the ARP requests in place of sub VLANs.

5.4. Configuration

Configuration Item	Description and Command	
Configuring Basic Functions of the Super VLAN	Mandatory	
	supervlan	Configures a super VLAN
	supervlanvlan-id	Configures a sub VLAN
	proxy-arp	Enables the ARP proxy function
	interface vlanvlan-id	Creates a virtual interface for a super VLAN
	ip addressip mask	Configures the IP address of the virtual interface of a super VLAN
	Optional	
	subvlan-address-range start-ip end-ip	Specifies the IP address range in a sub VLAN

5.4.1. Configuring Basic Functions of the Super VLAN

Configuration Effect

Enable the super VLAN function and configure an SVI for the super VLAN to implement L2/L3 communication between sub VLANs across VLANs.

Users in all sub VLANs of a super VLAN share the same IP gateway. It is unnecessary to specify a network segment for every VLAN, which saves the IP addresses.

Notes



A super VLAN does not belong to any physical port. Therefore, the device configured with the super VLAN cannot process packets that contain the super VLAN tag.



Both the super VLAN function and the ARP proxy function of each sub VLAN must be enabled.



An SVI and an IP address must be configured for a super VLAN. The SVI is a virtual interface used for communication of users in all sub VLANs.

Configuration Steps

→ Configuring a Super VLAN

- Mandatory.
- No physical port exists in a super VLAN.
- The ARP proxy function must be enabled. This function is enabled by default.
- You can run the supervlan command to change a common VLAN into a super VLAN.
- After a common VLAN becomes a super VLAN, ports added to this VLAN will be deleted from this VLAN because no physical port exists in a super VLAN.



A super VLAN is valid only after you configure sub VLANs for this super VLAN.



VLAN 1 cannot be configured as a super VLAN.



A super VLAN cannot be configured as a sub VLAN of another super VLAN. A sub VLAN of a super VLAN cannot be configured as a super VLAN.

Command	supervlan
Parameter Description	N/A
Defaults	By default, a VLAN is a common VLAN.
Command Mode	VLAN configuration mode
Usage Guide	By default, the super VLAN function is disabled. No physical port can be added to a super VLAN. Once a VLAN is not a super VLAN, all its sub VLANs become common static VLANs.

→ Configuring a Virtual Interface for a Super VLAN

- Mandatory.
- No physical port can be added to a super VLAN. You can configure the L3 SVI for a VLAN.



When a super VLAN is configure with an SVI, it allocates a L3 interface i to each sub VLANs. If a sub VLAN is not allocated a L3 interfacedue to resource deficiency, the sub VLAN becomes a common VLAN again.

Command	interface vlanvlan-id
Parameter Description	vlan-id: Indicates the ID of the super VLAN.
Defaults	By default, no super VLAN is configured.
Command Mode	Global configuration mode
Usage Guide	A L3 interface must be configured as the virtual interface of a super VLAN.

→ Configuring the Gateway of a Super VLAN

- Mandatory.
- The IP gateway on the L3 SVI is configured as the proxy for all users in sub VLANs to respond to ARP requests.

Command	ip addressip mask
Parameter Description	ip: Indicates the IP address of the gateway on the virtual interface of a super VLAN. Mask: Indicates the mask.
Defaults	By default, no gateway is configured for a super VLAN.
Command Mode	Interface configuration mode
Usage Guide	Run this command to configure the gateway for a super VLAN. Users of all sub VLANs of the super VLAN share this gateway.

→ Configuring a Sub VLAN

- Mandatory.
- Physical ports can be added to sub VLANs. Sub VLANs of a super VLAN share the gateway address of the super VLAN and reside in the same network segment.
- The ARP proxy function must be enabled. This function is enabled by default.
- You can run the subvlanvlan-id-list command to change a common VLAN into a sub VLAN of a super VLAN. Physical ports can be added to sub VLANs. *Communication of users in a sub VLAN is managed by the super VLAN.



You must change a sub VLAN into a common VLAN before you can delete this sub VLAN by running the no vlan command.



One sub VLAN belongs to only one super VLAN.

Command	subvlanvlan-id-list
Parameter Description	vlan-id-list : Specifies multiple VLANs as sub VLANs of a super VLAN.
Defaults	By default, a VLAN is a common VLAN.
Command Mode	VLAN configuration mode
Usage Guide	<p>Connection interfaces can be added to a sub VLAN. You must change a sub VLAN into a common VLAN before you can delete this sub VLAN by running the no vlan [id]command.</p> <p>You cannot configure a L3 SVI of the VLAN for a sub VLAN.</p> <div style="display: flex; align-items: flex-start; margin-top: 10px;"> <div style="margin-right: 10px; text-align: center;">  </div> <div> <p>If you have configured a L3 SVI for a super VLAN, the attempt of adding more sub VLANs may fail due to resource deficiency.</p> </div> </div> <div style="display: flex; align-items: flex-start; margin-top: 10px;"> <div style="margin-right: 10px; text-align: center;">  </div> <div> <p>If you configure sub VLANs to a super VLAN, and then configure a L3 SVI of the VLAN for a super VLAN, some sub VLANs may become common VLANs again due to resource deficiency.</p> </div> </div>

→ Configuring the ARP Proxy

- (Mandatory) The ARP proxy function is enabled by default.
- Users in sub VLANs can implement L2/L3 communication across VLANs through the gateway proxy only after the ARP proxy function is enabled on both the super VLAN and sub VLANs.
- Users in sub VLANs can communicate with users of other VLANs only after the ARP proxy function is enabled on both the super VLAN and sub VLANs.



The ARP proxy function must be enabled on both the super VLAN and sub VLANs. Otherwise, this function does not take effect.

Command	proxy-arp
Parameter Description	N/A
Defaults	By default, the ARP proxy function is enabled.

Command Mode	VLAN configuration mode
Usage Guide	By default, the ARP proxy function is enabled. Run this command to enable the ARP proxy function on both the super VLAN and sub VLANs. Users in sub VLANs can implement L2/L3 communication across VLANs only after the ARP proxy function is enabled on both the super VLAN and sub VLANs.

→ Configuring the IP Address Range of the Sub VLAN

- You can allocate an IP address range to each sub VLAN. Users in a sub VLAN can communicate with users of other VLANs only when their IP addresses are in the specified range.
- Unless otherwise specified, you do not need to configure the IP address range.



IP addresses dynamically allocated to users through DHCP may not be in the allocated IP address range. If the IP addresses allocated through DHCP are not in the specified range, users in a sub VLAN cannot communicate with users of other VLANs. Therefore, be cautious in using the `subvlan-address-range start-ip end-ip` command.



The IP address range of a sub VLAN must be within the IP address range of the super VLAN to which the sub VLAN belongs. Otherwise, users in sub VLANs cannot communicate with each other.



IP addresses of users in a sub VLAN must be within the IP address range of the sub VLAN. Otherwise, users in the sub VLAN cannot communicate with each other.

Command	<code>subvlan-address-range start-ip end-ip</code>
Parameter Description	<code>start-ip</code> : Indicates the start IP address of a sub VLAN. <code>end-ip</code> : Indicates the end IP address of a sub VLAN.
Defaults	By default, no IP address range is configured.
Command Mode	VLAN configuration mode

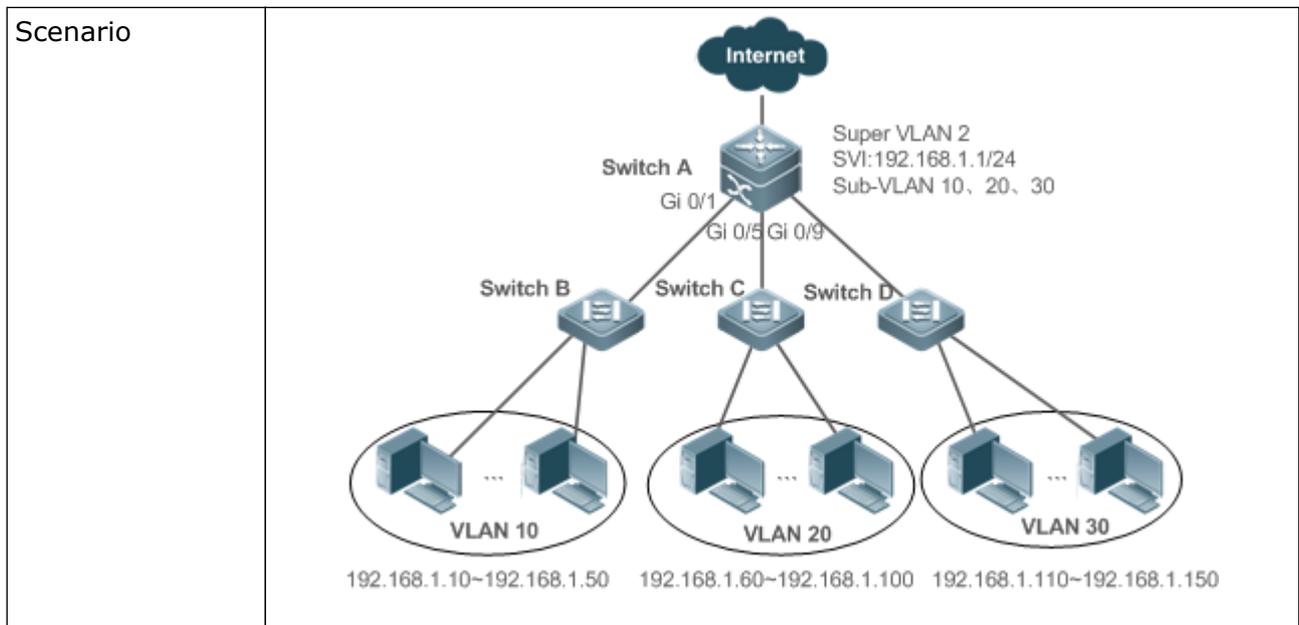
Usage Guide	<p>Optional.</p> <p>Run this command to configure the IP address range of users in a sub VLAN. IP address ranges of different sub VLANs of a super VLAN cannot overlap with each other.</p> <div style="display: flex; flex-direction: column; gap: 10px;"> <div data-bbox="459 555 536 622"> <p>The IP address range of a sub VLAN must be within the IP address range of the super VLAN to which the sub VLAN belongs. Otherwise, users in sub VLANs cannot communicate with each other.</p> </div> <div data-bbox="459 741 536 808"> <p>Users in a sub VLAN can communicate with users of other VLANs only when their IP addresses (either dynamically allocated through DHCP or statically configured) are in the configured IP address range.</p> </div> <div data-bbox="459 927 536 994"> <p>IP addresses allocated through DHCP may not be in the configured IP address range. In this case, users in a sub VLAN cannot communicate with users of other VLANs. Therefore, be cautious when using this command.</p> </div> </div>
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Verification

After each sub VLAN is correlated with the gateway of the super VLAN, users in sub VLANs can ping each other.

Configuration Example

→ Configuring a Super VLAN on the Network so That Users in its Sub VLANs Use the Same Network Segment and Share the Same IP Gateway to Save IP Addresses



Configuration Steps	Perform the related super VLAN configuration on the core switch. On the access switches, configure the common VLANs corresponding to the sub VLANs on the core switch.
A	<pre> SwitchA#configure terminal Enter configuration commands, one per line. End with CNTL/Z. SwitchA(config)#vlan 2 SwitchA(config-vlan)#exit SwitchA(config)#vlan 10 SwitchA(config-vlan)#exit SwitchA(config)#vlan 20 SwitchA(config-vlan)#exit SwitchA(config)#vlan 30 SwitchA(config-vlan)#exit SwitchA(config)#vlan 2 SwitchA(config-vlan)#supervlan SwitchA(config-vlan)#subvlan 10,20,30 SwitchA(config-vlan)#exit SwitchA(config)#interface vlan 2 SwitchA(config-if-VLAN 2)#ip address 192.168.1.1 255.255.255.0 SwitchA(config)#vlan 10 SwitchA(config-vlan)#subvlan-address-range 192.168.1.10 192.168.1.50 SwitchA(config-vlan)#exit SwitchA(config)#vlan 20 SwitchA(config-vlan)#subvlan-address-range 192.168.1.60 192.168.1.100 SwitchA(config-vlan)#exit SwitchA(config)#vlan 30 SwitchA(config-vlan)#subvlan-address-range 192.168.1.110 192.168.1.150 SwitchA(config)#interface range gigabitEthernet 0/1,0/5,0/9 SwitchA(config-if-range)#switchport mode trunk </pre>
Verification	Verify that the source host (192.168.1.10) and the destination host (192.168.1.60) can ping each other.

A	<pre>SwitchA(config-if-range)#show supervlan supervlan id supervlan arp-proxy subvlan id subvlan arp-proxy subvlan ip range ----- ----- 2 ON 10 ON192.168.1.10 - 192.168.1.50 20 ON 192.168.1.60 - 192.168.1.100 30 ON 192.168.1.110 - 192.168.1.150</pre>
---	--

Common Errors

The SVI and IP gateway are not configured for the super VLAN. Consequently, communication fails between sub VLANs and between sub VLANs and other VLANs.

The ARP proxy function is disabled on the super VLAN or sub VLANs. Consequently, users in sub VLANs cannot communicate with users of other VLANs.

The IP address range of the sub VLAN is configured, but IP addresses allocated to users are not in this range.

5.5. Monitoring

Displaying

Description	Command
Displays the super VLAN configuration.	show supervlan

Debugging



System resources are occupied when debugging information is output. Therefore, disable debugging immediately after use.

Description	Command
Debugs the super VLAN.	debug bridge svlan

6. Configuring Private VLAN

6.1. Overview

Private VLAN divides the Layer-2 broadcast domain of a VLAN into multiple subdomains. Each subdomain is composed of one private VLAN pair: primary VLAN and secondary VLAN. One private VLAN domain may consist of multiple private VLAN pairs and each private VLAN pair represents one subdomain. In a private VLAN domain, all private VLAN pairs share the same primary VLAN. The secondary VLAN IDs of subdomains are different.

If a service provider allocates one VLAN to each user, the number of users that can be supported by the service provider is restricted because one device supports a maximum of 4,096 VLANs. On a Layer-3 device, one subnet address or a series of addresses are allocated to each VLAN, which results in the waste of IP addresses. The private VLAN technology properly solves the preceding two problems. Private VLAN is hereinafter called PVLAN for short.

6.2. Applications

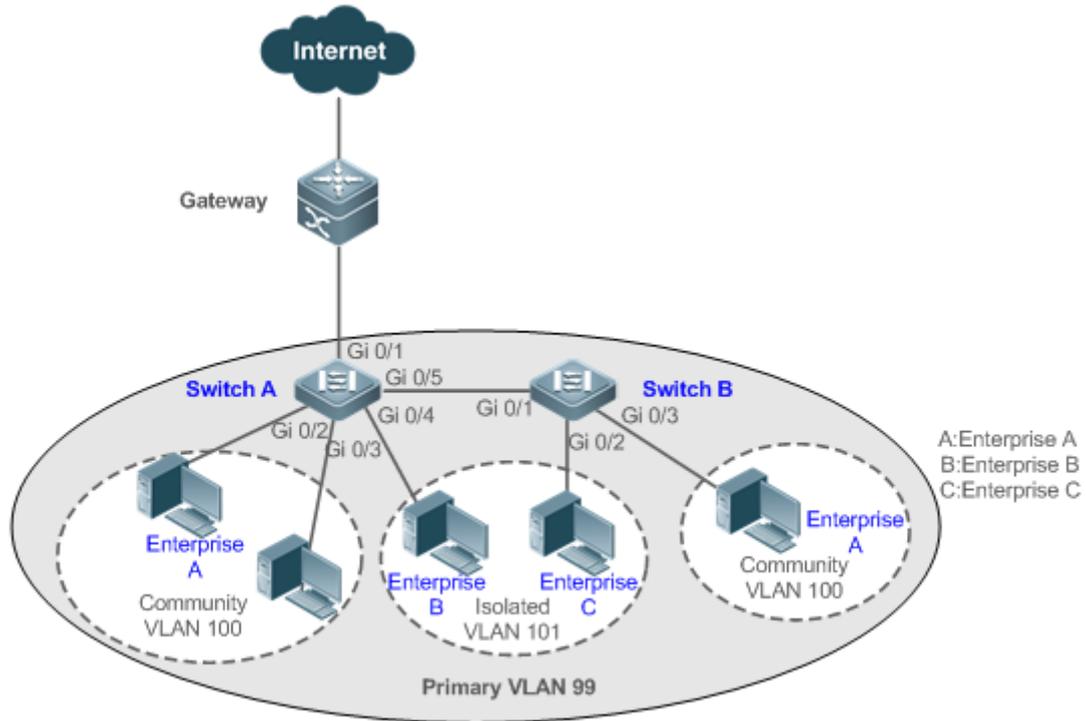
Application	Description
Cross-Device Layer-2 Application of PVLAN	Users of an enterprise can communicate with each other but the user communication between enterprises is isolated.
Layer-3 Application of PVLAN on a Single Device	All enterprise users share the same gateway address and can communicate with the external network.

6.2.1. Cross-Device Layer-2 Application of PVLAN

Scenario

As shown in the following figure, in the hosting service operation network, enterprise user hosts are connected to the network through Switch A or Switch B. The main requirements are as follows:

- Users of an enterprise can communicate with each other but the user communication between enterprises is isolated.
- All enterprise users share the same gateway address and can communicate with the external network.



Remarks	Switch A and Switch B are access switches. PVLAN runs across devices. The ports for connecting the devices need to be configured as Trunk ports, that is, Port Gi 0/5 of Switch A and Port Gi 0/1 of Switch B are configured as Trunk ports. Port Gi 0/1 for connecting Switch A to the gateway needs to be configured as a promiscuous port. Port Gi 0/1 of the gateway can be configured as a Trunk port or Hybrid port and the Native VLAN is the primary VLAN of PVLAN.
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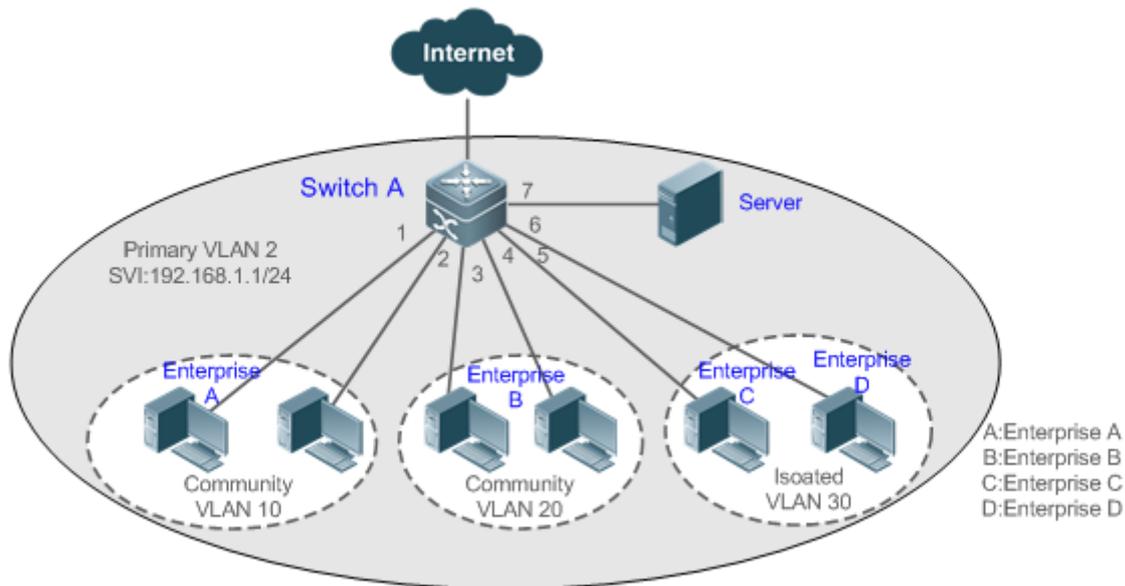
Deployment

- Configure all enterprises to be in the same PVLAN (primary VLAN 99 in this example). All enterprise users share the same Layer-3 interface through this VLAN to communicate with the external network.
- If an enterprise has multiple user hosts, allocate the user hosts of different enterprises to different community VLANs. That is, configure the ports connected to the enterprise user hosts as the host ports of a community VLAN, so as to implement user communication inside an enterprise but isolate the user communication between enterprises.
- If an enterprise has only one user host, configure the ports connected to the user hosts of such enterprises as the host ports of an isolated VLAN so as to implement isolation of user communication between the enterprises.

6.2.2. Layer-3 Application of PVLAN on a Single Device

As shown in the following figure, in the hosting service operation network, enterprise user hosts are connected to the network through the Layer-3 device Switch A. The main requirements are as follows:

- Users of an enterprise can communicate with each other but the user communication between enterprises is isolated.
- All enterprise users can access the server.
- All enterprise users share the same gateway address and can communicate with the external network.



Remarks	Switch A is a gateway switch. When user hosts are connected to a single device, Port Gi 0/7 for connecting to the server is configured as a promiscuous port so that enterprise users can communicate with the server. Layer-3 mapping needs to be performed on the primary VLAN and secondary VLANs so that the users can communicate with the external network.
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Deployment

- Configure the port that is directly connected to the server as a promiscuous port. Then, all enterprise users can communicate with the server through the promiscuous port.
- Configure the gateway address of PVLAN on the Layer-3 device (Switch A in this example) (in this example, set the SVI address of VLAN 2 to 192.168.1.1/24) and configure the mapping between the primary VLAN and secondary VLANs on the Layer-3 interface. Then, all enterprise users can communicate with the external network through the gateway address.

6.3. Features

Basic Concepts

→ PVLAN

PVLAN supports three types of VLANs: primary VLANs, isolated VLANs, and community VLANs. A PVLAN domain has only one primary VLAN. Secondary VLANs implement Layer-2 isolation in the same PVLAN domain. There are two types of secondary VLANs.

→ Isolated VLAN

Ports in the same isolated VLAN cannot mutually make Layer-2 communication. A PVLAN domain has only one isolated VLAN.

→ Community VLAN

Ports in the same community VLAN can make Layer-2 communication with each other but cannot make Layer-2 communication with ports in other community VLANs. A PVLAN domain can have multiple community VLANs.

→ Layer-2 Association of PVLAN

PVLAN pairs exist only after Layer-2 association is performed among the three types of VLANs of PVLAN. Then, a primary VLAN has a specified secondary VLAN and a secondary VLAN has a specified primary VLAN. A primary VLAN and secondary VLANs are in the one-to-many relationship.

→ Layer-3 Association of PVLAN

In PVLAN, Layer-3 interfaces, that is, switched virtual interfaces (SVIs) can be created only in a primary VLAN. Users in a secondary VLAN can make Layer-3 communication only after Layer-3 association is performed between the secondary VLAN and the primary VLAN. Otherwise, the users can make only Layer-2 communication.

→ Isolated Port

A port in an isolated VLAN can communicate only with a promiscuous port. An isolated port can forward the received packets to a Trunk port but a Trunk port cannot forward the packets with the VID of an isolated VLAN to an isolated port.

→ Community Port

Community ports are ports in a community VLAN. Community ports in the same community VLAN can communicate with each other and can communicate with promiscuous ports. They cannot communicate with community ports in other community VLANs or isolated ports in an isolated VLAN.

→ Promiscuous Port

Promiscuous ports are ports in a primary VLAN. They can communicate with any ports, including isolated ports and community ports in secondary VLANs of the same PVLAN domain.

→ Promiscuous Trunk Port

A promiscuous Trunk port is a member port that belongs to multiple common VLANs and multiple PVLANS at the same time. It can communicate with any ports in the same VLAN.

- In a common VLAN, packet forwarding complies with 802.1Q.
- In PVLAN, for tagged packets to be forwarded by a promiscuous Trunk port, if the VID of the packets is a secondary VLAN ID, the VID is converted into the corresponding primary VLAN ID before packet forwarding.

→ Isolated Trunk Port

An isolated Trunk port is a member port that belongs to multiple common VLANs and multiple PVLANS at the same time.

- In an isolated VLAN, an isolated Trunk port can communicate only with a promiscuous port.
- In a community VLAN, an isolated Trunk port can communicate with community ports in the same community VLAN and promiscuous ports.
- In a common VLAN, packet forwarding complies with 802.1Q.
- An isolated Trunk port can forward the received packets of an isolated VLAN ID to a Trunk port but a Trunk port cannot forward the packets with the VID of an isolated VLAN to an isolated port.
- For tagged packets to be forwarded by an isolated Trunk port, if the VID of the packets is a primary VLAN ID, the VID is converted into a secondary VLAN ID before packet forwarding.



In PVLAN, SVIs can be created only in a primary VLAN and SVIs cannot be created in secondary VLANs.



Ports in PVLAN can be used as mirroring source ports but cannot be used as mirroring destination ports. Overview

Feature	Description
PVLAN Layer-2 Isolation and IP Address Saving	<p>Ports of different PVLAN types can be configured to implement interworking and isolation of VLAN intermediate user hosts.</p> <p>After Layer-2 mapping is performed between a primary VLAN and secondary VLANs, only Layer-2 communication is supported. If Layer-3 communication is required, users in a secondary VLAN need to use SVIs of the primary VLAN to make Layer-3 communication.</p>

6.3.1. PVLAN Layer-2 Isolation and IP Address Saving

Add users to subdomains of PVLAN to isolate communication between enterprises and between enterprise users.

Working Principle

Configure PVLAN, configure Layer-2 association and Layer-3 association between a primary VLAN and SubVLANs of PVLAN, and configure ports connected to user hosts, external network devices, and servers as different types of PVLAN ports. In this way, subdomain division and communication of users in subdomains with the external network and servers can be implemented.

→ Packet Forwarding Relationship Between Ports of Different Types

Output Port Input Port	Promiscuous Port	Isolated Port	Community Port	Isolated Trunk Port (in the Same VLAN)	Promiscuous Trunk Port (in the Same VLAN)	Trunk Port (in the Same VLAN)
Promiscuous Port	Supported	Supported	Supported	Supported	Supported	Supported
Isolated Port	Supported	Unsupported	Unsupported	Unsupported	Supported	Supported
Community Port	Supported	Unsupported	Supported	Supported	Supported	Supported
Isolated Trunk Port (in the Same VLAN)	Supported	Unsupported	Supported	Unsupported (unsupported in an isolated VLAN but supported in a non-isolated VLAN)	Supported	Supported
Promiscuous Trunk Port (in the Same VLAN)	Supported	Supported	Supported	Supported	Supported	Supported

Trunk Port (in the Same VLAN)	Supported	Unsupported	Supported	Unsupported (unsupported in an isolated VLAN but supported in a non-isolated VLAN)	Supported	Supported
-------------------------------	-----------	-------------	-----------	--	-----------	-----------

→ VLAN Tag Changes After Packet Forwarding Between Ports of Different Types

Output Port Input Port	Promiscuous Port	Isolated Port	Community Port	Isolated Trunk Port (in the Same VLAN)	Promiscuous Trunk Port (in the Same VLAN)	Trunk Port (in the Same VLAN)
Promiscuous Port	Unchanged	Unchanged	Unchanged	A secondary VLAN ID is added.	A primary VLAN ID tag is added and the VLAN tag keeps unchanged in the non-PVLAN.	A primary VLAN ID tag is added.
Isolated Port	Unchanged	NA	NA	NA	A primary VLAN ID tag is added and the VLAN tag keeps unchanged in the non-PVLAN.	An isolated VLAN ID tag is added.
Community Port	Unchanged	NA	Unchanged	A community VLAN ID tag is added.	A primary VLAN ID tag is added and the VLAN tag keeps unchanged in the non-PVLAN.	A community VLAN ID tag is added.
Isolated Trunk Port (in the Same VLAN)	The VLAN tag is removed.	NA	The VLAN tag is removed.	The VLAN tag keeps unchanged in a non-isolated VLAN.	A primary VLAN ID tag is added and the VLAN tag keeps unchanged in the non-PVLAN.	Unchanged
Promiscuous Trunk Port (in the Same VLAN)	The VLAN tag is removed.	Unchanged	Unchanged	A secondary VLAN ID is added.	A primary VLAN ID tag is added and the VLAN tag keeps unchanged in the non-PVLAN.	Unchanged

Trunk Port (in the Same VLAN)	The VLAN tag is removed .	NA	The VLAN tag is removed .	The VLAN tag is converted into a secondary VLAN ID in a primary VLAN and the VLAN tag keeps unchanged in other non-isolated VLANs.	A primary VLAN ID tag is added and the VLAN tag keeps unchanged in the non-PVLAN.	Unchanged
Switch CPU	Untag	Untag	Untag	A secondary VLAN ID tag is added.	A primary VLAN ID tag is added and the VLAN tag keeps unchanged in the non-PVLAN.	A primary VLAN ID tag is added.

6.4. Configuration

Configuration	Description and Command	
<u>Configuring Basic Functions of PVLAN</u>		(Mandatory) It is used to configure a primary VLAN and secondary VLANs.
	private-vlan {community isolated primary}	Configures the PVLAN type.
		(Mandatory) It is used to configure Layer-2 association between a primary VLAN and secondary VLANs of PVLAN to form PVLAN pairs.
	private-vlan association {svlist add svlist remove svlist}	Configures Layer-2 association between a primary VLAN and secondary VLANs to form PVLAN pairs.
	WARNING (Optional) It is used to allocate users to an isolated VLAN or community VLAN.	
	switchport mode private-vlan host	Configures a PVLAN host port.
	switchport private-vlan host-association p_vid s_vid	Associates Layer-2 ports with PVLAN and allocates ports to subdomains.
		(Optional) It is used to configure a port as a promiscuous port.
	switchport mode private-vlan promiscuous	Configures a PVLAN promiscuous port.
switchport private-vlan mapping p_vid { svlist add svlist remove svlist }	Configures the primary VLAN to which a PVLAN promiscuous port belongs and a list of secondary VLANs. PVLAN packets can be transmitted or received through this port only after the configuration is performed.	

<p><u>Configuring Basic Functions of PVLAN</u></p>	 <p>(Optional) It is used to allocate users to isolated Trunk ports to implement association of multiple PVLANS.</p>
	<p>switchport private-vlan association trunk p_vid s_vid</p> <p>Configures a port connected to a user host as an isolated Trunk port after PVLAN is created and Layer-2 association is performed. Ports of this type support association with multiple PVLAN pairs. The p_vid and s_vid parameters indicate the primary VLAN and isolated VLAN respectively.</p>
	 <p>(Optional) It is used to allocate users to promiscuous Trunk ports to implement association of multiple PVLANS.</p>
	<p>switchport private-vlan promiscuous trunk p_vid s_list</p> <p>Configures a port connected to a user host as a promiscuous Trunk port after PVLAN is created and Layer-2 association is performed. Ports of this type support association with multiple PVLAN pairs. The p_vid and s_list parameters indicate the primary VLAN ID and secondary VLAN ID list respectively.</p>
	 <p>(Optional) It is used to configure Layer-3 communication for users in a secondary VLAN.</p>
	<p>private-vlan mapping { svlist add svlist remove svlist }</p> <p>Configures the SVI of the primary VLAN and configures Layer-3 association between the primary VLAN and secondary VLANs after PVLAN is created and Layer-2 association is performed. Users in a SubVLAN can make Layer-3 communication through the SVI of the primary VLAN.</p>

6.4.1. Configuring Basic Functions of PVLAN

Configuration Effect

- Enable PVLAN subdomains to form to implement isolation between enterprises and between enterprise users.
- Implement Layer-3 mapping between multiple secondary VLANs and the primary VLAN so that and multiple VLANs uses the same IP gateway, thereby helping save IP addresses.

Notes

- After a primary VLAN and a secondary VLAN are configured, a PVLAN subdomain exist only after Layer-2 association is performed between them.
- A port connected to a use host must be configured as a specific PVLAN port so that the user host joins a subdomain to implement the real user isolation.
- The port connected to the external network and the port connected to a server must be configured as promiscuous ports so that upstream and downstream packets are forwarded normally.
- Users in a secondary VLAN can make Layer-3 communication through the SVI of the primary VLAN only after Layer-3 mapping is performed between the secondary VLAN and the primary VLAN.

Configuration Steps

→ Configuring PVLAN

- Mandatory.
- A primary VLAN and a secondary VLAN must be configured. The two types of VLANs cannot exist independently.
- Run the private-vlan { community | isolated | primary } command to configure a VLAN as the primary VLAN of PVLAN and other VLANs as secondary VLANs.

Command	private-vlan { community isolated primary }
Parameter Description	community: Specifies that the VLAN type is community VLAN. isolated: Specifies that the VLAN type is isolated VLAN. primary: Specifies that the VLAN type is the primary VLAN of a PVLAN pair.
Defaults	VLANs are common VLANs and do not have the attributes of PVLAN.
Command Mode	VLAN mode
Usage Guide	This command is used to specify the primary VLAN and secondary VLANs of PVLAN.

→ Configuring Layer-2 Association of PVLAN

- Mandatory.
- PVLAN subdomains form, and isolated ports, community ports, and Layer-3 association can be configured only after Layer-2 association is performed between the primary VLAN and secondary VLANs of PVLAN.
- By default, after various PVLANS are configured, the primary VLANs and secondary VLANs are independent of each other. A primary VLAN has a secondary VLAN and a secondary VLAN has a primary VLAN only after Layer-2 association is performed.
- Run the private-vlan association { svlist | add svlist | remove svlist } command to config-

ure or cancel the Layer-2 association between the primary VLAN and secondary VLANs of PVLAN. A PVLAN subdomain forms only after Layer-2 association is configured,. The PVLAN subdomain does not exist after Layer-2 association is cancelled. If Layer-2 association is not performed, when isolated ports and promiscuous ports are used to configure associated PVLAN pairs, the configuration will fail or the association between ports and VLANs will be cancelled.

Command	private-vlan association { svlist add svlist remove svlist }
Parameter Description	svlist: Specifies the list of secondary VLANs to be associated or disassociated. add svlist: Adds the secondary VLANs to be associated. remove svlist: Cancels the association between svlist and the primary VLAN.
Defaults	By default, the primary VLAN and secondary VLANs are not associated.
Command Mode	Primary VLAN mode of PVLAN
Usage Guide	This command is used to configure Layer-2 association between a primary VLAN and secondary VLANs to form PVLAN pairs. Each primary VLAN can be associated with only one isolated VLAN but can be associated with multiple community VLANs.

→ Configuring Layer-3 Association of PVLAN

- If users in a secondary VLAN domain need to make Layer-3 communication, configure a Layer-3 interface SVI for the primary VLAN and then configure Layer-3 association between the primary VLAN and secondary VLANs on the SVI.
- By default, SVIs can be configured only in a primary VLAN. Secondary VLANs do not support Layer-3 communication.
- If users in a secondary VLAN of PVLAN need to make Layer-3 communication, the SVI of the primary VLAN needs to be used to transmit and receive packets.
- Run the private-vlan mapping { svlist | add svlist | remove svlist } command to configure or cancel the Layer-3 association between the primary VLAN and secondary VLANs of PVLAN. Users in a secondary VLAN can make Layer-3 communication with the external network only after Layer-3 association is configured. After Layer-3 association is cancelled, users in a secondary VLAN cannot make Layer-3 communication.

Command	private-vlan mapping { svlist add svlist remove svlist }
Parameter Description	svlist: Indicates the list of secondary VLANs, for which Layer-3 mapping needs to be configured. add svlist: Adds the secondary VLANs to be associated with a Layer-3 interface. remove svlist: Cancels the secondary VLANs associated with a Layer-3 interface.

Defaults	By default, the primary VLAN and secondary VLANs are not associated.
Command Mode	Interface configuration mode of the primary VLAN
Usage Guide	A Layer-3 SVI must be configured for the primary VLAN first. Layer-3 interfaces can be configured only in a primary VLAN. Layer-2 association must be performed between associated secondary VLANs and the primary VLAN.

→ Configuring Isolated Ports and Community Ports

- After the primary VLAN and secondary VLANs of PVLAN as well as Layer-2 association are configured, allocate the device ports connected to user hosts so as to specify the subdomains to which the user hosts belong.
- If an enterprise has only one user host, set the port connected to the user host as an isolated port.
- If an enterprise has multiple user hosts, set the ports connected to the user hosts as community ports.

Command	switchport mode private-vlan host switchport private-vlan host-association p_vid s_vid
Parameter Description	p_vid: Indicates the primary VLAN ID in a PVLAN pair. s_vid: Indicates the secondary VLAN ID in a PVLAN pair. The port is an associated port if the VLAN is an isolated VLAN and the port is a community port if the VLAN is a community VLAN.
Defaults	By default, the interface works in Access mode; no private VLAN pairs are associated.
Command Mode	Both commands run in interface configuration mode.
Usage Guide	Both the preceding commands need to be configured. Before a port is configured as an isolated port or promiscuous port, and the port mode must be configured as the host port mode. Whether a port is configured as an isolated port or community port depends on the s_vid parameter. p_vid and s_vid must be respectively the IDs of the primary VLAN and secondary VLAN in a PVLAN pair, on which Layer-2 association is performed. One host port can be associated with only one PVLAN pair.

→ Configuring a Promiscuous Port

- According to the table listing port packet transmission and receiving rules in section "Features", the single port type of PVLAN cannot ensure symmetric forwarding of upstream and downstream packets. Ports for connecting to the external network or server need to be configured as promiscuous ports to ensure that users can successfully access the external net-

work or server.

Command	switchport mode private-vlan promiscuous switchport private-vlan mapping p_vid{ svlist add svlist remove svlist }
Parameter Description	p_vid: Indicates the primary VLAN ID in a PVLAN pair. svlist: Indicates the secondary VLAN associated with a promiscuous port. Layer-2 association must be performed between it and p_vid. add svlist: Adds a secondary VLAN to be associated with a port. remove svlist: Cancels the secondary VLAN associated with a port.
Defaults	By default, an interface works in Access mode; a promiscuous port is not associated with a secondary VLAN.
Command Mode	Interface configuration mode
Usage Guide	The port mode must be configured as the promiscuous mode. If a port is configured as a promiscuous port, it must be associated with PVLN pairs. Otherwise, the port cannot bear or forward services. One promiscuous port can be associated with multiple PVLAN pairs within one primary VLAN but cannot be associated with multiple primary VLANs.

→ Configuring an Isolated Trunk Port and Associating the Port with a PVLAN Pair of a Layer-2 Interface

- When a downlink device of a device does not support PVLAN, if a port needs to isolate packets of some VLANs, the port must be configured as an isolated Trunk port and the association between the port and a PVLAN pair of a Layer-2 interface must be configured.
- After a port is configured as an isolated Trunk port, the port serves as a PVLAN uplink port. When the port receives packets with the VLAN tag of a PVLAN, the port serves as the isolated port of the PVLAN. When the port receives other packets, the port serves as a common Trunk port.

Command	switchport mode trunk switchport private-vlan association trunk p_vid s_vid
Parameter Description	p_vid: Indicates the primary VLAN ID in a PVLAN pair. s_vid: Indicates the associated isolated VLAN. Layer-2 association must be performed between it and p_vid.
Command Mode	Interface configuration mode
Usage Guide	The associated PVLAN must be a VLAN pair on which Layer-2 association is performed. The interface must work in Trunk port mode. One Trunk port can be associated with multiple PVLAN pairs.

→ Configuring a Promiscuous Trunk Port and Associating the Port with a PVLAN Pair of a Layer-2 Interface

- When the management VLAN and the primary VLAN of a device are not the same, if a port needs to allow packets of the management VLAN and primary VLAN at the same time, the port must be configured as a promiscuous Trunk port and the association between the port and a PVLAN pair of a Layer-2 interface must be configured.
- After a port is configured as a promiscuous Trunk port, the port serves as a PVLAN uplink port. When the port receives packets with the VLAN tag of a PVLAN, the port serves as the promiscuous port of the PVLAN. When the port receives other packets, the port serves as a common Trunk port.

Command	switchport mode trunk switchport private-vlan promiscuous trunk p_vid s_list
Parameter Description	p_vid: Indicates the primary VLAN ID in a PVLAN pair. svlist: Indicates the secondary VLAN associated with a promiscuous port Layer-2 association must be performed between it and p_vid.
Command Mode	Interface configuration mode
Usage Guide	The interface must work in Trunk port mode. Layer-2 association must be performed on the associated primary VLAN and secondary VLANs.

Verification

Make user hosts connected to PVLAN ports transmit and receive packets as per PVLAN port forwarding rules to implement isolation. Configure Layer-3 association to make users in the primary VLAN and secondary VLANs of the same PVLAN to share the same gateway IP address and make Layer-3 communication.

Configuration Example

→ Cross-Device Layer-2 Application of PVLAN

<p>Figure 6 3</p>	
<p>Configuration Steps</p>	<ul style="list-style-type: none"> • Configure all enterprises to be in the same PVLAN (primary VLAN 99 in this example). All enterprise users share the same Layer-3 interface through this VLAN to communicate with the external network. • If an enterprise has multiple user hosts, allocate each enterprise to a different community VLAN (in this example, allocate Enterprise A to Community VLAN 100) to implement user communication inside an enterprise and isolate user communication between enterprises. • If an enterprise has only one user host, allocate such enterprises to the same isolated VLAN (in this example, allocate Enterprise B and Enterprise C to Isolated VLAN 101) to isolate user communication between enterprises.

A

```
SwitchA#configure terminal
Enter configuration commands, one per line. End with CNTL/Z.
SwitchA(config)#vlan 99
SwitchA(config-vlan)#private-vlan primary
SwitchA(config-vlan)#exit
SwitchA(config)#vlan 100
SwitchA(config-vlan)#private-vlan community
SwitchA(config-vlan)#exit
SwitchA(config)#vlan 101
SwitchA(config-vlan)#private-vlan isolated
SwitchA(config-vlan)#exit
SwitchA(config)#vlan 99
SwitchA(config-vlan)#private-vlan association 100-101
SwitchA(config-vlan)#exit
SwitchA(config)#interface range gigabitEthernet 0/2-3
SwitchA(config-if-range)#switchport mode private-vlan host
SwitchA(config-if-range)#switchport private-vlan host-association
99 100
SwitchA(config-if-range)#exit
SwitchA(config)#interface gigabitEthernet 0/4
SwitchA(config-if-GigabitEthernet 0/4)#switchport mode private-
vlan host
SwitchA(config-if-GigabitEthernet 0/4)#switchport private-vlan
host-association 99 101
SwitchA(config)#interface gigabitEthernet 0/5
SwitchA(config-if-GigabitEthernet 0/5)#switchport mode trunk
SwitchA(config-if-GigabitEthernet 0/5)#exit
```

B	<pre> SwitchB#configure terminal Enter configuration commands, one per line. End with CNTL/Z. SwitchB(config)#vlan 99 SwitchB(config-vlan)#private-vlan primary SwitchB(config-vlan)#exit SwitchB(config)#vlan 100 SwitchB(config-vlan)#private-vlan community SwitchB(config-vlan)#exit SwitchB(config)#vlan 101 SwitchB(config-vlan)#private-vlan isolated SwitchB(config-vlan)#exit SwitchB(config)#vlan 99 SwitchB(config-vlan)#private-vlan association 100-101 SwitchB(config-vlan)#exit SwitchB(config)#interface gigabitEthernet 0/2 SwitchB(config-if-GigabitEthernet 0/2)#switchport mode private- vlan host SwitchB(config-if-GigabitEthernet 0/2)# switchport private-vlan host-association 99 101 SwitchB(config-if-GigabitEthernet 0/2)#exit SwitchB(config)#interface gigabitEthernet 0/3 SwitchB(config-if-GigabitEthernet 0/3)#switchport mode private- vlan host SwitchB(config-if-GigabitEthernet 0/3)# switchport private-vlan host-association 99 100 SwitchB(config-if-GigabitEthernet 0/3)#exit SwitchB(config)#interface gigabitEthernet 0/1 SwitchB(config-if-GigabitEthernet 0/1)#switchport mode trunk SwitchB(config-if-GigabitEthernet 0/1)#exit </pre>
Verification	Check whether VLANs and ports are correctly configured, and check whether packet forwarding is correct according to packet forwarding rules in section "Features".

A

```

SwitchA#show running-config
!
vlan 99
private-vlan primary
private-vlan association add 100-101
!
vlan 100
private-vlan community
!
vlan 101
private-vlan isolated
!
interface GigabitEthernet 0/1
switchport mode private-vlan promiscuous
switchport private-vlan mapping 99 add 100-101
!
interface GigabitEthernet 0/2
switchport mode private-vlan host
switchport private-vlan host-association 99 100
!
interface GigabitEthernet 0/3
switchport mode private-vlan host
switchport private-vlan host-association 99 100
!
interface GigabitEthernet 0/4
switchport mode private-vlan host
switchport private-vlan host-association 99 101
!
interface GigabitEthernet 0/5
switchport mode trunk
!
SwitchA# show vlan private-vlan
VLAN Type      Status  Routed  Ports          Associated
VLANs
-----
99   primary   active  Disabled  Gi0/1, Gi0/5   100-
101
100  community active  Disabled  Gi0/2, Gi0/3, Gi0/5   99
101  isolated  active  Disabled  Gi0/4, Gi0/5
99
                
```

...

B	<pre>SwitchB#show running-config ! vlan 99 private-vlan primary private-vlan association add 100-101 ! vlan 100 private-vlan community ! vlan 101 private-vlan isolated ! interface GigabitEthernet 0/1 switchport mode trunk ! interface GigabitEthernet 0/2 switchport mode private-vlan host switchport private-vlan host-association 99 101 ! interface GigabitEthernet 0/3 switchport mode private-vlan host switchport private-vlan host-association 99 100</pre>
---	---

Common Errors

- Layer-2 association is not performed between the primary VLAN and secondary VLANs of PVLAN, and a port VLAN list fails to be added when isolated ports, promiscuous ports, and community ports are configured.
- One host port fails to be associated with multiple PVLAN pairs.

Configuration Example

→ Layer-3 Application of PVLAN on a Single Device

<p>Figure 6-4</p>	<p>The diagram illustrates a network setup for PVLAN on a single device (Switch A). At the top, an Internet cloud is connected to Switch A. Switch A has several ports: port 7 is connected to a Server; port 6 is connected to Enterprise A; port 4 is connected to Enterprise B; and port 5 is connected to Enterprise D. Enterprise C is also connected to Switch A but is isolated within VLAN 30. The primary VLAN is VLAN 2, with an SVI address of 192.168.1.1/24. Secondary VLANs include VLAN 10 (Community), VLAN 20 (Community), and VLAN 30 (Isolated). A legend on the right identifies Enterprise A, B, C, and D.</p>
<p>Configuration Steps</p>	<ul style="list-style-type: none"> • Configure the PVLAN function on the device (Switch A in this example). For details about the configuration, see configuration tips in "Cross-Device Layer-2 Application of PVLAN." • Set the port that is directly connected to the server (Port Gi 0/7 in this example) as a promiscuous port. Then, all enterprise users can communicate with the server through the promiscuous port. • Configure the gateway address of PVLAN on the Layer-3 device (Switch A in this example) (in this example, set the SVI address of VLAN 2 to 192.168.1.1/24) and configure the Layer-3 interface mapping between the primary VLAN (VLAN 2 in this example) and secondary VLANs (VLAN 10, VLAN 20, and VLAN 30 in this example). Then, all enterprise users can communicate with the external network through the gateway address. <p> Run PVLAN cross devices and configure the ports for connecting to the devices as Trunk ports.</p>

A	<pre> SwitchA#configure terminal Enter configuration commands, one per line. End with CNTL/Z. SwitchA(config)#vlan 2 SwitchA(config-vlan)#private-vlan primary SwitchA(config-vlan)#exit SwitchA(config)#vlan 10 SwitchA(config-vlan)#private-vlan community SwitchA(config-vlan)#exit SwitchA(config)#vlan 20 SwitchA(config-vlan)#private-vlan community SwitchA(config-vlan)#exit SwitchA(config)#vlan 30 SwitchA(config-vlan)#private-vlan isolated SwitchA(config-vlan)#exit SwitchA(config)#vlan 2 SwitchA(config-vlan)#private-vlan association 10,20,30 SwitchA(config-vlan)#exit SwitchA(config)#interface range gigabitEthernet 0/1-2 SwitchA(config-if-range)#switchport mode private-vlan host SwitchA(config-if-range)#switchport private-vlan host-association 2 10 SwitchA(config-if-range)#exit SwitchA(config)#interface range gigabitEthernet 0/3-4 SwitchA(config-if-range)#switchport mode private-vlan host SwitchA(config-if-range)#switchport private-vlan host-association 2 20 SwitchA(config-if-range)#exit SwitchA(config)#interface range gigabitEthernet 0/5-6 SwitchA(config-if-range)#switchport mode private-vlan host SwitchA(config-if-range)#switchport private-vlan host-association 2 30 SwitchA(config-if-range)#exit SwitchA(config)#interface gigabitEthernet 0/7 SwitchA(config-if-GigabitEthernet 0/7)#switchport mode private- vlan promiscuous SwitchA(config-if-GigabitEthernet 0/7)#switchport private-vlan mapping 2 10,20,30 SwitchA(config-if-GigabitEthernet 0/7)#exit SwitchA(config)#interface vlan 2 SwitchA(config-if-VLAN 2)#ip address 192.168.1.1 255.255.255.0 SwitchA(config-if-VLAN 2)#private-vlan mapping 10,20,30 SwitchA(config-if-VLAN 2)#exit </pre>
Verification	Ping the gateway address 192.168.1.1 from user hosts in different subdo- mains. The ping operation is successful.

