HP A5830 Switch Series
ACL and QoS

Configuration Guide

Abstract

This document describes the software features for the HP A Series products and guides you through the software configuration procedures. These configuration guides also provide configuration examples to help you apply software features to different network scenarios.

This documentation is intended for network planners, field technical support and servicing engineers, and network administrators working with the HP A Series products.

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Legal and notice information

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Configuring ACL

Unless otherwise stated, ACLs refer to both IPv4 and IPv6 ACLs throughout this document.

Overview

An ACL is a set of rules (or permit or deny statements) for identifying traffic based on criteria such as source IP address, destination IP address, and port number.

ACLs are primarily used for packet filtering. A packet filter drops packets that match a deny rule and permits packets that match a permit rule. ACLs are also used by many modules, such as QoS and IP routing, for traffic classification and identification.

Applications on the switch

An ACL is implemented in hardware or software, depending on the module that uses it. If the module, such as the packet filter or QoS module, is implemented in hardware, the ACL is applied to hardware to process traffic. If the module, the routing or user interface access control module (Telnet, SNMP, or web) for example, is implemented in software, the ACL is applied to software to process traffic.

The user interface access control module denies packets that do not match any ACL. Some modules, QoS for example, ignore the permit or deny action in ACL rules and do not base their drop or forwarding decisions on the action set in ACL rules. See the specified module for information about ACL application.

Categories

Category	ACL number	IP version	Match criteria
Basic ACLs	2000 to 2999	IPv4	Source IPv4 address
		IPv6	Source IPv6 address
Advanced ACLs	3000 to 3999	IPv4	Source IPv4 address, destination IPv4 address, packet priority, protocols over IPv4, and other Layer 3 and Layer 4 header fields
		IPv6	Source IPv6 address, destination IPv6 address, packet priority, protocols over IPv6, and other Layer 3 and Layer 4 header fields
Ethernet frame header ACLs	4000 to 4999	IPv4 and IPv6	Layer 2 header fields, such as source and destination MAC addresses, 802.1p priority, and link layer protocol type

Numbering and naming ACLs

Each ACL category has a unique range of ACL numbers. When creating an ACL, you must assign it a number. In addition, you can assign the ACL a name for ease of identification. After creating an ACL with a name, you cannot rename it or delete its name.

For an Ethernet frame header ACL, the ACL number and name must be globally unique. For an IPv4 basic or advanced ACLs, its ACL number and name must be unique among all IPv4 ACLs, and for an IPv6 basic or advanced ACL, its ACL number and name must be unique among all IPv6 ACLs. You can assign an IPv4 ACL and an IPv6 ACL the same number and name.

Match order

The rules in an ACL are sorted in a specific order. When a packet matches a rule, the device stops the match process and performs the action defined in the rule. If an ACL contains overlapping or conflicting rules, the matching result and action to take depend on the rule order.

The following ACL match orders are available:

- **config**—Sorts ACL rules in ascending order of rule ID. A rule with a lower ID is matched before a rule with a higher ID. If you use this approach, carefully check the rules and their order.
- **auto**—Sorts ACL rules in depth-first order. Depth-first ordering makes sure that any subset of a rule is always matched before the rule. Table 1 lists the sequence of tie breakers that depth-first ordering uses to sort rules for each type of ACL.

Table 1 Sort ACL rules in depth-first order

ACL category	Sequence of tie breakers
IPv4 basic ACL	1. More 0s in the source IP address wildcard (more 0s means a narrower IP address range) 2. Smaller rule ID
IPv4 advanced ACL	3. Specific protocol type rather than IP (IP represents any protocol over IP) 4. More 0s in the source IP address wildcard mask 5. More 0s in the destination IP address wildcard 6. Narrower TCP/UDP service port number range 7. Smaller rule ID
IPv6 basic ACL	8. Longer prefix for the source IP address (a longer prefix means a narrower IP address range) 9. Smaller rule ID
IPv6 advanced ACL	10. Specific protocol type rather than IP (IP represents any protocol over IPv6) 11. Longer prefix for the source IPv6 address 12. Longer prefix for the destination IPv6 address 13. Narrower TCP/UDP service port number range 14. Smaller rule ID
Ethernet frame header ACL	15. More 1s in the source MAC address mask (more 1s means a smaller MAC address) 16. More 1s in the destination MAC address mask 17. Smaller rule ID

NOTE:

A wildcard mask, also called an "inverse mask," is a 32-bit binary and represented in dotted decimal notation. In contrast to a network mask, the 0 bits in a wildcard mask represent "do care" bits, and the 1 bits represent "don't care" bits. If the "do care" bits in an IP address are identical to the "do care" bits in an IP address criterion, the IP address matches the criterion. All "don't care" bits are ignored. The 0s and 1s in a wildcard mask can be noncontiguous. For example, 0.255.0.255 is a valid wildcard mask.

Rule comments and rule range remarks

Add a comment about an ACL rule to make it easy to understand. The rule comment appears below the rule statement.

Add a rule range remark to indicate the start or end of a range of rules created for the same purpose. A rule range remark always appears above the specified ACL rule. If the specified rule has not been created yet, the position of the comment in the ACL is as follows:

- If the match order is config, the remark is inserted into the ACL in descending order of rule ID.
- If the match order is auto, the remark is placed at the end of the ACL. After you create the rule, the remark appears above the rule.

For more information about how to use rule range remarks, see the **rule remark** command in *ACL and QoS Command Reference* for your device.

Rule numbering

Numbering step

If you do not assign an ID to the rule you are creating, the system automatically assigns it a rule ID. The rule numbering step sets the increment by which the system automatically numbers rules. For example, the default ACL rule numbering step is 5. If you do not assign IDs to rules you are creating, they are automatically numbered 0, 5, 10, 15, and so on. The wider the numbering step, the more rules you can insert between two rules.

By introducing a gap between rules rather than contiguously numbering rules, you have the flexibility of inserting rules in an ACL. This feature is important for a config order ACL, where ACL rules are matched in ascending order of rule ID.

Automatic numbering and renumbering

The ID automatically assigned to an ACL rule takes the nearest higher multiple of the numbering step to the current highest rule ID, starting with 0.

For example, if the numbering step is 5 (the default), and there are five ACL rules numbered 0, 5, 9, 10, and 12, the newly defined rule is numbered 15. If the ACL does not contain any rule, the first rule is numbered 0.

Whenever the step changes, the rules are renumbered, starting from 0. For example, if there are five rules numbered 5, 10, 13, 15, and 20, changing the step from 5 to 2 causes the rules to be renumbered 0, 2, 4, 6, and 8.

Filtering fragments with ACLs

Traditional packet filtering matches only first fragments of packets, and allows all subsequent non-first fragments to pass through. Attackers can fabricate non-first fragments to attack networks.

To avoids the risks, the HP ACL implementation:

- Filters all fragments by default, including non-first fragments.
- Allows for matching criteria modification, for example, filters non-first fragments only.

ACL configuration task list

Task	Remarks
Configuring a time range	Optional. Applicable to IPv4 and IPv6 ACLs.
Configuring a basic ACL	Required. Configure at least one task.
Configuring an advanced ACL	
Configuring an Ethernet frame header ACL	
Copying an ACL	Optional. Applicable to IPv4 and IPv6.
Packet filtering with ACLs	Optional. Applicable to IPv4 and IPv6.

Configuring a time range

Implement ACL rules based on the time of day by applying a time range to them. A time-based ACL rule only takes effect in any time periods specified by the time range.

The following basic types of time range are available:

- **Periodic time range**—Recurs periodically on a day or days of the week.
- **Absolute time range**—Represents only a period of time and does not recur.

Create multiple statements in a time range. The active period of a time range is calculated as follows:

1. Combining all periodic statements.
2. Combining all absolute statements.
3. Taking the intersection of the two statement sets as the active period of the time range.

Create a maximum of 256 time ranges, each with a maximum of 32 periodic statements and 12 absolute statements.

To configure a time range:

Step…	Command…	Remarks
1. Enter system view.	**system-view**	—
2. Configure a time range.	**time-range** *time-range-name* { *start-time* **to** *end-time days* [**from** *time1 date1*] [**to** *time2 date2*] | **from** *time1 date1* [**to** *time2 date2*] | **to** *time2 date2* }	Required By default, no time range exists. Repeat this command with the same time range name to create multiple statements for a time range.

Configuring a basic ACL

Configuring an IPv4 basic ACL

IPv4 basic ACLs match packets based only on source IP addresses.

To configure an IPv4 basic ACL:

Step…	Command…	Remarks
1. Enter system view.	**system-view**	—
2. Create an IPv4 basic ACL and enter its view.	**acl number** *acl-number* [**name** *acl-name*] [**match-order** { **auto** | **config** }]	Required. By default, no ACL exists. IPv4 basic ACLs are numbered ranging from 2000 to 2999. Use **acl name** *acl-name* to enter the view of a named IPv4 ACL.
3. Configure a description for the IPv4 basic ACL.	**description** *text*	Optional. By default, an IPv4 basic ACL has no ACL description.
4. Set the rule numbering step.	**step** *step-value*	Optional. 5 by default.
5. Create or edit a rule.	**rule** [*rule-id*] { **deny** | **permit** } [**counting** | **fragment** | **logging** | **source** { *sour-addr sour-wildcard* | **any** } | **time-range** *time-range-name*] *	Required. By default, an IPv4 basic ACL does not contain any rule. If the ACL is for QoS traffic classification, the **logging** and **counting** keywords (even if specified) do not take effect.
6. Add or edit a rule comment.	**rule** *rule-id* **comment** *text*	Optional. By default, an IPv4 ACL rule has no rule description.
7. Add or edit a rule range remark.	**rule** [*rule-id*] **remark** *text*	Optional By default, no rule range remarks are configured.
8. Enable counting ACL rule matches performed in hardware.	**hardware-count enable**	Optional. Disabled by default. When the ACL is referenced by a QoS policy, this command does not take effect.

Configuring an IPv6 basic ACL

To configure an IPv6 basic ACL:

Step…	Command…	Remarks
1. Enter system view.	**system-view**	—
2. Create an IPv6 basic ACL view and enter its view.	**acl ipv6 number** *acl6-number* [**name** *acl6-name*] [**match-order** { **auto** | **config** }]	Required. By default, no ACL exists. IPv6 basic ACLs are numbered ranging from 2000 to 2999. Use **acl ipv6 name** *acl6-name* to enter the view of a named IPv6 ACL.
3. Configure a description for the IPv6 basic ACL.	**description** *text*	Optional. By default, an IPv6 basic ACL has no ACL description.
4. Set the rule numbering step.	**step** *step-value*	Optional. 5 by default.
5. Create or edit a rule.	**rule** [*rule-id*] { **deny** | **permit** } [**counting** | **fragment** | **logging** | **routing** [**type** *routing-type*] | **source** { *ipv6-address prefix-length* | *ipv6-address/prefix-length* | **any** } | **time-range** *time-range-name*] *	Required. By default, an IPv6 basic ACL does not contain any rule. If the ACL is for QoS traffic classification or packet filtering, do not specify the **fragment** and **routing** keywords. The keywords can cause ACL application failure. The **logging** and **counting** keywords (even if specified) do not take effect for QoS.
6. Add or edit a rule comment.	**rule** *rule-id* **comment** *text*	Optional. By default, an IPv6 basic ACL rule has no rule description.
7. Add or edit a rule range remark.	**rule** [*rule-id*] **remark** *text*	Optional. By default, no rule range remarks are configured.
8. Enable counting ACL rule matches performed in hardware.	**hardware-count enable**	Optional. Disabled by default. When the ACL is referenced by a QoS policy, this command does not take effect.