A...

```
SwitchA#show running-config
!
vlan 2
private-vlan primary
private-vlan association add 10,20,30
!
vlan 10
private-vlan community
!
vlan 20
private-vlan community
!
vlan 30
private-vlan isolated
!
interface GigabitEthernet 0/1
switchport mode private-vlan host
switchport private-vlan host-association 2 10
!
interface GigabitEthernet 0/2
switchport mode private-vlan host
switchport private-vlan host-association 2 10
!
interface GigabitEthernet 0/3
switchport mode private-vlan host
switchport private-vlan host-association 2 20
!
interface GigabitEthernet 0/4
switchport mode private-vlan host
switchport private-vlan host-association 2 20
!
```

```

...A

interface GigabitEthernet 0/5
switchport mode private-vlan host
switchport private-vlan host-association 2 30
!
interface GigabitEthernet 0/6
switchport mode private-vlan host
switchport private-vlan host-association 2 30
!
interface GigabitEthernet 0/7
switchport mode private-vlan promiscuous
switchport private-vlan mapping 2 add 10,20,30
!
interface VLAN 2
no ip proxy-arp
ip address 192.168.1.1 255.255.255.0
private-vlan mapping add 10,20,30
!
SwitchA#show vlan private-vlan
VLAN Type Status Routed Ports Associated VLANs
-----
2 primary active Enabled Gi0/7 10,20,30
10 community active Enabled Gi0/1, Gi0/2 2
20 community active Enabled Gi0/3, Gi0/4 2
30 isolated active Enabled Gi0/5, Gi0/6 2
    
```

→ Common Errors

- No Layer-2 association is performed on the primary VLAN and secondary VLANs of PVLAN and the Layer-3 association fails to be configured.
- The device is connected to the external network before Layer-3 association is configured. As a result, the device cannot communicate with the external network.
- The interfaces for connecting to the server and the external network are not configured as promiscuous interfaces, which results in asymmetric forwarding of upstream and downstream packets.

6.5. Monitoring

Displaying

Description	Command
Displays PVLAN configuration.	show vlan private-vlan

Debugging

System resources are occupied when debugging information is output. Therefore, disable debugging immediately after use.

Description	Command
Debugs PVLAN.	debug bridge pvlan

7. Configuring MSTP

7.1. Overview

Spanning Tree Protocol (STP) is a Layer-2 management protocol. It cannot only selectively block redundant links to eliminate Layer-2 loops but also can back up links.

Similar to many protocols, STP is continuously updated from Rapid Spanning Tree Protocol (RSTP) to Multiple Spanning Tree Protocol (MSTP) as the network develops.

For the Layer-2 Ethernet, only one active link can exist between two local area networks (LANs). Otherwise, a broadcast storm will occur. To enhance the reliability of a LAN, it is necessary to establish a redundant link and keep some paths in backup state. If the network is faulty and a link fails, you must switch the redundant link to the active state. STP can automatically activate the redundant link without any manual operations. STP enables devices on a LAN to:

- Discover and start the best tree topology on the LAN.
- Troubleshoot a fault and automatically update the network topology so that the possible best tree topology is always selected.

The LAN topology is automatically calculated based on a set of bridge parameters configured by the administrator. The best topology tree can be obtained by properly configuring these parameters. RSTP is completely compatible with 802.1D STP. Similar to traditional STP, RSTP provides loop-free and redundancy services. It is characterized by rapid speed. If all bridges in a LAN support RSTP and are properly configured by the administrator, it takes less than 1 second (about 50 seconds if traditional STP is used) to re-generate a topology tree after the network topology changes.

STP and RSTP have the following defects:

- STP migration is slow. Even on point-to-point links or edge ports, it still takes two times of the forward delay for ports to switch to the forwarding state.
- RSTP can rapidly converge but has the same defect with STP: Since all VLANs in a LAN share the same spanning tree, packets of all VLANs are forwarded along this spanning tree. Therefore, redundant links cannot be blocked according to specific VLANs and data traffic cannot be balanced among VLANs.

MSTP, defined by the IEEE in 802.1s, resolves defects of STP and RSTP. It cannot only rapidly converge but also can enable traffic of different VLANs to be forwarded along respective paths, thereby providing a better load balancing mechanism for redundant links. In general, STP/RSTP works based on ports while MSTP works based on instances. An instance is a set of multiple VLANs. Binding multiple VLANs to one instance can reduce the communication overhead and resource utilization.

The device supports STP, RSTP, and MSTP, and comply with IEEE 802.1D, IEEE 802.1w, and IEEE 802.1s.

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

7.2. Applications

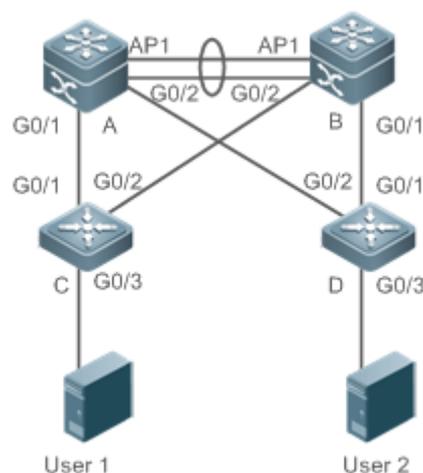
Application	Description
MSTP+VRRP Dual-Core Topology	With a hierarchical network architecture model, the MSTP+VRRP mode is used to implement redundancy and load balancing to improve system availability of the network.
BPDU Tunnel	In QinQ network environment, Bridge Protocol Data Unit (BPDU) Tunnel is used to implement tunnel-based transparent transmission of STP packets.

7.2.1. MSTP+VRRP Dual-Core Topology

Scenario

The typical application of MSTP is the MSTP+VRRP dual-core solution. This solution is an excellent solution to improve system availability of the network. Using a hierarchical network architecture model, it is generally divided into three layers (core layer, convergence layer, and access layer) or two layers (core layer and access layer). They form the core network system to provide data exchange service.

The main advantage of this architecture is its hierarchical structure. In the hierarchical network architecture, all capacity indicators, characteristics, and functions of network devices at each layer are optimized based on their network locations and roles, enhancing their stability and availability.



Remarks	The topology is divided into two layers: core layer (Devices A and B) and access layer (Devices C and D).
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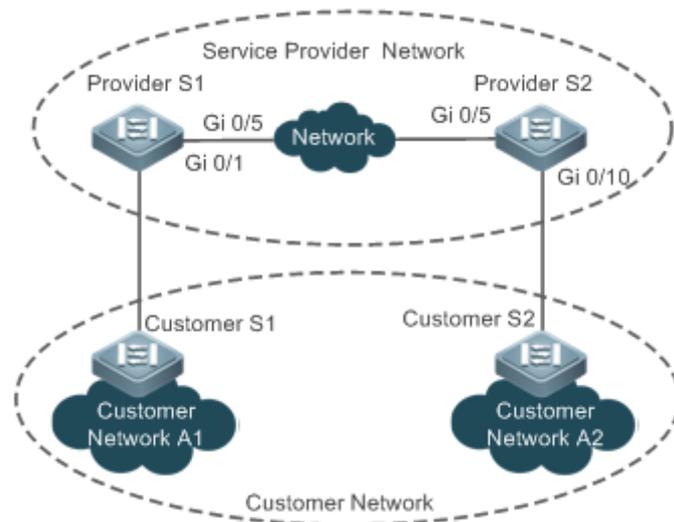
Deployment

- Core layer: Multiple MSTP instances are configured to realize load balancing. For example, two instances are created: Instance 1 and Instance 2. Instance 1 maps VLAN 10 while Instance 2 maps VLAN 20. Device A is the root bridge of Instances 0 and 1 (Instance 0 is CIST, which exists by default). Device B is the root bridge of Instance 2.
- Core layer: Devices A and B are the active VRRP devices respectively on VLAN 10 and VLAN 20.
- Access layer: Configure the port directly connected to the terminal (PC or server) as a Port-Fast port, and enable BPDU guard to prevent unauthorized users from accessing illegal devices.

7.2.2. BPDU Tunnel

Scenario

The QinQ network is generally divided into two parts: customer network and service provider (SP) network. You can enable BPDU Tunnel to calculate STP packets of the customer network independently of the SP network, thereby preventing STP packets between the customer network from affecting the SP network.



Remarks	As shown in the above figure, the upper part is the SP network and the lower part is the customer network. The SP network consists of two provider edges (PEs): Provider S1 and Provider S2. Customer Network A1 and Customer Network A2 are a user's two sites in different regions. Customer S1 and Customer S2, access devices from the customer network to the SP network, access the SP network respectively through Provider S1 and Provider S2. Using BPDU Tunnel, Customer Network A1 and Customer Network A2 in different regions can perform unified spanning tree calculation across the SP network, not affecting the spanning tree calculation of the SP network.
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Deployment

- Enable basic QinQ on the PEs (Provider S1/Provider S2 in this example) so that data packets of the customer network are transmitted within the specified VLAN on the SP network.
- Enable STP transparent transmission on the PEs (Provider S1/Provider S2 in this example) so that the SP network can transmit STP packets of the customer network through BPDU Tunnel.

7.3. Features

Basic Concepts

→ BPDU

To generate a stable tree topology network, the following conditions must be met:

- Each bridge has a unique ID consisting of the bridge priority and MAC address.
- The overhead of the path from the bridge to the root bridge is called root path cost.
- A port ID consists of the port priority and port number.

Bridges exchange BPDU packets to obtain information required for establishing the best tree topology. These packets use the multicast address 01-80-C2-00-00-00 (hexadecimal) as the destination address.

A BPDU consists of the following elements:

- Root bridge ID assumed by the local bridge
- Root path cost of the local bridge
- Bridge ID (ID of the local bridge)
- Message age (age of a packet)
- Port ID (ID of the port sending this packet)

- Forward-Delay Time, Hello Time, Max-Age Time are time parameters specified in the MSTP.
- Other flags, such as flags indicating network topology changes and local port status.

If a bridge receives a BPDU with a higher priority (smaller bridge ID and lower root path cost) at a port, it saves the BPDU information at this port and transmits the information to all other ports. If the bridge receives a BPDU with a lower priority, it discards the information.

Such a mechanism allows information with higher priorities to be transmitted across the entire network. BPDU exchange results are as follows:

- A bridge is selected as the root bridge.
- Except the root bridge, each bridge has a root port, that is, a port providing the shortest path to the root bridge.
- Each bridge calculates the shortest path to the root bridge.
- Each LAN has a designated bridge located in the shortest path between the LAN and the root bridge. A port designated to connect the bridge and the LAN is called designated port.
- The root port and designated port enter the forwarding status.

→ Bridge ID

According to IEEE 802.1W, each bridge has a unique ID. The spanning tree algorithm selects the root bridge based on the bridge ID. The bridge ID consists of eight bytes, of which the last six bytes are the MAC address of the bridge. In its first two bytes (as listed in the following table), the first four bits indicate the priority; the last eight bits indicate the system ID for use in extended protocol. In RSTP, the system ID is 0. Therefore, the bridge priority should be an integral multiple of 4,096.

	Bit	Value
Priority value	16	32,768
	15	16,384
	14	8,192
	13	4,096

System ID	12	2,048
	11	1,024
	10	512
	9	256
	8	128
	7	64
	6	32
	5	16
	4	8
	3	4
	2	2
	1	1

→ Spanning-Tree Timers

The following three timers affect the performance of the entire spanning tree:

- Hello timer: Interval for periodically sending a BPDU packet.
- Forward-Delay timer: Interval for changing the port status, that is, interval for a port to change from the listening state to the learning state or from the learning state to the forwarding state when RSTP runs in STP-compatible mode.
- Max-Age timer: The longest time-to-live (TTL) of a BPDU packet. When this timer elapses, the packet is discarded.

→ Port Roles and Port States

Each port plays a role on a network to reflect different functions in the network topology.

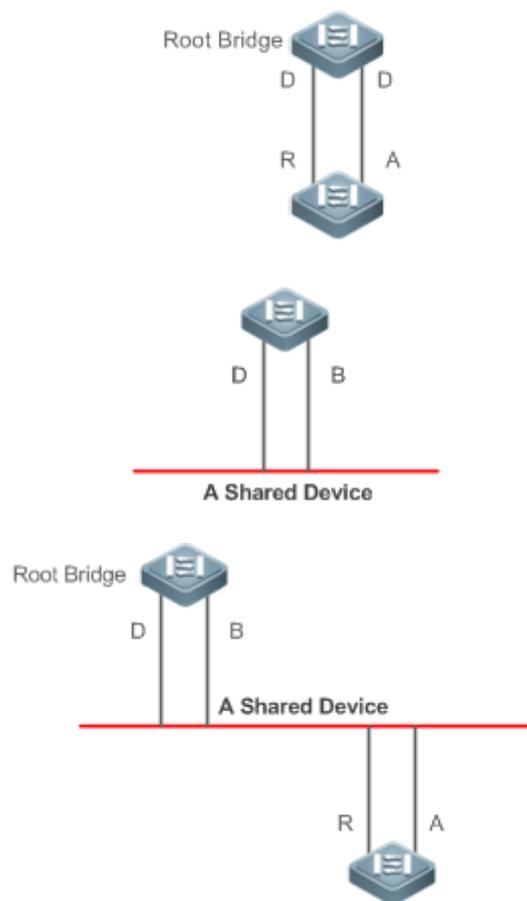
- Root port: Port providing the shortest path to the root bridge.
- Designated port: Port used by each LAN to connect the root bridge.
- Alternate port: Alternative port of the root port. Once the root port loses effect, the alternate port immediately changes to the root port.
- Backup port: Backup port of the designated port. When a bridge has two ports connected

to a LAN, the port with the higher priority is the designated port while the port with the lower priority is the backup port.

- Disabled port: Inactive port. All ports with the operation state being down play this role. The following figures show the roles of different ports:

R = Root port D = Designated port A = Alternate port B = Backup port

Unless otherwise specified, port priorities decrease from left to right.



Each port has three states indicating whether to forward data packets so as to control the entire spanning tree topology.

- Discarding: Neither forwards received packets nor learns the source MAC address.
- Learning: Does not forward received packets but learns the source MAC address, which is a transitive state.
- Forwarding: Forwards received packets and learns the source MAC address. For a stable network topology, only the root port and designated port can enter the forwarding state while other ports are always in discarding state.

→ Hop Count

Internal spanning trees (ISTs) and multiple spanning tree instances (MSTIs) calculate whether the BPDU packet time expires based on an IP TTL-alike mechanism Hop Count, instead of Mes-

sage Age and Max Age.

It is recommended to run the spanning-tree max-hops command in global configuration mode to configure the hop count. In a region, every time a BPDU packet passes through a device from the root bridge, the hop count decreases by 1. When the hop count becomes 0, the BPDU packet time expires and the device discards the packet.

To be compatible with STP and RSTP outside the region, MSTP also retains the Message Age and Max Age mechanisms.

Overview

Feature	Description
STP	STP, defined by the IEEE in 802.1D, is used to eliminate physical loops at the data link layer in a LAN.
RSTP	RSTP, defined by the IEEE in 802.1w, is optimized based on STP to rapidly converge the network topology.
MSTP	MSTP, defined by the IEEE in 802.1s, resolves defects of STP, RSTP, and Per-VLAN Spanning Tree (PVST). It cannot only rapidly converge but also can forward traffic of different VLANs along respective paths, thereby providing a better load balancing mechanism for redundant links.
MSTP Optical Features	MSTP includes the following features: PortFast, BPDU guard, BPDU filter, TC protection, TC guard, TC filter, BPDU check based on the source MAC address, BPDU filter based on the illegal length, Auto Edge, root guard, and loop guard.

7.3.1. STP

STP is used to prevent broadcast storms incurred by loops and provide link redundancy.

Working Principle

For the Layer-2 Ethernet, only one active link can exist between two LANs. Otherwise, a broadcast storm will occur. To enhance the reliability of a LAN, it is necessary to establish a redundant link and keep some paths in backup state. If the network is faulty and a link fails, you must switch the redundant link to the active state. STP can automatically activate the redundant link without any manual operations. STP enables devices on a LAN to:

- *Discover and start the best tree topology on the LAN.
- Troubleshoot a fault and automatically update the network topology so that the possible best tree topology is always selected.

The LAN topology is automatically calculated based on a set of bridge parameters configured by the administrator. The best topology tree can be obtained by properly configuring these parameters.

7.3.2. RSTP

RSTP is completely compatible with 802.1D STP. Similar to traditional STP, RSTP provides loop-free and redundancy services. It is characterized by rapid speed. If all bridges in a LAN support RSTP and are properly configured by the administrator, it takes less than 1 second (about 50 seconds if traditional STP is used) to re-generate a topology tree after the network topology changes.

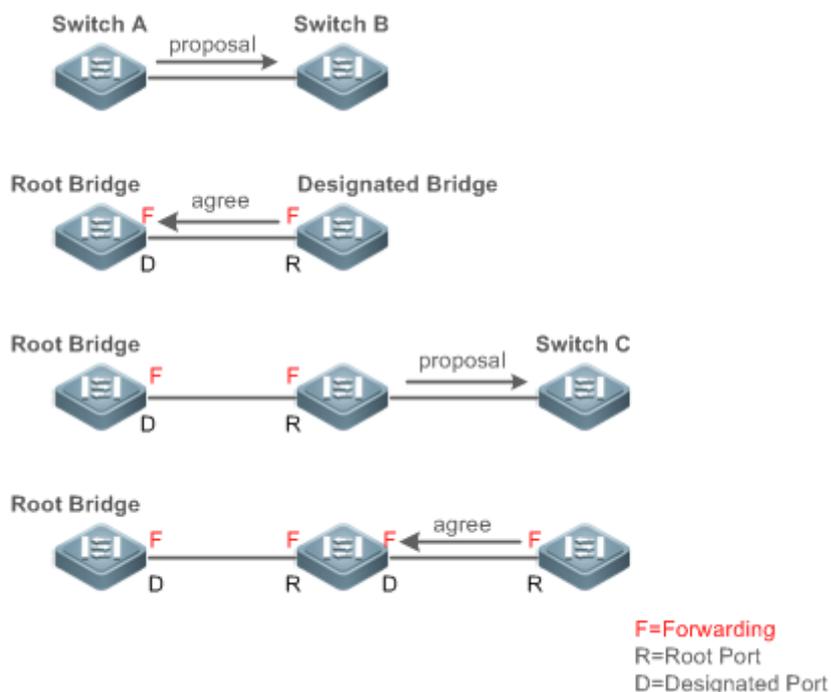
Working Principle

→ Fast RSTP Convergence

RSTP has a special feature, that is, to make ports quickly enter the forwarding state.

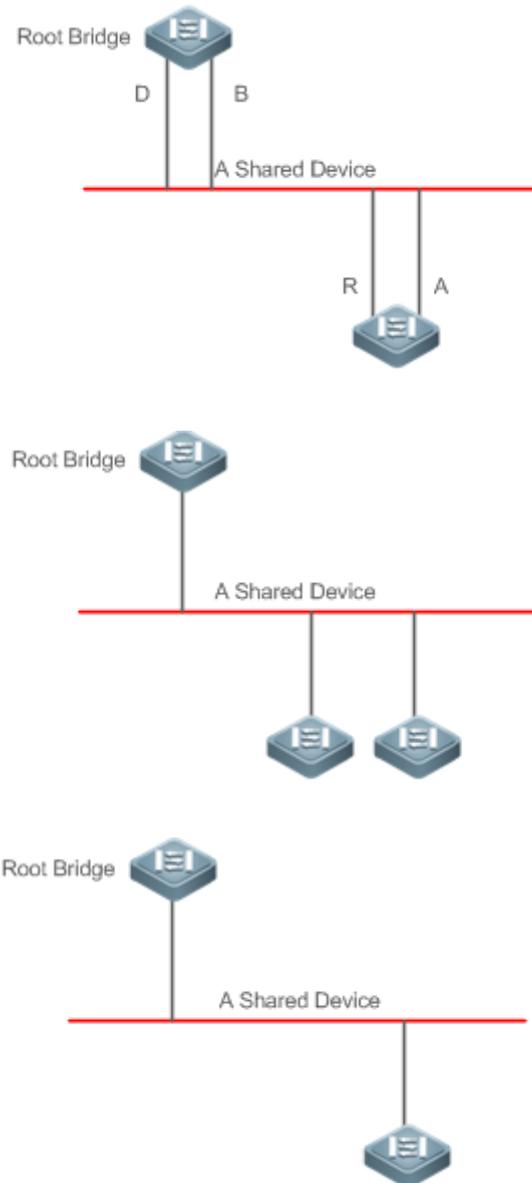
STP enables a port to enter the forwarding state 30 seconds (two times of the Forward-Delay Time; the Forward-Delay Time can be configured, with a default value of 15 seconds) after selecting a port role. Every time the topology changes, the root port and designated port reselected by each bridge enter the forwarding state 30 seconds later. Therefore, it takes about 50 seconds for the entire network topology to become a tree.

RSTP differs greatly from STP in the forwarding process. As shown in Figure 7 6, Switch A sends an RSTP Proposal packet to Switch B. If Switch B finds the priority of Switch A higher, it selects Switch A as the root bridge and the port receiving the packet as the root port, enters the forwarding state, and then sends an Agree packet from the root port to Switch A. If the designated port of Switch A is agreed, the port enters the forwarding state. Switch B’s designated port resends a Proposal packet to extend the spanning tree by sequence. Theoretically, RSTP can recover the network tree topology to rapidly converge once the network topology changes.





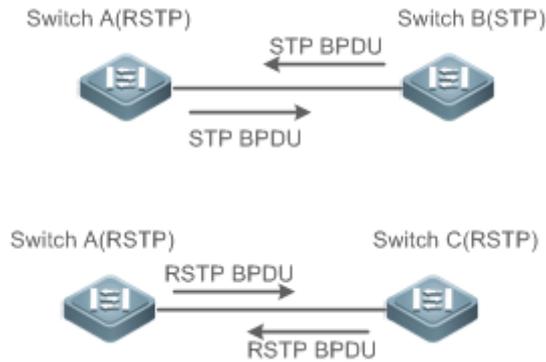
The above handshake process is implemented only when the connection between ports is in point-to-point mode. To give the devices their full play, it is recommended not to enable point-to-point connection between devices.



→ Compatibility Between RSTP and STP RSTP is completely compatible with STP. RSTP automatically checks whether the connected bridge supports STP or RSTP based on the received BPDU version number. If the port connects to an STP bridge, the port enters the forwarding state 30 seconds later, which cannot give RSTP its full play.

Another problem may occur when RSTP and STP are used together. As shown in the following figures, Switch A (RSTP) connects to Switch B (STP). If Switch A finds itself connected to an STP bridge, it sends an STP BPDU packet. However, if Switch B is replaced with Switch C (RSTP) but Switch A still sends STP BPDU packets, Switch C will assume itself connected to the STP bridge. As a result, two RSTP devices work under STP, greatly reducing the efficiency.

RSTP provides the protocol migration feature to forcibly send RSTP BPDU packets (the peer bridge must support RSTP). In this case, Switch A is enforced to send an RSTP BPDU and Switch C then finds itself connected to the RSTP bridge. As a result, two RSTP devices work under RSTP, as shown in Figure 7-11.



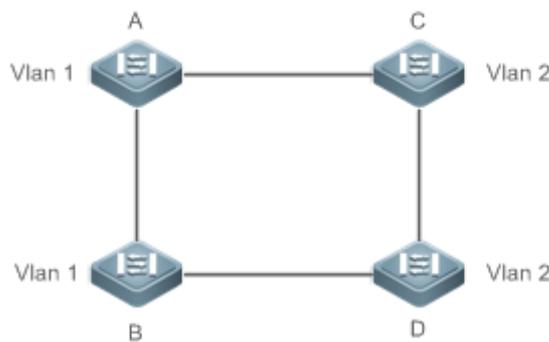
7.3.3 MSTP

MSTP resolves defects of STP and RSTP. It cannot only rapidly converge but also can forward traffic of different VLANs along respective paths, thereby providing a better load balancing mechanism for redundant links.

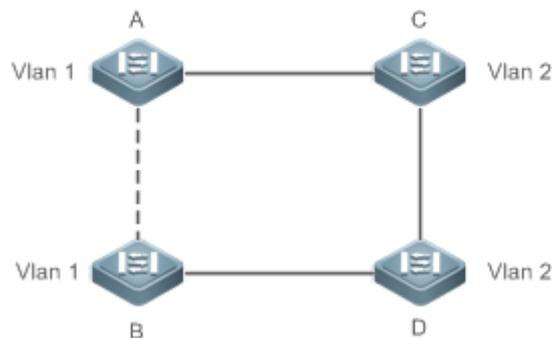
Working Principle

The device supports MSTP. MSTP is a new spanning tree protocol developed from traditional STP and RSTP and includes the fast RSTP forwarding mechanism.

Since traditional spanning tree protocols are irrelevant to VLANs, problems may occur in specific network topologies:

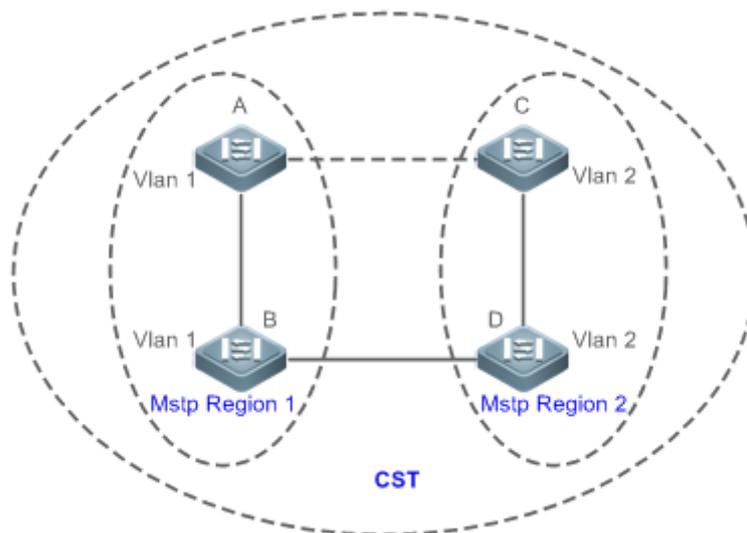


If the link from Device A to Device B through Devices C and D costs less than the link from Device A direct to Device B, the link between Device A and Device B enters the discarding state (as shown in Figure 7 13). Since Devices C and D do not include VLAN 1 and cannot forward data packets of VLAN 1, VLAN 1 of Device A fails to communicate with VLAN 1 of Device B.



MSTP is developed to resolve this problem. It divides one or multiple VLANs of a device into an instance. Devices configured with the same instance form an MST region to run an independent spanning tree (called IST). This MST region, like a big device, implements the spanning tree algorithm with other MST regions to generate a complete spanning tree called common spanning tree (CST).

Based on this algorithm, the above network can form the topology shown in Figure 7 14 under the MSTP algorithm: Devices A and B are in MSTP region 1 in which no loop occurs, and therefore no link enters the discarding state. This also applies to MSTP Region 2. Region 1 and Region 2, like two big devices having loops, select a link to enter the discarding state based on related configuration.



This prevents loops to ensure proper communication between C devices in the same VLAN.

→ MSTP Region Division

To give MSTP its due play, properly divide MSTP regions and configure the same MST configuration information for devices in the same MSTP region.

MST configuration information include:

- MST configuration name: Consists of at most 32 bytes to identify an MSTP region.

- MST Revision Number: Consists of 16 bits to identify an MSTP region.
- MST instance-VLAN mapping table: A maximum number of 64 instances (with their IDs ranging from 1 to 64) are created for each device and Instance 0 exists mandatorily. Therefore, the system supports a maximum number of 65 instances. Users can assign 1 to 4,994 VLANs belonging to different instances (ranging from 0 to 64) as required. Unassigned VLANs belong to Instance 0 by default. In this case, each MSTI is a VLAN group and implements the spanning tree algorithm of the MSTI specified in the BPDU packet, not affected by CIST and other MSTIs.

Run the spanning-tree mst configuration command in global configuration mode to enter the MST configuration mode to configure the above information.

MSTP BPDUs carry the above information. If the BPDU received by a device carries the same MST configuration information with the information on the device, it regards that the connected device belongs to the same MST region with itself. Otherwise, it regards the connected device originated from another MST region.

It is recommended to configure the instance-VLAN mapping table after disabling MSTP. After the configuration, re-enable MSTP to ensure stability and convergence of the network topology.

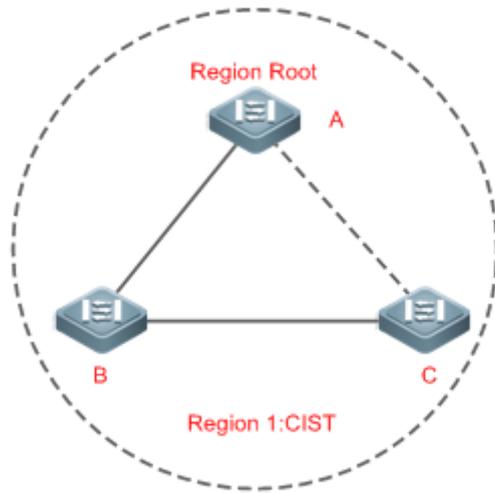
→ IST (Spanning Tree in an MSTP Region)

After MSTP regions are divided, each region selects an independent root bridge for each instance based on the corresponding parameters such as bridge priority and port priority, assigns roles to each port on each device, and specifies whether the port is in forwarding or discarding state in the instance based on the port role.

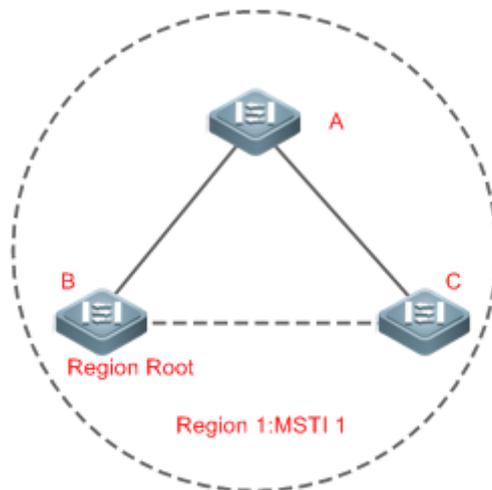
Through MSTP BPDU exchange, an IST is generated and each instance has their own spanning trees (MSTIs), in which the spanning tree corresponding to Instance 0 and CST are uniformly called Common Instance Spanning Tree (CIST). That is, each instance provides a single and loop-free network topology for their own VLAN groups.

As shown in Figure 7 15, Devices A, B, and C form a loop in Region 1.

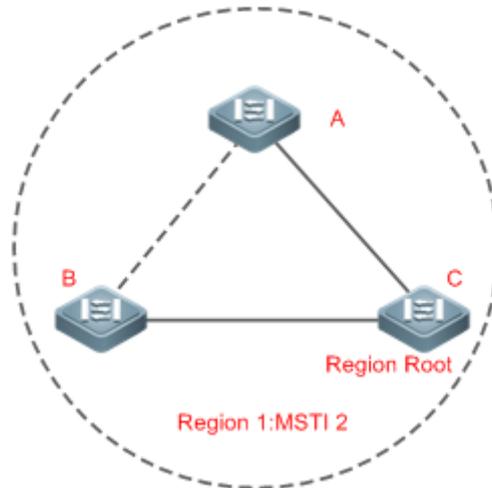
As shown in Figure 7 15, Device A has the highest priority in the CIST (Instance 0) and thereby is selected as the region root. Then MSTP enables the link between A and C to enter the discarding state based on other parameters. Therefore, for the VLAN group of Instance 0, only links from A to B and from B to C are available, interrupting the loop of this VLAN group.



As shown in Figure 7 16, Device B has the highest priority in the MSTI 1 (Instance 1) and thereby is selected as the region root. Then MSTP enables the link between B and C to enter the discarding state based on other parameters. Therefore, for the VLAN group of Instance 1, only links from A to B and from A to C are available, interrupting the loop of this VLAN group.



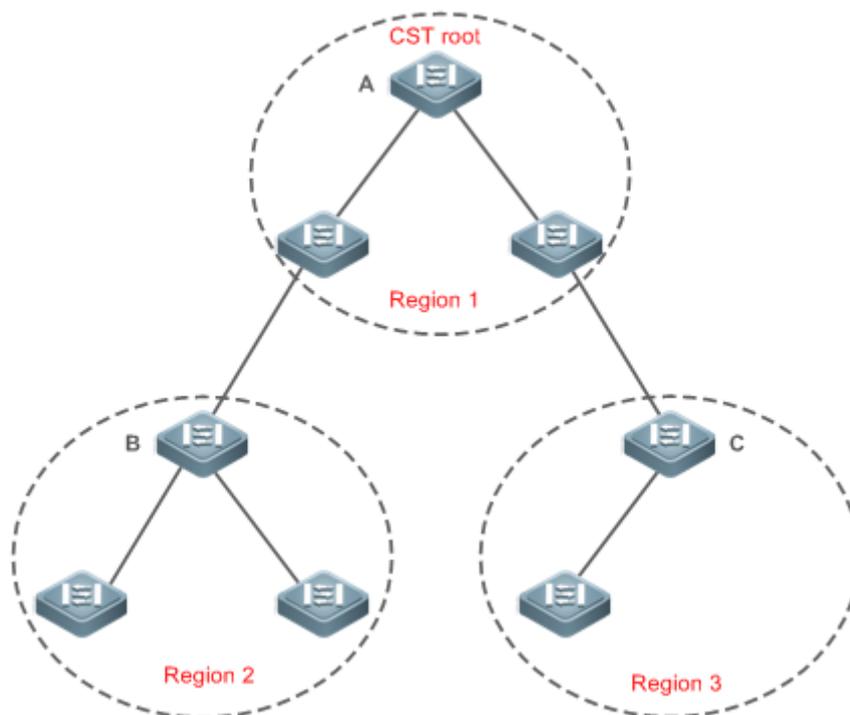
As shown in Figure 7 17, Device C has the highest priority in the MSTI 2 (Instance 2) and thereby is selected as the region root. Then MSTP enables the link between B and C to enter the discarding state based on other parameters. Therefore, for the VLAN group of Instance 2, only links from B to C and from A to C are available, interrupting the loop of this VLAN group.



Note that MSTP does not care which VLAN a port belongs to. Therefore, users should configure the path cost and priority of a related port based on the actual VLAN configuration to prevent MSTP from interrupting wrong loops.

→ CST (Spanning Tree Between MSTP Regions)

Each MSTP region is like a big device for the CST. Different MSTP regions form a bit network topology tree called CST. As shown in Figure 7 18, Device A, of which the bridge ID is the smallest, is selected as the root in the entire CST and the CIST regional root in this region. In Region 2, since the root path cost from Device B to the CST root is lowest, Device B is selected as the CIST regional root in this region. For the same reason, Device C is selected as the CIST regional root.



The CIST regional root may not be the device of which the bridge ID is the smallest in the

region but indicates the device of which the root path cost from this region to the CST root is the smallest.

For the MSTI, the root port of the CIST regional root has a new role "master port". The master port acts as the outbound port of all instances and is in forwarding state for all instances. To make the topology more stable, we suggest that the master port of each region to the CST root be on the same device of the region if possible.

→ Compatibility Among MSTP, RSTP, and STP

Similar to RSTP, MSTP sends STP BPDUs to be compatible with STP. For details, see "Compatibility Between RSTP and STP".

Since RSTP processes MSTP BPDUs of the CIST, MSTP does not need to send RSTP BPDUs to be compatible with it.

Each STP or RSTP device is a single region and does not form the same region with any devices.

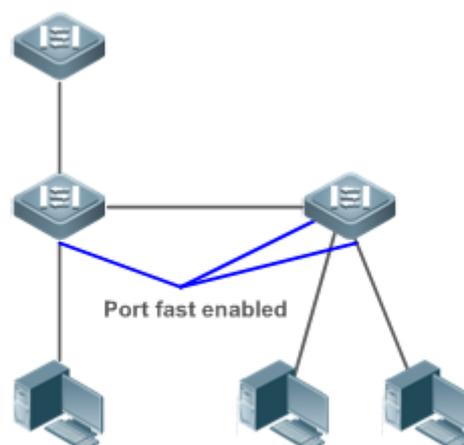
7.3.3. MSTP Optional Features

MSTP optional features mainly include PortFast port, BPDU guard, BPDU filter, TC guard, and guard. The optional features are mainly used to deploy MSTP configurations based on the network topology and application characteristics in the MSTP network. This enhances the stability, robustness, and anti-attack capability of MSTP, meeting application requirements of MSTP in different customer scenarios.

Working Principle

→ PortFast

If a port of a device connects directly to the network terminal, this port is configured as a PortFast port to directly enter the forwarding state. If the PortFast port is not configured, the port needs to wait for 30 seconds to enter the forwarding state. Figure 7 19 shows which ports of a device can be configured as PortFast ports.



If a PortFast port still receives BPDUs, its Port Fast Operational State is Disabled and the port enters the forwarding state according to the normal STP algorithm.

→ BPDU Guard

BPDU guard can be enabled globally or enabled on an interface.

It is recommended to run the spanning-tree portfast bpduguard default command in global configuration mode to enable global BPDU guard. If PortFast is enabled on a port or this port is automatically identified as an edge port, this port enters the error-disabled state to indicate the configuration error immediately after receiving a BPDU. At the same time, the port is disabled, indicating that a network device may be added by an unauthorized user to change the network topology.

It is also recommended to run the spanning-tree bpduguard enable command in interface configuration mode to enable BPDU guard on a port (whether PortFast is enabled or not on the port). In this case, the port enters the error-disabled state immediately after receiving a BPDU.

→ BPDU Filter

BPDU filter can be enabled globally or enabled on an interface.

It is recommended to run the spanning-tree portfast bpdudfilter default command in global configuration mode to enable global BPDU filter. In this case, the PortFast port neither receives nor sends BPDUs and therefore the host connecting directly to the PortFast port receives no BPDUs. If the port changes its Port Fast Operational State to Disabled after receiving a BPDU, BPDU filter automatically loses effect.

It is also recommended to run the spanning-tree bpdudfilter enable command in interface configuration mode to enable BPDU filter on a port (whether PortFast is enabled or not on the port). In this case, the port neither receives nor sends BPDUs but directly enters the forwarding state.

→ TC Protection

TC BPDUs are BPDU packets carrying the TC. If a switch receives such packets, it indicates the network topology changes and the switch will delete the MAC address table. For Layer-3 switches in this case, the forwarding module is re-enabled and the port status in the ARP entry changes. When a switch is attacked by forged TC BPDUs, it will frequently perform the above operations, causing heavy load and affecting network stability. To prevent this problem, you can enable TC protection.

TC protection can only be globally enabled or disabled. This function is disabled by default.

When TC protection is enabled, the switch deletes TC BPDUs within a specified period (generally 4 seconds) after receiving them and monitors whether any TC BPDU packet is received during the period. If a device receives TC BPDU packets during this period, it deletes them when the period expires. This can prevent the device from frequently deleting MAC address entries and ARP entries.

→ TC Guard

TC protection ensures less dynamic MAC addresses and ARP entries removed when a large number of TC packets are generated on the network. However, a device receiving TC attack packets still performs many removal operations and TC packets can be spread, affecting the entire network. Users can enable TC guard to prevent TC packets from spreading globally or on a port. If TC guard is enabled globally or on a port, a port receiving TC packets filters these TC packets or TC packets generated by itself so that TC packets will not be spread to other ports. This can effectively control possible TC attacks in the network to ensure network stability. Particularly on Layer-3 devices, this function can effectively prevent the access-layer device from flapping and interrupting the core route.



If TC guard is used incorrectly, the communication between networks is interrupted.



It is recommended to enable this function only when illegal TC attack packets are received in the network.



If TC guard is enabled globally, no port spreads TC packets to others. This function can be enabled only on laptop access devices.



If TC guard is enabled on a port, the topology changes incurred and TC packets received on the port will not be spread to other ports. This function can be enabled only on uplink ports, particularly on ports of the convergence core.

→ TC Filter

If TC guard is enabled on a port, the port does not forward TC packets received and generated by the port to other ports performing spanning tree calculation on the device. When the status of a port changes (for example, from blocking to forwarding), the port generates TC packets, indicating that the topology may have changed.

In this case, since TC guard prevents TC packets from spreading, the device may not clear the MAC addresses of the port when the network topology changes, causing a data forwarding error.

To resolve this problem, TC filter is introduced. TC filter does not process TC packets received by ports but processes TC packets in case of normal topology changes. If TC filter is enabled, the address removal problem will be avoided and the core route will not be interrupted when ports not enabled with PortFast frequently go up or down, and the core routing entries can be updated in a timely manner when the topology changes.



TC filter is disabled by default.

→ BPDU Source MAC Address Check

BPDU source MAC address check prevents BPDU packets from maliciously attacking switches and causing MSTP abnormal. When the switch connected to a port on a point-to-point link is determined, you can enable BPDU source MAC address check to receive BPDU packets sent only by the peer switch and discard all other BPDU packets, thereby preventing malicious attacks. You can enable the BPDU source MAC address check in interface configuration mode for a specific port. One port can only filter one MAC address. If you run the `no bpdu src-mac-check` command to disable BPDU source MAC address check on a port, the port receives all BPDU packets.

→ BPDU Filter

If the Ethernet length of a BPDU exceeds 1,500, this BPDU will be discarded, preventing receipt of illegal BPDU packets.

→ Auto Edge

If the designated port of a device does not receive a BPDU from the downlink port within a specific period (3 seconds), the device regards a network device connected to the designated port, configures the port as an edge port, and switches the port directly into the forwarding state. The edge port will be automatically identified as a non-edge port after receiving a BPDU.

You can run the `spanning-tree autoedge disabled` command to disable Auto Edge.

This function is enabled by default.



If Auto Edge conflicts with the manually configured PortFast, the manual configuration prevails.



Since this function is used for rapid negotiation and forwarding between the designated port and the downlink port, STP does not support this function. If the designated port is in forwarding state, the Auto Edge configuration does not take effect on this port. It takes only when rapid negotiation is re-performed, for example, when the network cable is removed and plugged.



If BPDU filter has been enabled on a port, the port directly enters the forwarding state and is not automatically identified as an edge port.



This function applies only to the designated port.

→ Root Guard

In the network design, the root bridge and backup root bridge are usually divided into the same region. Due to incorrect configuration of maintenance personnel or malicious attacks in the network, the root bridge may receive configuration information with a higher priority and thereby switches to the backup root bridge, causing incorrect changes in the network topology. Root guard is to resolve this problem.

If root guard is enabled on a port, its roles on all instances are enforced as the designated port. Once the port receives configuration information with a higher priority, it enters the root-inconsistent (blocking) state. If the port does not receive configuration information with a higher priority within a period, it returns to its original state.

If a port enters the blocking state due to root guard, you can manually restore the port to the normal state by disabling root guard on this port or disabling spanning tree guard (running spanning-tree guard none in interface configuration mode).



If root guard is used incorrectly, the network link will be interrupted.



If root guard is enabled on a non-designated port, this port will be enforced as a designated port and enter the BKN state. This indicates that the port enters the blocking state due to root inconsistency.



If a port enters the BKN state due to receipt of configuration information with a higher priority in MST0, this port will be enforced in the BKN state in all other instances.



Root guard and loop guard cannot take effect on a port at the same time.

→ Loop Guard

Due to the unidirectional link failure, the root port or backup port becomes the designated port

and enters the forwarding state if it does not receive BPDUs, causing a network loop. Loop guard is to prevent this problem.

If a port enabled with loop guard does not receive BPDUs, the port switches its role but stays in discarding state till it receives BPDUs and recalculates the spanning tree.



You can enable loop guard globally or on a port.



Root guard and loop guard cannot take effect on a port at the same time.



Before MSTP is restarted on a port, the port enters the blocking state in loop guard. If the port still receives no BPDU after MSTP is restarted, the port will become a designated port and enter the forwarding state. Therefore, it is recommended to identify the cause why a port enters the blocking state in loop protection and rectify the fault as soon as possible before restarting MSTP. Otherwise, the spanning tree topology will still become abnormal after MSTP is restarted.

→ BPDU Transparent Transmission

In IEEE 802.1Q, the destination MAC address 01-80-C2-00-00-00 of the BPDU is used as a reserved address. That is, devices compliant with IEEE 802.1Q do not forward the BPDU packets received. However, devices may need to transparently transmit BPDU packets in actual network deployment. For example, if STP is disabled on a device, the device needs to transparently transmit BPDU packets so that the spanning tree between devices is properly calculated.



BPDU transparent transmission is disabled by default.



BPDU transparent transmission takes effect only when STP is disabled. If STP is enabled on a device, the device does not transparently transmit BPDU packets.

→ BPDU Tunnel

The QinQ network is generally divided into two parts: customer network and SP network. Before a user packet enters the SP network, it is encapsulated with the VLAN tag of an SP network and also retains the original VLAN tag as data. As a result, the packet carries two VLAN tags to pass through the SP network. In the SP network, packets are transmitted only based on the outer-layer VLAN tag. When packets leave the SP network, the outer-layer VLAN tag is removed.

The STP packet transparent transmission feature, namely BPDU Tunnel, can be used to realize the transmission of STP packets between the customer network without any impact on the SP network. If an STP packet sent from the customer network enters a PE, the PE changes the destination MAC address of the packet to a private address before the packet is forwarded by the SP network. When the packet reaches the PE at the peer end, the PE changes the destination MAC address to a public address and returns the packet to the customer network at the peer end, realizing transparent transmission across the SP network. In this case, STP on the customer network is calculated independently of that on the SP network.

7.4. Configuration

Configuration	Description and Command	
Enabling STP	 (Mandatory) It is used to enable STP.	
	spanning-tree	Enables STP and configures basic attributes.
	spanning-tree mode	Configures the STP mode.
Configuring STP Compatibility	 (Optional) It is used to be compatible with competitor devices.	
	spanning-tree compatible enable	Enables the compatibility mode of a port.
	clear spanning-tree detected-protocols	Performs mandatory version check for BPDUs.
Configuring an MSTP Region	 (Optional) It is used to configure an MSTP region.	
	spanning-tree mst configuration	Enters the MST configuration mode.
Enabling Fast RSTP Convergence	 (Optional) It is used to configure whether the link type of a port is point-to-point connection.	
	spanning-tree link-type	Configures the link type.
Configuring Priorities	 (Optional) It is used to configure the switch priority or port priority.	
	spanning-tree priority	Configures the switch priority.
	spanning-tree port-priority	Configures the port priority.

Configuring the Port Path Cost	 (Optional) It is used to configure the path cost of a port or the default path cost calculation method.
	spanning-tree cost Configures the port path cost.
	spanning-tree pathcost method Configures the default path cost calculation method.
Configuring the Maximum Hop Count of a BPDU Packet	 (Optional) It is used to configure the maximum hop count of a BPDU packet.
	spanning-tree max-hops Configures the maximum hop count of a BPDU packet.
Enabling Port-Fast-related Features	 (Optional) It is used to enable PortFast-related features.
	spanning-tree portfast Enables PortFast.
	spanning-tree portfast bpduguard default Enables BPDU guard on all ports.
	spanning-tree bpduguard enabled Enables BPDU guard on a port.
	spanning-tree portfast bpdufilter default Enables BPDU filter on all ports.
spanning-tree bpdufilter enabled Enables BPDU filter on a port.	
Enabling TC-related Features	 (Optional) It is used to enable TC-related features.
	spanning-tree tc-protection Enables TC protection.
	spanning-tree tc-protection tc-guard Enables TC guard on all ports.
	spanning-tree tc-guard Enables TC guard on a port.
spanning-tree ignore tc Enables TC filter on a port.	

Enabling BPDU Source MAC Address Check		(Optional) It is used to enable BPDU source MAC address check.
	bpdu src-mac-check	Enables BPDU source MAC address check on a port.
Configuring Auto Edge		(Optional) It is used to configure Auto Edge.
	spanning-tree autoedge	Enables Auto Edge on a port. This function is enabled by default.
Enabling Guard-related Features		(Optional) It is used to enable port guard features.
	spanning-tree guard root	Enables root guard on a port.
	spanning-tree loopguard default	Enables loop guard on all ports.
	spanning-tree guard loop	Enables loop guard on a port.
	spanning-tree guard none	Disables the guard feature on a port.
Enabling BPDU Transparent Transmission		(Optional) It is used to enable BPDU transparent transmission
	bridge-frame forwarding protocol bpdu	Enables BPDU transparent transmission.
Enabling BPDU Tunnel		(Optional) It is used to enable BPDU Tunnel.
	l2protocol-tunnel stp	Enables BPDU Tunnel globally.
	l2protocol-tunnel stp enable	Enables BPDU Tunnel on a port.
	l2protocol-tunnel stp tunnel-dmac	Configures the transparent transmission address of BPDU Tunnel.

7.4.1. Enabling STP

Configuration Effect

- Enable STP globally and configure the basic attributes.
- Configure the STP mode.

Notes

- STP is disabled by default. Once STP is enabled, the device starts to run STP. The device runs MSTP by default.
- The default STP mode is MSTP mode.
- STP and Transparent Interconnection of Lots of Links (TRILL) of the data center cannot be enabled at the same time.

Configuration Steps

- Enabling STP
- Mandatory.
- Unless otherwise specified, enable STP on each device.
- Run the spanning-tree [forward-time seconds | hello-time seconds | max-age seconds] command to enable STP and configure basic attributes.
- The forward-time ranges from 4 to 30. The hello-time ranges from 1 to 10. The max-age ranges from 6 to 40.



Running the clear commands may lose vital information and thus interrupt services. The value ranges of forward-time, hello-time, and max-age are related. If one of them is modified, the other two ranges are affected. The three values must meet the following condition: $2 \times (\text{Hello Time} + 1 \text{ second}) \leq \text{Max-Age Time} \leq 2 \times (\text{Forward-Delay Time} - 1 \text{ second})$. Otherwise, the topology may become unstable.

Command	spanning-tree [forward-time seconds hello-time seconds max-age seconds tx-hold-count numbers]
Parameter Description	<p>forward-time seconds: Indicates the interval when the port status changes. The value ranges from 4 to 30 seconds. The default value is 15 seconds.</p> <p>hello-time seconds: Indicates the interval when a device sends a BPDU packet. The value ranges from 1 to 10 seconds. The default value is 2 seconds.</p> <p>max-age second: Indicates the longest TTL of a BPDU packet. The value ranges from 6 to 40 seconds. The default value is 20 seconds.</p> <p>tx-hold-count numbers: Indicates the maximum number of BPDUs sent per second. The value ranges from 1 to 10. The default value is 3.</p>
Defaults	STP is disabled by default.

Command Mode	Global configuration mode
Usage Guide	The value ranges of forward-time, hello-time, and max-age are related. If one of them is modified, the other two ranges are affected. The three values must meet the following condition: $2 \times (\text{Hello Time} + 1 \text{ second}) \leq \text{Max-Age Time} \leq 2 \times (\text{Forward-Delay Time} - 1 \text{ second})$ Otherwise, the topology may become unstable.

→ Configuring the STP Mode

- Optional.
- According to related 802.1 protocol standards, STP, RSTP, and MSTP are mutually compatible, without any configuration by the administrator. However, some vendors' devices do not work according to 802.1 protocol standards, possibly causing incompatibility. Therefore, the administrator can switch the STP mode to a lower version if other vendors' devices are incompatible with this device.
- Run the spanning-tree mode [stp | rstp | mstp] command to modify the STP mode.

Command	spanning-tree mode [stp rstp mstp]
Parameter Description	stp: Spanning Tree Protocol (IEEE 802.1d) rstp: Rapid Spanning Tree Protocol (IEEE 802.1w) mstp: Multiple Spanning Tree Protocol (IEEE 802.1s)
Defaults	The default value is mstp.
Command Mode	Global configuration mode
Usage Guide	However, some vendors' devices do not work according to 802.1 protocol standards, possibly causing incompatibility. If other vendors' devices are incompatible with this device, run this command to switch the STP mode to a lower version.

Verification

- Display the configuration.

Configuration Example

→ Enabling STP and Configuring Timer Parameters

Scenario	
Configuration Steps	<ul style="list-style-type: none"> • Enable STP and set the STP mode to STP on the devices. • Configure the timer parameters of root bridge DEV A as follows: Hello Time=4s, Max Age=25s, Forward Delay=18s.
DEV A	<p>Step 1: Enable STP and set the STP mode to STP.</p> <pre>Switch#configure terminal Enter configuration commands, one per line. End with CNTL/Z. Switch(config)#spanning-tree Switch(config)#spanning-tree mode stp Step 2: Configure the timer parameters of root bridge DEV A. Switch(config)#spanning-tree hello-time 4 Switch(config)#spanning-tree max-age 25 Switch(config)#spanning-tree forward-time 18</pre>
DEV B	<p>Enable STP and set the STP mode to STP.</p> <pre>Switch#configure terminal Enter configuration commands, one per line. End with CNTL/Z. Switch(config)#spanning-tree Switch(config)#spanning-tree mode stp</pre>
Verification	<ul style="list-style-type: none"> • Run the show spanning-tree summary command to display the spanning tree topology and protocol configuration parameters.

DEV A	<div style="border: 1px solid #ccc; border-radius: 5px; padding: 10px; margin-bottom: 10px;"> <pre>Switch#show spanning-tree summary</pre> </div> <div style="border: 1px solid #ccc; border-radius: 5px; padding: 10px; margin-bottom: 10px;"> <pre>Spanning tree enabled protocol stp Root ID Priority 0 Address 00d0.f822.3344 this bridge is root Hello Time 4 sec Forward Delay 18 sec Max Age 25 sec</pre> </div> <div style="border: 1px solid #ccc; border-radius: 5px; padding: 10px; margin-bottom: 10px;"> <pre>Bridge ID Priority 0 Address 00d0.f822.3344 Hello Time 4 sec Forward Delay 18 sec Max Age 25 sec</pre> </div> <div style="border: 1px solid #ccc; border-radius: 5px; padding: 10px;"> <table border="1" style="width: 100%; border-collapse: collapse;"> <thead> <tr> <th style="text-align: left;">Interface</th> <th style="text-align: left;">Role</th> <th style="text-align: left;">Sts</th> <th style="text-align: left;">Cost</th> <th style="text-align: left;">Prio</th> <th style="text-align: left;">OperEdge</th> <th style="text-align: left;">Type</th> </tr> </thead> <tbody> <tr> <td>Gi0/2</td> <td>Desg</td> <td>FWD</td> <td>20000</td> <td>128</td> <td>False</td> <td>P2p</td> </tr> <tr> <td>Gi0/1</td> <td>Desg</td> <td>FWD</td> <td>20000</td> <td>128</td> <td>False</td> <td>P2p</td> </tr> </tbody> </table> </div>	Interface	Role	Sts	Cost	Prio	OperEdge	Type	Gi0/2	Desg	FWD	20000	128	False	P2p	Gi0/1	Desg	FWD	20000	128	False	P2p
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Gi0/2	Desg	FWD	20000	128	False	P2p																
Gi0/1	Desg	FWD	20000	128	False	P2p																

DEV B	<div style="border: 1px solid #ccc; border-radius: 5px; padding: 10px; margin-bottom: 10px;"> <pre>Switch#show spanning-tree summary</pre> </div> <div style="border: 1px solid #ccc; border-radius: 5px; padding: 10px; margin-bottom: 10px;"> <pre>Spanning tree enabled protocol stp Root ID Priority 0 Address 00d0.f822.3344 this bridge is root Hello Time 4 sec Forward Delay 18 sec Max Age 25 sec</pre> </div> <div style="border: 1px solid #ccc; border-radius: 5px; padding: 10px; margin-bottom: 10px;"> <pre>Bridge ID Priority 32768 Address 001a.a917.78cc Hello Time 2 sec Forward Delay 15 sec Max Age 20 sec</pre> </div> <div style="border: 1px solid #ccc; border-radius: 5px; padding: 10px;"> <table border="1" style="width: 100%; border-collapse: collapse;"> <thead> <tr> <th style="text-align: left;">Interface</th> <th style="text-align: left;">Role</th> <th style="text-align: left;">Sts</th> <th style="text-align: left;">Cost</th> <th style="text-align: left;">Prio</th> <th style="text-align: left;">OperEdge</th> <th style="text-align: left;">Type</th> </tr> </thead> <tbody> <tr> <td>Gi0/2</td> <td>Altn</td> <td>BLK</td> <td>20000</td> <td>128</td> <td>False</td> <td>P2p</td> </tr> <tr> <td colspan="7">Bound(STP)</td> </tr> <tr> <td>Gi0/1</td> <td>Root</td> <td>FWD</td> <td>20000</td> <td>128</td> <td>False</td> <td>P2p</td> </tr> <tr> <td colspan="7">Bound(STP)</td> </tr> </tbody> </table> </div>	Interface	Role	Sts	Cost	Prio	OperEdge	Type	Gi0/2	Altn	BLK	20000	128	False	P2p	Bound(STP)							Gi0/1	Root	FWD	20000	128	False	P2p	Bound(STP)						
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Common Errors

N/A

7.4.2. Configuring STP Compatibility

Configuration Effect

- Enable the compatibility mode of a port to realize interconnection between this device and other SPs' devices.
- Enable protocol migration to perform forcible version check to affect the compatibility between RSTP and STP.

Notes

- If the compatibility mode is enabled on a port, this port will add different MSTI information into the to-be-sent BPDU based on the current port to realize interconnection between this device and other SPs' devices.

Configuration Steps

→ Enabling the Compatibility Mode on a Port

- Optional.

Command	spanning-tree compatible enable
Parameter Description	N/A
Defaults	The compatibility mode is disabled on a port by default.
Command Mode	Interface configuration mode
Usage Guide	If the compatibility mode is enabled on a port, this port will add different MSTI information into the to-be-sent BPDU based on the current port to realize interconnection between this device and other SPs' devices.

→ Enabling Protocol Migration

- Optional.
- If the peer device supports RSTP, you can enforce version check on the local device to force the two devices to run RSTP.
- Run the clear spanning-tree detected-protocols [interface interface-id] command to enforce version check on a port. For details, see "Compatibility Between RSTP and STP".

Command	clear spanning-tree detected-protocols [interface interface-id]
Parameter Description	interface interface-id: Indicates a port.
Defaults	N/A
Command Mode	Privileged EXEC mode
Usage Guide	This command is used to enforce a port to send RSTP BPDU packets and perform forcible check on them.

Verification

- Display the configuration.

Configuration Example

→ Enabling STP Compatibility

Scenario	
Configuration Steps	<ul style="list-style-type: none"> • Configure Instances 1 and 2 on Devices A and B, and map Instance 1 with VLAN 10 and Instance 2 with VLAN 20. • Configure Gi0/1 and Gi0/2 to respectively belong to VLAN 10 and VLAN 20, and enable STP compatibility.
DEV A	<p>Step 1: Configure Instances 1 and 2, and map Instances 1 and 2 respectively with VLANs 10 and 20.</p> <pre>Switch#configure terminal Enter configuration commands, one per line. End with CNTL/Z. Switch(config)#spanning-tree mst configuration Switch(config-mst)#instance 1 vlan 10 Switch(config-mst)#instance 2 vlan 20</pre> <p>Step 2: Configure the VLAN the port belongs to, and enable STP compatibility on the port.</p> <pre>Switch(config)#int gi 0/1 Switch(config-if-GigabitEthernet 0/1)#switchport access vlan 10 Switch(config-if-GigabitEthernet 0/1)#spanning-tree compatible enable Switch(config-if-GigabitEthernet 0/1)#int gi 0/2 Switch(config-if-GigabitEthernet 0/2)#switchport access vlan 20 Switch(config-if-GigabitEthernet 0/2)#spanning-tree compatible enable</pre>
DEV B	Perform the same steps as DEV A.

<p>Verification</p>	<ul style="list-style-type: none"> Run the show spanning-tree summary command to check whether the spanning tree topology is correctly calculated.
<p>DEV A...</p>	<pre>Switch#show spanning-tree summary Spanning tree enabled protocol mstp MST 0 vlans map : 1-9, 11-19, 21-4094 Root ID Priority 32768 Address 001a.a917.78cc this bridge is root Hello Time 2 sec Forward Delay 15 sec Max Age 20 sec Bridge ID Priority 32768 Address 001a.a917.78cc Hello Time 2 sec Forward Delay 15 sec Max Age 20 sec Interface Role Sts Cost Prio OperEdge Type ----- ----- Gi0/2 Desg FWD 20000 128 False P2p Gi0/1 Desg FWD 20000 128 False P2p</pre>

<p>...A...</p>	<pre> MST 1 vlans map : 10 Region Root Priority 32768 Address 001a.a917.78cc this bridge is region root Bridge ID Priority 32768 Address 001a.a917.78cc Interface Role Sts Cost Prio OperEdge Type ----- ----- Gi0/1 Desg FWD 20000 128 False P2p </pre>
<p>...A</p>	<pre> MST 2 vlans map : 20 Region Root Priority 32768 Address 001a.a917.78cc this bridge is region root Bridge ID Priority 32768 Address 001a.a917.78cc Interface Role Sts Cost Prio OperEdge Type ----- ----- Gi0/2 Desg FWD 20000 128 False P2p </pre>

<p>DEV B...</p>	<pre>Switch#show spanning-tree summary Spanning tree enabled protocol mstp MST 0 vlans map : 1-9, 11-19, 21-4094 Root ID Priority 32768 Address 001a.a917.78cc this bridge is root Hello Time 2 sec Forward Delay 15 sec Max Age 20 sec Bridge ID Priority 32768 Address 00d0.f822.3344 Hello Time 4 sec Forward Delay 18 sec Max Age 25 sec Interface Role Sts Cost Prio OperEdge Type ----- ----- Gi0/2 Altn BLK 20000 128 False P2p Gi0/1 Root FWD 20000 128 False P2p</pre>
<p>...B...</p>	<pre>MST 1 vlans map : 10 Region Root Priority 32768 Address 001a.a917.78cc this bridge is region root Bridge ID Priority 32768 Address 00d0.f822.3344 Interface Role Sts Cost Prio OperEdge Type ----- ----- Gi0/1 Root FWD 20000 128 False P2p</pre>

...B	<pre> MST 2 vlans map : 20 Region Root Priority 32768 Address 001a.a917.78cc this bridge is region root Bridge ID Priority 32768 Address 00d0.f822.3344 Interface Role Sts Cost Prio OperEdge Type ----- ----- Gi0/2 Root FWD 20000 128 False P2p </pre>
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Common Errors

N/A

7.4.3. Configuring an MSTP Region

Configuration Effect

- Configure an MSTP region to adjust which devices belong to the same MSTP region and thereby affect the network topology.

Notes

- To make multiple devices belong to the same MSTP region, configure the same name, revision number, and instance-VLAN mapping table for them.
- You can configure VLANs for Instances 0 to 64, and then the remaining VLANs are automatically allocated to Instance 0. One VLAN belongs to only one instance.
- It is recommended to configure the instance-VLAN mapping table after disabling STP. After the configuration, re-enable MSTP to ensure stability and convergence of the network topology.

Configuration Steps

→ Configuring an MSTP Region

- Optional.
- Configure an MSTP region when multiple devices need to belong to the same MSTP region.
- Run the spanning-tree mst configuration command to enter the MST configuration mode.
- Run the instance instance-id vlan vlan-range command to configure the MSTI-VLAN map-

ping.

- Run the name name command to configure the MST name.
- Run the revision version command to configure the MST version number.

Command	spanning-tree mst configuration
Parameter Description	N/A
Defaults	N/A
Command Mode	Global configuration mode
Usage Guide	Run this command to enter the MST configuration mode.

Command	instance instance-id vlan vlan-range
Parameter Description	instance-id: Indicates the MSTI ID, ranging from 0 to 64. vlan-range: Indicates the VLAN ID, ranging from 1 to 4,094.
Defaults	The default instance-VLAN mapping is that all VLANs are in Instance 0.
Command Mode	MST configuration mode
Usage Guide	To add a VLAN group to an MSTI, run this command. For example, instance 1 vlan 2-200: Adds VLANs 2 to 200 to Instance 1. instance 1 vlan 2,20,200: Adds VLANs 2, 20, and 200 to Instance 1. You can use the no form of this command to remove VLANs from an instance. Removed VLANs are automatically forwarded to Instance 0.

Command	name name
Parameter Description	name: Indicates the MST name. It consists of a maximum of 32 bytes.
Defaults	The default name is an empty character string.
Command Mode	MST configuration mode
Usage Guide	N/A

Command	revision version
Parameter Description	version: Indicates the MST revision number, ranging from 0 to 65,535.
Defaults	The default revision number is 0.
Command Mode	MST configuration mode
Usage Guide	N/A

Verification

- Display the configuration.
- Run the show spanning-tree mst configuration command to display the MSTP region configuration.

Configuration Example

→ Enabling MSTP to Achieve VLAN Load Balancing in the MSTP+VRRP Topology

Scenario	
Configuration Steps	<ul style="list-style-type: none"> • Enable MSTP and create Instances 1 and 2 on Switches A, B, C, and D. • Configure Switch A as the root bridge of Instances 0 and 1 and Switch B as the root bridge of Instance 2. • Configure Switch A as the VRRP master device of VLANs 1 and 10 and Switch B as the VRRP master device of VLAN 20.

A	<p>Step 1: Configure VLANs 10 and 20, and configure ports as Trunk ports.</p> <pre>A(config)#vlan 10 A(config-vlan)#vlan 20 A(config-vlan)#exit A(config)#int range gi 0/1-2 A(config-if-range)#switchport mode trunk A(config-if-range)#int ag 1 A(config-if-AggregatePort 1)# switchport mode trunk</pre> <p>Step 2: Enable MSTP and create Instances 1 and 2.</p> <pre>A(config)#spanning-tree A(config)# spanning-tree mst configuration A(config-mst)#instance 1 vlan 10 A(config-mst)#instance 2 vlan 20 A(config-mst)#exit</pre> <p>Step 3: Configure Switch A as the root bridge of Instances 0 and 1.</p> <pre>A(config)#spanning-tree mst 0 priority 4096 A(config)#spanning-tree mst 1 priority 4096 A(config)#spanning-tree mst 2 priority 8192</pre> <p>Step 4: Configure VRRP priorities to enable Switch A to act as the VRRP master device of VLAN 10, and configure the virtual gateway IP address of VRRP.</p> <pre>A(config)#interface vlan 10 A(config-if-VLAN 10)ip address 192.168.10.2 255.255.255.0 A(config-if-VLAN 10) vrrp 1 priority 120 A(config-if-VLAN 10) vrrp 1 ip 192.168.10.1</pre>
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A	<p>Step 5 Set the VRRP priority to the default value 100 to enable Switch A to act as the VRRP backup device of VLAN 20.</p> <pre>A(config)#interface vlan 20 A(config-if-VLAN 20)ip address 192.168.20.2 255.255.255.0 A(config-if-VLAN 20) vrrp 1 ip 192.168.20.1</pre>
B	<p>Step 1: Configure VLANs 10 and 20, and configure ports as Trunk ports.</p> <pre>B(config)#vlan 10 B(config-vlan)#vlan 20 B(config-vlan)#exit B(config)#int range gi 0/1-2 B(config-if-range)#switchport mode trunk B(config-if-range)#int ag 1 B(config-if-AggregatePort 1)# switchport mode trunk</pre> <p>Step 2: Enable MSTP and create Instances 1 and 2.</p> <pre>B(config)#spanning-tree B(config)# spanning-tree mst configuration B(config-mst)#instance 1 vlan 10 B(config-mst)#instance 2 vlan 20 B(config-mst)#exit</pre> <p>Step 3: Configure Switch A as the root bridge of Instance 2.</p> <pre>B(config)#spanning-tree mst 0 priority 8192 B(config)#spanning-tree mst 1 priority 8192 B(config)#spanning-tree mst 2 priority 4096</pre>

B	<p>Step 4: Configure the virtual gateway IP address of VRRP.</p> <pre>B(config)#interface vlan 10 B(config-if-VLAN 10)ip address 192.168.10.3 255.255.255.0 B(config-if-VLAN 10) vrrp 1 ip 192.168.10.1</pre> <p>Step 5 Set the VRRP priority to 120 to enable Switch B to act as the VRRP backup device of VLAN 20.</p> <pre>B(config)#interface vlan 20 B(config-if-VLAN 20)vrrp 1 priority 120 B(config-if-VLAN 20)ip address 192.168.20.3 255.255.255.0 B(config-if-VLAN 20) vrrp 1 ip 192.168.20.1</pre>
C	<p>Step 1: Configure VLANs 10 and 20, and configure ports as Trunk ports.</p> <pre>C(config)#vlan 10 C(config-vlan)#vlan 20 C(config-vlan)#exit C(config)#int range gi 0/1-2 C(config-if-range)#switchport mode trunk</pre> <p>Step 2: Enable MSTP and create Instances 1 and 2.</p> <pre>C(config)#spanning-tree C(config)# spanning-tree mst configuration C(config-mst)#instance 1 vlan 10 C(config-mst)#instance 2 vlan 20 C(config-mst)#exit</pre>

C	<p>Step 3: Configure the port connecting Device C directly to users as a Port-Fast port and enable BPDU guard.</p> <pre>C(config)#int gi 0/3 C(config-if-GigabitEthernet 0/3)#spanning-tree portfast C(config-if-GigabitEthernet 0/3)#spanning-tree bpduguard enable</pre>																												
D	<p>Perform the same steps as Device C.</p>																												
Verification	<ul style="list-style-type: none"> • Run the show spanning-tree summary command to check whether the spanning tree topology is correctly calculated. • Run the show vrrp brief command to check whether the VRRP master/backup devices are successfully created. 																												
A...	<pre>Switch#show spanning-tree summary</pre> <pre>Spanning tree enabled protocol mstp MST 0 vlans map : 1-9, 11-19, 21-4094 Root ID Priority 4096 Address 00d0.f822.3344 this bridge is root Hello Time 4 sec Forward Delay 18 sec Max Age 25 sec</pre> <pre>Bridge ID Priority 4096 Address 00d0.f822.3344 Hello Time 4 sec Forward Delay 18 sec Max Age 25 sec</pre> <table border="1"> <thead> <tr> <th>Interface</th> <th>Role</th> <th>Sts</th> <th>Cost</th> <th>Prio</th> <th>OperEdge</th> <th>Type</th> </tr> </thead> <tbody> <tr> <td>Ag1</td> <td>Desg</td> <td>FWD</td> <td>19000</td> <td>128</td> <td>False</td> <td>P2p</td> </tr> <tr> <td>Gi0/1</td> <td>Desg</td> <td>FWD</td> <td>200000</td> <td>128</td> <td>False</td> <td>P2p</td> </tr> <tr> <td>Gi0/2</td> <td>Desg</td> <td>FWD</td> <td>200000</td> <td>128</td> <td>False</td> <td>P2p</td> </tr> </tbody> </table>	Interface	Role	Sts	Cost	Prio	OperEdge	Type	Ag1	Desg	FWD	19000	128	False	P2p	Gi0/1	Desg	FWD	200000	128	False	P2p	Gi0/2	Desg	FWD	200000	128	False	P2p
Interface	Role	Sts	Cost	Prio	OperEdge	Type																							
Ag1	Desg	FWD	19000	128	False	P2p																							
Gi0/1	Desg	FWD	200000	128	False	P2p																							
Gi0/2	Desg	FWD	200000	128	False	P2p																							

<p>...A...</p>	<pre> MST 1 vlans map : 10 Region Root Priority 4096 Address 00d0.f822.3344 this bridge is region root Bridge ID Priority 4096 Address 00d0.f822.3344 Interface Role Sts Cost Prio OperEdge Type ----- Ag1 Desg FWD 19000 128 False P2p Gi0/1 Desg FWD 200000 128 False P2p Gi0/2 Desg FWD 200000 128 False P2p </pre>
<p>...A</p>	<pre> MST 2 vlans map : 20 Region Root Priority 4096 Address 001a.a917.78cc this bridge is region root Bridge ID Priority 8192 Address 00d0.f822.3344 Interface Role Sts Cost Prio OperEdge Type ----- Ag1 Root FWD 19000 128 False P2p Gi0/1 Desg FWD 200000 128 False P2p Gi0/2 Desg FWD 200000 128 False P2p </pre>

B...

```
Switch#show spanning-tree summary
```

```
Spanning tree enabled protocol mstp
MST 0 vlans map : 1-9, 11-19, 21-4094
Root ID    Priority    4096
           Address    00d0.f822.3344
           this bridge is root
           Hello Time  4 sec Forward Delay 18 sec Max Age 25
sec
```

```
Bridge ID  Priority    8192
           Address    001a.a917.78cc
           Hello Time  2 sec Forward Delay 15 sec Max Age 20
sec
```

Interface	Role	Sts	Cost	Prio	OperEdge	Type
Ag1	Root	FWD	19000	128	False	P2p
Gi0/1	Desg	FWD	200000	128	False	P2p
Gi0/2	Desg	FWD	200000	128	False	P2p

<p>...B...</p>	<pre> MST 1 vlans map : 10 Region Root Priority 4096 Address 00d0.f822.3344 this bridge is region root Bridge ID Priority 8192 Address 001a.a917.78cc Interface Role Sts Cost Prio OperEdge Type ----- Ag1 Root FWD 19000 128 False P2p Gi0/1 Desg FWD 200000 128 False P2p Gi0/2 Desg FWD 200000 128 False P2p </pre>
<p>...B</p>	<pre> MST 2 vlans map : 20 Region Root Priority 4096 Address 001a.a917.78cc this bridge is region root Bridge ID Priority 4096 Address 001a.a917.78cc Interface Role Sts Cost Prio OperEdge Type ----- Ag1 Desg FWD 19000 128 False P2p Gi0/1 Desg FWD 200000 128 False P2p Gi0/2 Desg FWD 200000 128 False P2p </pre>

<p>C...</p>	<pre>Switch#show spanning-tree summary Spanning tree enabled protocol mstp MST 0 vlans map : 1-9, 11-19, 21-4094 Root ID Priority 4096 Address 00d0.f822.3344 this bridge is root Hello Time 4 sec Forward Delay 18 sec Max Age 25 sec Bridge ID Priority 32768 Address 001a.a979.00ea Hello Time 2 sec Forward Delay 15 sec Max Age 20 sec Interface Role Sts Cost Prio Type OperEdge ----- Fa0/2 Altn BLK 200000 128 P2p False Fa0/1 Root FWD 200000 128 P2p False</pre>
<p>...C...</p>	<pre>MST 1 vlans map : 10 Region Root Priority 4096 Address 00d0.f822.3344 this bridge is region root Bridge ID Priority 32768 Address 001a.a979.00ea Interface Role Sts Cost Prio Type OperEdge ----- Fa0/2 Altn BLK 200000 128 P2p False Fa0/1 Root FWD 200000 128 P2p False</pre>

...C	<pre> MST 2 vlans map : 20 Region Root Priority 4096 Address 001a.a917.78cc this bridge is region root Bridge ID Priority 32768 Address 001a.a979.00ea Interface Role Sts Cost Prio Type OperEdge ----- Fa0/2 Root FWD 200000 128 P2p False Fa0/1 Altn BLK 200000 128 P2p False </pre>
D	Omitted.

Common Errors

- MST region configurations are inconsistent in the MSTP topology.
- VLANs are not created before you configure the mapping between the instance and VLAN.
- A device runs STP or RSTP in the MSTP+VRRP topology, but calculates the spanning tree according to the algorithms of different MST regions.

7.4.4. Enabling Fast RSTP Convergence

Configuration Effect

- Configure the link type to make RSTP rapidly converge.

Notes * If the link type of a port is point-to-point connection, RSTP can rapidly converge. For details, see "Fast RSTP Convergence". If the link type is not configured, the device automatically sets the link type based on the duplex mode of the port. If a port is in full duplex mode, the device sets the link type to point-to-point. If a port is in half duplex mode, the device sets the link type to shared. You can also forcibly configure the link type to determine whether the port connection is point-to-point connection.

Configuration Steps

→ Configuring the Link Type

- Optional.

Command	spanning-tree link-type [point-to-point shared]
Parameter Description	point-to-point: Forcibly configures the link type of a port to be point-to-point. shared: Forcibly configures the link type of a port to be shared.
Defaults	If a port is in full duplex mode, the link type of the port is point-to-point. If a port is in half duplex mode, the link type of the port is shared.
Command Mode	Interface configuration mode
Usage Guide	If the link type of a port is point-to-point connection, RSTP can rapidly converge. If the link type is not configured, the device automatically sets the link type based on the duplex mode of the port.

Verification

- Display the configuration.
- Run the show spanning-tree [mst instance-id] interface interface-id command to display the spanning tree configuration of the port.

Configuration Example

→ Enabling Fast RSTP Convergence

Configuration Steps	Set the link type of a port to point-to-point.
	<pre>Switch(config)#int gi 0/1 Switch(config-if-GigabitEthernet 0/1)#spanning-tree link-type point-to-point</pre>
Verification	<ul style="list-style-type: none"> • Run the show spanning-tree summary command to display the link type of the port.

```
Switch#show spanning-tree summary

Spanning tree enabled protocol mstp
MST 0 vlans map : ALL
Root ID    Priority    32768
          Address    001a.a917.78cc
          this bridge is root
          Hello Time  2 sec Forward Delay 15 sec Max Age 20
sec

Bridge ID  Priority    32768
          Address    00d0.f822.3344
          Hello Time  2 sec Forward Delay 15 sec Max Age 20
sec

Interface      Role Sts Cost      Prio   OperEdge Type
-----
-----
Gi0/1          Root FWD 20000    128    False   P2p
```

Common Errors

N/A

7.4.5. Configuring Priorities

Configuration Effect

- Configure the switch priority to determine a device as the root of the entire network and to determine the topology of the entire network.
- Configure the port priority to determine which port enters the forwarding state.

Notes

- It is recommended to set the priority of the core device higher (to a smaller value) to ensure stability of the entire network. You can assign different switch priorities to different instances so that each instance runs an independent STP based on the assigned priorities. Devices in different regions use the priority only of the CIST (Instance 0). As described in bridge ID, the switch priority has 16 optional values: 0, 4,096, 8,192, 12,288, 16,384, 20,480, 24,576, 28,672, 32,768, 36,864, 40,960, 45,056, 49,152, 53,248, 57,344, 61,440. They are integral multiples of 4,096. The default value is 32,768.

- If two ports are connected to a shared device, the device selects a port with a higher priority (smaller value) to enter the forwarding state and a port with a lower priority (larger value) to enter the discarding state. If the two ports have the same priority, the device selects the port with a smaller port ID to enter the forwarding state. You can assign different port priorities to different instances on a port so that each instance runs an independent STP based on the assigned priorities.
- Similar to the switch priority, the port priority also has 16 optional values: 0, 16, 32, 48, 64, 80, 96, 112, 128, 144, 160, 176, 192, 208, 224, 240. They are integral multiples of 16. The default value is 128.

Configuration Steps

→ Configuring the Switch Priority

- Optional.
- To change the root or topology of a network, configure the switch priority.

Command	spanning-tree [mst instance-id] priority priority
Parameter Description	mst instance-id: Indicates the instance ID, ranging from 0 to 64. priority priority: Indicates the switch priority. There are 16 optional values: 0, 4,096, 8,192, 12,288, 16,384, 20,480, 24,576, 28,672, 32,768, 36,864, 40,960, 45,056, 49,152, 53,248, 57,344, 61,440. They are integral multiples of 4,096.
Defaults	The default value of instance-id is 0 while that of priority is 32,768.
Command Mode	Global configuration mode
Usage Guide	Configure the switch priority to determine a device as the root of the entire network and to determine the topology of the entire network.

→ Configuring the Port Priority

- Optional.
- To change the preferred port entering the forwarding state, configure the port priority.

Command	spanning-tree [mst instance-id] port-priority priority
Parameter Description	mst instance-id: Indicates the instance ID, ranging from 0 to 64. port-priority priority: Indicates the port priority. There are 16 optional values: 0, 16, 32, 48, 64, 80, 96, 112, 128, 144, 160, 176, 192, 208, 224, 240. They are integral multiples of 4,096.
Defaults	The default value of instance-id is 0. The default value of priority is 128.

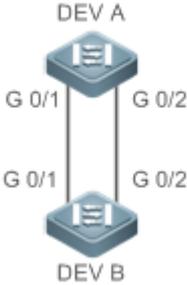
Command Mode	Interface configuration mode
Usage Guide	If a loop occurs in a region, the port with a higher priority is preferred to enter the forwarding state. If two ports have the same priority, the port with a smaller port ID is selected to enter the forwarding state. Run this command to determine which port in the loop of a region enters the forwarding state.

Verification

- Display the configuration.
- Run the show spanning-tree [mst instance-id] interface interface-id command to display the spanning tree configuration of the port.

Configuration Example

→ Configuring the Port Priority

Scenario	
Configuration Steps	<ul style="list-style-type: none"> • Configure the bridge priority so that DEV A becomes the root bridge of the spanning tree. • Configure the priority of Gi0/2 on DEV A is 16 so that Gi0/2 on DEV B can be selected as the root port.
DEV A	<p>Step 1: Enable STP and configure the bridge priority.</p> <pre>Switch(config)#spanning-tree Switch(config)#spanning-tree mst 0 priority 0</pre> <p>Step 2: Configure the priority of Gi 0/2.</p> <pre>Switch(config)# int gi 0/2 Switch(config-if-GigabitEthernet 0/2)#spanning-tree mst 0 port-priority 16</pre>

DEV B	<div style="border: 1px solid #ccc; background-color: #f0f0f0; padding: 5px; border-radius: 5px;"> Switch(config)#spanning-tree </div>																					
Verification	<ul style="list-style-type: none"> Run the show spanning-tree summary command to display the topology calculation result of the spanning tree. 																					
DEV A	<div style="border: 1px solid #ccc; background-color: #f0f0f0; padding: 10px; border-radius: 5px;"> <div style="border: 1px solid #ccc; background-color: #fff; padding: 5px; margin-bottom: 10px; border-radius: 5px;"> Switch# Switch#show spanning-tree summary </div> <div style="border: 1px solid #ccc; background-color: #fff; padding: 5px; margin-bottom: 10px; border-radius: 5px;"> <pre>Spanning tree enabled protocol mstp MST 0 vlans map : ALL Root ID Priority 0 Address 00d0.f822.3344 this bridge is root Hello Time 2 sec Forward Delay 15 sec Max Age 20 sec</pre> </div> <div style="border: 1px solid #ccc; background-color: #fff; padding: 5px; margin-bottom: 10px; border-radius: 5px;"> <pre>Bridge ID Priority 0 Address 00d0.f822.3344 Hello Time 2 sec Forward Delay 15 sec Max Age 20 sec</pre> </div> <div style="border: 1px solid #ccc; background-color: #fff; padding: 5px; border-radius: 5px;"> <table border="1" style="width: 100%; border-collapse: collapse;"> <thead> <tr> <th style="text-align: left;">Interface</th> <th style="text-align: left;">Role</th> <th style="text-align: left;">Sts</th> <th style="text-align: left;">Cost</th> <th style="text-align: left;">Prio</th> <th style="text-align: left;">OperEdge</th> <th style="text-align: left;">Type</th> </tr> </thead> <tbody> <tr> <td>Gi0/2</td> <td>Desg</td> <td>FWD</td> <td>20000</td> <td>16</td> <td>False</td> <td>P2p</td> </tr> <tr> <td>Gi0/1</td> <td>Desg</td> <td>FWD</td> <td>20000</td> <td>128</td> <td>False</td> <td>P2p</td> </tr> </tbody> </table> </div> </div>	Interface	Role	Sts	Cost	Prio	OperEdge	Type	Gi0/2	Desg	FWD	20000	16	False	P2p	Gi0/1	Desg	FWD	20000	128	False	P2p
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Gi0/2	Desg	FWD	20000	16	False	P2p																
Gi0/1	Desg	FWD	20000	128	False	P2p																

DEV B	<div style="border: 1px solid #ccc; border-radius: 5px; padding: 10px; margin-bottom: 10px;"> <pre>Switch#show spanning-tree summary</pre> </div> <div style="border: 1px solid #ccc; border-radius: 5px; padding: 10px; margin-bottom: 10px;"> <pre>Spanning tree enabled protocol mstp MST 0 vlans map : ALL Root ID Priority 0 Address 00d0.f822.3344 this bridge is root Hello Time 2 sec Forward Delay 15 sec Max Age 20 sec</pre> </div> <div style="border: 1px solid #ccc; border-radius: 5px; padding: 10px; margin-bottom: 10px;"> <pre>Bridge ID Priority 32768 Address 001a.a917.78cc Hello Time 2 sec Forward Delay 15 sec Max Age 20 sec</pre> </div> <div style="border: 1px solid #ccc; border-radius: 5px; padding: 10px;"> <table style="width: 100%; border-collapse: collapse;"> <thead> <tr> <th style="text-align: left;">Interface</th> <th style="text-align: left;">Role</th> <th style="text-align: left;">Sts</th> <th style="text-align: left;">Cost</th> <th style="text-align: left;">Prio</th> <th style="text-align: left;">OperEdge</th> <th style="text-align: left;">Type</th> </tr> <tr> <td colspan="7" style="border-top: 1px dashed black; border-bottom: 1px dashed black;"></td> </tr> </thead> <tbody> <tr> <td>Gi0/2</td> <td>Root</td> <td>FWD</td> <td>20000</td> <td>128</td> <td>False</td> <td>P2p</td> </tr> <tr> <td>Gi0/1</td> <td>Altn</td> <td>BLK</td> <td>20000</td> <td>128</td> <td>False</td> <td>P2p</td> </tr> </tbody> </table> </div>	Interface	Role	Sts	Cost	Prio	OperEdge	Type								Gi0/2	Root	FWD	20000	128	False	P2p	Gi0/1	Altn	BLK	20000	128	False	P2p
Interface	Role	Sts	Cost	Prio	OperEdge	Type																							
Gi0/2	Root	FWD	20000	128	False	P2p																							
Gi0/1	Altn	BLK	20000	128	False	P2p																							

Common Errors

N/A

7.4.6. Configuring the Port Path Cost

Configuration Effect

- Configure the path cost of a port to determine the forwarding state of the port and the topology of the entire network.
- If the path cost of a port uses its default value, configure the path cost calculation method to affect the calculation result.

Notes

- A device selects a port as the root port if the path cost from this port to the root bridge is the lowest. Therefore, the port path cost determines the root port of the local device. The default port path cost is automatically calculated based on the port rate (Media Speed). A port with a higher rate will have a low path cost. Since this method can calculate the most scientific path cost, do not change the path cost unless required. You can assign different path costs to different instances on a port so that each instance runs an independent STP

based on the assigned path costs.

- If the port path cost uses the default value, the device automatically calculates the port path cost based on the port rate. However, IEEE 802.1d-1998 and IEEE 802.1t define different path costs for the same link rate. The value is a short integer ranging from 1 to 65,535 in 802.1d-1998 while is a long integer ranging from 1 to 200,000,000 in IEEE 802.1t. The path cost of an aggregate port (AP) has two solutions: 1. Microsens solution: Port Path Cost x 95%; 2. Solution recommended in standards: 20,000,000,000/Actual link bandwidth of the AP, in which Actual link bandwidth of the AP = Bandwidth of a member port x Number of active member ports. The administrator must unify the path cost calculation method in the entire network. The default standard is the private long integer standard.
- The following table lists path costs automatically configured for different link rate in two solutions.

Port Rate	Port	IEEE 802.1d (short)	IEEE 802.1t (long)	IEEE 802.1t (long standard)
10M	Common port	100	2000000	2000000
	AP	95	1900000	2000000÷linkupcnt
100M	Common port	19	200000	200000
	AP	18	190000	200000÷linkupcnt
1000M	Common port	4	20000	20000
	AP	3	19000	20000÷linkupcnt
10000M	Common port	2	2000	2000
	AP	1	1900	20000÷linkupcnt

- Microsens' long integer standard is used by default. After the solution is changed to the path cost solution recommended by the standards, the path cost of an AP changes with the number of member ports in UP state. If the port path cost changes, the network topology also will change.
- If an AP is static, linkupcnt in the table is the number of active member ports. If an AP is an LACP AP, linkupcnt in the table is the number of member ports forwarding AP data. If no member port in the AP goes up, linkupcnt is 1. For details about AP and LACP, see the Configuring AP.

Configuration Steps

→ Configuring the Port Path Cost

- Optional.
- To determine which port or path data packets prefer to pass through, configure the port path cost.

Command	spanning-tree [mst instance-id] cost cost
Parameter Description	mst instance-id: Indicates the instance ID, ranging from 0 to 64. cost cost: Indicates the path cost, ranging from 1 to 200,000,000.
Defaults	The default value of instance-id is 0. The default value is automatically calculated based on the port rate. 1000 Mbps—20000 100 Mbps—200000 10 Mbps—2000000
Command Mode	Interface configuration mode
Usage Guide	A larger value of cost indicates a higher path cost.

→ Configuring the Default Path Cost Calculation Method

- Optional.
- To change the path cost calculation method, configure the default path cost calculation method.

Command	spanning-tree pathcost method { long [standard] short }
Parameter Description	long: Uses the path cost specified in 802.1t. standard: Uses the cost calculated according to the standard. short: Uses the path cost specified in 802.1d.
Defaults	The path cost specified in 802.1t is used by default.
Command Mode	Global configuration mode
Usage Guide	Usage Guide If the port path cost uses the default value, the device automatically calculates the port path cost based on the port rate.

Verification

- Display the configuration.

- Run the show spanning-tree [mst instance-id] interface interface-id command to display the spanning tree configuration of the port.

Configuration Example

→ Configuring the Port Path Cost

Scenario	
Configuration Steps	<ul style="list-style-type: none"> • Configure the bridge priority so that DEV A becomes the root bridge of the spanning tree. • Configure the path cost of Gi 0/2 on DEV B is 1 so that Gi 0/2 can be selected as the root port.
DEV A	<pre>Switch(config)#spanning-tree Switch(config)#spanning-tree mst 0 priority 0</pre>
DEV B	<pre>Switch(config)#spanning-tree Switch(config)# int gi 0/2 Switch(config-if-GigabitEthernet 0/2)# spanning-tree cost 1</pre>
Verification	<ul style="list-style-type: none"> • Run the show spanning-tree summary command to display the topology calculation result of the spanning tree.

DEV A	<div style="border: 1px solid #ccc; border-radius: 5px; padding: 10px; margin-bottom: 10px;"> <pre>Switch# Switch#show spanning-tree summary</pre> </div> <div style="border: 1px solid #ccc; border-radius: 5px; padding: 10px; margin-bottom: 10px;"> <pre>Spanning tree enabled protocol mstp MST 0 vlans map : ALL Root ID Priority 0 Address 00d0.f822.3344 this bridge is root Hello Time 2 sec Forward Delay 15 sec Max Age 20 sec</pre> </div> <div style="border: 1px solid #ccc; border-radius: 5px; padding: 10px; margin-bottom: 10px;"> <pre>Bridge ID Priority 0 Address 00d0.f822.3344 Hello Time 2 sec Forward Delay 15 sec Max Age 20 sec</pre> </div> <div style="border: 1px solid #ccc; border-radius: 5px; padding: 10px;"> <table border="0" style="width: 100%; border-collapse: collapse;"> <thead> <tr> <th style="text-align: left;">Interface</th> <th style="text-align: left;">Role</th> <th style="text-align: left;">Sts</th> <th style="text-align: left;">Cost</th> <th style="text-align: left;">Prio</th> <th style="text-align: left;">OperEdge</th> <th style="text-align: left;">Type</th> </tr> <tr> <td colspan="7" style="border-top: 1px dashed black; border-bottom: 1px dashed black;"></td> </tr> </thead> <tbody> <tr> <td>Gi0/2</td> <td>Desg</td> <td>FWD</td> <td>20000</td> <td>128</td> <td>False</td> <td>P2p</td> </tr> <tr> <td>Gi0/1</td> <td>Desg</td> <td>FWD</td> <td>20000</td> <td>128</td> <td>False</td> <td>P2p</td> </tr> </tbody> </table> </div>	Interface	Role	Sts	Cost	Prio	OperEdge	Type								Gi0/2	Desg	FWD	20000	128	False	P2p	Gi0/1	Desg	FWD	20000	128	False	P2p
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Gi0/2	Desg	FWD	20000	128	False	P2p																							
Gi0/1	Desg	FWD	20000	128	False	P2p																							

DEV B	<div style="border: 1px solid #ccc; border-radius: 5px; padding: 10px; margin-bottom: 10px;"> <pre>Switch#show spanning-tree summary</pre> </div> <div style="border: 1px solid #ccc; border-radius: 5px; padding: 10px; margin-bottom: 10px;"> <pre>Spanning tree enabled protocol mstp MST 0 vlans map : ALL Root ID Priority 0 Address 00d0.f822.3344 this bridge is root Hello Time 2 sec Forward Delay 15 sec Max Age 20 sec</pre> </div> <div style="border: 1px solid #ccc; border-radius: 5px; padding: 10px; margin-bottom: 10px;"> <pre>Bridge ID Priority 32768 Address 001a.a917.78cc Hello Time 2 sec Forward Delay 15 sec Max Age 20 sec</pre> </div> <div style="border: 1px solid #ccc; border-radius: 5px; padding: 10px;"> <table style="width: 100%; border-collapse: collapse;"> <thead> <tr> <th style="text-align: left;">Interface</th> <th style="text-align: left;">Role</th> <th style="text-align: left;">Sts</th> <th style="text-align: left;">Cost</th> <th style="text-align: left;">Prio</th> <th style="text-align: left;">OperEdge</th> <th style="text-align: left;">Type</th> </tr> <tr> <td colspan="7" style="border-top: 1px dashed black; border-bottom: 1px dashed black;"></td> </tr> </thead> <tbody> <tr> <td>Gi0/2</td> <td>Root</td> <td>FWD</td> <td>1</td> <td>128</td> <td>False</td> <td>P2p</td> </tr> <tr> <td>Gi0/1</td> <td>Altn</td> <td>BLK</td> <td>20000</td> <td>128</td> <td>False</td> <td>P2p</td> </tr> </tbody> </table> </div>	Interface	Role	Sts	Cost	Prio	OperEdge	Type								Gi0/2	Root	FWD	1	128	False	P2p	Gi0/1	Altn	BLK	20000	128	False	P2p
Interface	Role	Sts	Cost	Prio	OperEdge	Type																							
Gi0/2	Root	FWD	1	128	False	P2p																							
Gi0/1	Altn	BLK	20000	128	False	P2p																							

Common Errors

- N/A

7.4.7. Configuring the Maximum Hop Count of a BPDU Packet

Configuration Effect

- Configure the maximum hop count of a BPDU packet to change the BPDU TTL and thereby affect the network topology.