Configuring an advanced ACL

Configuring an IPv4 advanced ACL

IPv4 advanced ACLs match packets based on source IP addresses, destination IP addresses, packet priorities, protocols over IP, and other protocol header information, such as TCP/UDP source and destination port numbers, TCP flags, ICMP message types, and ICMP message codes.

Compared to IPv4 basic ACLs, IPv4 advanced ACLs allow more flexible and accurate filtering.

To configure an IPv4 advanced ACL:

Step…	Command…	Remarks
1. Enter system view.	**system-view**	—
2. Create an IPv4 advanced ACL and enter its view.	**acl number** *acl-number* [**name** *acl-name*] [**match-order** { **auto** | **config** }]	Required. By default, no ACL exists. IPv4 advanced ACLs are numbered ranging from 3000 to 3999. Use **acl name** *acl-name* to enter the view of a named IPv4 ACL.
3. Configure a description for the IPv4 advanced ACL.	**description** *text*	Optional. By default, an IPv4 advanced ACL has no ACL description.
4. Set the rule numbering step.	**step** *step-value*	Optional. 5 by default.
5. Create or edit a rule.	**rule** [*rule-id*] { **deny** | **permit** } *protocol* [{ { **ack** *ack-value* | **fin** *fin-value* | **psh** *psh-value* | **rst** *rst-value* | **syn** *syn-value* | **urg** *urg-value* } * | **established** } | **counting** | **destination** { *dest-addr dest-wildcard* | **any** } | **destination-port** *operator port1* [*port2*] | **dscp** *dscp* | **fragment** | **icmp-type** { *icmp-type* [*icmp-code*] | *icmp-message* } | **logging** | **precedence** *precedence* | **source** { *sour-addr sour-wildcard* | **any** } | **source-port** *operator port1* [*port2*] | **time-range** *time-range-name* | **tos** *tos*] *	Required. By default, an IPv4 advanced ACL does not contain any rule. If an IPv4 advanced ACL is for QoS traffic classification or packet filtering, do not specify **neq** for the *operator* argument. The **logging** and **counting** keywords (even if specified) do not take effect for QoS traffic classification.
6. Add or edit a rule comment.	**rule** *rule-id* **comment** *text*	Optional. By default, an IPv4 advanced ACL rule has no rule description.
7. Add or edit a rule range remark.	**rule** [*rule-id*] **remark** *text*	Optional. By default, no rule range remarks are configured.
8. Enable counting ACL rule matches performed in hardware.	**hardware-count enable**	Optional. Disabled by default. When the ACL is referenced by a QoS policy, this command does not take effect.

Configuring an IPv6 advanced ACL

IPv6 advanced ACLs match packets based on the source IPv6 addresses, destination IPv6 addresses, packet priorities, protocols carried over IPv6, and other protocol header fields such as the TCP/UDP

source port number, TCP/UDP destination port number, ICMPv6 message type, and ICMPv6 message code.

Compared to IPv6 basic ACLs, IPv6 advanced ACLs allow more flexible and accurate filtering.

To configure an IPv6 advanced ACL:

Step…	Command…	Remarks
1. Enter system view.	**system-view**	—
2. Create an IPv6 advanced ACL and enter its view.	**acl ipv6 number** *acl6-number* [**name** *acl6-name*] [**match-order** { **auto** | **config** }]	Required. By default, no ACL exists. IPv6 advanced ACLs are numbered ranging from 3000 to 3999. Use **acl ipv6 name** *acl6-name* to enter the view of a named IPv6 ACL.
3. Configure a description for the IPv6 advanced ACL.	**description** *text*	Optional. By default, an IPv6 advanced ACL has no ACL description.
4. Set the rule numbering step.	**step** *step-value*	Optional. 5 by default.
5. Create or edit a rule.	**rule** [*rule-id*] { **deny** | **permit** } *protocol* [{ { **ack** *ack-value* | **fin** *fin-value* | **psh** *psh-value* | **rst** *rst-value* | **syn** *syn-value* | **urg** *urg-value* } * | **established** } | **counting** | **destination** { *dest dest-prefix* | *dest/dest-prefix* | **any** } | **destination-port** *operator port1* [*port2*] | **dscp** *dscp* | **flow-label** *flow-label-value* | **fragment** | **icmp6-type** { *icmp6-type icmp6-code* | *icmp6-message* } | **logging** | **routing** [**type** *routing-type*] | **source** { *source source-prefix* | *source/source-prefix* **| any** } | **source-port** *operator port1* [*port2*] | **time-range** *time-range-name*] *	Required. By default IPv6 advanced ACL does not contain any rule. If an IPv6 advanced ACL is for QoS traffic classification or packet filtering: • Do not specify the **fragment** and **routing** keywords, or specify **neq** for the *operator* argument. • Do not specify the **flow-label** keyword if the ACL is for outbound QoS traffic classification or outbound packet filtering. The **logging** and **counting** keywords (even if specified) do not take effect for QoS traffic classification.
6. Add or edit a rule comment.	**rule** *rule-id* **comment** *text*	Optional. By default, an IPv6 advanced ACL rule has no rule description.
7. Add or edit a rule range remark.	**rule** [*rule-id*] **remark** *text*	Optional. By default, no rule range remarks are configured.

Step…	Command…	Remarks
8. Enable counting ACL rule matches performed in hardware.	**hardware-count enable**	Optional. Disabled by default. When the ACL is referenced by a QoS policy, this command does not take effect.

Configuring an Ethernet frame header ACL

Ethernet frame header ACLs, also called "Layer 2 ACLs," match packets based on Layer 2 protocol header fields, such as source MAC address, destination MAC address, 802.1p priority (VLAN priority), and link layer protocol type.