Notes

- The default maximum hop count of a BPDU packet is 20. Generally, it is not recommended to change the default value.

Configuration Steps

→ Configuring the Maximum Hop Count

- (Optional) If the network topology is so large that a BPDU packet exceeds the default 20

hops, it is recommended to change the maximum hop count.

Command	spanning-tree max-hops hop-count
Parameter Description	hop-count: Indicates the number of devices a BPDU passes through before being discarded. It ranges from 1 to 40.
Defaults	The default value of hop-count is 20.
Command Mode	Global configuration mode
Usage Guide	In a region, the BPDU sent by the root bridge includes a hop count. Every time a BPDU passes through a device from the root bridge, the hop count decreases by 1. When the hop count becomes 0, the BPDU times out and the device discards the packet. This command specifies the number of devices a BPDU passes through in a region before being discarded. Changing the maximum hop count will affect all instances.

Verification

- Display the configuration.
- Run the show spanning-tree max-hops command to display the configured maximum hop count.

Configuration Example

→ Configuring the Maximum Hop Count of a BPDU Packet

Configuration Steps	<ul style="list-style-type: none"> • Set the maximum hop count of a BPDU packet to 25.
	<pre>Switch(config)# spanning-tree max-hops 25</pre>
Verification	<ul style="list-style-type: none"> • Run the show spanning-tree command to display the configuration.

	<pre>Switch# show spanning-tree StpVersion : MSTP SysStpStatus : ENABLED MaxAge : 20 HelloTime : 2 ForwardDelay : 15 BridgeMaxAge : 20 BridgeHelloTime : 2 BridgeForwardDelay : 15 MaxHops: 25 TxHoldCount : 3 PathCostMethod : Long BPDUGuard : Disabled BPDUFilter : Disabled LoopGuardDef : Disabled ##### mst 0 vlans map : ALL BridgeAddr : 00d0.f822.3344 Priority: 0 TimeSinceTopologyChange : 2d:0h:46m:4s TopologyChanges : 25 DesignatedRoot : 0.001a.a917.78cc RootCost : 0 RootPort : GigabitEthernet 0/1 CistRegionRoot : 0.001a.a917.78cc CistPathCost : 20000</pre>
--	---

7.4.8. Enabling PortFast-related Features

Configuration Effect

- After PortFast is enabled on a port, the port directly enters the forwarding state. However, since the Port Fast Operational State becomes disabled due to receipt of BPDUs, the port can properly run the STP algorithm and enter the forwarding state.
- If BPDU guard is enabled on a port, the port enters the error-disabled state after receiving a BPDU.
- If BPDU filter is enabled on a port, the port neither sends nor receives BPDUs.

Notes

- The global BPDU guard takes effect only when PortFast is enabled on a port.
- If BPDU filter is enabled globally, a PortFast-enabled port neither sends nor receives BPDUs. In this case, the host connecting directly to the PortFast-enabled port does not receive any

BPDUs. If the port changes its Port Fast Operational State to Disabled after receiving a BPDU, BPDU filter automatically fails.

- The global BPDU filter takes effect only when PortFast is enabled on a port.

Configuration Steps

→ Enabling PortFast

- Optional.
- If a port connects directly to the network terminal, configure this port as a PortFast port.
- In global configuration mode, run the spanning-tree portfast default command to enable PortFast on all ports and the no spanning-tree portfast default command to disable PortFast on all ports.
- In interface configuration mode, run the spanning-tree portfast command to enable PortFast on a port and the spanning-tree portfast disabled command to disable PortFast on a port.

Command	spanning-tree portfast default
Parameter Description	N/A
Defaults	PortFast is disabled on all ports by default.
Command Mode	Global configuration mode
Usage Guide	N/A

Command	spanning-tree portfast
Parameter Description	N/A
Defaults	PortFast is disabled on a port by default.
Command Mode	Interface configuration mode
Usage Guide	After PortFast is enabled on a port, the port directly enters the forwarding state. However, since the Port Fast Operational State becomes disabled due to receipt of BPDUs, the port can properly run the STP algorithm and enter the forwarding state.

→ Enabling BPDU Guard

- Optional.

- If device ports connect directly to network terminals, you can enable BPDU guard on these ports to prevent BPDU attacks from causing abnormality in the spanning tree topology. A port enabled with BPDU guard enters the error-disabled state after receiving a BPDU.
- If device ports connect directly to network terminals, you can enable BPDU guard to prevent loops on the ports. The prerequisite is that the downlink device (such as the hub) can forward BPDU packets.
- In global configuration mode, run the spanning-tree portfast bpduguard default command to enable BPDU guard on all ports and the no spanning-tree portfast bpduguard default command to disable BPDU guard on all ports.
- In interface configuration mode, run the spanning-tree bpduguard enabled command to enable BPDU guard on a port and the spanning-tree bpduguard disabled command to disable BPDU guard on a port.

Command	spanning-tree portfast bpduguard default
Parameter Description	N/A
Defaults	BPDU guard is globally disabled by default.
Command Mode	Command Mode Global configuration mode
Usage Guide	If BPDU guard is enabled on a port, the port enters the error-disabled state after receiving a BPDU. Run the show spanning-tree command to display the configuration.

Command	spanning-tree bpduguard enabled
Parameter Description	N/A
Defaults	BPDU guard is disabled on a port by default.
Command Mode	Interface configuration mode
Usage Guide	If BPDU guard is enabled on a port, the port enters the error-disabled state after receiving a BPDU.

→ Enabling BPDU Filter

- Optional.
- To prevent abnormal BPDU packets from affecting the spanning tree topology, you can enable BPDU filter on a port to filter abnormal BPDU packets.
- In global configuration mode, run the spanning-tree portfast bpdufilter default command to

enable BPDU filter on all ports and the no spanning-tree portfast bpdufilter default command to disable BPDU filter on all ports.

- In interface configuration mode, run the spanning-tree bpdufilter enabled command to enable BPDU filter on a port and the spanning-tree bpdufilter disabled command to disable BPDU filter on a port.

Command	spanning-tree portfast bpdufilter default
Parameter Description	N/A
Defaults	BPDU filter is globally disabled by default.
Command Mode	Global configuration mode
Usage Guide	If BPDU filter is enabled, corresponding ports neither send nor receive BPDUs.

Command	spanning-tree bpdufilter enabled
Parameter Description	N/A
Defaults	BPDU filter is disabled on a port by default.
Command Mode	Interface configuration mode
Usage Guide	If BPDU filter is enabled on a port, the port neither sends nor receives BPDUs.

Verification

- Display the configuration.
- Run the show spanning-tree [mst instance-id] interface interface-id command to display the spanning tree configuration of the port.

Configuration Example

→ Enabling PortFast on a Port

<p>Scenario</p>	
<p>Configuration Steps</p>	<ul style="list-style-type: none"> • Configure Gi 0/3 of DEV C as a PortFast port and enable BPDU guard.
<p>DEV C</p>	<pre>Switch(config)# int gi 0/3 Switch(config-if-GigabitEthernet 0/3)# spanning-tree portfast %Warning: portfast should only be enabled on ports connected to a single host. Connecting hubs, switches, bridges to this interface when portfast is enabled,can cause temporary loops. Switch(config-if-GigabitEthernet 0/3)#spanning-tree bpduguard enable</pre>
<p>Verification</p>	<ul style="list-style-type: none"> • Run the show spanning-tree interface command to display the port configuration.

DEV C	<pre>Switch#show spanning-tree int gi 0/3 PortAdminPortFast : Enabled PortOperPortFast : Enabled PortAdminAutoEdge : Enabled PortOperAutoEdge : Enabled PortAdminLinkType : auto PortOperLinkType : point-to-point PortBPDUGuard : Enabled PortBPDUFilter : Disabled PortGuardmode : None ##### MST 0 vlans mapped :ALL PortState : forwarding PortPriority : 128 PortDesignatedRoot : 0.00d0.f822.3344 PortDesignatedCost : 0 PortDesignatedBridge :0.00d0.f822.3344 PortDesignatedPortPriority : 128 PortDesignatedPort : 4 PortForwardTransitions : 1 PortAdminPathCost : 20000 PortOperPathCost : 20000 Inconsistent states : normal PortRole : designatedPort</pre>
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7.4.9. Enabling TC-related Features

Configuration Effect

- If TC protection is enabled on a port, the port deletes TC BPDU packets within a specified time (generally 4 seconds) after receiving them, preventing MAC and ARP entry from being removed.
- If TC guard is enabled, a port receiving TC packets filters TC packets received or generated by itself so that TC packets are not spread to other ports. In this way, possible TC attacks are efficiently prevented to keep the network stable.
- TC filter does not process TC packets received by ports but processes TC packets in case of normal topology changes.

Notes

- It is recommended to enable TC guard only when illegal TC attack packets are received in the network. Configuration Steps

→ Enabling TC Protection

- Optional.
- TC protection is disabled by default.
- In global configuration mode, run the spanning-tree tc-protection command to enable TC protection on all ports and the no spanning-tree tc-protection command to disable TC protection on all ports.
- TC protection can only be enabled or disabled globally.

Command	spanning-tree tc-protection
Parameter Description	N/A
Defaults	TC protection is disabled by default.
Command Mode	Global configuration mode
Usage Guide	N/A

→ Enabling TC Guard

- Optional.
- TC guard is disabled by default.
- To filter TC packets received or generated due to topology changes, you can enable TC guard.
- In global configuration mode, run the spanning-tree tc-protection tc-guard command to enable TC guard on all ports and the no spanning-tree tc-protection tc-guard command to disable TC guard on all ports.
- In interface configuration mode, run the spanning-tree tc-guard command to enable TC guard on a port and the no spanning-tree tc-guard command to disable TC guard on a port.

Command	spanning-tree tc-protection tc-guard
Parameter Description	N/A
Defaults	TC guard is globally disabled by default.
Command Mode	Global configuration mode
Usage Guide	Enable TC guard to prevent TC packets from spreading.

Command	spanning-tree tc-guard
Parameter Description	N/A
Defaults	TC guard is disabled on a port by default.
Command Mode	Interface configuration mode
Usage Guide	Enable TC guard to prevent TC packets from spreading.

→ Enabling TC Filter

- Optional.
- TC filter is disabled by default.
- To filter TC packets received on a port, you can enable TC filter on the port.
- In interface configuration mode, run the spanning-tree ignore tc command to enable TC filter on a port and the no spanning-tree ignore tc command to disable it on a port.

Command	spanning-tree ignore tc
Parameter Description	N/A
Defaults	TC filter is disabled by default.
Command Mode	Interface configuration mode
Usage Guide	If TC filter is enabled on a port, the port does not process received TC packets.

Verification

- Display the configuration.

Configuration Example

→ Enabling TC Guard on a Port

<p>Configuration Steps</p>	<p>Enable TC guard on a port.</p>
	<pre>Switch(config)#int gi 0/1 Switch(config-if-GigabitEthernet 0/1)#spanning-tree tc-guard</pre>
<p>Verification</p>	<ul style="list-style-type: none"> • Run the show run interface command to display the TC guard configuration of the port.
	<pre>Switch#show run int gi 0/1 Building configuration... Current configuration : 134 bytes interface GigabitEthernet 0/1 switchport mode trunk spanning-tree tc-guard</pre>

Common Errors

- If TC guard or TC filter is incorrectly configured, an error may occur during packet forwarding of the network device. For example, when the topology changes, the device fails to clear MAC address in a timely manner, causing packet forwarding errors.

7.4.10. Enabling BPDU Source MAC Address Check

Configuration Effect

- Enable BPDU source MAC address check. After this, a device receives only BPDU packets with the source MAC address being the specified MAC address and discards other BPDU packets.

Notes

- When the switch connected to a port on a point-to-point link is determined, you can enable BPDU source MAC address check so that the switch receives the BPDU packets sent only by the peer switch.

Configuration Steps

→ Enabling BPDU Source MAC Address Check

- Optional.
- To prevent malicious BPDU attacks, you can enable BPDU source MAC address check.
- In interface configuration mode, run the `bpdu src-mac-check H.H.H` command to enable BPDU source MAC address check on a port and the `no bpdu src-mac-check` command to disable it on a port.

Command	<code>bpdu src-mac-check H.H.H</code>
Parameter Description	H.H.H: Indicates an MAC address. The device receives only BPDU packets with this address being the source MAC address.
Defaults	BPDU source MAC address check is disabled by default.
Command Mode	Interface configuration mode
Usage Guide	BPDU source MAC address check prevents BPDU packets from maliciously attacking switches and causing MSTP abnormal. When the switch connected to a port on a point-to-point link is determined, you can enable BPDU source MAC address check to receive BPDU packets sent only by the peer switch and discard all other BPDU packets, thereby preventing malicious attacks. You can enable BPDU source MAC address check in interface configuration mode for a specific port. One port can only filter one MAC address.

Verification

- Display the configuration.

Configuration Example

→ Enabling BPDU Source MAC Address Check on a Port

Configuration Steps	Enable BPDU source MAC address check on a port.
	<pre>Switch(config)#int gi 0/1 Switch(config-if-GigabitEthernet 0/1)#bpdu src-mac-check 00d0.f800.1234</pre>
Verification	<ul style="list-style-type: none"> Run the show run interface command to display the spanning tree configuration of the port.
	<pre>Switch#show run int gi 0/1</pre> <pre>Building configuration... Current configuration : 170 bytes</pre> <pre>interface GigabitEthernet 0/1 switchport mode trunk bpdu src-mac-check 00d0.f800.1234 spanning-tree link-type point-to-point</pre>

Common Errors

- If BPDU source MAC address check is enabled on a port, the port receives only BPDU packets with the configured MAC address being the source MAC address and discards all other BPDU packets.

7.4.11. Configuring Auto Edge

Configuration Effect

- Enable Auto Edge. If a designated port does not receive any BPDUs within a specified time (3 seconds), it is automatically identified as an edge port. However, if the port receives BPDUs, its Port Fast Operational State will become Disabled.

Notes

- Unless otherwise specified, do not disable Auto Edge. Configuration Steps

→ Configuring Auto Edge

- Optional.
- Auto Edge is enabled by default.
- In interface configuration mode, run the spanning-tree autoedge command to enable Auto Edge on a port and the spanning-tree autoedge disabled command to disable it on a port.

Command	spanning-tree autoedge
Parameter Description	N/A
Defaults	Auto Edge is enabled by default.
Command Mode	Interface configuration mode
Usage Guide	If the designated port of a device does not receive a BPDU from the down-link port within a specific period (3 seconds), the device regards a network device connected to the designated port, configures the port as an edge port, and switches the port directly into the forwarding state. The edge port will be automatically identified as a non-edge port after receiving a BPDU. You can run the spanning-tree autoedge disabled command to disable Auto Edge.

Verification

- Display the configuration.

Configuration Example

→ Disabling Auto Edge on a Port

Configuration Steps	Disable Auto Edge on a port.
	<pre>Switch(config)#int gi 0/1 Switch(config-if-GigabitEthernet 0/1)#spanning-tree autoedge disabled</pre>

Verification	<ul style="list-style-type: none"> Run the show spanning-tree interface command to display the spanning tree configuration of the port.
	<pre>Switch#show spanning-tree interface gi 0/1 PortAdminPortFast : Disabled PortOperPortFast : Disabled PortAdminAutoEdge : Disabled PortOperAutoEdge : Disabled PortAdminLinkType : point-to-point PortOperLinkType : point-to-point PortBPDUGuard : Disabled PortBPDUFilter : Disabled PortGuardmode : None ##### MST 0 vlans mapped :ALL PortState : forwarding PortPriority : 128 PortDesignatedRoot : 0.00d0.f822.3344 PortDesignatedCost : 0 PortDesignatedBridge :0.00d0.f822.3344 PortDesignatedPortPriority : 128 PortDesignatedPort : 2 PortForwardTransitions : 6 PortAdminPathCost : 20000 PortOperPathCost : 20000 Inconsistent states : normal PortRole : designatedPort</pre>

Common Errors

N/A

7.4.12. Enabling Guard-related Features

Configuration Effect

- If root guard is enabled on a port, its roles on all instances are enforced as the designated port. Once the port receives configuration information with a higher priority, it enters the root-inconsistent (blocking) state. If the port does not receive configuration information with a higher priority within a period, it returns to its original state.
- Due to the unidirectional link failure, the root port or backup port becomes the designated port and enters the forwarding state if it does not receive BPDUs, causing a network loop.

Loop guard is to prevent this problem.

Notes

- Root guard and loop guard cannot take effect on a port at the same time.

Configuration Steps

→ Enabling Root Guard

- Optional.
- The root bridge may receive configuration with a higher priority due to incorrect configuration by maintenance personnel or malicious attacks in the network. As a result, the current root bridge may lose its role, causing incorrect topology changes. To prevent this problem, you can enable root guard on a designated port of a device.
- In interface configuration mode, run the spanning-tree guard root command to enable root guard on a port and the no spanning-tree guard root command to disable it on a port.

Command	spanning-tree guard root
Parameter Description	N/A
Defaults	Root guard is disabled by default.
Command Mode	Interface configuration mode
Usage Guide	If root guard is enabled, the current root bridge will not change due to incorrect configuration or illegal packet attacks.

→ Enabling Loop Guard

- Optional.
- You can enable loop guard on a port (root port, master port, or AP) to prevent it from failing to receive BPDUs sent by the designated bridge, increasing device stability. Otherwise, the network topology will change, possibly causing a loop.
- In global configuration mode, run the spanning-tree loopguard default command to enable loop guard on all ports and the no spanning-tree loopguard default command to disable it on all ports.
- In interface configuration mode, run the spanning-tree guard loop command to enable loop guard on a port and the no spanning-tree guard loop command to disable it on a port.

Command	spanning-tree loopguard default
Parameter Description	N/A

Defaults	Loop guard is disabled by default.
Command Mode	Global configuration mode
Usage Guide	Enabling loop guard on a root port or backup port will prevent possible loops caused by BPDU receipt failure.

Command	spanning-tree guard loop
Parameter Description	N/A
Defaults	Loop guard is disabled by default.
Command Mode	Interface configuration mode
Usage Guide	Enabling loop guard on a root port or backup port will prevent possible loops caused by BPDU receipt failure.

→ Disabling Guard

- Optional.

Command	spanning-tree guard none
Parameter Description	N/A
Defaults	Guard is disabled by default.
Command Mode	Interface configuration mode
Usage Guide	N/A

Verification

- Display the configuration.

Configuration Example

→ Enabling Loop Guard on a Port

Scenario	
Configuration Steps	<ul style="list-style-type: none"> • Configure DEV A as the root bridge and DEV B as a non-root bridge on a spanning tree. • Enable loop guard on ports Gi 0/1 and Gi 0/2 of DEV B.
DEV A	<pre>Switch(config)#spanning-tree Switch(config)#spanning-tree mst 0 priority 0</pre>
DEV B	<pre>Switch(config)#spanning-tree Switch(config)# int range gi 0/1-2 Switch(config-if-range)#spanning-tree guard loop</pre>
Verification	<ul style="list-style-type: none"> • Run the show spanning-tree interface command to display the spanning tree configuration of the port.
DEV A	<p>Omitted.</p>

<p>DEV B...</p>	<pre>Switch#show spanning-tree int gi 0/1 PortAdminPortFast : Disabled PortOperPortFast : Disabled PortAdminAutoEdge : Enabled PortOperAutoEdge : Disabled PortAdminLinkType : auto PortOperLinkType : point-to-point PortBPDUGuard : Disabled PortBPDUFilter : Disabled PortGuardmode : Guard loop ##### MST 0 vlans mapped :ALL PortState : forwarding PortPriority : 128 PortDesignatedRoot : 0.001a.a917.78cc PortDesignatedCost : 0 PortDesignatedBridge :0.001a.a917.78cc PortDesignatedPortPriority : 128 PortDesignatedPort : 17 PortForwardTransitions : 1 PortAdminPathCost : 20000 PortOperPathCost : 20000 Inconsistent states : normal PortRole : rootPort</pre>
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...B	<pre>Switch#show spanning-tree int gi 0/2 PortAdminPortFast : Disabled PortOperPortFast : Disabled PortAdminAutoEdge : Enabled PortOperAutoEdge : Disabled PortAdminLinkType : auto PortOperLinkType : point-to-point PortBPDUGuard : Disabled PortBPDUFilter : Disabled PortGuardmode : Guard loop ##### MST 0 vlans mapped :ALL PortState : discarding PortPriority : 128 PortDesignatedRoot : 0.001a.a917.78cc PortDesignatedCost : 0 PortDesignatedBridge :0.001a.a917.78cc PortDesignatedPortPriority : 128 PortDesignatedPort : 18 PortForwardTransitions : 1 PortAdminPathCost : 20000 PortOperPathCost : 20000 Inconsistent states : normal PortRole : alternatePort</pre>
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Common Errors

- If root guard is enabled on the root port, master port, or AP, the port may be incorrectly blocked. 7.4.13 Enabling BPDU Transparent Transmission

Configuration Effect

- If STP is disabled on a device, the device needs to transparently transmit BPDU packets so that the spanning tree between devices is properly calculated.

Notes

- BPDU transparent transmission takes effect only when STP is disabled. If STP is enabled on a device, the device does not transparently transmit BPDU packets.

Configuration Steps

→ Enabling BPDU Transparent Transmission

- Optional.
- If STP is disabled on a device that needs to transparently transmit BPDU packets, enable BPDU transparent transmission.
- In global configuration mode, run the bridge-frame forwarding protocol bpdu command to enable BPDU transparent transmission and the no bridge-frame forwarding protocol bpdu command to disable it.
- BPDU transparent transmission takes effect only when STP is disabled. If STP is enabled on a device, the device does not transparently transmit BPDU packets.

Command	bridge-frame forwarding protocol bpdu
Parameter Description	N/A
Defaults	BPDU transparent transmission is disabled by default.
Command Mode	Global configuration mode
Usage Guide	In IEEE 802.1Q, the destination MAC address 01-80-C2-00-00-00 of the BPDU is used as a reserved address. That is, devices compliant with IEEE 802.1Q do not forward the BPDU packets received. However, devices may need to transparently transmit BPDU packets in actual network deployment. For example, if STP is disabled on a device, the device needs to transparently transmit BPDU packets so that the spanning tree between devices is properly calculated. BPDU transparent transmission takes effect only when STP is disabled. If STP is enabled on a device, the device does not transparently transmit BPDU packets.

Verification

- Display the configuration.

Configuration Example

→ Enabling BPDU Transparent Transmission

Scenario	
	STP is enabled on DEV A and DEV C while is disabled on DEV B.

Configuration Steps	<ul style="list-style-type: none"> • Enable BPDU transparent transmission on DEV B so that STP between DEV A and DEV C can be correctly calculated.
DEV B	<pre>Switch(config)#bridge-frame forwarding protocol bpdu</pre>
Verification	<ul style="list-style-type: none"> • Run the show run command to check whether BPDU transparent transmission is enabled.
DEV B	<pre>Switch#show run</pre> <pre>Building configuration... Current configuration : 694 bytes bridge-frame forwarding protocol bpdu</pre>

7.4.13. Enabling BPDU Tunnel

Configuration Effect

- Enable BPDU Tunnel so that STP packets from the customer network can be transparently transmitted across the SP network. STP packet transmission between the customer network does not affect the SP network, causing STP on the customer network to be calculated independently of that on the SP network.

Notes

- BPDU Tunnel takes effect only when it is enabled in both global configuration mode and interface configuration mode.

Configuration Steps

→ Enabling BPDU Tunnel

- (Optional) In a QinQ network, you can enable BPDU Tunnel if STP needs to be calculated separately between customer networks and SP networks.
- BPDU Tunnel is disabled by default.
- In global configuration mode, run the `l2protocol-tunnel stp` command to globally enable BPDU Tunnel and the `no l2protocol-tunnel stp` command to globally disable it.
- In interface configuration mode, run the `l2protocol-tunnel stp enable` command to enable BPDU Tunnel on a port and the `no l2protocol-tunnel stp enable` command to disable it on a port.

- Run the `l2protocol-tunnel stp tunnel-dmac mac-address` command in global configuration mode to configure the transparent transmission address of BPDU Tunnel.
- BPDU Tunnel takes effect only when it is enabled in both global configuration mode and interface configuration mode.

Command	<code>l2protocol-tunnel stp</code>
Parameter Description	N/A
Defaults	BPDU Tunnel is disabled by default.
Command Mode	Global configuration mode
Usage Guide	BPDU Tunnel takes effect only when it is enabled in both global configuration mode and interface configuration mode.

Command	<code>l2protocol-tunnel stp enable</code>
Parameter Description	N/A
Defaults	BPDU Tunnel is disabled by default.
Command Mode	Interface configuration mode
Usage Guide	BPDU Tunnel takes effect only when it is enabled in both global configuration mode and interface configuration mode.

Command	<code>l2protocol-tunnel stp tunnel-dmac mac-address</code>
Parameter Description	<code>mac-address</code> : Indicates the STP address for transparent transmission.
Defaults	The default MAC address is <code>01d0.f800.0005</code> .
Command Mode	Global configuration mode

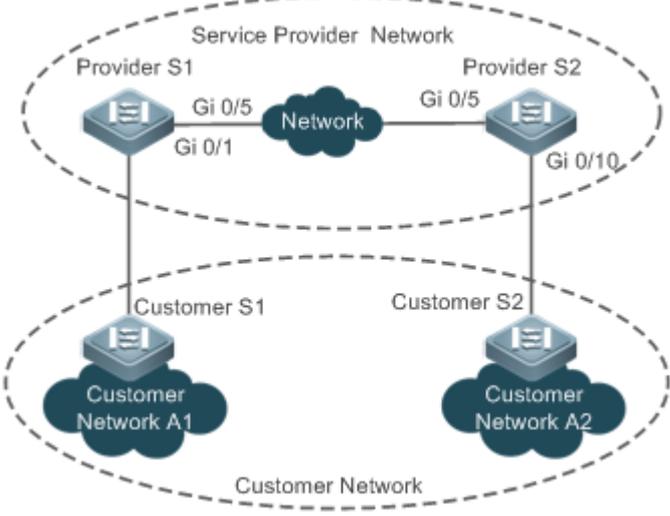
Usage Guide	<p>Usage Guide If an STP packet sent from a customer network enters a PE, the PE changes the destination MAC address of the packet to a private address before the packet is forwarded by the SP network. When the packet reaches the PE at the peer end, the PE changes the destination MAC address to a public address and returns the packet to the customer network at the peer end, realizing transparent transmission across the SP network. This private address is the transparent transmission address of BPDU Tunnel.</p> <div style="display: flex; align-items: flex-start;"> <div style="margin-right: 10px;">   </div> <div> <p>Optional transparent transmission addresses of STP packets include 01d0.f800.0005, 011a.a900.0005, 010f.e200.0003, 0100.0ccd.cdd0, 0100.0ccd.cdd1, and 0100.0ccd.cdd2.</p> <p>If no transparent transmission address is configured, BPDU Tunnel uses the default address 01d0.f800.0005.</p> </div> </div>
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Verification

- Run the show l2protocol-tunnel stp command to display the BPDU Tunnel configuration.

Configuration Example

→ Enabling BPDU Tunnel

Scenario	
Configuration Steps	<ul style="list-style-type: none"> • Enable basic QinQ on the PEs (Provider S1/Provider S2 in this example) so that data packets of the customer network are transmitted within VLAN 200 on the SP network. • Enable STP transparent transmission on the PEs (Provider S1/Provider S2 in this example) so that the SP network can transmit STP packets of the customer network through BPDU Tunnel.

Provider S1	<p>Step 1: Create VLAN 200 on the SP network.</p> <pre>Switch#configure terminal Enter configuration commands, one per line. End with CNTL/Z. Switch(config)#vlan 200 Switch(config-vlan)#exit</pre> <p>Step 2: Enable basic QinQ on the port connected to the customer network and use VLAN 20 for tunneling.</p> <pre>Switch(config)#interface gigabitEthernet 0/1 Switch(config-if-GigabitEthernet 0/1)#switchport mode dot1q-tunnel Switch(config-if-GigabitEthernet 0/1)#switchport dot1q-tunnel native vlan 200 Switch(config-if-GigabitEthernet 0/1)#switchport dot1q-tunnel allowed vlan add untagged 200</pre> <p>Step 3: Enable STP transparent transmission on the port connected to the customer network.</p> <pre>Switch(config-if-GigabitEthernet 0/1)#l2protocol-tunnel stp enable Switch(config-if-GigabitEthernet 0/1)#exit</pre> <p>Step 4: Enable STP transparent transmission in global configuration mode.</p> <pre>Switch(config)#l2protocol-tunnel stp</pre> <p>Step 5: Configure an Uplink port.</p> <pre>Switch(config)# interface gigabitEthernet 0/5 Switch(config-if-GigabitEthernet 0/5)#switchport mode uplink</pre>
Provider S2	Configure Provider S2 by performing the same steps.

Verification	<ul style="list-style-type: none"> • Check whether the BPDU Tunnel configuration is correct. • Verify the Tunnel port configuration by checking whether: 1. The port type is dot1q-tunnel; 2. The outer tag VLAN is consistent with the native VLAN and added to the VLAN list of the Tunnel port; 3. The port that accesses the SP network is configured as an Uplink port.
Provider S1	<p>Step 1: Check whether the BPDU Tunnel configuration is correct.</p> <pre>Switch#show l2protocol-tunnel stp</pre> <pre>L2protocol-tunnel: stp Enable L2protocol-tunnel destination mac address: 01d0.f800.0005 GigabitEthernet 0/1 l2protocol-tunnel stp enable</pre> <p>Step 2: Check whether the QinQ configuration is correct.</p> <pre>Switch#show running-config interface GigabitEthernet 0/1 switchport mode dot1q-tunnel switchport dot1q-tunnel allowed vlan add untagged 200 switchport dot1q-tunnel native vlan 200 l2protocol-tunnel stp enable spanning-tree bpdufilter enable ! interface GigabitEthernet 0/5 switchport mode uplink</pre>
Provider S2	Verify Provider S2 configuration by performing the same steps.

Common Errors

- In the SP network, BPDU packets can be correctly transparently transmitted only when the transparent transmission addresses of BPDU Tunnel are consistent.

7.5. Monitoring

Clearing



Running the clear commands may lose vital information and thus interrupt services.

Description	Command
Clears the statistics of packets sent and received on a port.	clear spanning-tree counters [interface interface-id]
Clears the STP topology change information.	clear spanning-tree mst instance-id topochange record

Displaying

Description	Command
Displays MSTP parameters and spanning tree topology information.	show spanning-tree
Displays the count of sent and received MSTP packets.	show spanning-tree counters [interface interface-id]
Displays MSTP instances and corresponding port forwarding status.	show spanning-tree summary
Displays the ports that are blocked by root guard or loop guard.	show spanning-tree inconsistentports
Displays the configuration of an MST region.	show spanning-tree mst configuration
Displays MSTP information of an instance.	show spanning-tree mst instance-id
Displays MSTP information of the instance corresponding to a port.	show spanning-tree mst instance-id interface interface-id
Displays topology changes of a port in an instance.	show spanning-tree mst instance-id topochange record
Displays MSTP information of all instances corresponding to a port.	show spanning-tree interface interface-id

Displays the forwarding time.	show spanning-tree forward-time
Displays the hello time.	show spanning-tree hello time
Displays the maximum hop count.	show spanning-tree max-hops
Displays the maximum number of BPDU packets sent per second.	show spanning-tree tx-hold-count
Displays the path cost calculation method.	show spanning-tree pathcost method
Displays BPDU Tunnel information.	show l2protocol-tunnel stp

Debugging



System resources are occupied when debugging information is output. Therefore, disable the debugging switch immediately after use.

Description	Command
Debugs all STPs.	debug mstp all
Debugs MSTP Graceful Restart (GR). 3debug mstp gr	Debugs BPDU packet receiving.
debug mstp rx	Debugs BPDU packet sending.
debug mstp tx	Debugs MSTP events.
debug mstp event	Debugs loop guard.
debug mstp loopguard	Debugs root guard.
debug mstp rootguard	Debugs the bridge detection state machine.
debug mstp bridgedetect	Debugs the port information state machine.
debug mstp portinfo	Debugs the port protocol migration state machine.
debug mstp protomigrat	Debugs MSTP topology changes.

debug mstp topochange	Debugs the MSTP receiving state machine.
debug mstp receive	Debugs the port role transition state machine.
debug mstp roletran	Debugs the port state transition state machine.
debug mstp statetran	Debugs the MSTP sending state machine.

8. Configuring GVRP

8.1. Overview

The GARP VLAN Registration Protocol (GVRP) is an application of the Generic Attribute Registration Protocol (GARP) used to dynamically configure and proliferate VLAN memberships. GVRP simplifies VLAN configuration and management. It reduces the workload of manually configuring VLANs and adding ports to VLANs, and reduces the possibility of network disconnection due to inconsistent configuration. With GVRP, you can dynamically maintain VLANs and add/remove ports to/from VLANs to ensure VLAN connectivity in a topology.

Protocols and Standards

IEEE standard 802.1D IEEE standard 802.1Q

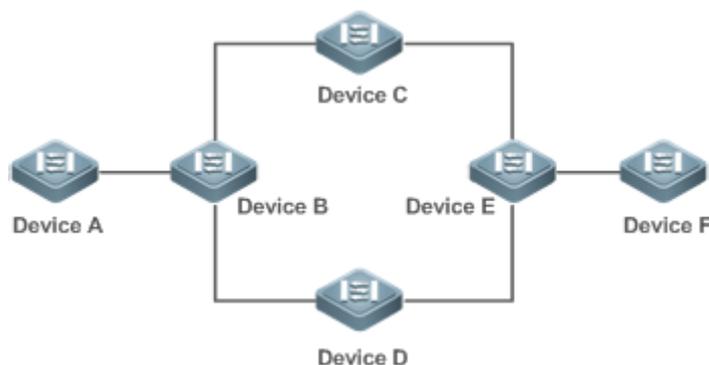
8.2. Applications

Application	Description
GVRP Configuration in a LAN	Connect two switches in a local area network (LAN) and realize VLAN synchronization.
GVRP PDUs Tunnel Application	Use the GVRP Protocol Data Units (PDUs) Tunnel feature to transparently transmit GVRP packets through a tunnel in a QinQ network environment.

8.2.1. GVRP Configuration in a LAN

Scenario

Enable GVRP and set the GVRP registration mode to Normal to register and deregister all dynamic and static VLANs between Device A and Device F.



Remarks	Device A, Device B, Device C, Device D, Device E, and Device F are switches. The ports connected between two devices are Trunk ports. On Device A and Device F, configure static VLANs used for communication. Enable GVRP on all switches.
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Deployment

- On each device, enable the GVRP and dynamic VLAN creation features, and ensure that dynamic VLANs can be created on intermediate devices.
- On Device A and Device F, configure static VLANs used for communication. Device B, Device C, Device D, and Device E will dynamically learn the VLANs through GVRP.

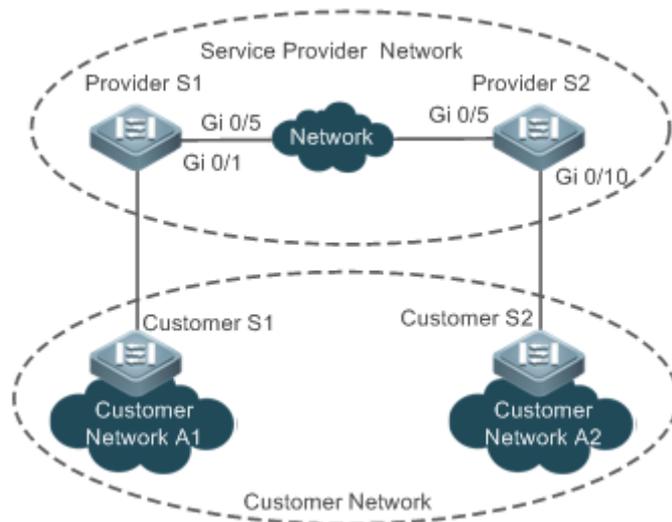


It is recommended that the Spanning Tree Protocol (STP) be enabled to avoid loops in the customer network topology.

8.2.2. GVRP PDUs Tunnel Application

Scenario

A QinQ network environment is generally divided into a customer network and a service provider (SP) network. The GVRP PDUs Tunnel feature allows GVRP packets to be transmitted between customer networks without impact on SP networks. The GVRP calculation in customer networks is separated from that in SP



Remarks	Figure 8 2 shows an SP network and a customer network. The SP network contains the provider edge (PE) devices Provider S1 and Provider S2. Customer Network A1 and Customer Network A2 are the same customer’s two sites in different locations. Customer S1 and Customer S2 are the access devices in the customer network, which are connected to the SP network through Provider S1 and Provider S2 respectively. The GVRP PDUs Tunnel feature allows Customer Network A1 and Customer Network A2 to perform unified GVRP calculation across the SP network, without impact on the SP network’s GVRP calculation.
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Deployment

- Enable basic QinQ on the PEs (Provider S1 and Provider S2) in the SP network to transmit data packets from the customer network through a specified VLAN in the SP network.
- Enable GVRP transparent transmission on the PEs (Provider S1 and Provider S2) in the SP network to allow the SP network to tunnel GVRP packets from the customer network via the GVRP PDUs Tunnel feature.

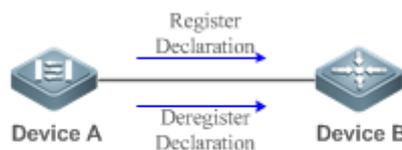
8.3. Features

Basic Concepts

→ GVRP

GVRP is an application of GARP used to register and deregister VLAN attributes in the following modes:

- When a port receives a VLAN attribute declaration, the port will register the VLAN attributes contained in the declaration (that is, the port will join the VLAN).
- When a port receives a VLAN attribute revocation declaration, the port will deregister the VLAN attributes contained in the declaration (that is, the port will exit the VLAN).



→ Dynamic VLAN

A VLAN that can be dynamically created and deleted without the need for manual configuration is called a dynamic VLAN.

You can manually convert a dynamic VLAN to a static VLAN, but not the way around.

A protocol state machine controls the joining of ports to dynamic VLANs created through GVRP. Only the Trunk ports that receive GVRP VLAN attribute declaration can join these VLANs. You cannot manually add ports to dynamic VLANs.

→ Message Types

(1) Join message

When a GARP application entity hopes other GARP entities to register its attributes, it will send a Join message. When a GARP entity receives a Join message from another entity or requires other entities to register its static attributes, it will send a Join message. There are two types of Join message: JoinEmpty and JoinIn.

- JoinEmpty message: Used to declare an unregistered attribute
- JoinIn message: Used to declare a registered attribute

(2) Leave message

When a GARP application entity hopes other GARP entities to deregister its attributes, it will send a Leave message. When a GARP entity receives a Leave message from another entity or requires other entities to deregister its statically deregistered attributes, it will send a Leave message. There are two types of Leave message: LeaveEmpty and LeaveIn.

- LeaveEmpty message: Used to deregister an unregistered attribute
- LeaveIn message: Used to deregister a registered attribute

(3) LeaveAll message

Each GARP application entity starts its LeaveAll timer during startup. When the timer times out, the entity sends a LeaveAll message to deregister all attributes to enable other GARP entities to reregister attributes. When the GARP application entity receives a LeaveAll message from another entity, it also sends a LeaveAll message. The LeaveAll timer is restarted when a LeaveAll message is sent again to initiate a new cycle.

→ Timer Types

GARP defines four timers used to control GARP message sending.

(1) Hold timer

The Hold timer controls the sending of GARP messages (including Join and Leave messages). When a GARP application entity has its attributes changed or receives a GARP message from another entity, it starts the Hold timer. During the timeout period, the GARP application entity encapsulates all GARP messages to be sent into packets as few as possible, and sends the packets when the timer times out. This reduces the quantity of sent packets and saves bandwidth resources.

(2) Join timer

The Join timer controls the sending of Join messages. After a GARP application entity sends a Join message, it waits for one timeout interval of the Join timer to ensure that the Join message is reliably transmitted to another entity. If the GARP application entity receives a JoinIn message from another entity before the timer times out, it will not resend the Join message; otherwise, it will resend the Join message. Not each attribute has its own Join timer, but each GARP application entity has one Join timer.

(3) Leave timer

The Leave timer controls attribute deregistration. When a GARP application entity hopes other entities to deregister one of its attributes, it sends a Leave message. Other entities which receive the Leave message start the Leave timer. The attribute will be deregistered only if these entities receive no Join message mapped to the attribute during the timeout period.

(4) LeaveAll timer

Each GARP application entity starts its own LeaveAll timer upon startup. When the timer times out, the entity sends a LeaveAll message to enable other entities to reregister attributes. Then the LeaveAll timer is restarted to initiate a new cycle.

→ GVRP Advertising Modes

GVRP allows a switch to inform other interconnected devices of its VLANs and instruct the peer device to create specific VLANs and add the ports that transmit GVRP packets to corresponding VLANs.

Two GVRP advertising modes are available:

- Normal mode: A device externally advertises its VLAN information, including dynamic and static VLANs.
- Non-applicant mode: A device does not externally advertise its VLAN information.

→ GVRP Registration Modes

A GVRP registration mode specifies whether the switch that receives a GVRP packet processes the VLAN information in the packet, such as dynamically creating a new VLAN and adding the port that receives the packet to the VLAN.

Two GVRP registration modes are available:

- Normal mode: Process the VLAN information in the received GVRP packet.
- Disabled mode: No to process the VLAN information in the received GVRP packet.

Overview

Feature	Description
Intra-Topology VLAN Information Synchronization	Dynamically creates VLANs and adds/removes ports to/from VLANs, which reduces the manual configuration workload and the probability of VLAN disconnection due to missing configuration.

8.3.1. Intra-Topology VLAN Information Synchronization

Working Principle

GVRP is an application of GARP based on the GARP working mechanism. GVRP maintains the dynamic registration information of VLANs on a device and propagates the information to other

devices. A GVRP-enabled device receives VLAN registration information from other devices and dynamically updates the local VLAN registration information. The device also propagates the local VLAN registration information to other devices so that all devices in a LAN maintain consistent VLAN information. The VLAN registration information propagated by GVRP includes the manually-configured static registration information on the local device and the dynamic registration information from other devices.

→ External VLAN Information Advertising

The Trunk port on a GVRP-enabled device periodically collects VLAN information within the port, including the VLANs that the Trunk port joins or exits. The collected VLAN information is encapsulated in a GVRP packet to be sent to the peer device. After the Trunk port on the peer device receives the packet, it resolves the VLAN information. Then corresponding VLANs will be dynamically created, and the Trunk port will join the created VLANs or exit other VLANs. For details about the VLAN information, see the above description of GVRP message types.

→ VLAN Registration and Deregistration

Upon receiving a GVRP packet, the switch determines whether to process the VLAN information in the packet according to the registration mode of the corresponding port. For details, see the above description of GVRP registration modes.

8.4. Configuration

Configuration	Description and Command	
Configuring Basic GVRP Features and VLAN Information Synchronization	 (Mandatory) It is used to enable GVRP and dynamic VLAN creation.	
	gvrp enable	Enables GVRP.
	gvrp dynamic-vlan-creation enable	Enables dynamic VLAN creation.
	switchport mode trunk	Switches to Trunk port mode. GVRP take effects only in Trunk mode.
	switchport trunk allowed vlan all	Allows the traffic from all VLANs to pass through.
	gvrp applicant state	Configures the advertising mode of a port. The Normal mode indicates to advertise VLAN information externally by sending a GVRP packet. The Non-applicant mode indicates not to advertise VLAN information externally.
	gvrp registration mode	Configures the registration mode of a port. The Normal mode indicates to process the VLAN information in the received GVRP packet, such as dynamically creating VLANs and adding ports to VLANs. The Disabled mode indicates not to process the VLAN information in the received GVRP packet.
	 (Optional) It is used to configure timers and the registration mode and advertising mode of a port.	
gvrp timer	Configures timers.	

Configuring GVRP PDUs Transparent Transmission		(Optional) It is used to configure GVRP PDUs transparent transmission.
	bridge-frame forwarding protocol gvrp	Enables GVRP PDUs transparent transmission.
Configuring the GVRP PDUs Tunnel Feature		(Optional) It is used to configure the GVRP PDUs Tunnel feature.
	l2protocol-tunnel gvrp	Enables the GVRP PDUs Tunnel feature in global configuration mode.
	l2protocol-tunnel gvrp enable	Enables the GVRP PDUs Tunnel feature in interface configuration mode.
	l2protocol-tunnel gvrp tunnel-dmac	Configures the transparent transmission address used by the GVRP PDUs Tunnel feature.

8.4.1. Configuring Basic GVRP Features and VLAN Information Synchronization

[Configuration Effect](#)

- Dynamically create/delete VLANs and add/remove ports to/from VLANs.
- Synchronize VLAN information between devices to ensure normal intra-topology communication.
- Reduce the manual configuration workload and simplify VLAN management.

[Notes](#)

- GVRP must be enabled on both connected devices. GVRP information is transmitted only by Trunk Links. The transmitted information contains the information of all VLANs on the current device, including dynamically learned VLANs and manually configured VLANs.
- If STP is enabled, only ports in Forwarding state participate in GVRP (such as receiving and sending GVRP PDUs) and have their VLAN information propagated by GVRP.
- All VLAN ports added by GVRP are tagged ports.
- The system does not save the VLAN information that is dynamically learned by GVRP. The information will be lost when the device is reset and cannot be saved manually.
- All devices that need to exchange GVRP information must maintain consistent GVRP timers (Join timer, Leave timer, and Leaveall timer).
- If STP is not enabled, all available ports can participate in GVRP. If Single Spanning Tree (SST) is enabled, only ports in Forwarding state in the SST Context participate in GVRP. If Multi Spanning Tree (MST) is enabled, GVRP can run in the Spanning Tree Context to which VLAN1 belongs. You cannot specify other Spanning Tree Context for GVRP.

Configuration Steps

→ Enabling GVRP

- Mandatory.
- Only GVRP-enabled devices can process GVRP packets.
- After GVRP is enabled on a device, the device sends GVRP packets carrying VLAN information. If GVRP is disabled on the device, the device does not send GVRP packets carrying VLAN information or process received GVRP packets.