To configure an Ethernet frame header ACL:

Step…	Command…	Remarks
1. Enter system view.	system-view	—
2. Create an Ethernet frame header ACL and enter its view.	**acl number** *acl-number* [**name** *acl-name*] [**match-order** { **auto** | **config** }]	Required. By default, no ACL exists. Ethernet frame header ACLs are numbered ranging from 4000 to 4999. Use **acl name** *acl-name* to enter the view of a named Ethernet frame header ACL.
3. Configure a description for the Ethernet frame header ACL.	**description** *text*	Optional. By default, an Ethernet frame header ACL has no ACL description.
4. Set the rule numbering step.	**step** *step-value*	Optional. 5 by default.
5. Create or edit a rule.	**rule** [*rule-id*] { **deny** | **permit** } [**cos** *vlan-pri* | **counting** | **dest-mac** *dest-addr dest-mask* | { **lsap** *lsap-type lsap-type-mask* | **type** *protocol-type protocol-type-mask* } | **source-mac** *sour-addr source-mask* | **time-range** *time-range-name*] *	Required. By default, an Ethernet frame header ACL does not contain any rule. The **lsap** keyword is not supported if the ACL is for QoS traffic classification.
6. Add or edit a rule comment.	**rule** *rule-id* **comment** *text*	Optional. By default, an Ethernet frame header ACL rule has no rule description.
7. Add or edit a rule range remark.	**rule** [*rule-id*] **remark** *text*	Optional. By default, no rule range remarks are configured.

Step…	Command…	Remarks
8. Enable counting ACL rule matches performed in hardware.	**hardware-count enable**	Optional. Disabled by default. When the ACL is referenced by a QoS policy, this command does not take effect.

Copying an ACL

Create an ACL by copying an existing ACL (source ACL). The new ACL (destination ACL) has the same properties and content as the source ACL, but not the same ACL number and name.

To successfully copy an ACL, make sure that:

- The destination ACL number is from the same category as the source ACL number.
- The source ACL already exists but the destination ACL does not.

Copying an IPv4 ACL

Step…	Command…	Remarks
1. Enter system view.	**system-view**	—
2. Copy an existing IPv4 ACL to create a new IPv4 ACL.	**acl copy** { *source-acl-number* | **name** *source-acl-name* } **to** { *dest-acl-number* | **name** *dest-acl-name* }	Required

Copying an IPv6 ACL

Step…	Command…	Remarks
1. Enter system view.	**system-view**	—
2. Copy an existing IPv6 ACL to generate a new one of the same category.	**acl ipv6 copy** { *source-acl6-number* | **name** *source-acl6-name* } **to** { *dest-acl6-number* | **name** *dest-acl6-name* }	Required

Packet filtering with ACLs

Use an ACL to filter incoming or outgoing IPv4 or IPv6 packets. Apply one IPv4 ACL, one IPv6 AL, and one Ethernet frame header ACL most to filter packets in the same direction of an interface.

ACLs on VLAN interfaces filter only packets forwarded at Layer 3.

The term *interface* in the packet filtering feature refers to VLAN interfaces, bridge mode (Layer 2) and route mode (Layer 3) Ethernet ports. Set an Ethernet port to operate in route mode by using the **port link-mode route** command (see *Layer 2—LAN Switching Configuration Guide*).

Applying an IPv4 or Ethernet frame header ACL for packet filtering

To apply an IPv4 or Ethernet frame header ACL for packet filtering:

Step…	Command…	Remarks
1. Enter system view.	**system-view**	—

Step…	Command…	Remarks
2. Enter interface view.	**interface** *interface-type interface-number*	—
3. Apply an IPv4 basic, IPv4 advanced, or Ethernet frame header ACL to the interface to filter packets.	**packet-filter** { *acl-number* | **name** *acl-name* } { **inbound** | **outbound** }	Required. By default, no ACL is applied to any interface.

Applying an IPv6 ACL for packet filtering

To apply an IPv6 ACL for packet filtering:

Step…	Command…	Remarks
1. Enter system view.	**system-view**	—
2. Enter interface view.	**interface** *interface-type interface-number*	—
3. Apply an IPv6 basic or IPv6 advanced ACL to the interface to filter IPv6 packets.	**packet-filter ipv6** { *acl6-number* | **name** *acl6-name* } { **inbound** | **outbound** }	Required. By default, no IPv6 ACL is applied to the interface.

Displaying and maintaining ACLs

Task…	Command…	Remarks
Display configuration and match statistics for one or all IPv4 ACLs.	**display acl** { *acl-number* | **all** | **name** *acl-name* } [**slot** *slot-number*] [**|** { **begin** | **exclude** | **include** } *regular-expression*]	Available in any view.
Display configuration and match statistics for one or all IPv6 ACLs.	**display acl ipv6** { *acl6-number* | **all** | **name** *acl6-name* } [**slot** *slot-number*] [**|** { **begin** | **exclude** | **include** } *regular-expression*]	Available in any view.
Display the usage of ACL rules.	**display acl resource** [**slot** *slot-number*] [**|** { **begin** | **exclude** | **include** } *regular-expression*]	Available in any view.
Display the application status of packet filtering ACLs on interfaces.	**display packet-filter** { { **all** | **interface** *interface-type interface-number* } [**inbound** | **outbound**] | **interface vlan-interface** *vlan-interface-number* [**inbound** | **outbound**] [**slot** *slot-number*] } [**|** { **begin** | **exclude** | **include** } *regular-expression*]	Available in any view.
Display the configuration and status of one or all time ranges.	**display time-range** { *time-range-name* | **all** } [**|** { **begin** | **exclude** | **include** } *regular-expression*]	Available in any view.
Clear statistics for one or all IPv4 ACLs.	**reset acl counter** { *acl-number* | **all** | **name** *acl-name* }	Available in user view.
Clear statistics for one or all IPv6 basic and advanced ACLs.	**reset acl ipv6 counter** { *acl6-number* | **all** | **name** *acl6-name* }	Available in user view.