Command	gvrp enable
Parameter Description	N/A
Defaults	By default, GVRP is disabled.
Command Mode	Global configuration mode
Usage Guide	GVRP can be enabled only in global configuration mode. If GVRP is not enabled globally, you can still set other GVRP parameters, but the parameter settings take effect only when GVRP starts running.

→ Enabling Dynamic VLAN Creation

- Mandatory.
- After dynamic VLAN creation is enabled on a device, the device will dynamically create VLANs upon receiving GVRP Join messages.



The parameters of a dynamic VLAN created through GVRP cannot be modified manually.

Command	gvrp dynamic-vlan-creation enable
Parameter Description	N/A
Defaults	By default, dynamic VLAN creation is disabled.
Command Mode	Global configuration mode
Usage Guide	When a port receives a JoinIn or JoinEmpty message that indicates a non-existent VLAN on the local device, GVRP may create this VLAN, depending on the configuration of this command.

→ Configuring Timers

- Optional.
- There are three GVRP timers: Join timer, Leave timer, and Leaveall timer, which are used to control message sending intervals.
- The timer interval relationships are as follows: The interval of the Leave timer must be three times or more greater than that of the Join timer; the interval of the Leaveall timer must be greater than that of the Leave timer.
- The three timers are controlled by the GVRP state machine and can be triggered by each other.

Command	<code>gvrp timer { join timer-value leave timer-value leaveall timer-value }</code>
Parameter Description	timer-value : 1-2,147,483,647 ms
Defaults	The default interval of the Join timer is 200 ms, that of the Leave timer is 600 ms, and that of the Leaveall timer is 10,000 ms.
Command Mode	Global configuration mode
Usage Guide	<p>The interval of the Leave timer must be three times or more greater than that of the Join timer.</p> <p>The interval of the Leaveall timer must be greater than that of the Leave timer.</p> <p>The time unit is milliseconds.</p> <p>The following timer intervals are recommended in actual networking:</p> <p>Join timer: 6,000 ms (6s)</p> <p>Leave timer: 30,000 ms (30s)</p> <p>Leaveall timer: 120,000 ms (2 minutes)</p> <div style="display: flex; align-items: center; margin-top: 10px;">  <p>Ensure that the GVRP timer settings on all interconnected GVRP devices are consistent; otherwise, GVRP may work abnormally.</p> </div>

→ Configuring the Advertising Mode of a Port

- Optional.
- Two GVRP advertising modes are available: Normal (default) and Non-applicant.
- Normal mode: Indicates that a device externally advertises its VLAN information.
- Non-applicant mode: Indicates that a device does not externally advertise its VLAN information.

Command	gvrp applicant state { normal non-applicant }
Parameter Description	normal: Indicates that a port externally advertises VLAN information. non-applicant: Indicates that a port does not externally advertise VLAN information.
Defaults	By default, ports are allowed to send GVRP notification.
Command Mode	Interface configuration mode
Usage Guide	This command is used to configure the GVRP advertising mode of a port.

→ Configuring the Registration Mode of a Port

- Optional.
- Two GVRP registration modes are available: Normal and Disabled.
- To enable dynamic VLAN registration on a port, run the gvrp registration mode normal command. To disable dynamic VLAN registration on a port, run the gvrp register mode disable command.
- If dynamic VLAN registration is enabled, dynamic VLANs will be created on the local device when the port receives a GVRP packet carrying VLAN information from the peer end. If dynamic VLAN registration is disabled, no dynamic VLAN will be created on the local device when the port receives a GVRP packet from the peer end.



The two registration modes do not affect the static VLANs on the port. The registration mode for manually-created static VLANs is always Fixed Registrar.

Command	gvrp registration mode { normal disabled }
Parameter Description	normal: Indicates that the port is allowed to join a dynamic VLAN. disabled: Indicates that the port is not allowed to join a dynamic VLAN.
Defaults	If GVRP is enabled, the port in Trunk mode is enabled with dynamic VLAN registration by default.
Command Mode	Interface configuration mode
Usage Guide	This command is used to configure the GVRP registration mode of a port.

→ Switching to Trunk Port Mode

- Mandatory.
- GVRP takes effect only on ports in Trunk mode.

Verification

- Run the show gvrp configuration command to check the configuration.
- Check whether a dynamic VLAN is configured and the corresponding port joins the VLAN.

Configuration Example

→ Enabling GVRP in a Topology and Dynamically Maintaining VLANs and the VLAN-Port Relationship

Scenario	
Configuration Steps	<ul style="list-style-type: none"> • On Switch A and Switch C, configure VLANs used for communication in the customer network. • Enable the GVRP and dynamic VLAN creation features on Switch A, Switch B, and Switch C. • Configure the ports connected between switches as Trunk ports, and ensure that the VLAN lists of Trunk ports include the communication VLANs. By default, a Trunk port allows the traffic from all VLANs to pass through. • It is recommended that STP be enabled to avoid loops.

A	<ol style="list-style-type: none">1. Create VLAN 1–200 used for communication in the customer network. <pre>A# configure terminal Enter configuration commands, one per line. End with CNTL/Z. A(config)# vlan range 1-200</pre>2. Enable the GVRP and dynamic VLAN creation features. <pre>A(config)# gvrp enable A(config)# gvrp dynamic-vlan-creation enable</pre>3. Configure the port connected to Switch B as a Trunk port. By default, a Trunk port allows the traffic from all VLANs to pass through. <pre>A(config)# interface gigabitEthernet 0/1 A(config-if-GigabitEthernet 0/1)# switchport mode trunk</pre>4. Configure the advertising mode and registration mode of the Trunk port. The Normal mode is used by default and does not need to be configured manually. <pre>A(config-if-GigabitEthernet 0/1)# gvrp applicant state normal A(config-if-GigabitEthernet 0/1)# gvrp registration mode normal A(config-if-GigabitEthernet 0/1)# end</pre>
C	<ul style="list-style-type: none">• The configuration on Switch C is the same as that on Switch A.

<p>B</p>	<p>1. Enable the GVRP and dynamic VLAN creation features.</p> <pre style="border: 1px solid #ccc; padding: 10px; background-color: #f9f9f9;"> B# configure terminal B(config)# gvrp enable B(config)# gvrp dynamic-vlan-creation enable </pre> <p>2. Configure the ports connected to Switch A and Switch C as Trunk ports.</p> <pre style="border: 1px solid #ccc; padding: 10px; background-color: #f9f9f9;"> B(config)# interface range GigabitEthernet 0/2-3 B(config-if-GigabitEthernet 0/2)# switchport mode trunk </pre>
<p>Verification</p>	<p>Check whether the GVRP configuration on each device is correct. Check whether VLAN 2–100 are dynamically created on Switch B and whether Port G 0/2 and Port G 0/3 on Switch B join the dynamic VLANs.</p>
<p>A</p>	<pre style="border: 1px solid #ccc; padding: 10px; background-color: #f9f9f9;"> A# show gvrp configuration Global GVRP Configuration: GVRP Feature:enabled GVRP dynamic VLAN creation:enabled Join Timers(ms):200 Leave Timers(ms):600 Leaveall Timers(ms):1000 Port based GVRP Configuration: PORT Applicant Status Registration Mode ----- GigabitEthernet 0/1 normal normal </pre>

<p>B</p>	<pre> B# show gvrp configuration Global GVRP Configuration: GVRP Feature:enabled GVRP dynamic VLAN creation:enabled Join Timers(ms):200 Leave Timers(ms):600 Leaveall Timers(ms):1000 Port based GVRP Configuration: PORT Applicant Status Registration Mode ----- GigabitEthernet 0/2 normal normal GigabitEthernet 0/3 normal normal </pre>
<p>C</p>	<pre> C# show gvrp configuration Global GVRP Configuration: GVRP Feature:enabled GVRP dynamic VLAN creation:enabled Join Timers(ms):200 Leave Timers(ms):600 Leaveall Timers(ms):1000 Port based GVRP Configuration: PORT Applicant Status Registration Mode ----- GigabitEthernet 0/1 normal normal </pre>

Common Errors

- The ports connected between devices are not in Trunk mode.
- The VLAN lists of the ports connected between devices do not include the VLANs used for communication in the customer network.
- The GVRP advertising modes and registration modes of Trunk ports are not set to Normal.

8.4.2. Enabling GVRP PDUs Transparent Transmission

Configuration Effect

Enable devices to transparently transmit GVRP PDU frames to realize normal inter-device GVRP

calculation when GVRP is not enabled.

Notes

GVRP PDUs transparent transmission takes effect only when GVRP is disabled. After GVRP is enabled, devices will not transparently transmit GVRP PDU frames.

Configuration Steps

→ Configuring GVRP PDUs Transparent Transmission

- Optional.
- Perform this configuration when you need to enable devices to transparently transmit GVRP PDU frames when GVRP is disabled.

Command	bridge-frame forwarding protocol gvrp
Parameter Description	N/A
Defaults	By default, GVRP PDUs transparent transmission is disabled.
Command Mode	Global configuration mode
Usage Guide	In the IEEE 802.1Q standard, the destination MAC address 01-80-C2-00-00-06 for GVRP PDUs is reserved. Devices compliant with IEEE 802.1Q do not forward received GVRP PDU frames. However, in actual network deployment, devices may need to transparently transmit GVRP PDU frames to realize normal inter-device GVRP calculation when GVRP is not enabled. GVRP PDUs transparent transmission takes effect only when GVRP is disabled. After GVRP is enabled, devices will not transparently transmit GVRP PDU frames.

Verification

Run the show run command to check whether GVRP PDUs transparent transmission is enabled.

Configuration Example

- Configuring GVRP PDUs Transparent Transmission

Scenario	
	Enable GVRP on DEV A and DEV C. (DEV B is not enabled with GVRP.)

Configuration Steps	Configure GVRP PDUs transparent transmission on DEV B to realize normal GVRP calculation between DEV A and DEV C.
DEV B	<pre>Switch(config)#bridge-frame forwarding protocol gvrp</pre>
Verification	Run the show run command to check whether GVRP PDUs transparent transmission is enabled.
DEV B	<pre>Switch#show run</pre> <pre>Building configuration... Current configuration : 694 bytes bridge-frame forwarding protocol gvrp</pre>

8.4.3. Configuring the GVRP PDUs Tunnel Feature

[Configuration Effect](#)

Transparently transmit GVRP packets between customer networks through tunnels in SP networks without impact on the SP networks, and thereby separate the GVRP calculation in customer networks from that in SP networks.

[Notes](#)

The GVRP PDUs Tunnel feature takes effect after it is enabled in global configuration mode and interface configuration mode.

[Configuration Steps](#)

→ Configuring the GVRP PDUs Tunnel Feature

- (Optional) Perform this configuration when you need to separate GVRP calculation between customer networks and SP networks in a QinQ environment.
- Run the `l2protocol-tunnel gvrp` command in global configuration mode to enable the GVRP PDUs Tunnel feature.
- Run the `l2protocol-tunnel gvrp enable` command in interface configuration mode to enable the GVRP PDUs Tunnel feature.
- Run the `l2protocol-tunnel gvrp tunnel-dmac mac-address` command to configure the transparent transmission address used by the GVRP PDUs Tunnel feature.

Command	l2protocol-tunnel gvrp
Parameter Description	N/A
Defaults	By default, the GVRP PDUs Tunnel feature is disabled.
Command Mode	Global configuration mode
Usage Guide	The GVRP PDUs Tunnel feature takes effect after it is enabled in global configuration mode and interface configuration mode.

Command	l2protocol-tunnel gvrp enable
Parameter Description	N/A
Defaults	By default, the GVRP PDUs Tunnel feature is disabled.
Command Mode	Interface configuration mode
Usage Guide	The GVRP PDUs Tunnel feature takes effect after it is enabled in global configuration mode and interface configuration mode.

Command	l2protocol-tunnel gvrp tunnel-dmac mac-address
Parameter Description	mac-address: Indicates the GVRP address used by transparent transmission.
Defaults	The default address is 01d0.f800.0006.
Command Mode	Global configuration mode

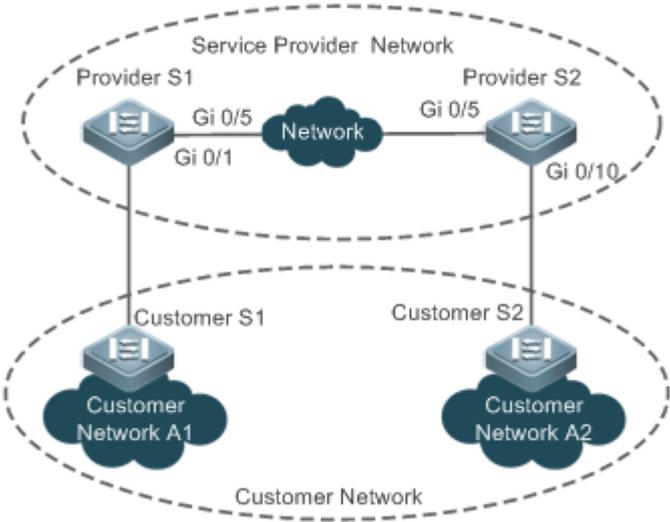
<p>Usage Guide</p>	<p>In GVRP PDUs Tunnel application, when a GVRP packet from a customer network enters the PE in an SP network, the destination MAC address of the packet is changed to a private address before the packet is forwarded in the SP network. When the packet reaches the peer PE, the destination MAC address is changed to a public address before the packet is sent to the customer network at the other end. In this way, the GVRP packet can be transparently transmitted across the SP network. The private address is the transparent transmission address used by the GVRP PDUs Tunnel feature.</p> <p> Address range for transparent transmission of GVRP packets: 01d0.f800.0006, 011a.a900.0006</p> <p> When no transparent transmission address is configured, the default address 01d0.f800.0006 is used.</p>
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Verification

Run the show l2protocol-tunnel gvrp command to check the GVRP PDUs Tunnel configuration.

Configuration Example

→ Configuring the GVRP PDUs Tunnel Feature

<p>Scenario</p>	
<p>Configuration Steps</p>	<ul style="list-style-type: none"> • Enable basic QinQ on the PEs (Provider S1 and Provider S2) in the SP network to transmit data packets from the customer network through VLAN 200 in the SP network. • Enable GVRP transparent transmission on the PEs (Provider S1 and Provider S2) in the SP network to allow the SP network to tunnel GVRP packets from the customer network via the GVRP PDUs Tunnel feature.

Provider S1	<p>Step 1: Create VLAN 200 of the SP network.</p> <pre>Switch#configure terminal Enter configuration commands, one per line. End with CNTL/Z. Switch(config)#vlan 200 Switch(config-vlan)#exit</pre> <p>Step 2: Enable basic QinQ on the port connected to the customer network to tunnel data from the customer network through VLAN 200.</p> <pre>Switch(config)#interface gigabitEthernet 0/1 Switch(config-if-GigabitEthernet 0/1)#switchport mode dot1q-tunnel Switch(config-if-GigabitEthernet 0/1)#switchport dot1q-tunnel native vlan 200 Switch(config-if-GigabitEthernet 0/1)#switchport dot1q-tunnel allowed vlan add untagged 200</pre> <p>Step 3: Enable GVRP transparent transmission on the port connected to the customer network.</p> <pre>Switch(config-if-GigabitEthernet 0/1)#l2protocol-tunnel gvrp enable Switch(config-if-GigabitEthernet 0/1)#exit</pre> <p>Step 4: Enable GVRP transparent transmission globally.</p> <pre>Switch(config)#l2protocol-tunnel gvrp</pre> <p>Step 5: Configure an uplink port.</p> <pre>Switch(config)# interface gigabitEthernet 0/5 Switch(config-if-GigabitEthernet 0/5)#switchport mode uplink</pre>
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Provider S2	The configuration on Provider S2 is similar to that on Provider S1.
Verification	<ul style="list-style-type: none"> • Check whether the GVRP PDUs Tunnel configuration is correct. • Check whether the Tunnel port is configured correctly. Pay attention to the following: <ul style="list-style-type: none"> ◦ The port type is dot1q-tunnel. ◦ The outer tag VLAN is the Native VLAN and added to the VLAN list of the Tunnel port. ◦ The ports on the PEs in the uplink direction are configured as Uplink ports.
Provider S1	<ol style="list-style-type: none"> 1. Check whether the GVRP PDUs Tunnel configuration is correct. Switch#show l2protocol-tunnel gvrp <div style="border: 1px solid #ccc; padding: 10px; margin: 10px 0;"> <pre>L2protocol-tunnel: Gvrp Enable L2protocol-tunnel destination mac address: 01d0.f800.0006 GigabitEthernet 0/1 l2protocol-tunnel gvrp enable</pre> </div> 2. Check whether the QinQ configuration is correct. <div style="border: 1px solid #ccc; padding: 10px; margin: 10px 0;"> <pre>Switch#show running-config interface GigabitEthernet 0/1 switchport mode dot1q-tunnel switchport dot1q-tunnel allowed vlan add untagged 200 switchport dot1q-tunnel native vlan 200 l2protocol-tunnel gvrp enable ! interface GigabitEthernet 0/5 switchport mode uplink</pre> </div>
Provider S2	The verification on Provider S2 is the same as that on Provider S1.

Common Errors

In an SP network, transparent transmission addresses are not configured consistently, which affects the transmission of GVRP PDU frames.

8.5. Monitoring

Clearing



Running the clear commands may lose vital information and thus interrupt services.

Description	Command
Clears port counters.	clear gvrp statistics { interface-id all }

Displaying

Description	Command
Displays port counters.	show gvrp statistics { interface-id all }
Displays the current GVRP status.	show gvrp status
Displays the current GVRP configuration.	show gvrp configuration
Displays the information of the GVRP PDUs Tunnel feature.	show l2protocol-tunnel gvrp

Debugging



System resources are occupied when debugging information is output. Therefore, disable debugging immediately after use.

Description	Command
Enables GVRP event debugging.	debug gvrp event
Enables GVRP timer debugging.	debug gvrp timer

9. Configuring LLDP

9.1. Overview

The Link Layer Discovery Protocol (LLDP), defined in the IEEE 802.1AB standard, is used to discover the topology and identify topological changes. LLDP encapsulates local information of a device into LLDP data units (LLDPDUs) in the type/length/value (TLV) format and then sends the LLDPDUs to neighbors. It also stores LLDPDUs from neighbors in the management information base (MIB) to be accessed by the network management system (NMS).

With LLDP, the NMS can learn about topology, for example, which ports of a device are connected to other devices and whether the rates and duplex modes at both ends of a link are consistent. Administrators can quickly locate and rectify a fault based on the information.

The LLDP-compliant device is capable of discovering neighbors when the peer is either of the following:

- LLDP-compliant device
- Endpoint device that complies with the Link Layer Discovery Protocol-Media Endpoint Discovery (LLDP-MED)

Protocols and Standards

- IEEE 802.1AB 2005: Station and Media Access Control Connectivity Discovery
- ANSI/TIA-1057: Link Layer Discovery Protocol for Media Endpoint Devices

9.2. Applications

Application	Description
Displaying Topology	Multiple switches, a MED device, and an NMS are deployed in the network topology.
Conducting Error Detection	Two switches are directly connected and incorrect configuration will be displayed.

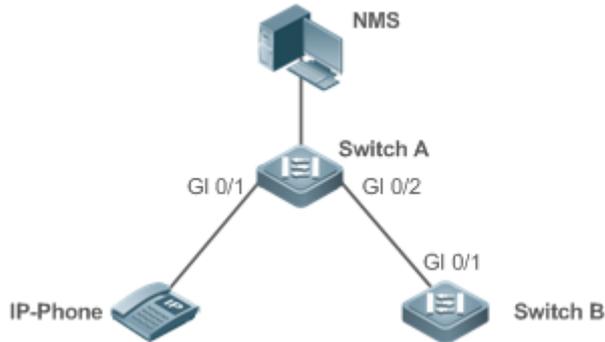
9.2.1. Displaying Topology

Scenario

Multiple switches, a MED device, and an NMS are deployed in the network topology. As shown in the following figure, the LLDP function is enabled by default and no additional configuration is required.

- Switch A and Switch B discover that they are neighbors.
- Switch A discovers its neighbor MED device, that is, IP-Phone, through port GigabitEthernet 0/1.

- The NMS accesses MIB of switch A.



Remarks	Microsens Switch A, Switch B, and IP-Phone support LLDP and LLDP-MED. LLDP on switch ports works in TxRx mode. The LLDP transmission interval is 30 seconds and transmission delay is 2 seconds by default.
---------	---

Deployment

- Run LLDP on a switch to implement neighbor discovery.
- Run the Simple Network Management Protocol (SNMP) on the switch so that the NMS acquires and sets LLDP-relevant information on the switch.

9.2.2. Conducting Error Detection

Scenario

Two switches are directly connected and incorrect configuration will be displayed. As shown in the following figure, the LLDP function and LLDP error detection function are enabled by default, and no additional configuration is required.

- After you configure a virtual local area network (VLAN), port rate and duplex mode, link aggregation, and maximum transmission unit (MTU) of a port on Switch A, an error will be prompted if the configuration does not match that on Switch B, and vice versa.



Remarks	Microsens Switch A and Switch B support LLDP. LLDP on switch ports works in TxRx mode. The LLDP transmission interval is 30 seconds and transmission delay is 2 seconds by default.
---------	---

Deployment

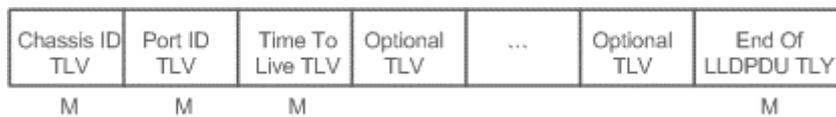
- Run LLDP on a switch to implement neighbor discovery and detect link fault.

9.3. Features

Basic Concepts

→ LLDPDU

LLDPDU is a protocol data unit encapsulated into an LLDP packet. Each LLDPDU is a sequence of TLV structures. The TLV collection consists of three mandatory TLVs, a series of optional TLVs, and one End Of TLV. The following figure shows the format of an LLDPDU.



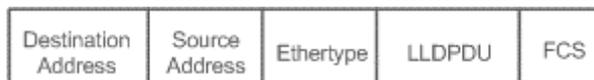
In the preceding figure:

- M indicates a mandatory TLV.
- In an LLDPDU, Chassis ID TLV, Port ID TLV, Time To Live TLV, and End Of LLDPDU TLV are mandatory and TLVs of other TLVs are optional.

→ LLDP Encapsulation Format

LLDP packets can be encapsulated in two formats: Ethernet II and Subnetwork Access Protocols (SNAP).

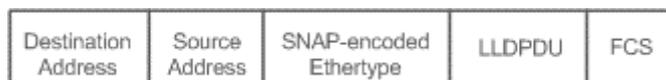
The following figure shows the format of LLDP packets encapsulated in the Ethernet II format.



In the preceding figure:

- Destination Address: Indicates the destination MAC address, which is the LLDP multicast address 01-80-C2-00-00-0E.
- Source Address: Indicates the source MAC address, which is the port MAC address.
- Ethertype: Indicates the Ethernet type, which is 0x88CC.
- LLDPDU: Indicates the LLDP protocol data unit.
- FCS: Indicates the frame check sequence.

Figure 9-5 shows the format of LLDP packets encapsulated in the SNAP format.



In the preceding figure:

- Destination Address: Indicates the destination MAC address, which is the LLDP multicast address 01-80-C2-00-00-0E.

- Source Address: Indicates the source MAC address, which is the port MAC address.
- SNAP-encoded Ethertype: Indicates the Ethernet type of the SNMP encapsulation, which is AA-AA-03-00-00-00-88-CC.
- LLDPDU: Indicates the LLDP protocol data unit.
- FCS: Indicates the frame check sequence.

→ TLV

TLVs encapsulated into an LLDPDU can be classified into two types:

- Basic management TLVs
- Organizationally specific TLVs

Basic management TLVs are a collection of basic TLVs used for network management. Organizationally specific TLVs are defined by standard organizations and other institutions, for example, the IEEE 802.1 organization and IEEE 802.3 organization define their own TLV collections.

1. Basic management TLVs

The basic management TLV collection consists of two types of TLVs: mandatory TLVs and optional TLVs. A mandatory TLV must be contained in an LLDPDU for advertisement and an optional TLV is contained selectively.

The following table describes basic management TLVs.

TLV Type	Description	Mandatory/Optional
End Of LLDPDU TLV	Indicates the end of an LLDPDU, occupying two bytes.	Mandatory
Chassis ID TLV	Identifies a device with a MAC address.	Mandatory
Port ID TLV	Identifies a port sending LLDPDUs.	Fixed
Time To Live TLV	Indicates the time to live (TTL) of local information on a neighbor. When a device receives a TLV containing TTL 0, it deletes the neighbor information.	Mandatory
Port Description TLV	Indicates the descriptor of the port sending LLDPDUs.	Optional
System Name TLV	Describes the device name.	Optional

System Description TLV	Indicates the device description, including the hardware version, software version, and operating system information.	Optional
System Capabilities TLV	Describes main functions of the device, such as the bridge, routing, and relay functions.	Optional
Management Address TLV	Indicates the management address, which contains the interface ID and object identifier (OID).	Optional



LLDP-compliant switch supports advertisement of basic management TLVs.

2. Organizationally specific TLVs

Different organizations, such as the IEEE 802.1, IEEE 802.3, IETF and device suppliers, define specific TLVs to advertise specific information about devices. The organizationally unique identifier (OUI) field in a TLV is used to distinguish different organizations.

- Organizationally specific TLVs are optional and are advertised in an LLDPDU selectively. Currently, there are three types of common organizationally specific TLVs: IEEE 802.1 organizationally specific TLVs, IEEE 802.3 organizationally specific TLVs, and LLDP-MED TLVs.

The following table describes IEEE 802.1 organizationally specific TLVs.

TLV Type	Description
Port VLAN ID TLV	Indicates the VLAN identifier of a port.
Port And Protocol VLAN ID TLV	Indicates the protocol VLAN identifier of a port.
VLAN Name TLV	Indicates the VLAN name of a port.
Protocol Identity TLV	Indicates the protocol type supported by a port.



LLDP-compliant switch does not send the Protocol Identity TLV but receive this TLV.

- IEEE 802.3 organizationally specific TLVs

The following table describes IEEE 802.3 organizationally specific TLVs.

TLV Type	Description
MAC/PHY Configuration//Status TLV	Indicates the rate and duplex mode of a port, and whether to support and enable auto-negotiation.
Power Via MDI TLV	Indicates the power supply capacity of a port.
Link Aggregation TLV	Indicates the link aggregation capacity of a port and the current aggregation state.
Maximum Frame Size TLV	Indicates the maximum size of the frame transmitted by a port.



LLDP-compliant device supports advertisement of IEEE 802.3 organizationally specific TLVs.

- LLDP-MED TLV

LLDP-MED is an extension to LLDP based on IEEE 802.1AB LLDP. It enables users to conveniently deploy the Voice Over IP (VoIP) network and detect faults. It provides applications including the network configuration policies, device discovery, PoE management, and inventory management, meeting requirements for low cost, effective management, and easy deployment.

The following table describes LLDP-MED TLVs.

TLV Type	Description
LLDP-MED Capabilities TLV	Indicates the type of the LLDP-MED TLV encapsulated into an LLDPDU and device type (network connectivity device or endpoint device), and whether to support LLDP-MED,.
Network Policy TLV	Advertises the port VLAN configuration, supported application type (such as voice or video services), and Layer-2 priority information.
Location Identification TLV	Locates and identifies an endpoint device.
Extended Power-via-MDI TLV	Provides more advanced power supply management.
Inventory – Hardware Revision TLV	Inventory – Hardware Revision TLV

Inventory – Firmware Revision TLV	Indicates the firmware version of the MED device.
Inventory – Software Revision TLV	Indicates the software version of the MED device.
Inventory – Serial Number TLV	Indicates the serial number of the MED device.
Inventory – Manufacturer Name TLV	Indicates the name of the manufacturer of the MED device.
Inventory – Model Name TLV	Indicates the module name of the MED device.
Inventory – Asset ID TLV	Indicates the asset identifier of the MED device, used for inventory management and asset tracking.



This LLDP-compliant device supports advertisement of LLDP-MED TLVs.

Overview

Feature	Description
LLDP Work Mode	Configures the mode of transmitting and receiving LLDP packets.
LLDP Transmission Mechanism	Enables directly connected LLDP-compliant devices to send LLDP packets to the peer.
LLDP Reception Mechanism	Enables directly connected LLDP-compliant devices to receive LLDP packets from the peer.

9.3.1. LLDP Work Mode

Configure the LLDP work mode so as to specify the LLDP packet transmission and reception mode.

Working Principle

LLDP provides three work modes:

- TxRx: Transmits and receives LLDPDUs.
- Rx Only: Only receives LLDPDUs.

- Tx Only: Only transmits LLDPDUs.

When the LLDP work mode is changed, the port initializes the protocol state machine. You can set a port initialization delay to prevent repeated initialization of a port due to frequent changes of the LLDP work mode.

[Related Configuration](#)

→ [Configuring the LLDP Work Mode](#)

The default LLDP work mode is TxRx. You can run the `lldp mode` command to configure the LLDP work mode. If the work mode is set to TxRx, the device can both transmit and receive LLDP packets. If the work mode is set to Rx Only, the device can only receive LLDP packets. If the work mode is set to Tx Only, the device can only transmit LLDP packets. If the work mode is disabled, the device cannot transmit or receive LLDP packets.

9.3.2 LLDP Transmission Mechanism

LLDP packets inform peers of their neighbors. When the LLDP transmission mode is cancelled or disabled, LLDP packets cannot be transmitted to neighbors.

[Working Principle](#)

LLDP periodically transmits LLDP packets when working in TxRx or Tx Only mode. When information about the local device changes, LLDP immediately transmits LLDP packets. You can configure a delay time to avoid frequent transmission of LLDP packets caused by frequent changes of local information.

LLDP provides two types of packets:

- Standard LLDP packet, which contains management and configuration information about the local device.
- Shutdown packet: When the LLDP work mode is disabled or the port is shut down, LLDP Shutdown packets will be transmitted. A Shutdown packet consists of the Chassis ID TLV, Port ID TLV, Time To Live TLV, and End OF LLDP TLV. TTL in the Time to Live TLV is 0. When a device receives an LLDP Shutdown packet, it considers that the neighbor information is invalid and immediately deletes it.

When the LLDP work mode is changed from disabled or Rx to TxRx or Tx, or when LLDP discovers a new neighbor (that is, a device receives a new LLDP packet and the neighbor information is not stored locally), the fast transmission mechanism is started so that the neighbor quickly learns the device information. The fast transmission mechanism enables a device to transmit multiple LLDP packets at an interval of 1 second.

[Related Configuration](#)

→ [Configuring the LLDP Work Mode](#)

The default work mode is TxRx.

Run the `lldp mode txrx` or `lldp mode tx` command to enable the LLDP packet transmission function. Run the `lldp mode rx` or `no lldp mode` command to disable the LLDP packet transmission function.

In order to enable LLDP packet reception, set the work mode to TxRx or Rx Only. If the work mode is set to Rx Only, the device can only receive LLDP packets.

→ Configuring the LLDP Transmission Delay

The default LLDP transmission delay is 2 seconds.

Run the `lldp timer tx-delay` command to change the LLDP transmission delay.

If the delay is set to a very small value, the frequent change of local information will cause frequent transmission of LLDP packets. If the delay is set to a very large value, no LLDP packet may be transmitted even if local information is changed.

→ Configuring the LLDP Transmission Interval

The default LLDP transmission interval is 30 seconds.

Run the `lldp timer tx-interval` command to change the LLDP transmission interval.

If the interval is set to a very small value, LLDP packets may be transmitted frequently. If the interval is set to a very large value, the peer may not discover the local device in time.

→ Configuring the TLVs to Be Advertised

By default, an interface is allowed to advertise TLVs of all types except Location Identification TLV.

Run the `lldp tlv-enable` command to change the TLVs to be advertised.

→ Configuring the LLDP Fast Transmission Count

By default, three LLDP packets are fast transmitted.

Run the `lldp fast-count` command to change the number of LLDP packets that are fast transmitted. Increase or decrease the TLVs in LLDP.

9.3.2. LLDP Reception Mechanism

A device can discover the neighbor and determine whether to age the neighbor information according to received LLDP packets.

Working Principle

A device can receive LLDP packets when working in TxRx or Rx Only mode. After receiving an LLDP packet, a device conducts validity check. After the packet passes the check, the device checks whether the packet contains information about a new neighbor or about an existing neighbor and stores the neighbor information locally. The device sets the TTL of neighbor information according to the value of TTL TLV in the packet. If the value of TTL TLV is 0, the neighbor information is aged immediately.

[Related Configuration](#)

→ Configuring the LLDP Work Mode

The default LLDP work mode is TxRx.

Run the `lldp mode txrx` or `lldp mode rx` command to enable the LLDP packet reception function. Run the `lldp mode tx` or `no lldp mode` command to disable the LLDP packet reception function.

In order to enable LLDP packet reception, set the work mode to TxRx or Rx Only. If the work mode is set to Tx Only, the device can only transmit LLDP packets.

9.4. Configuration

Configuration	Description and Command	
Configuring the LLDP Function	 (Optional) It is used to enable or disable the LLDP function in global or interface configuration mode.	
	<code>lldp enable</code>	Enables the LLDP function.
	<code>no lldp enable</code>	Disables the LLDP function.
Configuring the LLDP Work Mode	 (Optional) It is used to configure the LLDP work mode.	
	<code>lldp mode {rx tx txrx }</code>	Configures the LLDP work mode.
	<code>no lldp mode</code>	Shuts down the LLDP work mode.
Configuring the TLVs to Be Advertised	 (Optional) It is used to configure the TLVs to be advertised.	
	<code>lldp tlv-enable</code>	Configures the TLVs to be advertised.
	<code>no lldp tlv-enable</code>	Cancels TLVs.

Configures the Management Address to Be Advertised	 (Optional) It is used to configure the management address to be advertised in LLDP packets.
	lldp management-address-tlv [ip-address] Configures the management address to be advertised in LLDP packets.
	no lldp management-address-tlv Cancels the management address.
Configuring the LLDP Fast Transmission Count	 (Optional) It is used to configure the number of LLDP packets that are fast transmitted.
	lldp fast-count value Configures the LLDP fast transmission count.
	no lldp fast-count Restores the default LLDP fast transmission count.
Configuring the TTL Multiplier and Transmission Interval	 (Optional) It is used to configure the TTL multiplier and transmission interval.
	lldp hold-multiplier value Configures the TTL multiplier.
	no lldp hold-multiplier Restores the default TTL multiplier.
	lldp timer tx-interval seconds Configures the transmission interval.
	no lldp timer tx-interval Restores the default transmission interval.
Configuring the Transmission Delay	 (Optional) It is used to configure the delay time for LLDP packet transmission.
	lldp timer tx-delay seconds Configures the transmission delay.
	no lldp timer tx-delay Restores the default transmission delay.

Configuring the Initialization Delay	 (Optional) It is used to configure the delay time for LLDP to initialize on any interface.
	lldp timer reinit-delay seconds Configures the initialization delay.
	no lldp timer reinit-delay Restores the default initialization delay.
Configuring the LLDP Trap Function	 (Optional) It is used to configure the LLDP Trap function.
	lldp notification remote-change enable Enables the LLDP Trap function.
	no lldp notification remote-change enable Disables the LLDP Trap function.
	lldp timer notification-interval Configures the LLDP Trap transmission interval.
no lldp timer notification-interval Restores the default LLDP Trap transmission interval.	
Configuring the LLDP Error Detection Function	 (Optional) It is used to configure the LLDP error detection function.
	lldp error-detect Enables the LLDP error detection function.
	no lldp error-detect Disables the LLDP error detection function.
Configuring the LLDP Encapsulation Format	 (Optional) It is used to configure the LLDP encapsulation format.
	lldp encapsulation snap Sets the LLDP encapsulation format to SNAP.
	no lldp encapsulation snap Sets the LLDP encapsulation format to Ethernet II.

Configuring the LLDP Network Policy	 (Optional) It is used to configure the LLDP Network Policy.	
	lldp network-policy profile profile-num	Configures an LLDP Network Policy.
	no lldp network-policy profile profile-num	Deletes an LLDP Network Policy.
Configuring the Civic Address	 (Optional) It is used to configure the civic address of a device.	
	{ country state county city division neighborhood street-group leading-street-dir trailing-street-suffix street-suffix number street-number-suffix landmark additional-location-information name postal-code building unit floor room type-of-place postal-community-name post-office-box additional-code } ca-word	Configures the civic address of a device.
	no { country state county city division neighborhood street-group leading-street-dir trailing-street-suffix street-suffix number street-number-suffix landmark additional-location-information name postal-code building unit floor room type-of-place postal-community-name post-office-box additional-code } ca-word	Deletes civic address of a device.
Configuring the Emergency Telephone Number	 (Optional) It is used to configure the emergency telephone number of a device.	
	lldp location elin identifier id elin-location tel-number	Configures the emergency telephone number of a device.
	no lldp location elin identifier id	Deletes the emergency telephone number of a device.

Configuring the Detection of Compatible Neighbors		(Optional) It is used to configure the detection of compatible neighbors function.	
		lldp compliance vendor	Enables the detection of compatible neighbors.
		no lldp compliance vendor	Disables the detection of compatible neighbors.
Configuring the Function of Ignoring PVID Detection		(Optional) It is used to ignore PVID detection.	
		lldp ignore pvid-error-detect	Enables the function of ignoring PVID detection.
		no lldp ignore pvid-error-detect	Disables the function of ignoring PVID detection.

9.4.1. Configuring the LLDP Function

Configuration Effect

- Enable or disable the LLDP function.

Notes

- To make the LLDP function take effect on an interface, you need to enable the LLDP function globally and on the interface.

Configuration Steps

- Optional.
- Configure the LLDP function in global or interface configuration mode.

Display LLDP status

- Check whether the LLDP function is enabled in global configuration mode.
- Check whether the LLDP function is enabled in interface configuration mode.

Related Commands

→ Enabling the LLDP Function

Command	lldp enable
Parameter Description	N/A
Command Mode	Global configuration mode/Interface configuration mode
Usage Guide	The LLDP function takes effect on an interface only after it is enabled in global configuration mode and interface configuration mode.

→ Disabling the LLDP Function

Command	no lldp enable
Parameter Description	N/A
Command Mode	Global configuration mode/Interface configuration mode
Usage Guide	N/A

Configuration Example

→ Disabling the LLDP Function

Configuration Steps	Disable the LLDP function in global configuration mode.
	<div style="border: 1px solid #ccc; border-radius: 10px; padding: 10px; background-color: #f9f9f9; margin: 10px auto; width: fit-content;"> <pre>Switch(config)#no lldp enable</pre> </div>
Verification	Display global LLDP status.

```
Switch(config)#show lldp status
Global status of LLDP: Disable
```

Common Errors

- If the LLDP function is enabled on an interface but disabled in global configuration mode, the LLDP function does not take effect on the interface.
- A port can learn a maximum of five neighbors.
- If a neighbor does not support LLDP but it is connected to an LLDP-supported device, a port may learn information about the device that is not directly connected to the port because the neighbor may forward LLDP packets.

9.4.2. Configuring the LLDP Work Mode

Configuration Effect

- If you set the LLDP work mode to TxRx, the interface can transmit and receive packets.
- If you set the LLDP work mode to Tx, the interface can only transmit packets but cannot receive packets.
- If you set the LLDP work mode to Rx, the interface can only receive packets but cannot transmit packets.
- If you disable the LLDP work mode, the interface can neither receive nor transmit packets.

Notes

- LLDP runs on physical ports (AP member ports for AP ports). Stacked ports and VSL ports do not support LLDP.

Configuration Steps

→ Optional.

- Set the LLDP work mode to Tx or Rx as required.

Verification

Display LLDP status information on an interface

- Check whether the configuration takes effect.

Related Commands

→ Configuring the LLDP Work Mode

Command	lldp mode { rx tx txrx }
Parameter Description	rx: Only receives LLDPDUs. tx: Only transmits LLDPDUs. txrx: Transmits and receives LLDPDUs.
Command Mode	Interface configuration mode
Usage Guide	To make LLDP take effect on an interface, make sure to enable LLDP globally and set the LLDP work mode on the interface to Tx, Rx or TxRx.

→ Disabling the LLDP Work Mode

Command	no lldp mode
Parameter Description	N/A
Command Mode	Interface configuration mode
Usage Guide	After the LLDP work mode on an interface is disabled, the interface does not transmit or receive LLDP packets.

Configuration Example

→ Configuring the LLDP Work Mode

Configuration Steps	Set the LLDP work mode to Tx in interface configuration mode.
	<pre>Switch(config)#interface gigabitEthernet 0/1 Switch(config-if-GigabitEthernet 0/1)#lldp mode tx</pre>
Verification	Display LLDP status information on the interface.

```
Switch(config-if-GigabitEthernet 0/1)#show lldp status interface
gigabitethernet 0/1
Port [GigabitEthernet 0/1]
Port status of LLDP           : Enable
Port state                     : UP
Port encapsulation            : Ethernet II
Operational mode              : TxOnly
Notification enable           : NO
Error detect enable           : YES
Number of neighbors           : 0
Number of MED neighbors       : 0
```

9.4.3. Configuring the TLVs to Be Advertised

Configuration Effect

- Configure the type of TLVs to be advertised to specify the LLDPDUs in LLDP packets.

Notes

- If you configure the all parameter for the basic management TLVs, IEEE 802.1 organizationally specific TLVs, and IEEE 802.3 organizationally specific TLVs, all optional TLVs of these types are advertised.
- If you configure the all parameter for the LLDP-MED TLVs, all LLDP-MED TLVs except Location Identification TLV are advertised.
- If you want to configure the LLDP-MED Capability TLV, configure the LLDP 802.3 MAC/PHY TLV first; If you want to cancel the LLDP 802.3 MAC/PHY TLV, cancel the LLDP-MED Capability TLV first.
- If you want to configure LLDP-MED TLVs, configure the LLDP-MED Capability TLV before configuring other types of LLDP-MED TLVs. If you want to cancel LLDP-MED TLVs, cancel the LLDP-MED Capability TLV before canceling other types of LLDP-MED TLVs. If a device is connected to an IP-Phone that supports LLDP-MED, you can configure the Network Policy TLV to push policy configuration to the IP-Phone.
- If a device supports the DCBX function by default, ports of the device are not allowed to advertise IEEE 802.3 organizationally specific TLVs and LLDP-MED TLVs by default.

Configuration Steps

→ Optional.

- Configure the type of TLVs to be advertised on an interface.

Verification

Display the configuration of TLVs to be advertised on an interface

- Check whether the configuration takes effect.

[Related Commands](#)

→ Configuring TLVs to Be Advertised

Command	lldp tlv-enable { basic-tlv { all port-description system-capability system-description system-name } dot1-tlv { all port-vlan-id protocol-vlan-id [vlan-id] vlan-name [vlan-id] } dot3-tlv { all link-aggregation mac-physic max-frame-size power } med-tlv { all capability inventory location { civic-location elin } identifier id network-policy profile [profile-num] power-over-ethernet } }
Parameter Description	<p>basic-tlv: Indicates the basic management TLV.</p> <p>port-description: Indicates the Port Description TLV.</p> <p>system-capability: Indicates the System Capabilities TLV.</p> <p>system-description: Indicates the System Description TLV.</p> <p>system-name: Indicates the System Name TLV.</p> <p>dot1-tlv: Indicates the IEEE 802.1 organizationally specific TLVs.</p> <p>port-vlan-id: Indicates the Port VLAN ID TLV.</p> <p>protocol-vlan-id: Indicates the Port And Protocol VLAN ID TLV.</p> <p>vlan-id: Indicates the Port Protocol VLAN ID, ranging from 1 to 4,094.</p> <p>vlan-name: Indicates the VLAN Name TLV.</p> <p>vlan-id: Indicates the VLAN name, ranging from 1 to 4,094.</p> <p>dot3-tlv: Indicates the IEEE 802.3 organizationally specific TLVs.</p> <p>link-aggregation: Indicates the Link Aggregation TLV.</p> <p>mac-physic: Indicates the MAC/PHY Configuration/Status TLV.</p> <p>max-frame-size: Indicates the Maximum Frame Size TLV.</p> <p>power: Indicates the Power Via MDI TLV.</p> <p>med-tlv: Indicates the LLDP MED TLV.</p> <p>capability: Indicates the LLDP-MED Capabilities TLV.</p> <p>Inventory: Indicates the inventory management TLV, which contains the hardware version, firmware version, software version, SN, manufacturer name, module name, and asset identifier.</p> <p>location: Indicates the Location Identification TLV.</p> <p>civic-location: Indicates the civic address information and postal information.</p> <p>elin: Indicates the emergency telephone number.</p> <p>id: Indicates the policy ID, ranging from 1 to 1,024.</p> <p>network-policy: Indicates the Network Policy TLV.</p> <p>profile-num: Indicates the Network Policy ID, ranging from 1 to 1,024.</p> <p>power-over-ethernet: Indicates the Extended Power-via-MDI TLV.</p>
Command Mode	Interface configuration mode
Usage Guide	N/A

→ Canceling TLVs

Command	no lldp tlv-enable {basic-tlv { all port-description system-capability system-description system-name } dot1-tlv { all port-vlan-id protocol-vlan-id vlan-name } dot3-tlv { all link-aggregation mac-physic max-frame-size power } med-tlv { all capability inventory location { civic-location elin } identifier id network-policy profile [profile-num] power-over-ethernet } }
Parameter Description	<p>basic-tlv: Indicates the basic management TLV. port-description: Indicates the Port Description TLV. system-capability: Indicates the System Capabilities TLV. system-description: Indicates the System Description TLV. system-name: Indicates the System Name TLV. dot1-tlv: Indicates the IEEE 802.1 organizationally specific TLVs. port-vlan-id: Indicates the Port VLAN ID TLV. protocol-vlan-id: Indicates the Port And Protocol VLAN ID TLV. vlan-name: Indicates the VLAN Name TLV. dot3-tlv: Indicates the IEEE 802.3 organizationally specific TLVs. link-aggregation: Indicates the Link Aggregation TLV. mac-physic: Indicates the MAC/PHY Configuration/Status TLV. max-frame-size: Indicates the Maximum Frame Size TLV. power: Indicates the Power Via MDI TLV. med-tlv: Indicates the LLDP MED TLV. capability: Indicates the LLDP-MED Capabilities TLV. Inventory: Indicates the inventory management TLV, which contains the hardware version, firmware version, software version, SN, manufacturer name, module name, and asset identifier. location: Indicates the Location Identification TLV. civic-location: Indicates the civic address information and postal information. elin: Indicates the emergency telephone number. id: Indicates the policy ID, ranging from 1 to 1,024. network-policy: Indicates the Network Policy TLV. profile-num: Indicates the Network Policy ID, ranging from 1 to 1,024. power-over-ethernet: Indicates the Extended Power-via-MDI TLV.</p>
Command Mode	Interface configuration mode
Usage Guide	N/A

Configuration Example

→ Configuring TLVs to Be Advertised

Configuration Steps	Cancel the advertisement of the IEEE 802.1 organizationally specific Port And Protocol VLAN ID TLV.
	<pre>Switch(config)#interface gigabitethernet 0/1 Switch(config-if-GigabitEthernet 0/1)#no lldp tlv-enable dot1-tlv protocol-vlan-id</pre>
Verification	Display LLDP TLV configuration in interface configuration mode.

```

Switch(config-if-GigabitEthernet 0/1)#show lldp tlv-config
interface gigabitethernet 0/1
LLDP tlv-config of port [GigabitEthernet 0/1]
      NAME                               STATUS DEFAULT
-----
Basic optional TLV:
Port Description TLV                     YES      YES
System Name TLV                          YES      YES
System Description TLV                   YES      YES
System Capabilities TLV                   YES      YES
Management Address TLV                    YES      YES

IEEE 802.1 extend TLV:
Port VLAN ID TLV                         YES      YES
Port And Protocol VLAN ID TLV            NO       YES
VLAN Name TLV                             YES      YES

IEEE 802.3 extend TLV:
MAC-Physic TLV                           YES      YES
Power via MDI TLV                         YES      YES
Link Aggregation TLV                      YES      YES
Maximum Frame Size TLV                    YES      YES

LLDP-MED extend TLV:
Capabilities TLV                           YES      YES
Network Policy TLV                         YES      YES
Location Identification TLV                NO       NO
Extended Power via MDI TLV                 YES      YES
Inventory TLV                              YES      YES
    
```

9.4.4. Configures the Management Address to Be Advertised

Configuration Effect

- Configure the management address to be advertised in LLDP packets in interface configuration mode.
- After the management address to be advertised is cancelled, the management address in LLDP packets is subject to the default settings.