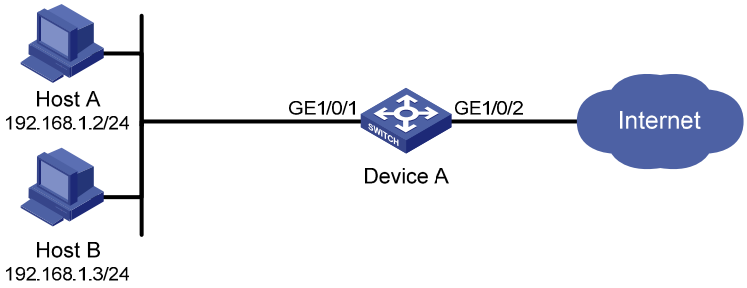
ACL configuration examples

IPv4 packet filtering configuration example

Network requirements

As shown in Figure 1, apply an ACL to the inbound direction of interface GigabitEthernet 1/0/1 on Device A so that every day from 08:00 to 18:00 the interface allows only packets sourced from Host A to pass.

Figure 1 Network diagram for applying an IPv4 ACL to an interface for packet filtering



Configuration procedure

Create a time range from 08:00 to 18:00 every day.

```
<DeviceA> system-view
[DeviceA] time-range study 8:00 to 18:00 daily
```

Create IPv4 ACL 2009, and configure two rules in the ACL. One rule permits packets sourced from Host A and the other denies packets sourced from any other host during the time range **study**.

```
[DeviceA] acl number 2009
[DeviceA-acl-basic-2009] rule permit source 192.168.1.2 0 time-range study
[DeviceA-acl-basic-2009] rule deny source any time-range study
[DeviceA-acl-basic-2009] quit
```

Apply IPv4 ACL 2009 to filter incoming packets on GigabitEthernet 1/0/1.

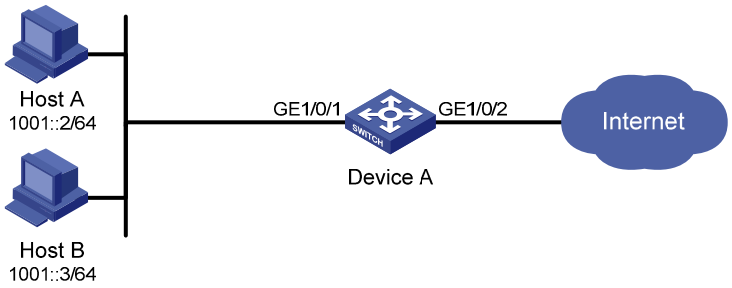
```
[DeviceA] interface gigabitethernet 1/0/1
[DeviceA-GigabitEthernet1/0/1] packet-filter 2009 inbound
[DeviceA-GigabitEthernet1/0/1] quit
```

IPv6 packet filtering configuration example

Network requirements

As shown in Figure 2, apply an IPv6 ACL to the incoming traffic of GigabitEthernet 1/0/1 on Device A so that every day from 08:00 to 18:00 the interface allows only packets from Host A to pass through.

Figure 2 Network diagram for applying an IPv6 ACL to an interface for packet filtering



Configuration procedure

Create a time range from 08:00 to 18:00 every day.

```
<DeviceA> system-view
[DeviceA] time-range study 8:0 to 18:0 daily
```

Create IPv6 ACL 2009, and configure two rules for the ACL. One permits packets sourced from Host A and the other denies packets sourced from any other host during the time range **study**.

```
[DeviceA] acl ipv6 number 2009
[DeviceA-acl6-basic-2009] rule permit source 1001::2 128 time-range study
[DeviceA-acl6-basic-2009] rule deny source any time-range study
[DeviceA-acl6-basic-2009] quit
```

Apply IPv6 ACL 2009 to filter incoming packets on GigabitEthernet 1/0/1.

```
[DeviceA] interface gigabitethernet 1/0/1
[DeviceA-GigabitEthernet1/0/1] packet-filter ipv6 2009 inbound
[DeviceA-GigabitEthernet1/0/1] quit
```

Configuring QoS

Overview

In data communications, QoS is a network's ability to provide differentiated service guarantees for diversified traffic in terms of bandwidth, delay, jitter, and drop rate.

Network resources are scarce. The contention for resources requires that QoS prioritize important traffic flows over trivial ones. For example, in the case of fixed bandwidth, if a traffic flow gets more bandwidth, the other traffic flows get less bandwidth and may be affected. When making a QoS scheme, you must consider the characteristics of various applications to balance the interests of diversified users and to utilize network resources.

The following section describes some typical QoS service models and widely used, mature, QoS techniques.

Service models

Best-effort service model

The best-effort model is single-service and is the simplest service model. In this service model, the network does its best to deliver packets, but does not guarantee delay or reliability.

The best-effort service model is the default model in the Internet and applies to most network applications. It uses the FIFO queuing mechanism.

IntServ model

The IntServ model is a multiple-service model that can accommodate diverse QoS requirements. This service model provides the most granularly differentiated QoS by identifying and guaranteeing definite QoS for each data flow.

In the IntServ model, an application must request service from the network before it sends data. IntServ signals the service request with RSVP. All nodes receiving the request reserve resources as requested and maintain state information for the application flow.

The IntServ model demands high storage and processing capabilities because it requires all nodes along the transmission path to maintain resource state information for each flow. This model is suitable for small-sized or edge networks, but not large-sized networks, for example, the core layer of the Internet, where billions of flows are present.

DiffServ model

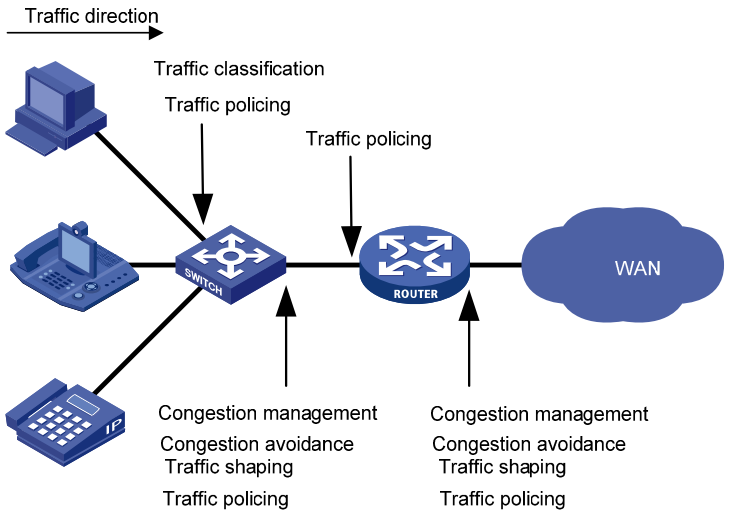
The DiffServ model is a multiple-service model that can satisfy diverse QoS requirements. It is easy to implement and extend. DiffServ does not signal the network to reserve resources before sending data, as IntServ does.

All QoS techniques in this document are based on the DiffServ model.

QoS techniques in a network

The QoS techniques include traffic classification, traffic policing, traffic shaping, line rate, congestion management, and congestion avoidance.

Figure 3 Position of the QoS techniques in a network



As shown in Figure 3, traffic classification, traffic shaping, traffic policing, congestion management, and congestion avoidance mainly implement the following functions:

- Traffic classification uses certain match criteria to assign packets with the same characteristics to a class. Based on classes, you can provide differentiated services.
- Traffic policing monitors flows entering or leaving a device, and imposes penalties on traffic flows that exceed the pre-set threshold to prevent aggressive use of network resources. You can apply traffic policing to both incoming and outgoing traffic of a port.
- Traffic shaping proactively adapts the output rate of traffic to the network resources available on the downstream device to eliminate packet drops. Traffic shaping usually applies to the outgoing traffic of a port.
- Congestion management provides a resource scheduling policy to determine the packet forwarding sequence when congestion occurs. Congestion management usually applies to the outgoing traffic of a port.
- Congestion avoidance monitors the network resource usage, and is usually applied to the outgoing traffic of a port. When congestion worsens, congestion avoidance reduces the queue length by dropping packets.

Configuration approaches

The following approaches are available for configuring QoS: Non-policy approach

and Policy approach

.

Some features support both approaches, but some support only one.

Non-policy approach

In non-policy approach, you can configure QoS service parameters without using a QoS policy. For example, you can use the line rate feature to set a rate limit on an interface without using a QoS policy.

Policy approach

In policy approach, you configure QoS service parameters by using QoS policies. A QoS policy defines the shaping, policing, or other QoS actions to take on different classes of traffic. It is a set of class-behavior associations.

A class is a set of match criteria for identifying traffic and uses the AND or OR operator:

- If the operator is AND, a packet must match all criteria to match the class.
- If the operator is OR, a packet matches the class if it matches any of the criteria in the class.

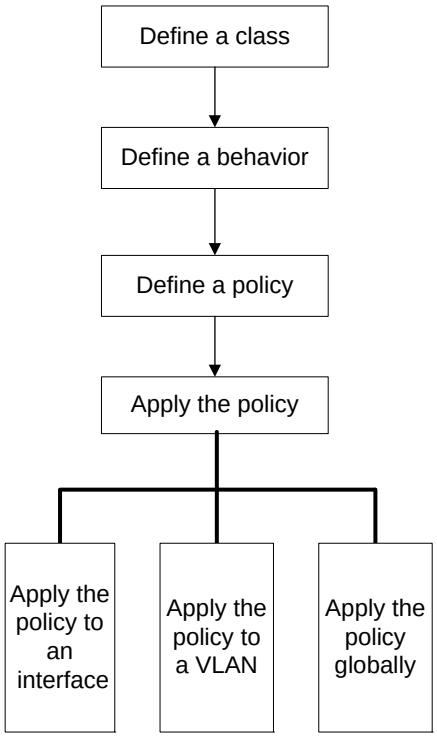
A traffic behavior defines a set of QoS actions to take on packets, such as priority marking and redirect.

By associating a traffic behavior with a class in a QoS policy, you apply the specific set of QoS actions to the class of traffic.

Configuring a QoS policy

Figure 4 shows how to configure a QoS policy.

Figure 4 QoS policy configuration procedure



Defining a class

To define a class, specify its name and then configure the match criteria in class view:

Step…	Command…	Remarks
1. Enter system view.	**system-view**	—
2. Create a class and enter class view.	**traffic classifier** *tcl-name* [**operator** { **and** | **or** }]	Required. By default, the operator of a class is AND. The operator of a class can be AND or OR. • **AND**: A packet is assigned to a class only when the packet matches all criteria in the class. • **OR**: A packet is assigned to a class if it matches any of the criteria in the class.
3. Configure match criteria.	**if-match** *match-criteria*	Required. The *match-criteria* specifies a match criterion.

If a class that uses the AND operator has multiple **if-match acl**, **if-match acl ipv6**, **if-match customer-vlan-id** or **if-match service-vlan-id** clauses, a packet that matches any of the clauses matches the class.

To successfully execute the traffic behavior associated with a traffic class that uses the AND operator, define only one **if-match** clause for any of the following match criteria and enter only one value for any of the following *list* arguments, for example, the *8021p-list* argument:

- **customer-dot1p** *8021p-list*
- **destination-mac** *mac-address*
- **dscp** *dscp-list*
- **ip-precedence** *ip-precedence-list*
- **service-dot1p** *8021p-list*
- **source-mac** *mac-address*

To create multiple if-match clauses for these match criteria or specify multiple values for the *list* arguments, make sure that the operator of the class is OR.