Notes

- LLDP runs on physical ports (AP member ports for AP ports). Stacked ports and VSL ports do not support LLDP.

Configuration Steps

- Optional.
- Configure the management address to be advertised in LLDP packets in interface configuration mode.

Verification

Display LLDP information on a local interface

- Check whether the configuration takes effect.

Related Commands

→ Configuring the Management Address to Be Advertised

Command	lldp management-address-tlv [ip-address]
Parameter Description	ip-address: Indicates the management address to be advertised in an LLDP packet.
Command Mode	Interface configuration mode
Usage Guide	A management address is advertised through LLDP packets by default. The management address is the IPv4 address of the minimum VLAN supported by the port. If no IPv4 address is configured for the VLAN, LLDP keeps searching for the qualified IP address. If no IPv4 address is found, LLDP searches for the IPv6 address of the minimum VLAN supported by the port. If no IPv6 address is found, the loopback address 127.0.0.1 is used as the management address.

→ Canceling the Management Address

Command	no lldp management-address-tlv
Parameter Description	N/A
Command Mode	Interface configuration mode

Usage Guide	<p>A management address is advertised through LLDP packets by default. The management address is the IPv4 address of the minimum VLAN supported by the port. If no IPv4 address is configured for the VLAN, LLDP keeps searching for the qualified IP address. If no IPv4 address is found, LLDP searches for the IPv6 address of the minimum VLAN supported by the port.</p> <p>If no IPv6 address is found, the loopback address 127.0.0.1 is used as the management address.</p>
-------------	---

Configuration Example

→ Configuring the Management Address to Be Advertised

Configuration Steps	Set the management address to 192.168.1.1 on an interface.
	<pre>Switch(config)#interface gigabitethernet 0/1 Switch(config-if-GigabitEthernet 0/1)#lldp management-address-tlv 192.168.1.1</pre>
Verification	Display configuration on the interface.

	<pre>Switch(config-if-GigabitEthernet 0/1)#show lldp local- information interface GigabitEthernet 0/1 Lldp local-information of port [GigabitEthernet 0/1] Port ID type : Interface name Port id : GigabitEthernet 0/1 Port description : GigabitEthernet 0/1</pre>
	<pre>Management address subtype : ipv4 Management address : 192.168.1.1 Interface numbering subtype : ifIndex Interface number : 1 Object identifier :</pre>
	<pre>802.1 organizationally information Port VLAN ID : 1 Port and protocol VLAN ID(PPVID) : 1 PPVID Supported : YES PPVID Enabled : NO VLAN name of VLAN 1 : VLAN0001 Protocol Identity :</pre>
	<pre>802.3 organizationally information Auto-negotiation supported : YES Auto-negotiation enabled : YES PMD auto-negotiation advertised : 1000BASE-T full duplex mode, 100BASE-TX full duplex mode, 100BASE-TX half duplex mode Operational MAU type : speed(100)/duplex(Full) PoE support : NO Link aggregation supported : YES Link aggregation enabled : NO Aggregation port ID : 0 Maximum frame Size : 1500</pre>
	<pre>LLDP-MED organizationally information Power-via-MDI device type : PD Power-via-MDI power source : Local Power-via-MDI power priority : Power-via-MDI power value : Model name : Model name</pre>

9.4.5. Configuring the LLDP Fast Transmission Count

Configuration Effect

- Configure the number of LLDP packets that are fast transmitted.

Configuration Steps

- Optional.
- Configure the number of LLDP packets that are fast transmitted in global configuration mode.

Verification

Displaying the global LLDP status information

- Check whether the configuration takes effect.

Related Commands

→ Configuring the LLDP Fast Transmission Count

Command	lldp fast-count value
Parameter Description	value: Indicates the number of LLDP packets that are fast transmitted. The value ranges from 1 to 10. The default value is 3.
Command Mode	Global configuration mode
Usage Guide	N/A

→ Restoring the Default LLDP Fast Transmission Count

Command	no lldp fast-count
Parameter Description	N/A
Command Mode	Global configuration mode
Usage Guide	N/A

Configuration Example

→ Configuring the LLDP Fast Transmission Count

Configuration Steps	Set the LLDP fast transmission count to 5 in global configuration mode.
	<pre>Switch(config)#lldp fast-count 5</pre>
Verification	Display the global LLDP status information.
	<pre>Switch(config)#show lldp status Global status of LLDP : Enable Neighbor information last changed time : Transmit interval : 30s Hold multiplier : 4 Reinit delay : 2s Transmit delay : 2s Notification interval : 5s Fast start counts : 5</pre>

9.4.6. Configuring the TTL Multiplier and Transmission Interval**Configuration Effect**

- Configure the TTL multiplier.
- Configure the LLDP packet transmission interval.

Configuration Steps

- Indicates the LLDP packet transmission interval. The value ranges from 1 to 32,768, which is larger than the standard MIB range (5 to 32,768). Thus, it can meet more requirements.

Verification

Display LLDP status information on an interface

- Check whether the configuration takes effect.

Related Commands

→ Configuring the TTL Multiplier

Command	lldp hold-multiplier value
Parameter Description	value: Indicates the TTL multiplier. The value ranges from 2 to 10. The default value is 4.
Command Mode	Global configuration mode
Usage Guide	In an LLDP packet, the value of Time To Live TLV is calculated based on the following formula: Time to Live TLV= TTL multiplier x Packet transmission interval + 1. Therefore, you can modify the Time to Live TLV in LLDP packets by configuring the TTL multiplier.

→ Restoring the Default TTL Multiplier

Command	no lldp hold-multiplier
Parameter Description	N/A
Command Mode	Global configuration mode
Usage Guide	In an LLDP packet, the value of Time To Live TLV is calculated based on the following formula: Time to Live TLV = TTL multiplier x Packet transmission interval + 1. Therefore, you can modify the Time to Live TLV in LLDP packets by configuring the TTL multiplier.

→ Configuring the Transmission Interval

Command	lldp timer tx-interval seconds
Parameter Description	seconds: Indicates the LLDP packet transmission interval. The value ranges from 1 to 32,768.
Command Mode	Global configuration mode
Usage Guide	N/A

→ Restoring the Default Transmission Interval

Command	no lldp timer tx-interval
Parameter Description	N/A
Command Mode	Global configuration mode
Usage Guide	N/A

Configuration Example

→ Configuring the TTL Multiplier and Transmission Interval

Configuration Steps	Set the TTL multiplier to 3 and the transmission interval to 20 seconds. The TTL of local device information on neighbors is 61 seconds.
	<pre>Switch(config)#lldp hold-multiplier 3 Switch(config)#lldp timer tx-interval 20</pre>
Verification	Display the global LLDP status information.
	<pre>Switch(config)#lldp hold-multiplier 3 Switch(config)#lldp timer tx-interval 20 Switch(config)#show lldp status Global status of LLDP : Enable Neighbor information last changed time : Transmit interval : 20s Hold multiplier : 3 Reinit delay : 2s Transmit delay : 2s Notification interval : 5s Fast start counts : 3</pre>

9.4.7. Configuring the Transmission Delay

Configuration Effect

- Configure the delay time for LLDP packet transmission.

Configuration Steps

- Optional.
- Perform the configuration in global configuration mode.

Verification

Displaying the global LLDP status information

- Check whether the configuration takes effect.

Related Commands

→ Configuring the Transmission Delay

Command	lldp timer tx-delay seconds
Parameter Description	seconds: Indicates the transmission delay. The value ranges from 1 to 8,192.
Command Mode	Global configuration mode
Usage Guide	When local information of a device changes, the device immediately transmits LLDP packets to its neighbors. Configure the transmission delay to prevent frequent transmission of LLDP packets caused by frequent changes of local information.

→ Restoring the Default Transmission Delay

Command	no lldp timer tx-delay
Parameter Description	N/A
Command Mode	Global configuration mode
Usage Guide	When local information of a device changes, the device immediately transmits LLDP packets to its neighbors. Configure the transmission delay to prevent frequent transmission of LLDP packets caused by frequent changes of local information.

Configuration Example

→ Configuring the Transmission Delay

<p>Configuration Steps</p>	<p>Set the transmission delay to 3 seconds.</p>
	<pre>Switch(config)#lldp timer tx-delay 3</pre>
<p>Verification</p>	<p>Display the global LLDP status information.</p>
	<pre>Switch(config)#show lldp status Global status of LLDP : Enable Neighbor information last changed time : Transmit interval : 30s Hold multiplier : 4 Reinit delay : 2s Transmit delay : 3s Notification interval : 5s Fast start counts : 3</pre>

9.4.8. Configuring the Initialization Delay

Configuration Effect

- Configure the delay time for LLDP to initialize on any interface.

Configuration Steps

- Optional.
- Configure the delay time for LLDP to initialize on any interface.

Verification

Display the global LLDP status information

- Check whether the configuration takes effect.

Related Commands

→ Configuring the Initialization Delay

Command	lldp timer reinit-delay seconds
Parameter Description	seconds: Indicates the initialization delay . The value ranges from 1 to 10 seconds.
Command Mode	Global configuration mode
Usage Guide	Configure the initialization delay to prevent frequent initialization of the state machine caused by frequent changes of the port work mode.

→ Restoring the Default Initialization Delay

Command	no lldp timer reinit-delay
Parameter Description	N/A
Command Mode	Global configuration mode
Usage Guide	Configure the initialization delay to prevent frequent initialization of the state machine caused by frequent changes of the port work mode.

Configuration Example

→ Configuring the Initialization Delay

Configuration Steps	Set the initialization delay to 3 seconds.
	<pre>Switch(config)#lldp timer reinit-delay 3</pre>
Verification	Display the global LLDP status information.

	<pre>Switch(config)#show lldp status Global status of LLDP : Enable Neighbor information last changed time : Transmit interval : 30s Hold multiplier : 4 Reinit delay : 3s Transmit delay : 2s Notification interval : 5s Fast start counts : 3</pre>
--	--

9.4.9. Configuring the LLDP Trap Function

Configuration Effect

- Configure the interval for transmitting LLDP Trap messages.

Configuration Steps

→ Enabling the LLDP Trap Function

- Optional.
- Perform the configuration in interface configuration mode.

→ Configuring the LLDP Trap Transmission Interval

- Optional.
- Perform the configuration in global configuration mode.

Verification

Display LLDP status information

- Check whether the LLDP Trap function is enabled.
- Check whether the interval configuration takes effect.

Related Commands

→ Enabling the LLDP Trap Function

Command	lldp notification remote-change enable
Parameter Description	N/A

Command Mode	Interface configuration mode
Usage Guide	The LLDP Trap function enables a device to send its local LLDP information (such as neighbor discovery and communication link fault) to the NMS server so that administrators learn about the network performance

→ Disabling the LLDP Trap Function

Command	no lldp notification remote-change enable
Parameter Description	N/A
Command Mode	Interface configuration mode
Usage Guide	The LLDP Trap function enables a device to send its local LLDP information (such as neighbor discovery and communication link fault) to the NMS server so that administrators learn about the network performance.

→ Configuring the LLDP Trap Transmission Interval

Command	lldp timer notification-interval seconds
Parameter Description	seconds: Indicates the interval for transmitting LLDP Trap messages. The value ranges from 5 to 3,600 seconds. The default value is 5 seconds.
Command Mode	Global configuration mode
Usage Guide	Configure the LLDP Trap transmission interval to prevent frequent transmission of LLDP Trap messages. LLDP changes detected within this interval will be transmitted to the NMS server.

→ Restoring the LLDP Trap Transmission Interval

Command	no lldp timer notification-interval
Parameter Description	N/A
Command Mode	Global configuration mode

Usage Guide	Configure the LLDP Trap transmission interval to prevent frequent transmission of LLDP Trap messages. LLDP changes detected within this interval will be transmitted to the NMS server.
-------------	---

Configuration Example

→ Enabling the LLDP Trap Function and Configuring the LLDP Trap Transmission Interval

Configuration Steps	Enable the LLDP Trap function and set the LLDP Trap transmission interval to 10 seconds.
	<pre>Switch(config)#lldp timer notification-interval 10 Switch(config)#interface gigabitEthernet 0/1 Switch(config-if-GigabitEthernet 0/1)#lldp notification remote-change enable</pre>
Verification	Display LLDP status information.
	<pre>Switch(config-if-GigabitEthernet 0/1)#show lldp status Global status of LLDP : Enable Neighbor information last changed time : Transmit interval : 30s Hold multiplier : 4 Reinit delay : 2s Transmit delay : 2s Notification interval : 10s Fast start counts : 3 ----- Port [GigabitEthernet 0/1] ----- Port status of LLDP : Enable Port state : UP Port encapsulation : Ethernet II Operational mode : RxAndTx Notification enable : YES Error detect enable : YES Number of neighbors : 0 Number of MED neighbors : 0</pre>

9.4.10. Configuring the LLDP Error Detection Function

Configuration Effect

- Enable the LLDP error detection function. When LLDP detects an error, the error is logged.
- Configure the LLDP error detection function to detect VLAN configuration at both ends of a link, port status, aggregate port configuration, MTU configuration, and loops.

Notes

N/A

Configuration Steps

→ Optional.

- Enable or disable the LLDP error detection function in interface configuration mode.

Verification

Display LLDP status information on an interface

- Check whether the configuration takes effect.

Related Commands

→ Enabling the LLDP Error Detection Function

Command	lldp error-detect
Parameter Description	N/A
Command Mode	Interface configuration mode
Usage Guide	The LLDP error detection function relies on specific TLVs in LLDP packets exchanged between devices at both ends of a link. Therefore, a device needs to advertise correct TLVs to ensure the LLDP error detection function.

→ Disabling the LLDP Error Detection Function

Command	no lldp error-detect
Parameter Description	N/A
Command Mode	Interface configuration mode

Usage Guide	The LLDP error detection function relies on specific TLVs in LLDP packets exchanged between devices at both ends of a link. Therefore, a device needs to advertise correct TLVs to ensure the LLDP error detection function.
-------------	--

Configuration Example

→ Enabling the LLDP Error Detection Function

Configuration Steps	Enable the LLDP error detection function on interface GigabitEthernet 0/1.
	<pre>Switch(config)#interface gigabitethernet 0/1 Switch(config-if-GigabitEthernet 0/1)#lldp error-detect</pre>
Verification	Display LLDP status information on the interface.
	<pre>Switch(config-if-GigabitEthernet 0/1)#show lldp status interface gigabitethernet 0/1 Port [GigabitEthernet 0/1] Port status of LLDP : Enable Port state : UP Port encapsulation : Ethernet II Operational mode : RxAndTx Notification enable : NO Error detect enable : YES Number of neighbors : 0 Number of MED neighbors : 0</pre>

9.4.11. Configuring the LLDP Encapsulation Format

Configuration Effect

- Configure the LLDP encapsulation format.

Configuration Steps

→ Optional.

- Configure the LLDP encapsulation format on an interface.

Verification

Display LLDP status information of an interface

- Check whether the configuration takes effect.

Related Commands

→ Setting the LLDP Encapsulation Format to SNAP

Command	lldp encapsulation snap
Parameter Description	N/A
Command Mode	Interface configuration mode
Usage Guide	 The LLDP encapsulation format configuration on a device and its neighbors must be consistent.

→ Restoring the Default LLDP Encapsulation Format (Ethernet II)

Command	No lldp encapsulation snap
Parameter Description	N/A
Command Mode	Interface configuration mode
Usage Guide	 The LLDP encapsulation format configuration on a device and its neighbors must be consistent.

Configuration Example

→ Setting the LLDP Encapsulation Format to SNAP

Configuration Steps	Set the LLDP encapsulation format to SNAP.
	<pre>Switch(config)#interface gigabitethernet 0/1 Switch(config-if-GigabitEthernet 0/1)#lldp encapsulation snap</pre>
Verification	Display LLDP status information on the interface.

```
Switch(config-if-GigabitEthernet 0/1)#show lldp status interface
gigabitethernet 0/1
Port [GigabitEthernet 0/1]
Port status of LLDP           : Enable
Port state                    : UP
Port encapsulation            : Snap
Operational mode              : RxAndTx
Notification enable           : NO
Error detect enable           : YES
Number of neighbors           : 0
Number of MED neighbors       : 0
```

9.4.12. Configuring the LLDP Network Policy

Configuration Effect

- Configure the LLDP Network Policy.
- If a device is connected to an IP-Phone that supports LLDP-MED, you can configure the Network Policy TLV to push policy configuration to the IP-Phone, , which enables the IP-Phone to change the tag and QoS of voice streams. In addition to the LLDP Network Policy, perform the following steps on the device: 1. Enable the Voice VLAN function and add the port connected to the IP-Phone to the Voice VLAN. 2. Configure the port connected to the IP-Phone as a QoS trusted port (the trusted DSCP mode is recommended). 3. If 802.1X authentication is also enabled on the port, configure a secure channel for the packets from the Voice VLAN. If the IP-Phone does not support LLDP-MED, enable the voice VLAN function and add the MAC address of the IP-Phone to the Voice VLAN OUI list manually.
- For the configuration of the QoS trust mode, see Configuring IP QoS; for the configuration of the Voice VLAN, see Configuring Voice VLAN; for the configuration of the secure channel, see Configuring ACL.

Configuration Steps

- Optional.
- Configure the LLDP Network Policy.

Verification

Displaying the LLDP network policy configuration.

- Check whether the configuration takes effect.

Related Commands

→ Configuring the LLDP Network Policy

Command	lldp network-policy profile profile-num
Parameter Description	profile-num: Indicates the ID of an LLDP Network Policy. The value ranges from 1 to 1,024.
Command Mode	Global configuration mode
Usage Guide	Run this command to enter the LLDP network policy mode after specifying a policy ID. After entering the LLDP network policy mode, run the { voice voice-signaling } vlan command to configure a specific network policy.

→ Deleting the LLDP Network Policy

Command	no lldp network-policy profile profile-num
Parameter Description	profile-num: Indicates the LLDP Network Policy ID. The value ranges from 1 to 1,024.
Command Mode	Interface configuration mode
Usage Guide	Run this command to enter the LLDP network policy mode after specifying a policy ID. After entering the LLDP network policy mode, run the { voice voice-signaling } vlan command to configure a specific network policy.

Configuration Example

→ Configuring the LLDP Network Policy

Configuration Steps	Set the Network Policy TLV to 1 for LLDP packets to be advertised by port GigabitEthernet 0/1 and set the VLAN ID of the Voice application to 3, COS to 4, and DSCP to 6.
	<pre>Switch#config Switch(config)#lldp network-policy profile 1 Switch(config-lldp-network-policy)# voice vlan 3 cos 4 Switch(config-lldp-network-policy)# voice vlan 3 dscp 6 Switch(config-lldp-network-policy)#exit Switch(config)# interface gigabitEthernet 0/1 Switch(config-if-GigabitEthernet 0/1)# lldp tlv-enable med-tlv network-policy profile 1</pre>

Verification	Display the LLDP network policy configuration on the local device.
	<pre> network-policy information: ----- network policy profile :1 voice vlan 3 cos 4 voice vlan 3 dscp 6 </pre>

9.4.13. Configuring the Civic Address

Configuration Effect

- Configure the civic address of a device.

Configuration Steps

- Optional.
- Perform this configuration in LLDP Civic Address configuration mode.

Verification

Display the LLDP civic address of the local device

- Check whether the configuration takes effect.

Related Commands

→ Configuring the Civic Address of a Device

Command	Configure the LLDP civic address. Use the no option to delete the address. { country state county city division neighborhood street-group leading-street-dir trailing-street-suffix street-suffix number street-number-suffix landmark additional-location-information name postal-code building unit floor room type-of-place postal-community-name post-office-box additional-code } ca-word
---------	---

Parameter Description	<p>country: Indicates the country code, with two characters. CH indicates China.</p> <p>state: Indicates the CA type is 1.</p> <p>county: Indicates that the CA type is 2.</p> <p>city: Indicates that the CA type is 3.</p> <p>division: Indicates that the CA type is 4.</p> <p>neighborhood: Indicates that the CA type is 5.</p> <p>street-group: Indicates that the CA type is 6.</p> <p>leading-street-dir: Indicates that the CA type is 16.</p> <p>trailing-street-suffix: Indicates that the CA type is 17.</p> <p>street-suffix: Indicates that the CA type is 18.</p> <p>number: Indicates that the CA type is 19.</p> <p>street-number-suffix: Indicates that the CA type is 20.</p> <p>landmark: Indicates that the CA type is 21.</p> <p>additional-location-information: Indicates that the CA type is 22.</p> <p>name: Indicates that the CA type is 23.</p> <p>postal-code: Indicates that the CA type is 24.</p> <p>building: Indicates that the CA type is 25.</p> <p>unit: Indicates that the CA type is 26.</p> <p>floor: Indicates that the CA type is 27.</p> <p>room: Indicates that the CA type is 28.</p> <p>type-of-place: Indicates that the CA type is 29.</p> <p>postal-community-name: Indicates that the CA type is 30.</p> <p>post-office-box: Indicates that the CA type is 31.</p> <p>additional-code: Indicates that the CA type is 32.</p> <p>ca-word: Indicates the address.</p>
Command Mode	LLDP Civic Address configuration mode
Usage Guide	After entering the LLDP Civic Address configuration mode, configure the LLDP civic address.

→ Deleting the Civic Address of a Device

Command	no { country state county city division neighborhood street-group leading-street-dir trailing-street-suffix street-suffix number street-number-suffix landmark additional-location-information name postal-code building unit floor room type-of-place postal-community-name post-office-box additional-code }
---------	--

no { country state county city division neighborhood street-group leading-street-dir trailing-street-suffix street-suffix number street-number-suffix landmark additional-location-information name postal-code building unit floor room type-of-place postal-community-name post-office-box additional-code } Parameter Description	N/A
Command Mode	LLDP Civic Address configuration mode
Usage Guide	After entering the LLDP Civic Address configuration mode, configure the LLDP civic address.

→ Configuring the Device Type

Command	device-type device-type
Parameter Description	device-type: Indicates the device type. The value ranges from 0 to 2. The default value is 1. 0 indicates that the device type is DHCP server. 1 indicates that the device type is switch. 2 indicates that the device type is LLDP MED .
Command Mode	LLDP Civic Address configuration mode
Usage Guide	After entering the LLDP Civic Address configuration mode, configure the device type.

→ Restoring the Device Type

Command	no device-type
Parameter Description	N/A
Command Mode	LLDP Civic Address configuration mode
Usage Guide	After entering the LLDP Civic Address configuration mode, restore the default settings.

Configuration Example

→ Configuring the Civic Address of a Device

Configuration Steps	Set the address of port GigabitEthernet 0/1 as follows: set country to CH, city to Fuzhou, and postal code to 350000.
	<pre>Switch#config Switch(config)#lldp location civic-location identifier 1 Switch(config-lldp-civic)# country GE Switch(config-lldp-civic)# city Hamm Switch(config-lldp-civic)# postal-code 59067</pre>
Verification	Display the LLDP civic address of port GigabitEthernet 0/1 1.
	<pre>civic location information: ----- Identifier :1 country :GE device type :1 city :Hamm postal-code :59067</pre>

9.4.14. Configuring the Emergency Telephone Number**Configuration Effect**

- Configure the emergency telephone number of a device.

Configuration Steps

→ Optional.

- Perform this configuration in global configuration mode.

Verification

Display the emergency telephone number of the local device

- Check whether the configuration takes effect.

Related Commands

→ Configuring the Emergency Telephone Number of a Device

Command	lldp location elin identifier id elin-location tel-number
Parameter Description	id: Indicates the identifier of an emergency telephone number. The value ranges from 1 to 1,024. tel-number: Indicates emergency telephone number, containing 10-25 characters.
Command Mode	Global configuration mode
Usage Guide	Run this command to configure the emergency telephone number.

→ Deleting the Emergency Telephone Number of a Device

Command	no lldp location elin identifier id
Parameter Description	id: Indicates the identifier of an emergency telephone number. The value ranges from 1 to 1,024.
Command Mode	Global configuration mode
Usage Guide	N/A

Configuration Example

→ Configuring the Emergency Telephone Number of a Device

Configuration Steps	Set the emergency telephone number of port GigabitEthernet 0/1 to 123456789.
	<pre>Switch#config Switch(config)#lldp location elin identifier 1 elin-location 123456789</pre>
Verification	Display the emergency telephone number of port GigabitEthernet 0/1.
	<pre>elin location information: ----- Identifier :1 elin number :123456789</pre>

9.4.15. Configuring Compatible Neighbors Detection**Configuration Effect**

- Enables compatible neighbors detection function.

Configuration Steps

→ Optional.

- Perform this configuration in global configuration mode.

Verification

Display the LLDP information.

- Check whether the configuration takes effect.

Related Commands

→ Enabling compatible neighbors detection

Command	lldp compliance vendor
Parameter Description	N/A
Command Mode	Global configuration mode
Usage Guide	N/A

→ Disabling compatible neighbors detection

Command	no lldp compliance vendor
Parameter Description	N/A
Command Mode	Global configuration mode
Usage Guide	N/A

Configuration Example

→ Configuring Compatible Neighbors Detection

Configuration Steps	Configuring compatible neighbor detection.
	<pre>Switch(config)# lldp compliance vendor</pre>
Verification	Display the LLDP information.

	<pre>Switch(config)#show lldp status Global status of LLDP : Enable Global vendor compliance : YES</pre>
--	--

9.4.16. Configuring the Function of Ignoring PVID Detection

Configuration Effect

- Ignores the PVID detection.

Configuration Steps

→ Optional.

- According to the real condition, select whether to enable the function.

Verification

Display the LLDP information.

- Check whether the status of PVID detection in global LLDP is the same as your configuration.

Related Commands

→ Ignoring PVID Detection

Command	lldp ignore pvid-error-detect
Parameter Description	N/A
Command Mode	Global configuration mode
Usage Guide	Use the command to ignore PVID detection.

Configuration Example

→ Configuring the Function of Ignoring PVID Detection

Configuration Steps	Ignores PVID detection in global configuration mode.
	<pre>Switch#config Switch(config)#lldp ignore pvid-error-detect</pre>
Verification	Display the LLDP information.
	<pre>Switch(config)#show lldp status Global status of LLDP : Enable Neighbor information last changed time : Transmit interval : 30s Hold multiplier : 4 Reinit delay : 2s Transmit delay : 2s Notification interval : 5s Fast start counts : 5 Ignore PVID error detect : YES</pre>

9.5. Monitoring

Clearing



Running the clear commands may lose vital information and thus interrupt services.

Description	Command
Clears LLDP statistics.	clear lldp statistics [interface interface-name]
Clears LLDP neighbor information.	clear lldp table [interface interface-name]

Displaying

Description	Command
Displays LLDP information on the local device, which will be organized as TLVs and sent to neighbors.	show lldp local-information [global interface interface-name]
Displays the LLDP civic address or emergency telephone number of a local device.	show lldp location { civic-location elin-location } { identifier id interface interface-name static }
Displays LLDP information on a neighbor.	show lldp neighbors [interface interface-name] [detail]
Displays the LLDP network policy configuration of the local device.	show lldp network-policy { profile [profile-num] interface interface-name }
Displays LLDP statistics.	show lldp statistics [global interface interface-name]
Displays LLDP status information.	show lldp status [interface interface-name]
Displays the configuration of TLVs to be advertised by a port.	show lldp tlv-config [interface interface-name]

Debugging



System resources are occupied when debugging information is output. Therefore, disable debugging immediately after use.

Description	Command
Debugs LLDP error processing.	debug lldp error
Debugs LLDP event processing.	debug lldp event
Debugs LLDP hot backup processing.	debug lldp ha
Debugs the LLDP packet reception.	debug lldp packet
Debugs the LLDP state machine.	debug lldp stm

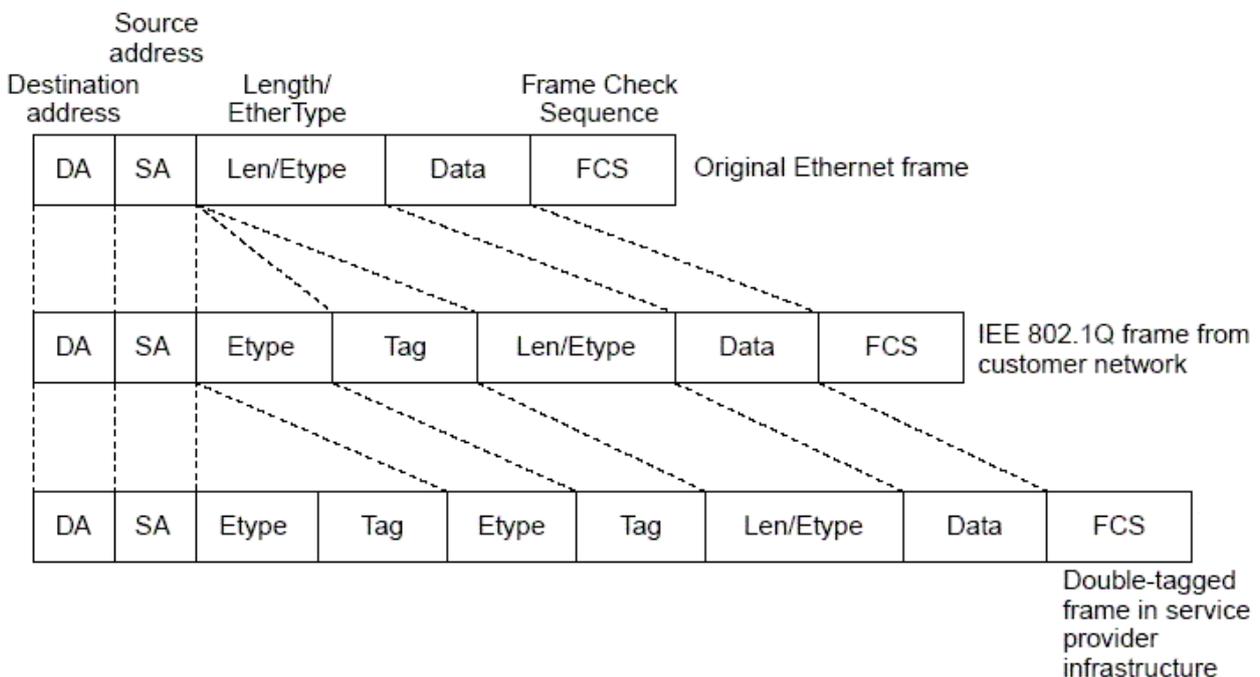
10. Configuring QinQ

10.1. Overview

QinQ is used to insert a public virtual local area network (VLAN) tag into a packet with a private VLAN tag to allow the double-tagged packet to be transmitted over a service provider (SP) network.

Users on a metropolitan area network (MAN) must be separated by VLANs. IEEE 802.1Q supports only 4,094 VLANs, far from enough. Through the double-tag encapsulation provided by QinQ, a packet is transmitted over the SP network based on the unique outer VLAN tag assigned by the public network. In this way, private VLANs can be reused, which increases the number of available VLAN tags and provides a simple Layer-2 virtual private network (VPN) feature.

Figure 10-1 shows the double-tag insertion process. The entrance to an SP network is called a dot1q-tunnel port, or Tunnel port for short. All frames entering provider edges (PEs) are considered untagged. All tags, whether untagged frames or frames with customer VLAN tags, are encapsulated with the tags of the SP network. The VLAN ID of the SP network is the ID of the default VLAN for the Tunnel port.



Protocols and Standards

- IEEE 802.1ad

10.2. Applications

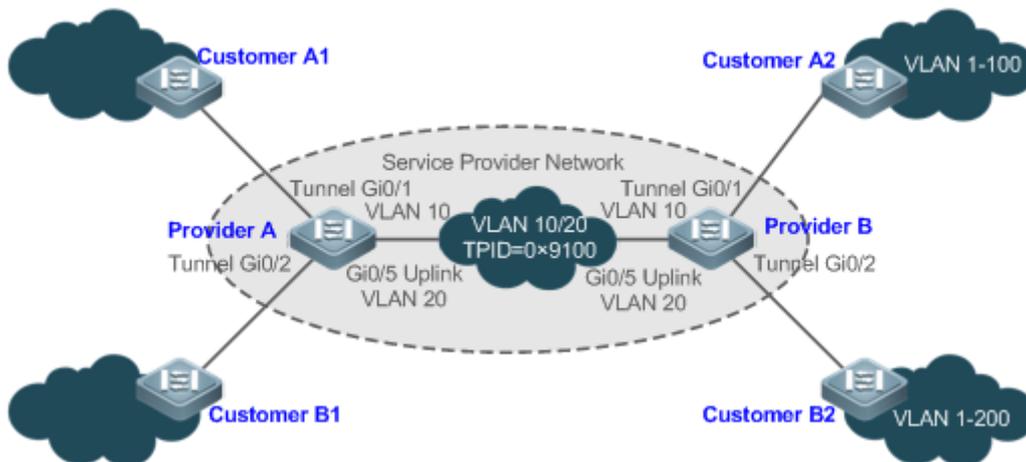
Application	Description
Implementing Layer-2 VPN Through Port-Based Basic QinQ	Data is transmitted from Customer A and Customer B to the peer end without conflict on the SP network even if the data comes from the same VLAN.
Implementing QinQ-Based Layer-2 Transparent Transmission	Customer Network A and Customer Network B in different areas can perform unified Multiple Spanning Tree Protocol (MSTP) calculation or VLAN deployment across the SP network without affecting the SP network.

10.2.1. Implementing Layer-2 VPN Through Port-Based Basic QinQ

Scenario

An SP provides the VPN service to Customer A and Customer B.

- Customer A and Customer B belong to different VLANs on the SP network and achieve communication through respective SP VLANs.
- The VLANs of Customer A and Customer B are transparent to the SP network. The VLANs can be reused without conflicts.
- The Tunnel port encapsulates a native VLAN tag in each packet. Packets are transmitted through the native VLAN over the SP network without impact on the VLANs of Customer A and Customer B, thus implementing simple Layer-2 VPN.



Remarks	<p>Customer A1 and Customer A2 are the customer edges (CEs) for Customer A network. Customer B1 and Customer B2 are the CEs for Customer B network.</p> <p>Provider A and Provider B are the PEs on the SP network. Customer A and Customer B access the SP network through Provider A and Provider B.</p> <p>The VLAN of Customer A ranges from 1 to 100.</p> <p>The VLAN of Customer B ranges from 1 to 200.</p>
---------	--

Deployment

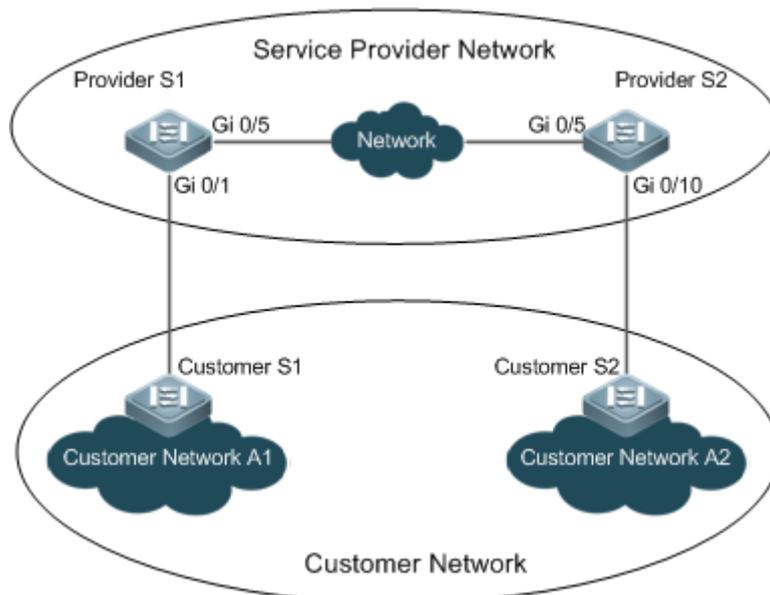
- Enable basic QinQ on PEs to implement Layer-2 VPN.
- The tag protocol identifiers (TPIDs) used by many switches (including MS400995M) are set to 0x8100, but the switches of some vendors do not use 0x8100. In the latter case, you need to change the TPID value on the Uplink ports of PEs to the values of the TPIDs used by third-party switches.
- Configure priority replication and priority mapping for class of service (CoS) on the Tunnel ports of PEs, and configure different QoS policies for different service flows (for details, see Configuring QoS).

10.2.2. Implementing QinQ-Based Layer-2 Transparent Transmission

Scenario

The Layer-2 transparent transmission between customer networks has no impact on the SP network.

- The Layer-2 packets on customer networks are transparent to SP networks and can be transmitted between the customer networks without impact on the SP networks.



Remarks	Customer S1 and Customer S2 access the SP network through Provider S1 and Provider S2. Provider S1 and Provider S2 are enabled with Layer-2 transparent transmission globally, and the Gi 0/1 and Gi 0/10 ports are enabled with Layer-2 transparent transmission.
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Deployment

- On the ports of the PEs (Provider S1 and Provider S2) connected to Customer S1 and Customer S2 respectively, configure Layer-2 transparent transmission between Customer Network A1 and Customer Network A2 without impact on the SP network.
- Configure STP transparent transmission based on user requirements to realize transparent transmission of bridge protocol data unit (BPDU) packets between Customer Network A1 and Customer Network A2 and to perform unified MSTP calculation across the SP network.
- Configure GARP VLAN Registration Protocol (GVRP) transparent transmission based on user requirements to realize transparent transmission of GVRP packets between Customer Network A1 and Customer Network A2 and dynamic VLAN configuration on the customer networks across the SP network.

10.3. Features

Basic Concepts

→ Basic QinQ

Configure basic QinQ on a Tunnel port and configure a native VLAN for the port. Packets entering the port are encapsulated with outer tags containing the native VLAN ID. Basic QinQ does not segregate service flows and cannot encapsulate packets flexibly based on VLANs.

→ TPID

An Ethernet frame tag consists of four fields: TPID, User Priority, Canonical Format Indicator (CFI), and VLAN ID.

By default, the TPID is 0x8100 according to IEEE802.1Q. On the switches of some vendors, the TPID is set to 0x9100 or other values. The TPID configuration aims to ensure that the TPIDs of packets to be forwarded are compatible with the TPIDs supported by third-party switches.

→ Priority Mapping and Priority Replication

The default value of User Priority in Ethernet frame tags is 0, indicating regular flows. You can set this field to ensure preferential transmission of certain packets. You can specify User Priority by setting the value of CoS in a QoS policy. Priority replication: If the SP network provides a QoS policy corresponding to a specified CoS in the inner tag, you can replicate the CoS of the inner tag to the outer tag to enable transparent transmission based on the QoS policy provided by the SP network.

Priority mapping: If the SP network provides various QoS policies corresponding to specified CoS values for different service flows, you can map the CoS value of the inner tag to the CoS value of the outer tag to ensure preferential transmission of service flows based on the QoS

policies provided by the SP network.

→ Layer-2 Transparent Transmission

STP and GVRP packets may affect the topology of the SP network. If you want to unify the topology of two customer networks separated by the SP network without affecting the SP network topology, transmit the STP and GVRP packets from the customer networks over the SP network transparently.

Overview

Feature	Description
Basic QinQ	Configures the Tunnel port and specifies whether packets sent from the port are tagged.
TPID Configuration	By default, the TPID is 0x8100 according to IEEE802.1Q. On the switches of some vendors, the TPIDs of outer tags are set to 0x9100 or other values. The TPID configuration aims to ensure that the TPIDs of packets to be forwarded are compatible with the TPIDs supported by third-party switches.
Layer-2 Transparent Transmission	Transmits Layer-2 packets between customer networks without impact on SP networks.
Priority Replication	If the SP network provides a QoS policy corresponding to a specified CoS value in the inner tag, you can replicate the CoS of the inner tag to the outer tag to enable transparent transmission based on the QoS policy provided by the SP network.
Priority Mapping	If the SP network provides various QoS policies corresponding to specified CoS values for different service flows, you can map the CoS value of the inner tag to the CoS value of the outer tag to ensure preferential transmission of service flows based on the QoS policies provided by the SP network.

10.3.1. Basic QinQ

Basic QinQ can be used to implement simple Layer-2 VPN, but it lacks flexibility in encapsulating outer tags.

Working Principle

After a Tunnel port receives a packet, the switch adds the outer tag containing the default VLAN ID to the packet. If the received packet already carries a VLAN tag, it is encapsulated as a double-tagged packet. If it does not have a VLAN tag, it is added with the VLAN tag containing the default VLAN ID.

10.3.2. TPID Configuration

Working Principle

An Ethernet frame tag consists of four fields, namely, TPID, User Priority, CFI, and VLAN ID. By default, the TPID is 0x8100 according to IEEE802.1Q. On the switches of some vendors, the TPIDs of outer tags are set to 0x9100 or other values. The TPID configuration feature allows you to configure TPIDs on ports, which will replace the TPIDs of the outer VLAN tags in packets with the configured TPIDs to realize TPID compatibility.

10.3.3. Layer-2 Transparent Transmission

Working Principle

The Layer-2 transparent transmission feature is designed to realize the transmission of Layer-2 packets between customer networks without impact on SP networks. When a Layer-2 packet from a customer network enters a PE, the PE changes the destination MAC address of the packet to a private address before forwarding the packet. The peer PE changes the destination MAC address to a public address to send the packet to the customer network at the other end, realizing transparent transmission on the SP network.

10.3.4. Priority Replication

Working Principle

If the SP network provides a QoS policy corresponding to a specified User Priority (CoS) in the inner tag, you can replicate the CoS of the inner tag to the outer tag to enable transparent transmission based on the QoS policy provided by the SP network.

10.3.5. Priority Mapping

Working Principle

If the SP network provides various QoS policies corresponding to specified CoS values for different service flows, you can map the CoS value of the inner tag to the CoS value of the outer tag to ensure preferential transmission of service flows based on the QoS policies provided by the SP network.

10.4. Configuration

Configuration	Description and Command	
Configuring QinQ	 Mandatory.	
	switchport mode dot1q-tunnel	Configures a Tunnel port.
	switchport dot1q-tunnel allowed vlan { [add] tagged vlist [add] untagged vlist remove vlist }	Adds the VLANs to the Tunnel port in tagged or untagged mode.
	switchport dot1q-tunnel native vlan VID	Configures the default VLAN for the Tunnel port.
Configuring TPIDs	 (Optional) It is used to realize TPID compatibility.	
	frame-tag tpid tpid	Configures the TPID of a frame tag. If you want to set it to 0x9100, configure the frame-tag tpid 9100 command. By default, the TPID is in hexadecimal format. You need to configure this feature on an egress port.
Configuring Priority Mapping and Priority Replication	 (Optional) It is used to apply the QoS policy provided by the SP network by priority replication.	
	inner-priority-trust enable	Replicates the value of the User Priority field in the inner tag (C-TAG) to the User Priority field of the outer tag (S-TAG).
	 (Optional) It is used to apply the QoS policy provided by the SP network by priority mapping.	
	dot1q-Tunnel cos inner-cos-value remark-cos outer-cos-value	Sets the value of the User Priority field in the outer tag (S-TAG) based on the User Priority field of the inner tag (C-TAG).

Configuring Layer-2 Transparent Transmission		(Optional) It is used to transmit MSTP and GVRP packets transparently based on the customer network topology without affecting the SP network topology.
	l2protocol-tunnel stp	Enables STP transparent transmission in global configuration mode.
	l2protocol-tunnel stp enable	Enables STP transparent transmission in interface configuration mode.
	l2protocol-tunnel gvrp	Enables GVRP transparent transmission in global configuration mode.
	l2protocol-tunnel gvrp enable	Enables GVRP transparent transmission in interface configuration mode.
	l2protocol-tunnel{STP GVRP}tunnel-dmac mac-address	Configures a transparent transmission address.



Pay attention to the following limitations when you configure QinQ:



Do not configure a routed port as the Tunnel port.



Do not enable 802.1X on the Tunnel port.



Do not enable the port security function on the Tunnel port.



When the Tunnel port is configured as the source port of the remote switched port analyzer (RSPAN), the packets whose outer tags contain VLAN IDs consistent with the RSPAN VLAN IDs are monitored.



If you want to match the ACL applied to the Tunnel port with the VLAN IDs of inner tags, use the inner keyword.



Configure the egress port of the customer network connected to the SP network as an Uplink port. If you configure the TPID of the outer tag on a QinQ-enabled port, set the TPID of the outer tag on the Uplink port to the same value.



By default, the maximum transmission unit (MTU) on a port is 1,500 bytes. After added with an outer VLAN tag, a packet is four bytes longer. It is recommended to increase the port MTU on the SP networks to at least 1,504 bytes.



After a switch port is enabled with QinQ, you must enable SVGL sharing before enabling IGMP snooping. Otherwise, IGMP snooping will not work on the QinQ-enabled port.



If a packet matches two or more ACL-based selective QinQ policies without priority, only one policy is executed. It is recommended to specify the priority.

10.4.1. Configuring QinQ

Configuration Effect

- Implement Layer-2 VPN based on a port-based QinQ policy.

Notes

- It is not recommended to configure the native VLAN of the Trunk port on the PE as its default VLAN, because the Trunk port strips off the tags containing the native VLAN IDs when sending packets.

Configuration Steps

→ Configuring the Tunnel port

- (Mandatory) Configure the Tunnel port in interface configuration mode.
- Run the switchport mode dot1q-tunnel command in interface configuration mode to configure the Tunnel port.

Command	switchport mode dot1q-tunnel
Parameter Description	N/A
Defaults	By default, no Tunnel port is configured.
Command Mode	Interface configuration mode
Usage Guide	N/A

→ Configuring the Native VLAN

- Mandatory.
- Configure the native VLAN for the Tunnel port.
- After you configure the native VLAN, add it to the VLAN list of the Tunnel port in untagged mode.
- Run the switchport dot1q-tunnel native vlan VID command in interface configuration mode to configure the default VLAN for the Tunnel port.

- If the native VLAN is added to the VLAN list in untagged mode, the outgoing packets on the Tunnel port are not tagged. If the native VLAN is added to the VLAN list in tagged mode, the outgoing packets on the Tunnel port are tagged with the native VLAN ID. To ensure the uplink and downlink transmission, add the native VLAN to the VLAN list in untagged mode.

Command	switchport dot1q-tunnel native vlan VID
Parameter Description	VID: Indicates the ID of the native VLAN. The value ranges from 1 to 4,094. The default value is 1.
Defaults	By default, the native VLAN is VLAN 1.
Command Mode	Interface configuration mode
Usage Guide	Use this command to configure the VLAN of the SP network.