Table 2 The value range for the *match-criteria* argument

Option	Description
acl [**ipv6**] { *acl-number* | **name** *acl-name* }	Matches an ACL. The *acl-number* argument ranges from 2000 to 3999 for an IPv4 ACL, 2000 to 3999 for an IPv6 ACL, and 4000 to 4999 for an Ethernet frame header ACL. The *acl-name* argument is a case-insensitive string of 1 to 63 characters, which must start with an alphabetic letter from a to z (or A to Z), and cannot be **all**.
any	Matches all packets.
dscp *dscp-list*	Matches DSCP values. The *dscp-list* argument is a list of up to eight DSCP values. A DSCP value can be a number from 0 to 63 or any keyword in Table 8.
destination-mac *mac-address*	Matches a destination MAC address.

Option	Description
customer-dot1p *8021p-list*	Matches the 802.1p priority of the customer network. The *8021p-list* argument is a list of up to eight 802.1p priority values. An 802.1p priority ranges from 0 to 7.
service-dot1p *8021p-list*	Matches the 802.1p priority of the service provider network. The *8021p-list* argument is a list of up to eight 802.1p priority values. An 802.1p priority ranges from 0 to 7.
ip-precedence *ip-precedence-list*	Matches IP precedence. The *ip-precedence-list* argument is a list of up to eight IP precedence values. An IP precedence ranges from 0 to 7.
protocol *protocol-name*	Matches a protocol. The *protocol-name* argument can be IP or IPv6.
qos-local-id *local-id-value*	Matches a local QoS ID, ranging from 1 to 4095. The local QoS IDs supported on the device are from 1 to 3999.
source-mac *mac-address*	Matches a source MAC address.
customer-vlan-id { *vlan-id-list* | *vlan-id1* **to** *vlan-id2* }	Matches the VLAN IDs of customer networks. The *vlan-id-list* argument is a list of up to eight VLAN IDs. The *vlan-id1* **to** *vlan-id2* specifies a VLAN ID range, where the *vlan-id1* must be smaller than the *vlan-id2*. A VLAN ID ranges from 1 to 4094.
service-vlan-id { *vlan-id-list* | *vlan-id1* **to** *vlan-id2* }	Matches the VLAN IDs of ISP networks. The *vlan-id-list* is a list of up to eight VLAN IDs. The *vlan-id1* **to** *vlan-id2* specifies a VLAN ID range, where the *vlan-id1* must be smaller than the *vlan-id2*. A VLAN ID ranges from 1 to 4094.

Defining a traffic behavior

A traffic behavior is a set of QoS actions (such as traffic filtering, shaping, policing, and priority marking) to take on a class of traffic. To define a traffic behavior, first create it and then configure QoS actions, such as priority marking and traffic redirecting, in traffic behavior view

Step…	Command…	Remarks
1. Enter system view.	**system-view**	—
2. Create a traffic behavior and enter traffic behavior view.	**traffic behavior** *behavior-name*	Required.
3. Configure actions in the traffic behavior.	Choose the command based on the purpose of the traffic behavior, such as traffic policing, traffic filtering, traffic redirecting, priority marking, and traffic accounting. See subsequent chapters.	

Associating a class with behavior in a policy

You associate a behavior with a class in a QoS policy to perform the actions defined in the behavior for the class of packets.

To associate a class with a behavior in a policy:

Step…	Command…	Remarks
1. Enter system view.	**system-view**	—
2. Create a policy and enter policy view.	**qos policy** *policy-name*	Required.
3. Associate a class with a behavior in the policy.	**classifier** *tcl-name* **behavior** *behavior-name* [**mode** { **dot1q-tag-manipulation** | **qppb-manipulation** }]	Required. Repeat this step to create more class-behavior associations.

The **dot1q-tag-manipulation** keyword is only for VLAN mapping purposes. For more information about VLAN mapping, see *Layer 2—LAN Switching Configuration Guide*.

With the **mode qppb-manipulation** keyword, a class-behavior association applies only to transmitting the **apply qos-local-id** command configuration in the BGP routing policy. The **if-match qos-local-id** command in the class matches the QoS-local ID set in the **apply qos-local-id** command in the routing policy. For more information, see *Layer 3—IP Routing Configuration Guide*. Support for this keyword depends on your switch model.

NOTE:

- If an ACL is referenced by a QoS policy for defining traffic match criteria, packets matching the ACL are organized as a class and the behavior defined in the QoS policy applies to the class regardless of whether the match mode of the if-match clause is deny or permit.
- In a QoS policy with multiple class-to-traffic-behavior associations, if the action of creating an outer VLAN tag, setting customer network VLAN ID, or setting service provider network VLAN ID is configured in a traffic behavior, do not configure any other action in this traffic behavior; otherwise, the QoS policy may not function as expected after it is applied. For more information about the action of setting customer network VLAN ID or service provider network VLAN ID, see *Layer 2—LAN Switching Configuration Guide*.

Applying the QoS policy

You can apply a QoS policy to the following occasions:

- **An interface**—Policy takes effect on the traffic sent or received on the interface.
- **A VLAN**—Policy takes effect on the traffic sent or received on all ports in the VLAN.
- **Globally**—Policy takes effect on the traffic sent or received on all ports.

You can modify classes, behaviors, and class-behavior associations in a QoS policy applied to an interface, VLAN, or globally. If a class references an ACL for traffic classification, you can delete or modify the ACL (such as add rules to, delete rules from, and modify rules of the ACL).

The QoS policies applied to ports, to VLANs, and globally are in the descending priority order. If the system finds a matching QoS policy for the incoming/outgoing traffic, the system stops matching the traffic against QoS policies.

Applying the QoS policy to an interface

Both bridge mode (Layer 2) and route mode (Layer 3) Ethernet ports support a QoS policy. The term *interface* in this section collectively refers to these types of ports. Use **port link-mode** to set an Ethernet port to operate in bridge or route mode (see *Layer 2—LAN Switching Configuration Guide*).