→ Adding the VLANs on the Tunnel port

- Mandatory.
- After you configure the native VLAN, add it to the VLAN list of the Tunnel port in untagged mode.
- If port-based QinQ is enabled, you do not need to add the VLANs of the customer network to the VLAN list of the Tunnel port.
- Run the switchport dot1q-tunnel allowed vlan { [add] tagged vlist | [add] untagged vlist | remove vlist } command in interface configuration mode to add VLANs to the VLAN list of the Tunnel port. Upon receiving packets from corresponding VLANs, the Tunnel port adds or removes tags based on the settings.

Command	switchport dot1q-tunnel allowed vlan { [add] tagged vlist [add] untagged vlist remove vlist }
Parameter Description	v_list: Indicates the list of the VLANs on the Tunnel port.
Defaults	By default, VLAN 1 is added to the VLAN list of the Tunnel port in untagged mode. Other VLANs are not added.
Command Mode	Interface configuration mode
Usage Guide	Use this command to add or remove VLANs on the Tunnel port and specify whether the outgoing packets are tagged or untagged. If basic QinQ is enabled, add the native VLAN to the VLAN list of the Tunnel port in untagged mode.

Verification

Check the Tunnel port configuration.

- Check whether the Tunnel port is configured properly on a switch.

Configuration Example

→ Configuring Basic QinQ to Implement Layer-2 VPN

<p>Scenario</p>	<p style="text-align: right;">① Service Provider Network</p>
<p>Configuration Steps</p>	<ul style="list-style-type: none"> • Configure Tunnel ports on the PEs and connect the CEs to the Tunnel ports. • Configure the native VLANs for the Tunnel ports and add the native VLANs to the VLAN lists of the Tunnel ports respectively in untagged mode. • Configure VLANs on the customer networks based on requirements. <p>NOTE: QinQ-enabled switches encapsulate outer tags in packets for transmission over the SP network. Therefore, you do not need to configure customer VLANs on the PEs.</p> <div style="border-left: 1px solid black; padding-left: 10px; margin-top: 10px;"> <p> The TPID is 0x8100 by default according to IEEE802.1Q. On some third-party switches, the TPID is set to a different value. If such switches are deployed, set the TPIDs on the ports connected to the third-party switches to realize TPID compatibility.</p> </div> <div style="border-left: 1px solid black; padding-left: 10px; margin-top: 10px;"> <p> If the PEs are connected through Trunk ports or Hybrid ports, do not configure the native VLANs for the Trunk ports or Hybrid ports as the default VLANs for the Tunnel ports. The Trunk ports or Hybrid ports strip off the VLAN tags containing the Native VLAN IDs when sending packets.</p> </div>

Provider A	<p>Step 1: Create VLAN 10 and VLAN 20 on the SP network to segregate the data of Customer A and Customer B.</p> <pre>ProviderA#configure terminal Enter configuration commands, one per line. End with CNTL/Z. ProviderA(config)#vlan 10 ProviderA(config-vlan)#exit ProviderA(config)#vlan 20 ProviderA(config-vlan)#exit</pre> <p>Step 2: Enable basic QinQ on the port connected to the network of Customer A to use VLAN 10 for tunneling.</p> <pre>ProviderA(config)#interface gigabitEthernet 0/1 ProviderA(config-if-GigabitEthernet 0/1)#switchport mode dot1q-tunnel ProviderA(config-if-GigabitEthernet 0/1)#switchport dot1q-tunnel native vlan 10 ProviderA(config-if-GigabitEthernet 0/1)#switchport dot1q-tunnel allowed vlan add untagged 10</pre> <p>Step 3: Enable basic QinQ on the port connected to the network of Customer B to use VLAN 20 for tunneling.</p> <pre>ProviderA(config)#interface gigabitEthernet 0/2 ProviderA(config-if-GigabitEthernet 0/2)#switchport mode dot1q-tunnel ProviderA(config-if-GigabitEthernet 0/2)#switchport dot1q-tunnel native vlan 20 ProviderA(config-if-GigabitEthernet 0/2)#switchport dot1q-tunnel allowed vlan add untagged 20</pre> <p>Step 4: Configure an Uplink port.</p> <pre>ProviderA(config)# interface gigabitEthernet 0/5 ProviderA(config-if-GigabitEthernet 0/5)#switchport mode uplink</pre>
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<p>Provider A</p>	<p>Step 5: Change the TPID of the outgoing packets on the Uplink port to a value (for example, 0x9100) recognizable by third-party switches.</p> <div style="border: 1px solid #ccc; padding: 10px; margin: 10px 0;"> <pre>ProviderA(config-if-GigabitEthernet 0/5)#frame-tag tpid 9100</pre> </div> <p>Step 6: Configure Provider B by performing the same steps.</p>
<p>Verification</p>	<p>Customer A1 sends a packet containing VLAN ID 100 destined to Customer A2. The packet through Provider A is tagged with the outer tag specified by the Tunnel port. The packet that reaches Customer A2 carries the original VLAN ID 100. Check whether the Tunnel port is configured correctly. Check whether the TPID is configured correctly.</p>

<p>Provider A</p>	<pre> ProviderA#show running-config interface GigabitEthernet 0/1 switchport mode dot1q-tunnel switchport dot1q-tunnel allowed vlan add untagged 10 switchport dot1q-tunnel native vlan 10 spanning-tree bpdufilter enable ! interface GigabitEthernet 0/2 switchport mode dot1q-tunnel switchport dot1q-tunnel allowed vlan add untagged 20 switchport dot1q-tunnel native vlan 20 spanning-tree bpdufilter enable ! interface GigabitEthernet 0/5 switchport mode uplink frame-tag tpid 0x9100 ProviderA#show interfaces dot1q-tunnel =====Interface Gi0/1===== Native vlan: 10 Allowed vlan list:1,10, Tagged vlan list: =====Interface Gi0/2===== Native vlan: 20 Allowed vlan list:1,20, Tagged vlan list: ProviderA#show frame-tag tpid Ports Tpid ----- Gi0/5 0x9100 </pre>
<p>Provider B</p>	<p>Check Provider B by performing the same steps.</p>

Common Errors

- The native VLAN is not added to the VLAN list of the Tunnel port in untagged mode.
- No TPID is configured on the port connected to the third-party switch on which TPID is not 0x8100. As a result, packets cannot be recognized by the third-party switch.

10.4.2. Configuring TPIDs

Configuration Effect

Configure the TPIDs in the tags on SP network devices to realize TPID compatibility.

Notes

If a PE connected to a third-party switch on which the TPID is not 0x8100, you need to configure the TPID on the port of the PE connected to the third-party switch.



Do not set the TPIDs to any of the following values: 0x0806 (ARP), 0x0200 (PUP), 0x8035 (RARP), 0x0800 (IP), 0x86DD (IPv6), 0x8863/0x8864 (PPPoE), 0x8847/0x8848 (MPLS), 0x8137 (IPX/SPX), 0x8000 (IS-IS), 0x8809 (LACP), 0x888E (802.1X), 0x88A7 (clusters), and 0x0789 (reserved by Microsens).

Configuration Steps

- If a PE connected to a third-party switch on which the TPID is not 0x8100, you need to configure the TPID on the port of the PE connected to the third-party switch.
- TPIDs can be configured in interface configuration mode and global configuration mode. The following example adopts interface configuration mode.

Configure the frame-tag tpid 0x9100 command in interface configuration mode to change the TPID to 0x9100. For details about the TPID value, see section 1.4.5.

Command	frame-tag tpid tpid
Parameter Description	tpid: Indicates the new value of the TPID.
Defaults	The default value of the TPID is 0x8100.
Command Mode	Interface configuration mode
Usage Guide	If a PE is connected to a third-party switch on which the TPID is not 0x8100, use this command to configure the TPID on the port connected to the third-party switch.

Verification

Check whether the TPID is configured.

Configuration Example

→ Configuring the TPID on a port

Configuration Steps	<p>Configure the TPID on a port.</p> <pre>Switch(config)# interface gigabitethernet 0/1 Switch(config-if)# frame-tag tpid 9100</pre>
Verification	<p>Display the TPID on the port.</p> <pre>Switch# show frame-tag tpid interfaces gigabitethernet 0/1 Port tpid ----- Gi0/1 0x9100</pre>

10.4.3. Configuring an Inner/Outer VLAN Tag Modification Policy

Configuration Effect

- Modify outer or inner tags based on the actual networking requirements.

Notes



The ACL-based QinQ policy prevails over the port-based and C-TAG-based QinQ policy.



When an ACL is deleted, the related policy will be automatically deleted.



Tag modification policies take effect only on Access ports, Trunk ports, Hybrid ports, and Uplink ports.



Tag modification policies are mainly used to modify inner and outer tags on the SP network.



If a packet matches two or more ACL-based selective QinQ policies without priority, only one policy is executed. It is recommended to specify the priority.

Configuration Steps

→ Configuring the Policy to Change the VLAN IDs of Outer Tags Based on Inner Tags

- Optional.
- Perform this configuration to change the VLAN IDs of outer tags based on the VLAN IDs of inner tags.
- You can change the VLAN IDs of the outer tags in the packets that enter Access ports, Trunk ports, Hybrid ports, and Uplink ports based on the VLAN IDs of the inner tags in these packets.

Command	dot1q relay-vid VID translate inner-vid v_list
Parameter Description	VID: Indicates the modified VLAN ID of the outer tag. v_list: Indicates the VLAN ID of the inner tag.
Defaults	By default, no policy is configured.
Command Mode	Interface configuration mode
Usage Guide	N/A

→ Configuring the Policy to Change the VLAN IDs of Outer Tags Based on the VLAN IDs of Outer and Inner Tags

- Optional.
- Perform this configuration to change the VLAN IDs of outer tags based on the VLAN IDs of inner and outer tags.
- You can change the VLAN IDs of the outer tags in the packets that enter Access ports, Trunk ports, Hybrid ports, and Uplink ports based on the VLAN IDs of the inner and outer tags in these packets.

Command	dot1q new-outer-vlan new-vid translate old-outer-vlan vid inner-vlan v_list
Parameter Description	new-vid: Indicates the modified VLAN ID of the outer tag. vid: Indicates the original VLAN ID of the outer tag. v_list: Indicates the VLAN ID of the inner tag.
Defaults	By default, no policy is configured.
Command Mode	Interface configuration mode
Usage Guide	N/A

→ Configuring the Policy to Change the VLAN IDs of Outer Tags Based on the Outer Tags

- Optional.
- Perform this configuration to change the VLAN IDs of outer tags based on these VLAN IDs.
- You can change the VLAN IDs of the outer tags in the packets that enter Access ports, Trunk ports, Hybrid ports, and Uplink ports based on these VLAN IDs.

Command	dot1q relay-vid VID translate local-vid v_list
Parameter Description	VID: Indicates the modified VLAN ID of the outer tag. v_list: Indicates the original VLAN ID of the outer tag.
Defaults	By default, no policy is configured.
Command Mode	Interface configuration mode
Usage Guide	N/A

→ Configuring a Policy to Change the VLAN IDs of Inner Tags Based on ACLs

- Optional.
- You can change the VLAN IDs of the inner tags in the packets that exit Access ports, Trunk ports, Hybrid ports, and Uplink ports based on the packet content.
- Before you configure such a policy, configure an ACL.

Command	traffic-redirect access-group acl inner-vlan vid out
Parameter Description	acl: Indicates the ACL. vid: Indicates the modified VLAN ID of the inner tag.
Defaults	By default, no policy is configured.
Command Mode	Interface configuration mode
Usage Guide	N/A

→ Configuring a Policy to Change the VLAN IDs of Outer Tags Based on ACLs

- Optional.
- You can change the VLAN IDs of the outer tags in the packets that exit Access ports, Trunk ports, Hybrid ports, and Uplink ports based on the packet content.
- Before you configure such a policy, configure an ACL.

Command	traffic-redirect access-group acl outer-vlan vid in
Parameter Description	acl: Indicates the ACL. vid: Indicates the modified VLAN ID of the outer tag.
Defaults	By default, no policy is configured.
Command Mode	Interface configuration mode
Usage Guide	N/A

Verification

Check whether the configuration takes effect and whether the port modifies the tags in received packets based on the policy.

Configuration Example

→ Configuring the Policy to Change the VLAN IDs of Outer Tags Based on the Outer Tags

Configuration Steps	<ul style="list-style-type: none"> • Configure inner/outer tag modification policies on a port based on the actual networking requirements. • The following example shows how to change VLAN IDs of outer tags based on outer tags and ACLs respectively. For details about other policies, see the description above. <p>Configure a policy to change outer VLAN tags based on the outer VLAN tags.</p> <pre> Switch(config)# interface gigabitEthernet 0/1 Switch(config-if)# switchport mode trunk Switch(config-if)# dot1q relay-vid 100 translate local-vid 10-20 Configure a policy to change outer VLAN tags based on ACLs. Switch# configure terminal Switch(config)# ip access-list standard 2 Switch(config-acl-std)# permit host 1.1.1.1 Switch(config-acl-std)# exit Switch(config)# interface gigabitEthernet 0/2 Switch(config-if)# switchport mode trunk Switch(config-if)# traffic-redirect access-group 2 outer-vlan 3 in </pre>
---------------------	---

Verification	<ul style="list-style-type: none"> • Check whether the configuration takes effect on the port. • Check whether the port changes the VLAN IDs of the outer tags in received packets based on the configured policy.
--------------	--

10.4.4. Configuring Priority Mapping and Priority Replication

Configuration Effect

- If an SP network provides a QoS policy based on the User Priority field of the inner tag, configure priority replication to apply the QoS policy to the outer tag.
- If an SP network provides a QoS policy based on the User Priority field of the inner tag, configure priority mapping to apply the User Priority field provided by the SP network to the outer tag.

Notes



Only a Tunnel port can be configured with priority replication, which has a higher priority than trusted QoS but lower than ACL-based QoS.



Priority replication and priority mapping cannot be both enabled on one port.



Only a Tunnel port can be configured with priority mapping, which prevails over QoS.



The configuration of priority mapping does not take effect if no trust mode is configured (trust none) or the trust mode is not matched with priority mapping.

Configuration Steps

- Only a Tunnel port can be configured with priority mapping or priority replication.
- Configure priority replication to apply the inner tag-based QoS policy provided by the SP network.
- Configure priority mapping to configure the User Priority field of the outer VLAN tag based on the inner tag and apply the QoS policy flexibly.
- To enable priority replication, run the inner-priority-trust enable command on the Tunnel port.
- To enable priority mapping, run the dot1q-Tunnel cos inner-cos-value remark-cos outer-cos-value command on the Tunnel port. inner-cos-value and outer-cos-value range from 0 to 7.



The following priority mapping is used when no priority mapping is configured:

```

inner pri  0  1  2  3  4  5  6  7
-----
outer pri  0  1  2  3  4  5  6  7
    
```

Command	inner-priority-trust enable
Parameter Description	N/A
Defaults	By default, priority replication is disabled.
Command Mode	Interface configuration mode
Usage Guide	N/A

Command	dot1q-Tunnel cos inner-cos-value remark-cos outer-cos-value
Parameter Description	inner-cos-value: Indicates the CoS value of the inner tag. outer-cos-value: Indicates the CoS value of the outer tag.
Defaults	By default, priority mapping is disabled.
Command Mode	Interface configuration mode
Usage Guide	N/A

Verification

- Run the show inner-priority-trust interfaces type intf-id command and the show interfaces type intf-id remark command to check whether priority mapping or priority replication takes effect.

Configuration Example

→ Configuring Priority Mapping and Priority Replication

<p>Configuration Steps</p>	<ul style="list-style-type: none"> To maintain the packet priority, you need to replicate the priority of the inner tag in a packet to the outer tag on the Tunnel port. To flexibly control the packet priority on the Tunnel port, you can add outer tags of different priorities to packets based on the priorities of the inner tags in the packets. <p>Configure priority replication.</p> <pre>Switch(config)# interface gigabitethernet 0/1 Switch(config-if)#mls qos trust cos Switch(config-if)# inner-priority-trust enable Switch(config)# end</pre> <p>Configure priority mapping.</p> <pre>Switch(config)# interface gigabitethernet 0/2 Switch(config-if)#dot1q-Tunnel cos 3 remark-cos 5</pre>
<p>Verification</p>	<ul style="list-style-type: none"> Display the priority configuration on the port. <p>Check whether priority replication is enabled on the Tunnel port.</p> <pre>Switch# show inner-priority-trust interfaces gigabitethernet 0/1 Port inner-priority-trust ----- ----- Gi0/1 enable</pre> <p>Display the priority mapping configured on the Tunnel port.</p> <pre>Switch# show interfaces gigabitethernet 0/1 remark Ports Type From value To value ----- ----- Gi0/1 Cos-To-Cos 3 5</pre>

Common Errors

See "Notes".

10.4.5. Configuring Layer-2 Transparent Transmission

Configuration Effect

Transmit Layer-2 packets transparently without impact on the SP network and the customer network.

Notes



If STP is not enabled, you need to run the bridge-frame forwarding protocol bpdu command to enable STP transparent transmission.



Transparent transmission enabled on a port takes effect only after enabled globally. When transparent transmission takes effect on the port, the port does not participate in related protocol calculation. If the port receives a packet whose destination MAC address is the special broadcast address, it determines that a networking error occurs and discards the packet.

Configuration Steps

→ Configuring STP Transparent Transmission

- Mandatory if you need to transparently transmit BPDU packets through STP.
- Enable STP transparent transmission in global configuration mode and interface configuration mode.
- Run the l2protocol-tunnel stp command in global configuration mode to enable STP transparent transmission.
- Run the l2protocol-tunnel stp enable command in interface configuration mode to enable STP transparent transmission.

Command	l2protocol-tunnel stp
Parameter Description	N/A
Defaults	By default, STP transparent transmission is disabled.
Command Mode	Global configuration mode
Usage Guide	N/A

Command	l2protocol-tunnel stp enable
Parameter Description	N/A
Defaults	By default, STP transparent transmission is disabled.
Command Mode	Interface configuration mode
Usage Guide	N/A

→ Configuring GVRP Transparent Transmission

- Mandatory if you need to transparently transmit GVRP packets.
- Enable GVRP transparent transmission in global configuration mode and interface configuration mode.
- Run the l2protocol-tunnel gvrp command in global configuration mode to enable GVRP transparent transmission.
- Run the l2protocol-tunnel gvrp enable command in interface configuration mode to enable GVRP transparent transmission.

Command	l2protocol-tunnel gvrp
Parameter Description	N/A
Defaults	By default, GVRP transparent transmission is disabled.
Command Mode	Global configuration mode
Usage Guide	N/A

Command	l2protocol-tunnel gvrp enable
Parameter Description	N/A
Defaults	By default, GVRP transparent transmission is disabled.
Command Mode	Interface configuration mode
Usage Guide	N/A

→ Configuring a Transparent Transmission Address

- Optional.
- Configure a transparent transmission address.

Command	l2protocol-tunnel { stp gvrp } tunnel-dmac mac-address	
Parameter Description	mac-address: Indicates the address used to transparently transmit packets.	
Defaults	By default, the first three bytes of the transparent transmission address is 01d0f8, and the last three bytes are 000005 and 000006 for STP and GVTP respectively.	
Command Mode	Interface configuration mode	
Usage Guide		<p>The following addresses are available for STP: 01d0.f800.0005, 011a.a900.0005, 010f.e200.0003, 0100.0ccd.cdd0, 0100.0ccd.cdd1, and 0100.0ccd.cdd2.</p> <p>The following addresses are available for GVRP: 01d0.f800.0006 and 011a.a900.0006.</p>
		<p>When no transparent transmission address is configured, the default settings are used.</p>

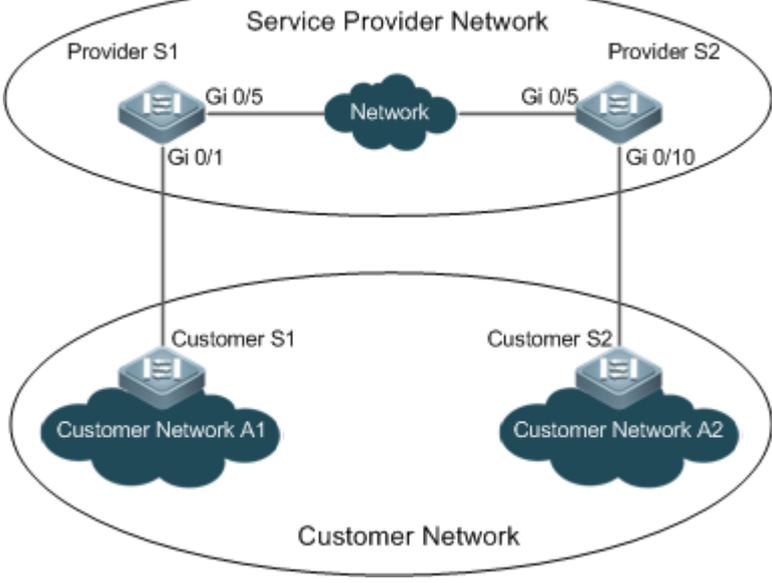
Verification

Run the show l2protocol-tunnel stp command and the show l2protocol-tunnel gvrp command to check whether the transparent transmission address is configured correctly.

Configuration Example

The following example shows how to configure STP transparent transmission.

→ Configuring STP Transparent Transmission

<p>Scenario</p>	 <p>The diagram illustrates a Service Provider Network (SPN) and a Customer Network. The SPN consists of two Provider Edge (PE) switches, Provider S1 and Provider S2, connected to a central Network. Provider S1 is connected to the central Network via Gi 0/5, and Provider S2 is connected via Gi 0/5. Provider S1 is also connected to Customer S1 (Customer Network A1) via Gi 0/1. Provider S2 is connected to Customer S2 (Customer Network A2) via Gi 0/10. The Customer Network is represented by two customer networks, A1 and A2, connected to the SPN.</p>
<p>Configuration Steps</p>	<ul style="list-style-type: none"> • On the PEs (Provider S1 and Provider S2), enable STP transparent transmission in global configuration mode and interface configuration mode. • Before you enable STP transparent transmission, enable STP in global configuration mode to allow the switches to forward STP packets.

Provider S1	<p>Step 1: Enable STP.</p> <pre>bridge-frame forwarding protocol bpdu</pre> <p>Step 2: Configure the VLAN for transparent transmission.</p> <pre>ProviderS1#configure terminal Enter configuration commands, one per line. End with CNTL/Z. ProviderS1(config)#vlan 200 ProviderS1(config-vlan)#exit</pre> <p>Step 3: Enable basic QinQ on the port connected to the customer network and use VLAN 200 for tunneling.</p> <pre>ProviderS1(config)#interface gigabitEthernet 0/1 ProviderS1(config-if-GigabitEthernet 0/1)#switchport mode dot1q-tunnel ProviderS1(config-if-GigabitEthernet 0/1)#switchport dot1q-tunnel native vlan 200</pre> <p>Step 4: Enable STP transparent transmission on the port connected to the customer network.</p> <pre>ProviderS1(config-if-GigabitEthernet 0/1)#l2protocol-tunnel stp enable ProviderS1(config-if-GigabitEthernet 0/1)#exit</pre> <p>Step 5: Enable STP transparent transmission in global configuration mode.</p> <pre>ProviderS1(config)#l2protocol-tunnel stp</pre> <p>Step 4: Configure an Uplink port.</p>
-------------	---

Provider S2	Configure Provider S2 by performing the same steps.
Verification	<p>Step 1: Check whether STP transparent transmission is enabled in global configuration mode and interface configuration mode.</p> <pre>ProviderS1#show l2protocol-tunnel stp</pre> <pre>L2protocol-tunnel: Stp Enable GigabitEthernet 0/1 l2protocol-tunnel stp enable</pre> <p>Step 2: Verify the configuration by checking whether:</p> <ul style="list-style-type: none"> • The port type is dot1q-tunnel. • The outer tag VLAN is consistent with the native VLAN and added to the VLAN list of the Tunnel port. • The port that accesses the SP network is configured as an Uplink port. <pre>ProviderS1#show running-config interface GigabitEthernet 0/1 switchport mode dot1q-tunnel switchport dot1q-tunnel allowed vlan add untagged 200 switchport dot1q-tunnel native vlan 200 l2protocol-tunnel stp enable spanning-tree bpdufilter enable ! interface GigabitEthernet 0/5 switchport mode uplink</pre>

Common Errors

- STP is not enabled in global configuration mode.
- Transparent transmission is not enabled in global configuration mode and interface configuration mode.

10.5. Monitoring

Displaying

Description	Command
Displays whether the specified port is a Tunnel port.	show dot1q-tunnel [interfaces intf-id]
Displays the configuration of the Tunnel port.	show interfaces dot1q-tunnel
Displays the C-TAG-based selective QinQ policies on the Tunnel port.	show registration-table [interfaces intf-id]
Displays the C-TAG-based selective QinQ policies on the Access port, Trunk port or Hybrid port.	show translation-table [interfaces intf-id]
Displays the TPID configuration on ports.	show frame-tag tpid interfaces [intf-id]
Displays the configuration of priority replication.	show inner-priority-trust
Displays the configuration of priority mapping.	show interface intf-name remark
Displays the configuration of Layer-2 transparent transmission.	show l2protocol-tunnel { gvrp stp }

Debugging



System resources are occupied when debugging information is output. Therefore, disable debugging immediately after use.

Description	Command
Debugs QinQ.	debug bridge qinq

11. Configuring ERPS

11.1. Overview

Ethernet Ring Protection Switching (ERPS), also known as G.8032, is a ring protection protocol developed by the International Telecommunication Union (ITU). It is a data link layer protocol designed for Ethernet rings. ERPS prevents broadcast storms caused by data loops in an idle Ethernet ring and can rapidly recover the communication between nodes in the event that a link is disconnected in the Ethernet ring.

The Spanning Tree Protocol (STP) is another technique used to solve the Layer-2 loop problem. STP is at the mature application stage but requires a relatively long (seconds) convergence time compared to ERPS. ERPS reaches a Layer-2 convergence speed of less than 50 ms, faster than that of STP.

Scenario

→ ITU-T G.8032/Y.1344: Ethernet ring protection switching

11.2. Applications

Application	Description
Single-Ring Protection	Only one ring exists in a network topology.
Tangent-Ring Protection	Two rings in a network topology share one device.
Intersecting-Ring Protection	Two or more rings in a network topology share one link.

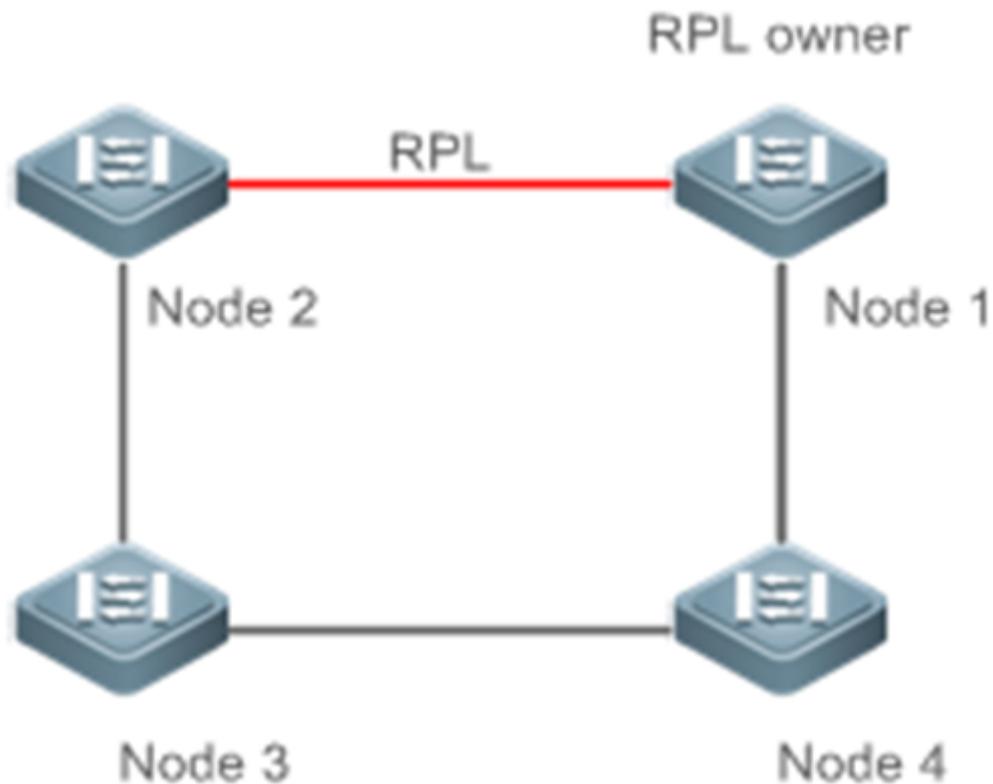
11.2.1. Single-Ring Protection

Scenario

Only one ring in a network topology needs to be protected.

In Figure 11 1, the network topology has only one ring, only one ring protection link (RPL) owner node, and only one RPL. All nodes must belong to the same ring automatic protection switching (R-APS) virtual local area network (VLAN).

- All devices in the ring network must support ERPS.
- Each link between devices must be a direct link without any intermediate device.



Remarks	The four devices in the ring network are aggregation switches.
---------	--

Deployment

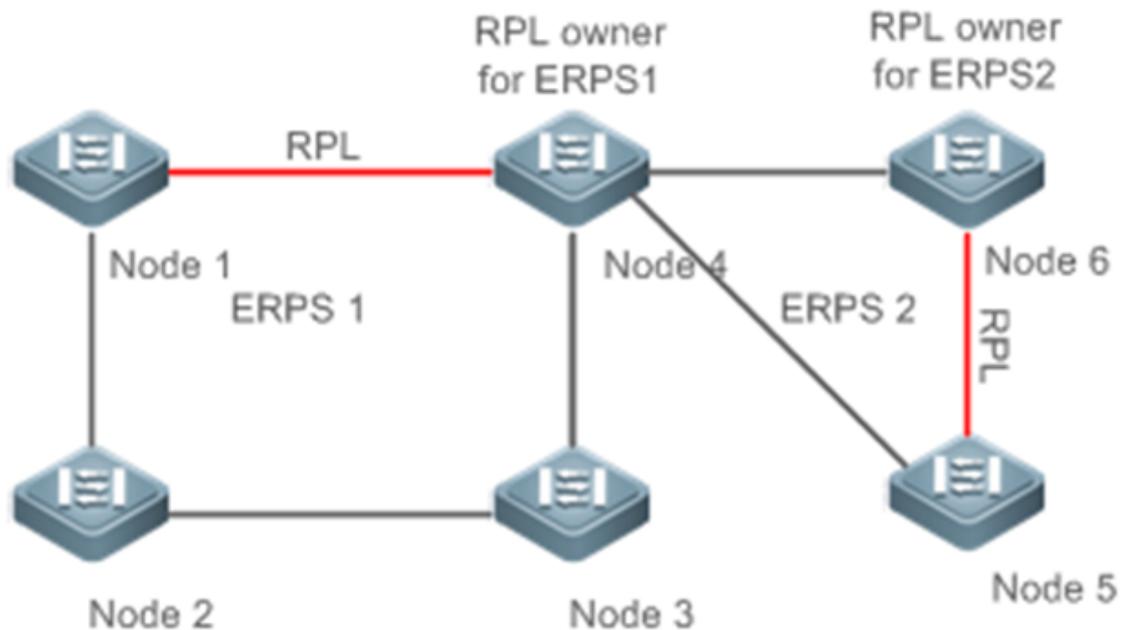
- All nodes in the physical topology are connected in ring mode.
- ERPS blocks the RPL to prevent loops. In Figure 11 1, the link between Node 1 and Node 2 is an RPL.
- ERPS is used to detect failures on each link between adjacent nodes.

11.2.2. Tangent-Ring Protection

Scenario

The two rings in a network topology that share one device need to be protected. In Figure 11 2, the two rings in the network topology share one device. Each ring has only one PRL owner node and only one RPL. The two rings belong to different R-APS VLANs.

- All devices in the ring network must support ERPS.
- Each link between devices must be a direct link without any intermediate device.



Remarks	The devices in the ring network are aggregation switches.
---------	---

Deployment

- All nodes in the physical topology are connected in ring mode.
- ERPS blocks the RPL of each ring to prevent loops.
- ERPS is used to detect failures on each link between adjacent nodes.

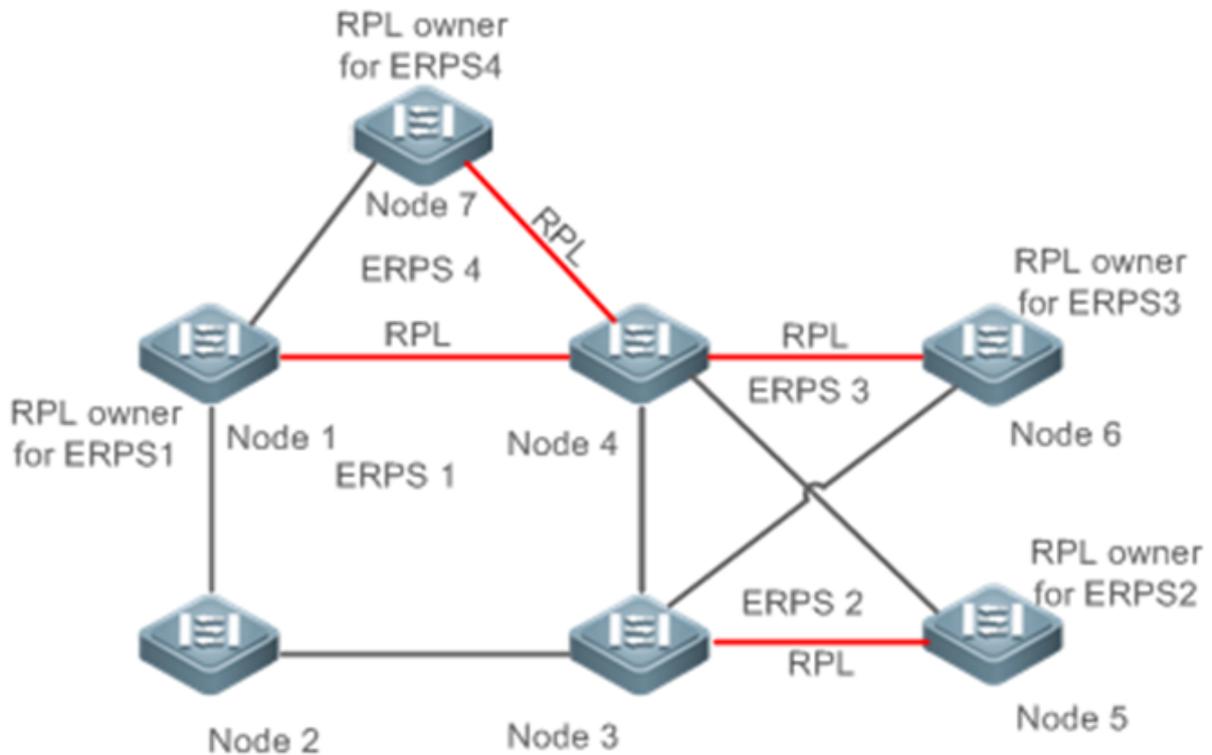
11.2.3. Intersecting-Ring Protection

Scenario

Two or more rings in a network topology share one link. (Each link between intersecting nodes must be a direct link without any intermediate node.)

In Figure 11 3, four rings exist in the network topology. Each ring has only one PRL owner node and only one RPL. The four rings belong to different R-APS VLANs.

- All devices in the ring network must support ERPS.
- Each link between devices must be a direct link without any intermediate device.



Remarks	The devices in the ring network are aggregation switches.
---------	---

Deployment

- All nodes in the physical topology are connected in ring mode.
- ERPS blocks the RPL of each ring to prevent loops.
- ERPS is used to detect failures on each link between adjacent nodes.

11.3. Features

Basic Concepts

→ Ethernet Ring

Ethernet rings are classified into common Ethernet rings and Ethernet subrings.

- Common Ethernet ring: Is an Ethernet topology with ring connection.
- Ethernet subring: An open topology that is mounted on other rings or networks through intersecting nodes and forms a closed topology with the channel between the intersecting nodes belonging to other rings or networks.

An Ethernet ring (a common Ethernet ring or an Ethernet subring) can be in one of the following states:

- Idle state: The physical links in the entire ring network are reachable.
- Protection state: A physical link in the ring network is disconnected.

→ Link and Channel

- RPL: An Ethernet ring (a common Ethernet ring or an Ethernet subring) has only one RPL. When an Ethernet ring is idle, the RPL is blocked and does not forward data packets to prevent loops. In Figure 11-2, the link between Node 1 and Node 4 is the RPL of ERPS 1, and Node 4 blocks the RPL port (the port mapped to the RPL). The link between Node 4 and Node 5 is the RPL of ERPS 2, and Node 5 blocks the RPL port.
- Subring link: Belongs to a subring in intersecting rings and is controlled by the subring. In Figure 11-3, ERPS 1 is a common Ethernet ring, and ERPS 2 is an Ethernet subring. The link between Node 4 and Node 5 and the link between Node 3 and Node 5 belong to ERPS 2. The other links belong to ERPS 1.



The link between Node 3 and Node 4 belongs to ERPS 1 rather than ERPS 2, and the link is not controlled by ERPS 2.

- R-APS virtual channel: Transmits ERPS packets of subrings between intersecting nodes in intersecting rings, but it does not belong to the subring. In Figure 14-3, Node 1 blocks the RPL, and the packets of subring ERPS 2 are transmitted through the direct link between Node 3 and Node 4 in Ethernet ring ERPS 1. The direct link between Node 3 and Node 4 is the R-APS virtual channel of ERPS 2.

→ Node

Each device in an Ethernet ring is a node.

ERPS has the following node roles for a specific Ethernet ring:

- RPL owner node: A node that is adjacent to an RPL and is used to block the RPL to prevent loops when the Ethernet ring is free of faults. An Ethernet ring (a common Ethernet ring or an Ethernet subring) has only one RPL owner node. In Figure 11-2, Node 1 functions as the RPL owner node of Ethernet ring ERPS 1, and Node 6 functions as the RPL owner node of Ethernet subring ERPS 2.
- Non-RPL owner node: Any other node than the RPL owner node in an Ethernet ring. In Figure 11-2, nodes except Node 1 and Node 6 are non-RPL owner nodes of their respective rings.

ERPS has the following roles globally (not for a specific Ethernet ring):

- Intersecting node: A node that belongs to multiple intersecting Ethernet rings. In Figure 11-3, Node 3 and Node 4 are intersecting nodes.
- Non-intersecting node: A node that belongs to only one intersecting Ethernet ring. In Figure 11-3, Node 2 is a non-intersecting node.

→ VLAN

ERPS supports two types of VLAN: R-APS VLAN and data VLAN.

- R-APS VLAN: A VLAN for transmitting ERPS packets. On a device, the ports accessing an ERPS ring belong to the R-APS VLAN, and only such ports can join the R-APS VLAN. R-APS VLANs of different ERPS rings must be different. IP address configuration is prohibited on the R-APS VLAN ports.
- Data VLAN: A VLAN for transmitting data packets. Both ERPS ports and non-ERPS ports can be assigned to a data VLAN.



R-APS VLANs of different ERPS rings must be configured differently to differentiate packets of different ERPS rings; otherwise, ERPS may be abnormal.

→ ERPS Packet

ERPS packets (also called R-APS packets) are classified into Signal Fail (SF) packets, No Request (NR) packets, No Request, RPL Blocked (NR, RB) packets, and flush packets.

- SF packet: When the link of a node is down, the node sends SF packets to notify other nodes of its link failure.
- NR packet: When the failed link is restored, the node sends an NR packet to notify the RPL owner node of its link recovery.
- (RR, RB) packet: When all nodes in an ERPS ring function properly, the RPL owner node sends (RR, RB) packets periodically.
- Flush packet: In an intersecting ring, when a topology change occurs in a subring, the intersecting nodes send flush packets to notify other devices in the Ethernet ring to which the subring is connected.

→ ERPS Timer

ERPS timers include the Holdoff timer, Guard timer, and WTR timer.

- Holdoff timer: Is used to minimize frequent ERPS topology switching due to intermittent link failures. After you configure the Holdoff timer, ERPS performs topology switching only if the link failure still persists after the timer times out.
- Guard timer: Is used to prevent a device from receiving expired R-APS messages. When the device detects that a link failure is cleared, it sends link recovery packets and starts the Guard timer. During the period before timer expiration, all packets except flush packets indicating a subring topology change will be discarded.
- Wait-to-restore (WTR) timer: Is effective only for RPL owner devices to avoid ring status misjudgment. When an RPL owner device detects that a failure is cleared, it does perform topology switching immediately but only if the Ethernet ring is recovered after the WTR timer times out. If a ring failure is detected again before timer expiration, the RPL owner device cancels the timer and does not perform topology switching.

Overview

Feature	Description

Ring Protection	Prevents broadcast storms caused by data loops and can rapidly recover the communication between nodes in the event that a link is disconnected in the Ethernet ring.
Load Balancing	Configures multiple Ethernet subrings in one ring network and forwards the traffic of different VLANs through different Ethernet subrings to balance load.

11.3.1. Ring Protection

Ring protection prevents broadcast storms caused by data loops and can rapidly recover the communication between nodes in the event that a link is disconnected in the Ethernet ring.

[Working Principle](#)

→ Normal Status

- All nodes in the physical topology are connected in ring mode.
- ERPS blocks the RPL to prevent loops.
- ERPS is used to detect failures on each link between adjacent nodes.

→ Link Failure

- A node adjacent to a failed node detects the failure.
- The nodes adjacent to a failed link block the failed link and send SF packets to notify other nodes in the same ring.
- The R-APS (SF) packet triggers the RPL owner node to unblock the RPL port. All nodes update their MAC address entries and ARP/ND entries and the ring enters the protection state.

→ Link Recovery

- When a failed link is restored, adjacent nodes still block the link and send NR packets indicating that no local failure exists.
- When the RPL owner node receives the first R-APS (NR) packet, it starts the WTR timer.
- When the timer times out, the RPL owner node blocks the RPL and sends an (NR, RB) packet.
- After receiving the (NR, RB) packet, other nodes update their MAC address entries and ARP/ND entries, and the node that sends the NR packet stops periodic packet transmission and unblocks the port.
- The ring network is restored to the normal state.

[Related Configuration](#)

→ Configuring the R-APS VLAN

By default, no R-APS VLAN is configured.

Run the `erps raps-vlan` command to configure the R-APS VLAN (management VLAN) of an ERPS ring to transmit ERPS packets.

→ Configuring an ERPS Ring

Run the `rpl-port` command in R-APS VLAN mode to configure the ERPS ring mapped to an R-APS VLAN.

→ Configuring an RPL and an RPL Owner Node

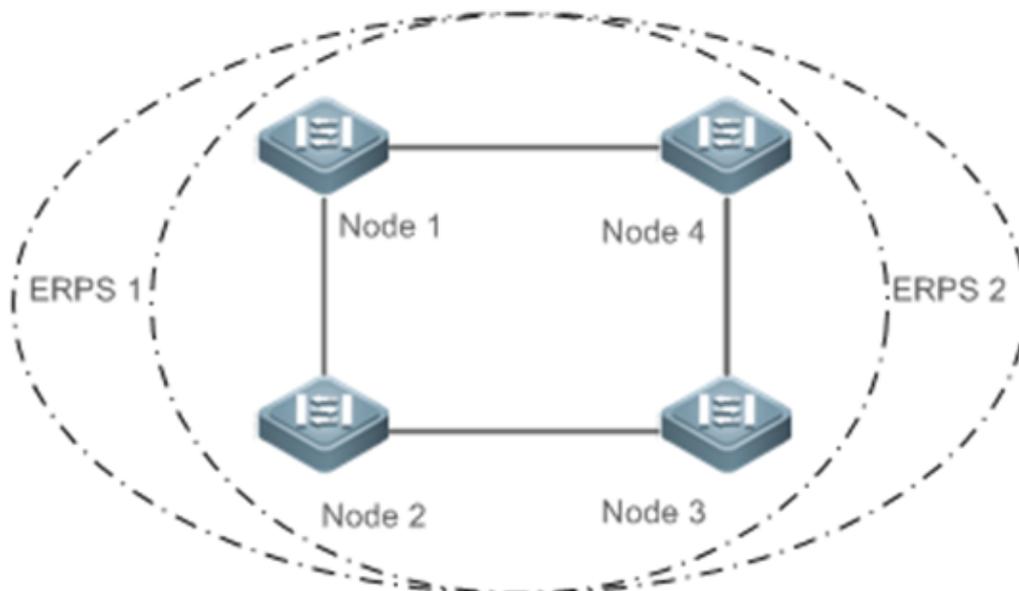
Run the `rpl-port` command in R-APS VLAN mode to specify an RPL and an RPL owner node.

11.3.2. Load Balancing

You can configure multiple Ethernet subrings in one physical ring network and forward the traffic of different VLANs through different Ethernet subrings to balance load.

Working Principle

The multiple VLANs in a ring network can have their respective traffic forwarded by different paths through ERPS to balance load.



In a physical ring network, multiple Ethernet rings can be configured to forward traffic of different VLANs (called protected VLANs) by different topologies to realize load balancing. In Figure 11 4, two Ethernet rings are configured with different protected VLANs in the physical ring network. Node 1 is the RPL owner node of ERPS 1 and Node 3 is RPL owner node of ERPS 2. With such configurations, data of different VLANs can be transmitted by different links to realize single-ring load balancing.

Related Configuration

→ Configuring the Protected VLAN of an Ethernet Ring

Run the protected-instance command in R-APS VLAN mode to configure a protected VLAN set to realize load balancing.

11.4. Configuration

Configuration	Description and Command	
Single-Ring Configuration (Basic Function)		(Mandatory) Perform this configuration in global configuration mode.
	erps enable	Enables ERPS.
	erps raps-vlan	Configures the R-APS VLAN of an Ethernet ring.
		(Mandatory) Perform this configuration in R-APS VLAN mode.
	ring-port	Configures an ERPS ring.
	rpl-port	Configures the RPL owner node.
	state enable	Enables the specified R-APS ring.
Tangent-Ring Configuration		Tangent-ring configuration is based on single-ring configuration.
Intersecting-Ring Configuration		(Optional) Perform this configuration in R-APS VLAN mode based on single-ring configuration.
	associate sub-ring raps-vlan	Associates Ethernet subrings.
	sub-ring tc-propagation enable	Enables subring topology change notification.
Load Balancing Configuration		(Optional) Perform this configuration in R-APS VLAN mode based on single-ring configuration.
	protected-instance	Configures the protected VLAN of an Ethernet ring.

ERPS Configuration Modification		(Optional) Perform this configuration in R-APS VLAN mode based on single-ring configuration.
	timer	Modifies timer parameters.

11.4.1. Single-Ring Configuration (Basic Function)

Configuration Effect

- The single-ring scenario is the basic scenario of ERPS.
- Build an ERPS single-ring topology to realize data link redundancy.
- In an ERPS ring network, quickly switch services from a failed link to a normal link.

Notes

- Only one RPL owner node and only one RPL can be configured in one ERPS ring.
- All nodes in one ERPS ring must belong to the same R-APS VLAN.
- Only trunk ports can join an ERPS ring, and the trunk attributes cannot be modified after the port joins the ring.
- The ports in an ERPS ring do not participate in STP calculation regardless of whether the ERPS ring is enabled or not. When you configure an ERPS ring, ensure that loops will not occur when STP calculation is disabled on ports in the ring.
- ERPS does not use the same ports as RERP and REUP.

Configuration Steps

→ Configuring the R-APS VLAN of an Ethernet Ring

- (Mandatory) Perform this configuration in global configuration mode.
- Configure the same R-APS VLAN on all switches in the ERPS ring to transmit ERPS packets.

→ Configuring ERPS Ring Ports

- (Mandatory) Perform this configuration in R-APS VLAN mode.
- Configure the ports that form the ERPS ring as ERPS ring ports.

→ Configuring an RPL Owner Port

- (Mandatory) Perform this configuration in R-APS VLAN mode.
- Configure a single device in each ERPS ring as an RPL owner node, which will control the port to be blocked.

→ Enabling the Specified R-APS Ring

- (Mandatory) Perform this configuration in R-APS VLAN mode.

- Enable the specified R-APS ring in the same R-APS VLAN on each switch.

→ Enabling ERPS Globally

- (Mandatory) Perform this configuration in global configuration mode.
- Enable ERPS globally on each switch in the ERPS ring.

Verification

- Run the show erps command one each node to check the configuration.

Related Commands

→ Configuring the R-APS VLAN of an Ethernet Ring

Command	erps raps-vlan vlan-id
Parameter Description	vlan-id: R-APS VLAN ID
Command Mode	Global configuration mode
Usage Guide	ERPS takes effect in a ring only after ERPS is enabled globally and for the ring respectively.

→ Configuring an ERPS Ring

Command	ring-port west {interface-name1 virtual-channel } east { interface-name2 virtual-channel}
Parameter Description	interface-name1: Indicates the name of the West port. interface-name2: Indicates the name of the East port. virtual-channel: Assigns a port to a virtual link.
Command Mode	R-APS VLAN mode
Usage Guide	The R-APS VLAN must be the unused VLAN on a device. VLAN 1 cannot be configured as the R-APS VLAN. In an Ethernet ring, different devices must be configured with the same R-APS VLAN. If you need to transparently transmit ERPS packets on a device not configured with ERPS, ensure that only the two ports on the device connected to the ERPS ring allow packets from the R-APS VLAN of the ERPS ring to pass through. Otherwise, packets from other VLANs may be transparently transmitted to the R-APS VLAN, causing impact on the ERPS ring.

→ Configuring an RPL Owner Port

Command	rpl-port { west east } rpl-owner
Parameter Description	west: Specifies the West port as an RPL owner port. east: Specifies the East port as an RPL owner port.
Command Mode	R-APS VLAN mode
Usage Guide	Each ring can be configured with only one RPL and only one RPL owner node.

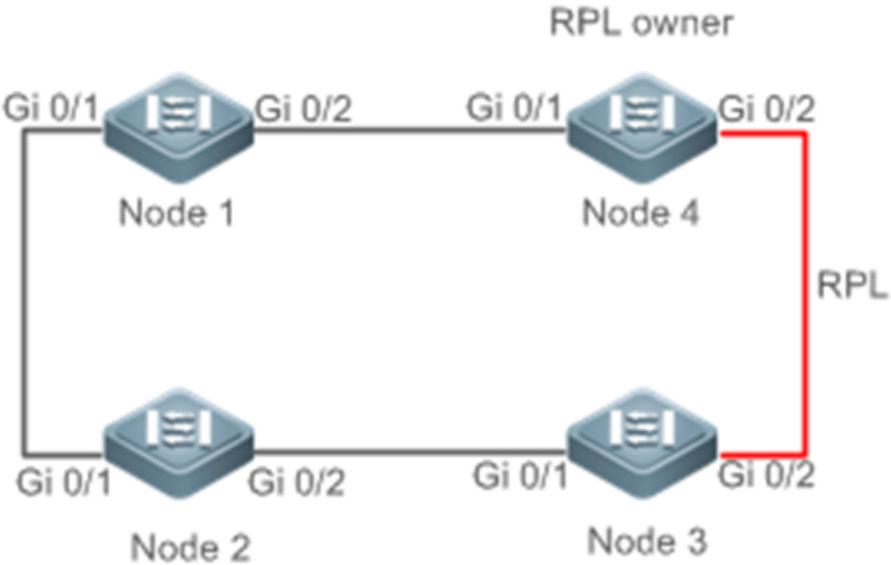
→ Enabling the Specified R-APS Ring

Command	state enable
Parameter Description	N/A
Command Mode	R-APS VLAN mode
Usage Guide	ERPS takes effect in a ring only after ERPS is enabled globally and for the ring respectively.

→ Enabling ERPS Globally

Command	erps enable
Parameter Description	N/A
Command Mode	Global configuration mode
Usage Guide	ERPS takes effect in a ring only after ERPS is enabled globally and for the ring respectively.

[Configuration Example](#)

<p>Scenario</p>	
<p>Configuration Steps</p>	<ul style="list-style-type: none"> • Configure the R-APS VLAN in privileged mode. • Configure the link mode of ports in the Ethernet ring. • Enter R-APS VLAN mode and configure the ports to be added to the Ethernet ring and participate in ERPS calculation. • Specify the RPL owner port. • Enable ERPS in the specified ring. • Enable ERPS globally.

Node 1	<ul style="list-style-type: none">• Enter privileged mode. <pre>Switch# configure terminal</pre>• Configure the R-APS VLAN. <pre>Switch(config)# erps raps-vlan 4093 Switch(config-erps 4093)# exit</pre>• Configure the link mode of ports in the Ethernet ring. <pre>Switch(config)# interface gigabitEthernet 0/1 Switch(config-if-gigabitEthernet 0/1)# switchport mode trunk Switch(config-if-gigabitEthernet 0/1)# exit Switch(config)# interface gigabitEthernet 0/2 Switch(config-if-gigabitEthernet 0/2)# switchport mode trunk Switch(config-if-gigabitEthernet 0/2)# exit</pre>• Enter ERPS configuration mode. <pre>Switch(config)# erps raps-vlan 4093</pre>• Configure the ports to be added to the Ethernet ring and participate in ERPS calculation. <pre>Switch(config-erps 4093)# ring-port west gigabitEthernet 0/1 east gigabitEthernet 0/2</pre>• Enable ERPS in the specified ring. <pre>Switch(config-erps 4093)# state enable</pre>
--------	--

Node 1	<ul style="list-style-type: none">• Enable ERPS globally. <pre>Switch(config-erps 4093)# exit Switch(config)# erps enable</pre>
Node 2	The configuration on Node 2 is the same as that on Node 1.
Node 3	The configuration on Node 3 is the same as that on Node 1.

Node 4	<ul style="list-style-type: none">• Enter privileged mode. <pre>Switch# configure terminal</pre>• Configure the R-APS VLAN. <pre>Switch(config)# erps raps-vlan 4093 Switch(config-erps 4093)# exit</pre>• Configure the link mode of ports in the Ethernet ring. <pre>Switch(config)# interface gigabitEthernet 0/1 Switch(config-if-gigabitEthernet 0/1)# switchport mode trunk Switch(config-if-gigabitEthernet 0/1)# exit Switch(config)# interface gigabitEthernet 0/2 Switch(config-if-gigabitEthernet 0/2)# switchport mode trunk Switch(config-if-gigabitEthernet 0/2)# exit</pre>• Enter ERPS configuration mode. <pre>Switch(config)# erps raps-vlan 4093</pre>• Configure the ports to be added to the Ethernet ring and participate in ERPS calculation. <pre>Switch(config-erps 4093)# ring-port west gigabitEthernet 0/1 east gigabitEthernet 0/2</pre>• Specify the RPL owner port. <pre>Switch(config-erps 4093)# rpl-port east rpl-owner</pre>
--------	--

<p>Node 4</p>	<p>Enable ERPS in the specified ring.</p> <pre>Switch(config-erps 4093)# state enable Switch(config-erps 4093)# exit</pre> <ul style="list-style-type: none"> • Enable ERPS globally. <pre>Switch(config)# erps enable</pre>
<p>Verification</p>	<p>Run the show erps command one each node to check the configuration. The configuration on Node 1 and Node 4 is used as an example.</p>
<p>Node 1</p>	<pre>Switch# show erps ERPS Information Global Status : Enabled Link monitored by : Not Oam ----- R-APS VLAN : 4093 Ring Status : Enabled West Port : Gi 0/1 (Forwardin) East Port : Gi 0/2 (Forwardin) RPL Port : None Protected VLANs : ALL RPL Owner : Enabled Holdoff Time : 0 milliseconds Guard Time : 500 milliseconds WTR Time : 2 minutes Current Ring State : Idle Associate R-APS VLAN :</pre>

Node 4	<pre> Switch# show erps ERPS Information Global Status : Enabled Link monitored by : Not Oam ----- R-APS VLAN : 4093 Ring Status : Enabled West Port : Gi 0/1 (Forwardin) East Port : Gi 0/2 (Blocking) RPL Port : East Port Protected VLANs : ALL RPL Owner : Enabled Holdoff Time : 0 milliseconds Guard Time : 500 milliseconds WTR Time : 2 minutes Current Ring State : Idle Associate R-APS VLAN : </pre>
--------	---

Common Errors

- The R-APS ring has been enabled but ERPS is not enabled globally, so ERPS still does not take effect.
- Multiple RPL owner nodes are configured in one ring.
- Different R-APS VLANs are configured for the nodes in one ring.

11.4.2. Tangent-Ring Configuration

Configuration Effect

- Configure a tangent ring that consists of two ERPS rings sharing one device to realize data link redundancy.
- Quickly switch services from a failed link in one ERPS ring to a normal link.

Notes

- The tangent-ring configuration is basically the same as the single-ring configuration. You only need to associate the two ERPS rings on the tangent node.
- Only one RPL owner node and only one RPL can be configured in each ERPS ring.
- All nodes in one ERPS ring must belong to the same R-APS VLAN.
- Only trunk ports can join an ERPS ring, and the trunk attributes cannot be modified after the port joins the ring.
- The ports in an ERPS ring do not participate in STP calculation regardless of whether the ERPS ring is enabled or not. When you configure an ERPS ring, ensure that loops will not occur when STP calculation is disabled on ports in the ring.

- ERPS does not use the same ports as RERP and REUP.

Configuration Steps

- The tangent-ring configuration is basically the same as the single-ring configuration. You only need to associate the two ERPS rings on the tangent node.

Verification

- Run the show erps command one each node to check the configuration.

Related Commands

- See the commands in section 14.4.1 "Single-Ring Configuration (Basic Function)."

Configuration Example

<p>Scenario</p>	
<p>Configuration Steps</p>	<ul style="list-style-type: none"> • Configure the R-APS VLAN in privileged mode. • Configure the link mode of ports in the Ethernet ring. • Enter R-APS VLAN mode and configure the ports to be added to the Ethernet ring and participate in ERPS calculation. • Specify the RPL owner port. • Enable ERPS in the specified ring. • Enable ERPS globally.

Node 1...	<ul style="list-style-type: none">• Enter privileged mode. <pre>Switch# configure terminal</pre>• Configure R-APS VLAN 4093. <pre>Switch(config)# erps raps-vlan 4093 Switch(config-erps 4093)# exit</pre>• Configure the link mode of ports in the Ethernet ring. <pre>Switch(config)# interface gigabitEthernet 0/1 Switch(config-if-gigabitEthernet 0/1)# switchport mode trunk Switch(config-if-gigabitEthernet 0/1)# exit Switch(config)# interface gigabitEthernet 0/2 Switch(config-if-gigabitEthernet 0/2)# switchport mode trunk Switch(config-if-gigabitEthernet 0/2)# exit</pre>• Enter ERPS configuration mode. <pre>Switch(config)# erps raps-vlan 4093</pre>• Configure the ports to be added to the Ethernet ring and participate in ERPS calculation. <pre>Switch(config-erps 4093)# ring-port west gigabitEthernet 0/1 east gigabitEthernet 0/2</pre>
-----------	--

Node 1	<ul style="list-style-type: none">• Enable ERPS in the specified ring. <pre>Switch(config-erps 4093)# state enable Switch(config-erps 4093)# exit</pre> <ul style="list-style-type: none">• Enable ERPS globally. <pre>Switch(config)# erps enable</pre>
Node 2	The configuration on Node 2 is the same as that on Node 1.

Node 3...

```
Switch# configure terminal
```

- Configure R-APS VLAN 4093.

```
Switch(config)# erps raps-vlan 4093  
Switch(config-erps 4093)# exit
```

- Configure the link mode of ports in the Ethernet ring.

```
Switch(config)# interface gigabitEthernet 0/1  
Switch(config-if-gigabitEthernet 0/1)# switchport mode trunk  
Switch(config-if-gigabitEthernet 0/1)# exit  
Switch(config)# interface gigabitEthernet 0/2  
Switch(config-if-gigabitEthernet 0/2)# switchport mode trunk  
Switch(config-if-gigabitEthernet 0/2)# exit
```

- Enter ERPS configuration mode.

```
Switch(config)# erps raps-vlan 4093  
Switch(config-erps 4093)# ring-port west gigabitEthernet 0/1 east  
gigabitEthernet 0/2  
Switch(config-erps 4093)# state enable  
Switch(config-erps 4093)# exit
```

<p>...Node 3</p>	<ul style="list-style-type: none">• Configure R-APS VLAN 100. <pre>Switch(config)# erps raps-vlan 100 Switch(config-erps 100)# exit Switch(config)# interface gigabitEthernet 0/3 Switch(config-if-gigabitEthernet 0/3)# switchport mode trunk Switch(config-if-gigabitEthernet 0/3)# exit Switch(config)# interface gigabitEthernet 0/4 Switch(config-if-gigabitEthernet 0/4)# switchport mode trunk Switch(config-if-gigabitEthernet 0/4)# exit</pre>• Enter ERPS configuration mode. <pre>Switch(config)# erps raps-vlan 100 Switch(config-erps 100)# ring-port west gigabitEthernet 0/3 east gigabitEthernet 0/4 Switch(config-erps 100)# state enable Switch(config-erps 4093)# exit Switch(config)# erps enable</pre>
------------------	--

Node 4

```
Switch# configure terminal
```

Configure R-APS VLAN 4093.

```
Switch(config)# erps raps-vlan 4093
Switch(config-erps 4093)# exit
```

Configure the link mode of ports in the Ethernet ring.

```
Switch(config)# interface gigabitEthernet 0/1
Switch(config-if-gigabitEthernet 0/1)# switchport mode trunk
Switch(config-if-gigabitEthernet 0/1)# exit
Switch(config)# interface gigabitEthernet 0/2
Switch(config-if-gigabitEthernet 0/2)# switchport mode trunk
Switch(config-if-gigabitEthernet 0/2)# exit
```

Enter ERPS configuration mode.

```
Switch(config)# erps raps-vlan 4093
Switch(config-erps 4093)# ring-port west gigabitEthernet 0/1 east
gigabitEthernet 0/2
```

Specify the RPL owner port.

```
Switch(config-erps 4093)# rpl-port east rpl-owner
Switch(config-erps 4093)# state enable
Switch(config-erps 4093)# exit
Switch(config)# erps enable
```

Node 5

```
Switch# configure terminal
```

- Configure R-APS VLAN 100.

```
Switch(config)# erps raps-vlan 100  
Switch(config-erps 100)# exit
```

- Configure the link mode of ports in the Ethernet ring.

```
Switch(config)# interface gigabitEthernet 0/1  
Switch(config-if-gigabitEthernet 0/1)# switchport mode trunk  
Switch(config-if-gigabitEthernet 0/1)# exit  
Switch(config)# interface gigabitEthernet 0/2  
Switch(config-if-gigabitEthernet 0/2)# switchport mode trunk  
Switch(config-if-gigabitEthernet 0/2)# exit
```

- Enter ERPS configuration mode.

```
Switch(config)# erps raps-vlan 100  
Switch(config-erps 100)# ring-port west gigabitEthernet 0/1 east  
gigabitEthernet 0/2  
Switch(config-erps 100)# state enable  
Switch(config-erps 100)# exit  
Switch(config)# erps enable
```

Node 6	<pre>Switch# configure terminal</pre> <ul style="list-style-type: none"> • Configure R-APS VLAN 100. <pre>Switch(config)# erps raps-vlan 100 Switch(config-erps 100)# exit</pre> <ul style="list-style-type: none"> • Configure the link mode of ports in the Ethernet ring. <pre>Switch(config)# interface gigabitEthernet 0/1 Switch(config-if-gigabitEthernet 0/1)# switchport mode trunk Switch(config-if-gigabitEthernet 0/1)# exit Switch(config)# interface gigabitEthernet 0/2 Switch(config-if-gigabitEthernet 0/2)# switchport mode trunk Switch(config-if-gigabitEthernet 0/2)# exit</pre> <ul style="list-style-type: none"> • Enter ERPS configuration mode. <pre>Switch(config)# erps raps-vlan 100 Switch(config-erps 100)# ring-port west gigabitEthernet 0/1 east gigabitEthernet 0/2</pre> <ul style="list-style-type: none"> • Specify the RPL owner port. <pre>Switch(config-erps 100)# rpl-port east rpl-owner Switch(config-erps 100)# state enable Switch(config)# erps enable</pre>
Verification	Run the show erps command one each node to check the configuration. The configuration on Node 3 is used as an example.

```

Switch# show erps
ERPS Information
Global Status           : Enabled
Link monitored by      : Not Oam
-----
R-APS VLAN             : 100
Ring Status            : Enabled
West Port              : Gi 0/3 (Forwarding)
East Port              : Gi 0/4 (Forwarding)
RPL Port               : None
Protected VLANs        : ALL
RPL Owner              : Disabled
Holdoff Time           : 0 milliseconds
Guard Time             : 500 milliseconds
WTR Time               : 2 minutes
Current Ring State     : Idle
Associate R-APS VLAN   :
-----
R-APS VLAN             : 4093
Ring Status            : Enabled
West Port              : Gi 0/1 (Forwarding)
East Port              : Gi 0/2 (Forwarding)
RPL Port               : East Port
Protected VLANs        : ALL
RPL Owner              : Disabled
Holdoff Time           : 0 milliseconds
Guard Time             : 500 milliseconds
WTR Time               : 2 minutes
Current Ring State     : Idle
Associate R-APS VLAN   :

```

Common Errors

- The R-APS ring has been enabled but ERPS is not enabled globally, so ERPS still does not take effect.
- Multiple RPL owner nodes are configured in one ring.
- Different R-APS VLANs are configured for the nodes in one ring.

11.4.3. Intersecting-Ring Configuration

Configuration Effect

- Configure multiple ERPS rings to share links, thus realizing data link redundancy.
- Quickly switch services from a failed link in one ERPS ring to a normal link.

Notes

- Only one RPL owner node and only one RPL can be configured in each ERPS ring.
- All nodes in one ERPS ring must belong to the same R-APS VLAN.
- All nodes in the Ethernet ring must be associated with their respective subrings.
- Only trunk ports can join an ERPS ring, and the trunk attributes cannot be modified after the port joins the ring.
- The ports in an ERPS ring do not participate in STP calculation regardless of whether the ERPS ring is enabled or not. When you configure an ERPS ring, ensure that loops will not occur when STP calculation is disabled on ports in the ring.
- ERPS does not use the same ports as RERP and REUP.

Configuration Steps

Perform the following configuration after you complete the single-ring configuration described above:

→ Enabling Subring Topology Change Notification

- (Optional) Perform this configuration in R-APS VLAN mode.
- Enable subring topology change notification on intersecting nodes.
- If the link between intersecting nodes is faulty or blocked in the event of a subring topology change, the intersecting nodes will send packets to instruct the nodes in other Ethernet rings associated with the subring to update the topology.

→ Associating Ethernet Subrings

- (Optional) Perform this configuration in R-APS VLAN mode.
- Associate nodes in the main ring with Ethernet subrings.
- After nodes are associated with Ethernet subrings, ERPS packets of the subrings can be transmitted to other Ethernet rings.

Verification

- Run the show erps command one each node to check the configuration.

Related Commands

→ Enabling Subring Topology Change Notification

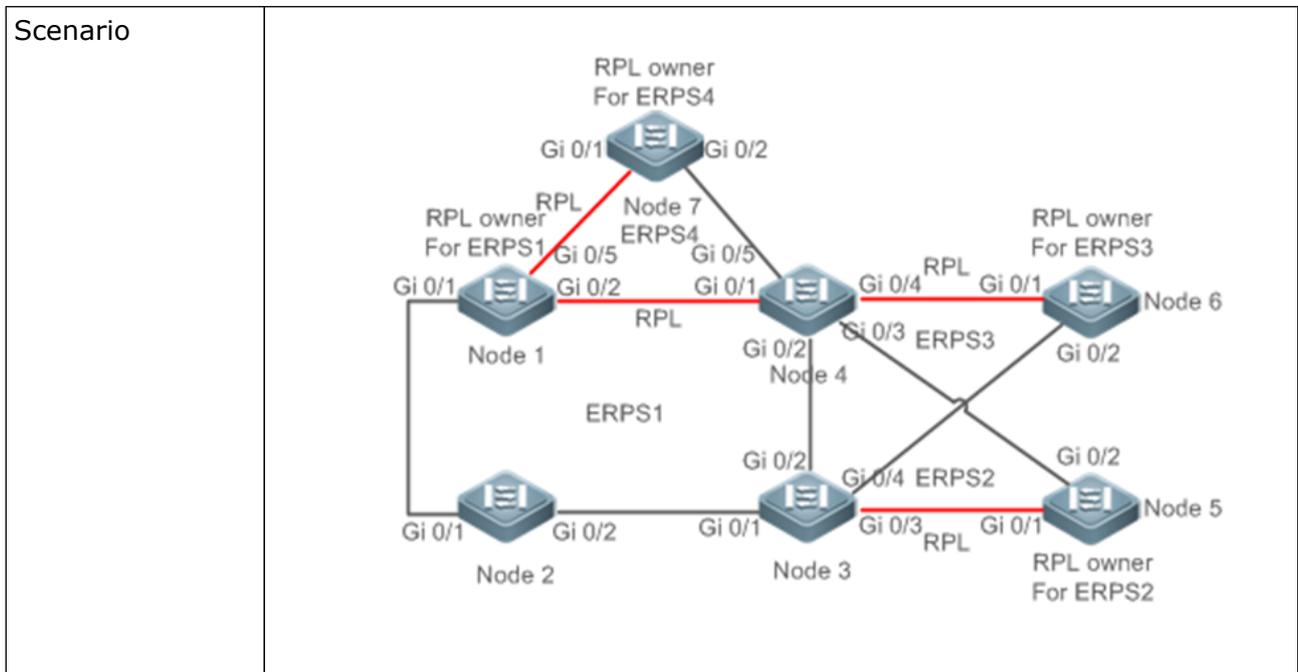
Command	sub-ring tc-propagation enable
Parameter Description	N/A
Command Mode	R-APS VLAN mode

Usage Guide	Run this command only on intersecting nodes.
-------------	--

→ Associating Ethernet Subrings

Command	associate sub-ring raps-vlan vlan-list
Parameter Description	vlan-list: Indicates the R-APS VLANs of subrings.
Command Mode	R-APS VLAN mode
Usage Guide	Run this command on all nodes in the Ethernet ring to allow its subrings to transmit ERPS packets to the Ethernet ring. After nodes are associated with subrings, ERPS packets of the subrings can be transmitted to other Ethernet rings. You can also use the command provided by the VLAN module to configure VLAN and its member ports to allow ERPS packets of subrings to be transmitted to other Ethernet rings while avoiding information leakage to user networks.

Configuration Example



Configuration Steps	<ul style="list-style-type: none">• Configure the R-APS VLAN in privileged mode.• Configure the link mode of ports in the Ethernet ring.• Enter R-APS VLAN mode and configure the ports to be added to the Ethernet ring and participate in ERPS calculation.• Specify the RPL owner port.• Enable ERPS in the specified ring.• Associate nodes in the Ethernet ring with subrings.• Enable subring topology change notification on intersecting nodes.• Enable ERPS globally.
---------------------	---

Node 1	<ul style="list-style-type: none">• Enter privileged mode. <pre>Switch# configure terminal</pre>• Configure R-APS VLAN 4093. <pre>Switch(config)# erps raps-vlan 4093 Switch(config-erps 4093)# exit</pre>• Configure the link mode of ports in the Ethernet ring. <pre>Switch(config)# interface gigabitEthernet 0/1 Switch(config-if-gigabitEthernet 0/1)# switchport mode trunk Switch(config-if-gigabitEthernet 0/1)# exit Switch(config)# interface gigabitEthernet 0/2 Switch(config-if-gigabitEthernet 0/2)# switchport mode trunk Switch(config-if-gigabitEthernet 0/2)# exit</pre>• Enter ERPS configuration mode. <pre>Switch(config)# erps raps-vlan 4093</pre>• Configure the ports to be added to the Ethernet ring and participate in ERPS calculation. <pre>Switch(config-erps 4093)# ring-port west gigabitEthernet 0/1 east gigabitEthernet 0/2</pre>• Specify the port and RPL owner node for the RPL. <pre>Switch(config-erps 4093)# rpl-port east rpl-owner</pre>
--------	--

Node 1	<ul style="list-style-type: none">• Enable ERPS in the specified ring. <pre>Switch(config-erps 4093)# state enable</pre>• Enable ERPS globally. <pre>Switch(config-erps 4093)# exit Switch(config)# erps enable</pre>• Configure the R-APS VLAN of the subring ERPS 4. <pre>Switch(config)# erps raps-vlan 300 Switch(config-erps 300)# exit</pre>• Configure the link mode of ports in ERPS 4. <pre>Switch(config)# interface gigabitEthernet 0/5 Switch(config-if-gigabitEthernet 0/5)# switchport mode trunk Switch(config-if-gigabitEthernet 0/5)# exit</pre>• Enter ERPS configuration mode. <pre>Switch(config)# erps raps-vlan 300</pre>• Configure the ports to be added to the Ethernet ring and participate in ERPS calculation. <pre>Switch(config-erps 300)# ring-port west gigabitEthernet 0/5 east virtual-channel</pre>• Enable ERPS in ERPS 4.
--------	--

Node 2	<ul style="list-style-type: none">• Enter privileged mode. <pre>Switch# configure terminal</pre>• Configure R-APS VLAN 4093. <pre>Switch(config)# erps raps-vlan 4093 Switch(config-erps 4093)# exit</pre>• Configure the link mode of ports in the Ethernet ring. <pre>Switch(config)# interface gigabitEthernet 0/1 Switch(config-if-gigabitEthernet 0/1)# switchport mode trunk Switch(config-if-gigabitEthernet 0/1)# exit Switch(config)# interface gigabitEthernet 0/2 Switch(config-if-gigabitEthernet 0/2)# switchport mode trunk Switch(config-if-gigabitEthernet 0/2)# exit</pre>• Enter ERPS configuration mode. <pre>Switch(config)# erps raps-vlan 4093</pre>• Configure the ports to be added to the Ethernet ring and participate in ERPS calculation. <pre>Switch(config-erps 4093)# ring-port west gigabitEthernet 0/1 east gigabitEthernet 0/2</pre>• Enable ERPS in the specified ring. <pre>Switch(config-erps 4093)# state enable</pre>
--------	---

Node 2	<ul style="list-style-type: none">• Enable ERPS globally. <pre>Switch(config-erps 4093)# exit Switch(config)# erps enable</pre> <ul style="list-style-type: none">• Associate ERPS 1 with ERPS 2, ERPS 3, and ERPS 4. <pre>Switch(config)# erps raps-vlan 4093 Switch(config-erps 4093)# associate sub-ring raps-vlan 100,200,300</pre>
--------	---

Node 3...	<ul style="list-style-type: none">• Perform the following configuration on Node 3 based on the configuration on Node 2:• Enter privileged mode. <pre>Switch# configure terminal</pre> <ul style="list-style-type: none">• Configure the R-APS VLAN of the subring ERPS 2. <pre>Switch(config)# erps raps-vlan 100 Switch(config-erps 100)# exit</pre> <ul style="list-style-type: none">• Configure the link mode of ports in ERPS 2. <pre>Switch(config)# interface gigabitEthernet 0/3 Switch(config-if-gigabitEthernet 0/3)# switchport mode trunk Switch(config-if-gigabitEthernet 0/3)# exit</pre> <ul style="list-style-type: none">• Enter ERPS configuration mode. <pre>Switch(config)# erps raps-vlan 100</pre> <ul style="list-style-type: none">• Configure the ports to be added to the Ethernet ring and participate in ERPS calculation. <pre>Switch(config-erps 100)# ring-port west virtual-channel east gigabitEthernet 0/3</pre> <ul style="list-style-type: none">• Enable ERPS in ERPS 2.
-----------	--

...Node 3...	<pre>Switch(config-erps 100)# state enable</pre> <ul style="list-style-type: none">• Configure the R-APS VLAN of the subring ERPS 3. <pre>Switch(config)# erps raps-vlan 200 Switch(config-erps 200)# exit</pre> <ul style="list-style-type: none">• Configure the link mode of ports in ERPS 3. <pre>Switch(config)# interface gigabitEthernet 0/4 Switch(config-if-gigabitEthernet 0/4)# switchport mode trunk Switch(config-if-gigabitEthernet 0/4)# exit</pre> <ul style="list-style-type: none">• Enter ERPS configuration mode. <pre>Switch(config)# erps raps-vlan 200</pre> <ul style="list-style-type: none">• Configure the ports to be added to the Ethernet ring and participate in ERPS calculation.
--------------	---

...Node 3

```
Switch(config-erps 200)# ring-port west virtual-channel east  
gigabitEthernet 0/4
```

- Enable ERPS in ERPS 2.

```
Switch(config-erps 200)# state enable
```

- Associate the Ethernet subrings ERPS 2, ERPS 3, and ERPS 4.

```
Switch(config-erps 200)# exit  
Switch(config)# erps raps-vlan 4093  
Switch(config-erps 4093)# associate sub-ring raps-vlan  
100,200,300
```

Node 4...	<ul style="list-style-type: none">• Perform the following configuration on Node 4 based on the configuration on Node 2.• Enter privileged mode. <pre>Switch# configure terminal</pre> <ul style="list-style-type: none">• Configure the R-APS VLAN of the subring ERPS 2. <pre>Switch(config)# erps raps-vlan 100 Switch(config-erps 100)# exit</pre> <ul style="list-style-type: none">• Configure the link mode of ports in ERPS 2. <pre>Switch(config)# interface gigabitEthernet 0/3 Switch(config-if-gigabitEthernet 0/3)# switchport mode trunk Switch(config-if-gigabitEthernet 0/3)# exit</pre> <ul style="list-style-type: none">• Enter ERPS configuration mode. <pre>Switch(config)# erps raps-vlan 100</pre> <ul style="list-style-type: none">• Configure the ports to be added to the Ethernet ring and participate in ERPS calculation. <pre>Switch(config-erps 100)# ring-port west virtual-channel east gigabitEthernet 0/3</pre>
-----------	---

...Node 4...	<ul style="list-style-type: none">• Enable ERPS in ERPS 2. <pre>Switch(config-erps 100)# state enable</pre>• Configure the R-APS VLAN of the subring ERPS 3. <pre>Switch(config)# erps raps-vlan 200 Switch(config-erps 200)# exit</pre>• Configure the link mode of ports in ERPS 3. <pre>Switch(config)# interface gigabitEthernet 0/4 Switch(config-if-gigabitEthernet 0/4)# switchport mode trunk Switch(config-if-gigabitEthernet 0/4)# exit</pre>• Enter ERPS configuration mode. <pre>Switch(config)# erps raps-vlan 200</pre>• Configure the ports to be added to the Ethernet ring and participate in ERPS calculation. <pre>Switch(config-erps 200)# ring-port west virtual-channel east gigabitEthernet 0/4</pre>
--------------	--

...Node 4	<ul style="list-style-type: none">• Enable ERPS in ERPS 3. <pre>Switch(config-erps 200)# state enable</pre> <ul style="list-style-type: none">• Configure the R-APS VLAN of the subring ERPS 4. <pre>Switch(config-erps 200)# exit Switch(config)# erps raps-vlan 300 Switch(config-erps 300)# exit</pre> <ul style="list-style-type: none">• Configure the link mode of ports in ERPS 4. <pre>Switch(config)# interface gigabitEthernet 0/5 Switch(config-if-gigabitEthernet 0/5)# switchport mode trunk Switch(config-if-gigabitEthernet 0/5)# exit</pre> <ul style="list-style-type: none">• Enter ERPS configuration mode. <pre>Switch(config)# erps raps-vlan 300</pre> <ul style="list-style-type: none">• Configure the ports to be added to the Ethernet ring and participate in ERPS calculation. <pre>Switch(config-erps 300)# ring-port west virtual-channel east gigabitEthernet 0/5</pre> <ul style="list-style-type: none">• Enable ERPS in ERPS 4. <pre>Switch(config-erps 300)# state enable</pre> <ul style="list-style-type: none">• Associate the Ethernet subrings ERPS 2, ERPS 3, and ERPS 4.
-----------	--

Node 5...	<ul style="list-style-type: none">• Enter privileged mode. <pre>Switch# configure terminal</pre>• Configure the R-APS VLAN. <pre>Switch(config)# erps raps-vlan 100 Switch(config-erps 100)# end</pre>• Configure the link mode of ports in the Ethernet ring. <pre>Switch(config)# interface gigabitEthernet 0/1 Switch(config-if-gigabitEthernet 0/1)# switchport mode trunk Switch(config-if-gigabitEthernet 0/1)# exit Switch(config)# interface gigabitEthernet 0/2 Switch(config-if-gigabitEthernet 0/2)# switchport mode trunk Switch(config-if-gigabitEthernet 0/2)# exit</pre>• Enter ERPS configuration mode. <pre>Switch(config)# erps raps-vlan 100</pre>• Configure the ports to be added to the Ethernet ring and participate in ERPS calculation. <pre>Switch(config-erps 100)# ring-port west gigabitEthernet 0/1 east gigabitEthernet 0/2</pre>
-----------	--

<p>...Node 5</p>	<ul style="list-style-type: none"> Specify the port and RPL owner node for the RPL. <pre>Switch(config-erps 100)# rpl-port east rpl-owner</pre> <ul style="list-style-type: none"> Enable ERPS in the specified ring. <pre>Switch(config-erps 100)# state enable</pre> <ul style="list-style-type: none"> Enable ERPS globally. <pre>Switch(config-erps 100)# exit Switch(config)# erps enable</pre>
<p>Node 6</p>	<ul style="list-style-type: none"> The configuration on Node 6 is basically the same as that on Node 5, except that you need to change the R-APS VLAN to VLAN 200.
<p>Node 7</p>	<ul style="list-style-type: none"> The configuration on Node 7 is basically the same as that on Node 5, except that you need to change the R-APS VLAN to VLAN 300.
<p>Verification</p>	<p>Run the show erps command one each node to check the configuration. The configuration on Node 3 is used as an example.</p>

```

Switch# show erps
ERPS Information
Global Status           : Enabled
Link monitored by      : Not Oam
-----
R-APS VLAN              : 100
Ring Status             : Enabled
West Port               : Virtual Channel
East Port               : Gi 0/3 (Forwarding)
RPL Port                : None
Protected VLANs        : ALL
RPL Owner               : Disabled
Holdoff Time           : 0 milliseconds
Guard Time             : 500 milliseconds
WTR Time                : 2 minutes
Current Ring State     : Idle
Associate R-APS VLAN   :
-----
R-APS VLAN              : 200
Ring Status             : Enabled
West Port               : Virtual Channel
East Port               : Gi 0/4 (Forwarding)
RPL Port                : None
Protected VLANs        : ALL
RPL Owner               : Disabled
Holdoff Time           : 0 milliseconds
Guard Time             : 500 milliseconds
WTR Time                : 2 minutes
Current Ring State     : Idle
Associate R-APS VLAN   :
-----
R-APS VLAN              : 4093
Ring Status             : Enabled
West Port               : Gi 0/1 (Forwarding)
East Port               : Gi 0/2 (Blocking)
RPL Port                : East Port
Protected VLANs        : ALL
RPL Owner               : Disabled
Holdoff Time           : 0 milliseconds
Guard Time             : 500 milliseconds
WTR Time                : 2 minutes
Current Ring State     : Idle
Associate R-APS VLAN   : 100,200,300
    
```

Common Errors

- The R-APS ring has been enabled but ERPS is not enabled globally, so ERPS still does not take effect.
- Multiple RPL owner nodes are configured in one ERPS ring.
- Different R-APS VLANs are configured for the nodes in one ERPS ring.
- The nodes in the man ring are not associated with Ethernet subrings.

11.4.4. Load Balancing Configuration

Configuration Effect

- Control the direction of data flows in an ERPS ring to realize load balancing.
- When a link in the ring network enabled with load balancing fails, the traffic can be quickly switched to a normal link.

Notes

- Before you configure load balancing, configure the VLAN-instance relationship in MST configuration mode.
- When you configure load balancing, add all data VLANs of the devices to the ERPS protected VLAN list; otherwise, any unprotected VLAN will cause loops.
- Only trunk ports can join an ERPS ring, and the trunk attributes cannot be modified after the port joins the ring.
- The ports in an ERPS ring do not participate in STP calculation regardless of whether the ERPS ring is enabled or not. When you configure an ERPS ring, ensure that loops will not occur when STP calculation is disabled on ports in the ring.
- ERPS does not use the same ports as RERP and REUP.

Configuration Steps

Perform the following configuration after you complete the single-ring configuration described above:

→ Configuring the Protected VLAN of an Ethernet Ring

- (Optional) Perform this configuration in global configuration mode.
- When you configure load balancing for an Ethernet ring, you must specify the protected VLAN.

Verification

- Run the show erps command one each node to check the configuration.

Related Commands

→ Configuring the Protected VLAN of an Ethernet Ring

Command	protected-instance instance-id-list
Parameter Description	instance-id-list: Indicates the instance protected by the Ethernet ring.
Command Mode	R-APS VLAN mode
Usage Guide	The protected instance of the Ethernet ring is the protected VLAN.

Configuration Example

Scenario	<p>The diagram shows a square Ethernet ring with four nodes: Node 1 (top-left), Node 2 (bottom-left), Node 3 (bottom-right), and Node 4 (top-right). Each node is connected to its neighbors via Gigabit Ethernet ports (Gi 0/1 and Gi 0/2). A red line traces the ring path. Node 1 is labeled 'RPL owner for ERPS1' and Node 3 is labeled 'RPL owner for ERPS2'. The ring is labeled 'RPL' on both the left and right sides.</p>
Configuration Steps	<ul style="list-style-type: none"> • Configure the R-APS VLAN in privileged mode. • Configure the link mode of ports in the Ethernet ring. • Configure the protected VLAN of the Ethernet ring. • Enter R-APS VLAN mode and configure the ports to be added to the Ethernet ring and participate in ERPS calculation. • Specify the RPL owner port. • Enable ERPS in the specified ring. • Enable ERPS globally.

Node 1	<ul style="list-style-type: none">• Enter privileged mode. <pre>Switch# configure terminal</pre> <ul style="list-style-type: none">• Configure the Ethernet subring ERPS 1 as follows:• Configure the link mode of ports in ERPS 1. <pre>Switch(config)# interface gigabitEthernet 0/1 Switch(config-if-gigabitEthernet 0/1)# switchport mode trunk Switch(config-if-gigabitEthernet 0/1)# exit Switch(config)# interface gigabitEthernet 0/2 Switch(config-if-gigabitEthernet 0/2)# switchport mode trunk Switch(config-if-gigabitEthernet 0/2)# exit</pre> <ul style="list-style-type: none">• Configure the protected VLAN, RPL owner port, and RPL of ERPS 1. <pre>Switch(config)# spanning-tree mst configuration Switch(config-mst)# instance 1 vlan 1-2000 Switch(config-mst)# exit Switch(config)# erps raps-vlan 100 Switch(config-erps 100)# protected-instance 1 Switch(config-erps 100)# ring-port west gigabitEthernet 0/1 east gigabitEthernet 0/2 Switch(config-erps 100)# rpl-port west rpl-owner</pre> <ul style="list-style-type: none">• Configure the Ethernet subring ERPS 2 as follows:• Configure the ports to be added to ERPS 2 and participate in ERPS calculation. <pre>Switch(config)# spanning-tree mst configuration Switch(config-mst)# instance 2 vlan 2001-4094 Switch(config-mst)# exit Switch(config)# erps raps-vlan 4093 Switch(config-erps 4093)# protected-instance 2 Switch(config-erps 4093)# ring-port west gigabitEthernet 0/1 east gigabitEthernet 0/2</pre>
--------	--

Node 1	<ul style="list-style-type: none"> • Enable ERPS in ERPS 2 and globally respectively. <pre style="border: 1px solid #ccc; padding: 10px; background-color: #f9f9f9;">Switch(config-erps 4093)# state enable Switch(config-erps 4093)# exit Switch(config)# erps enable</pre>
Node 2	<ul style="list-style-type: none"> • The configuration on Node 2 is the same as that on Node 1, except that RPL configuration is not required on Node 2.
Node 3	<ul style="list-style-type: none"> • The configuration on Node 3 is the same as that on Node 1, except that RPL configuration is not required on Node 3. • Configure the RPL of ERPS 2 on Node 3. The RPL of ERPS 1 does not need to be configured on Node 3. <pre style="border: 1px solid #ccc; padding: 10px; background-color: #f9f9f9;">Switch(config)# erps raps-vlan 4093 Switch(config-erps 4093)# rpl-port east rpl-owner</pre>
Node 4	The configuration on Node 4 is the same as that on Node 2.
Verification	Run the show erps command one each node to check the configuration. The configuration on Node 1 is used as an example.

Node 1	<pre> Switch# show erps ERPS Information Global Status : Enabled Link monitored by : Not Oam ----- R-APS VLAN : 200 Ring Status : Enabled West Port : Gi 0/1 (Blocking) East Port : Gi 0/2 (Forwarding) RPL Port : West Port Protected VLANs : 1-2000 RPL Owner : Enabled Holdoff Time : 0 milliseconds Guard Time : 500 milliseconds WTR Time : 2 minutes Current Ring State : Idle Associate R-APS VLAN : ----- R-APS VLAN : 4093 Ring Status : Enabled West Port : Gi 0/1 (Forwarding) East Port : Gi 0/2 (Blocking) RPL Port : West Port Protected VLANs : 2001-4094 RPL Owner : Enabled Holdoff Time : 0 milliseconds Guard Time : 500 milliseconds WTR Time : 2 minutes Current Ring State : Idle Associate R-APS VLAN : </pre>
--------	--

Common Errors

- The R-APS ring has been enabled but ERPS is not enabled globally, so ERPS still does not take effect.
- Multiple RPL owner nodes are configured in one ERPS ring.
- Different R-APS VLANs are configured for the nodes in one ERPS ring.

11.4.5. ERPS Configuration Modification

Configuration Effect

- Switch configuration smoothly when the ERPS ring topology is changed.

Notes

- When you modify the ERPS configuration on a device, to avoid loops, first run the shutdown command to shut down an ERPS port in the ring. When the configuration is completed, run the no shutdown command to restart the port.
- All nodes in one ERPS ring must belong to the same R-APS VLAN.
- If you only need to modify the ERPS timers, skip this section.

Configuration Steps

Run the shutdown command to shut down an ERPS port and disable ERPS. Then modify the ERPS configuration according to section 14.4.1 "Single-Ring Configuration (Basic Function)" and complete the following settings, which are optional.

→ Configuring the Holdoff Timer, Guard Timer, and WRT Timer

- Optional.
- Perform this configuration in R-APS VLAN mode based on the actual application requirements.

Verification

- Run the show erps command on each node to check the configuration.

Related Commands

→ Configuring the Holdoff Timer, Guard Timer, and WRT Timer

Command	timer { holdoff-time interval1 guard-time interval2 wtr-time interval3 }
Parameter Description	interval1: Indicates the Holdoff timer interval. The value ranges from 0 to 100, in the unit of 100 milliseconds. The default value is 0. interval2: Indicates the Guard timer interval. The value ranges from 1 to 200, in the unit of 10 milliseconds. The default value is 50. interval3: Indicates the WTR timer interval. The value ranges from 1 to 12, in the unit of minutes. The default value is 2.
Command Mode	R-APS VLAN mode

Usage Guide	<ul style="list-style-type: none"> • Holdoff timer: Is used to minimize frequent ERPS topology switching due to intermittent link failures. After you configure the Holdoff timer, ERPS performs topology switching only if the link failure still persists after the timer times out. • Guard timer: Is used to prevent a device from receiving expired R-APS messages. When the device detects that a link failure is cleared, it sends link recovery packets and starts the Guard timer. During the period before timer expiration, all packets except flush packets indicating a subring topology change will be discarded. • WTR timer: Is effective only for RPL owner devices to avoid ring status misjudgment. When an RPL owner device detects that a failure is cleared, it does perform topology switching immediately but only if the Ethernet ring is recovered after the WTR timer times out. If a ring failure is detected again before timer expiration, the RPL owner device cancels the timer and does not perform topology switching.
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Configuration Example

Scenario	
Configuration Steps	<ul style="list-style-type: none"> • ERPS configuration exists in the ring. The ERPS ports need to be switched because of a physical topology change. • Run the shutdown command to shut down a link in the ring and configure the link mode of ports after switching. • Disable ERPS in the ring in R-APS VLAN mode. • Reconfigure the ports that will participate in ERPS calculation. • Enable ERPS in the ring. • Modify the ERPS timers.

Node 1	<ul style="list-style-type: none">• Enter privileged mode. <pre>Switch# configure terminal Enter configuration commands, one per line. End with CNTL/Z.</pre>• Shutdown a link in the ring in interface configuration mode to avoid loops. <pre>Switch(config)# interface gigabitEthernet 0/1 Switch(config-if-gigabitEthernet 0/1)# shutdown Switch(config-if-gigabitEthernet 0/1)# exit</pre>• Configure the link mode of ports in the Ethernet ring. <pre>Switch(config)# interface gigabitEthernet 0/3 Switch(config-if-gigabitEthernet 0/3)# switchport mode trunk Switch(config-if-gigabitEthernet 0/3)# exit</pre>• Enter ERPS configuration mode. <pre>Switch(config)# erps raps-vlan 4093</pre>• Disable ERPS. <pre>Switch(config-erps 4093)# no state enable</pre>• Delete the previous ring configuration. <pre>Switch(config-erps 4093)# no ring-port</pre>• Reconfigure the ports that will participate in ERPS calculation. Change Gig 0/2 to Gig 0/3.
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<p>Node 4</p>	<ul style="list-style-type: none"> • Enter privileged mode. <pre>Switch# configure terminal</pre> <ul style="list-style-type: none"> • Modify timers in ERPS configuration mode. <pre>Switch(config)# erps raps-vlan 4093 Switch(config-erps 4093)# timer wtr-time 1</pre>
	<p>Wait for 1 minute. When the ERPS ring is restored to Idle, run the show erps command on Node 1 and Node 4 to check the configuration.</p>
<p>Node 1</p>	<pre>Switch# show erps ERPS Information Global Status : Enabled Link monitored by : Not Oam ----- R-APS VLAN : 4093 Ring Status : Enabled West Port : Gi 0/1 (Forwardin) East Port : Gi 0/3 (Forwardin) RPL Port : None Protected VLANs : ALL RPL Owner : Enabled Holdoff Time : 0 milliseconds Guard Time : 500 milliseconds WTR Time : 2 minutes Current Ring State : Idle Associate R-APS VLAN :</pre>

Node 4	<pre> Switch# show erps ERPS Information Global Status : Enabled Link monitored by : Not Oam ----- R-APS VLAN : 4093 Ring Status : Enabled West Port : Gi 0/1 (Forwardin) East Port : Gi 0/2 (Blocking) RPL Port : East Port Protected VLANs : ALL RPL Owner : Enabled Holdoff Time : 0 milliseconds Guard Time : 500 milliseconds WTR Time : 1 minutes Current Ring State : Idle Associate R-APS VLAN : </pre>
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Common Errors

- When the configuration is completed, the R-APS ring is not enabled again or the shutdown ports are not restarted by using the no shutdown command.

11.5. Monitoring

Displaying

Description	Command
Displays the ERPS configuration and status of devices.	show erps [global raps_vlan vlan-id [sub_ring]]

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