A policy can be applied to multiple interfaces, but only one policy can be applied in one direction (inbound or outbound) of an interface.

The QoS policy applied to the outgoing traffic of a port does not regulate local packets, which are critical protocol packets sent by the device that hosts the interface for maintaining the normal operation of the device. The most common local packets include link maintenance packets, STP, LDP, and RSVP packets.

To apply the QoS policy to an interface:

Step…		Command…	Remarks
1. Enter system view.		**system-view**	—
2. Enter interface view or port group view.	Enter interface view.	**interface** *interface-type interface-number*	Use either command. Settings in interface view take effect on the current interface. Settings in port group view take effect on all ports in the port group.
	Enter port group view.	**port-group manual** *port-group-name*	
3. Apply the policy to the interface or port group.		**qos apply policy** *policy-name* { **inbound** | **outbound** }	Required.

Applying the QoS policy to a VLAN

Apply a QoS policy to a VLAN to regulate traffic of the VLAN. However, QoS policies cannot be applied to dynamic VLANs, such as VLANs created by GVRP.

Step…	Command…	Remarks
1. Enter system view.	**system-view**	—
2. Apply the QoS policy to VLANs.	**qos vlan-policy** *policy-name* **vlan** *vlan-id-list* { **inbound** | **outbound** }	Required

Applying the QoS policy globally

Apply a QoS policy globally to the inbound or outbound direction of all ports.

Step…	Command…	Remarks
1. Enter system view.	**system-view**	—
2. Apply the QoS policy globally.	**qos apply policy** *policy-name* **global** { **inbound** | **outbound** }	Required

Displaying and maintaining QoS policies

Task…	Command…	Remarks
Display traffic class configuration.	**display traffic classifier user-defined** [*tcl-name*] [**|** { **begin** | **exclude** | **include** } *regular-expression*]	Available in any view.
Display traffic behavior configuration.	**display traffic behavior user-defined** [*behavior-name*] [**|** { **begin** | **exclude** | **include** } *regular-expression*]	Available in any view.
Display user-defined QoS policy configuration.	**display qos policy user-defined** [*policy-name* [**classifier** *tcl-name*]] [**|** { **begin** | **exclude** | **include** } *regular-expression*]	Available in any view.

Task…	Command…	Remarks
Display QoS policy configuration on the specified or all interfaces.	**display qos policy interface** [*interface-type interface-number*] [**inbound** | **outbound**] [**|** { **begin** | **exclude** | **include** } *regular-expression*]	Available in any view.
Display VLAN QoS policy configuration.	**display qos vlan-policy** { **name** *policy-name* | **vlan** *vlan-id* } [**slot** *slot-number*] [**inbound** | **outbound**] [**|** { **begin** | **exclude** | **include** } *regular-expression*]	Available in any view.
Display information about QoS policies applied globally.	**display qos policy global** [**slot** *slot-number*] [**inbound** | **outbound**] [**|** { **begin** | **exclude** | **include** } *regular-expression*]	Available in any view.
Clear VLAN QoS policy statistics.	**reset qos vlan-policy** [**vlan** *vlan-id*] [**inbound** | **outbound**]	Available in user view.
Clear the statistics for a QoS policy applied globally.	**reset qos policy global** [**inbound** | **outbound**]	Available in user view.

Configuring priority mapping

Both bridge mode (Layer 2) and route mode (Layer 3) Ethernet ports support the priority mapping function. The term *interface* in this chapter collectively refers to these types of ports. Use **port link-mode** to set an Ethernet port to operate in bridge or route mode (see *Layer 2—LAN Switching Configuration Guide*).

Overview

When a packet enters a device, depending on your configuration, the device assigns a set of QoS priority parameters to the packet based on either a certain priority field carried in the packet or the port priority of the incoming port. This process is called "priority mapping". During this process, the device can modify the priority of the packet depending on device status. The set of QoS priority parameters decides the scheduling priority and forwarding priority of the packet.

Priority mapping is implemented with priority mapping tables and involves priorities such as 802.1p priority, DSCP, IP precedence, local precedence, and drop precedence.

Types of priorities

Priorities fall into the following types: priorities carried in packets, and priorities locally assigned for scheduling only.

The packet-carried priorities include 802.1p priority, DSCP precedence, IP precedence, and so on. These priorities have global significance and affect the forwarding priority of packets across the network. For more information about these priorities, see the "Appendix."

The locally assigned priorities only have local significance. They are assigned by the device for scheduling only. These priorities include the local precedence and drop precedence:

- Local precedence is used for queuing. A local precedence value corresponds to an output queue. A packet with higher local precedence is assigned to a higher priority output queue to be preferentially scheduled.
- Drop precedence is used for making packet drop decisions. Packets with the highest drop precedence are dropped preferentially.

Priority mapping tables

Priority mapping is implemented with priority mapping tables. By looking up a priority mapping table, the device decides which priority value to assign to a packet for subsequent packet processing. The switch provides the following priority mapping tables:

- **dot1p-dp**: 802.1p-to-drop priority mapping table
- **dot1p-lp**: 802.1p-to-local priority mapping table
- **dscp-dot1p**: DSCP-to-802.1p priority mapping table, which applies to only IP packets
- **dscp-dp**: DSCP-to-drop priority mapping table, which applies to only IP packets
- **dscp-dscp**: DSCP-to-DSCP priority mapping table, which applies to only IP packets

The default priority mapping tables (see “Appendix A Default priority mapping tables”) are available for priority mapping. In most cases, they are adequate for priority mapping. If a default priority mapping table cannot meet your requirements, you can modify the priority mapping table as required.

Priority trust mode on a port

The priority trust mode on a port decides which priority is used for priority mapping table lookup. Port priority was introduced to use for priority mapping in addition to priority fields carried in packets. The device provides the following priority trust modes:

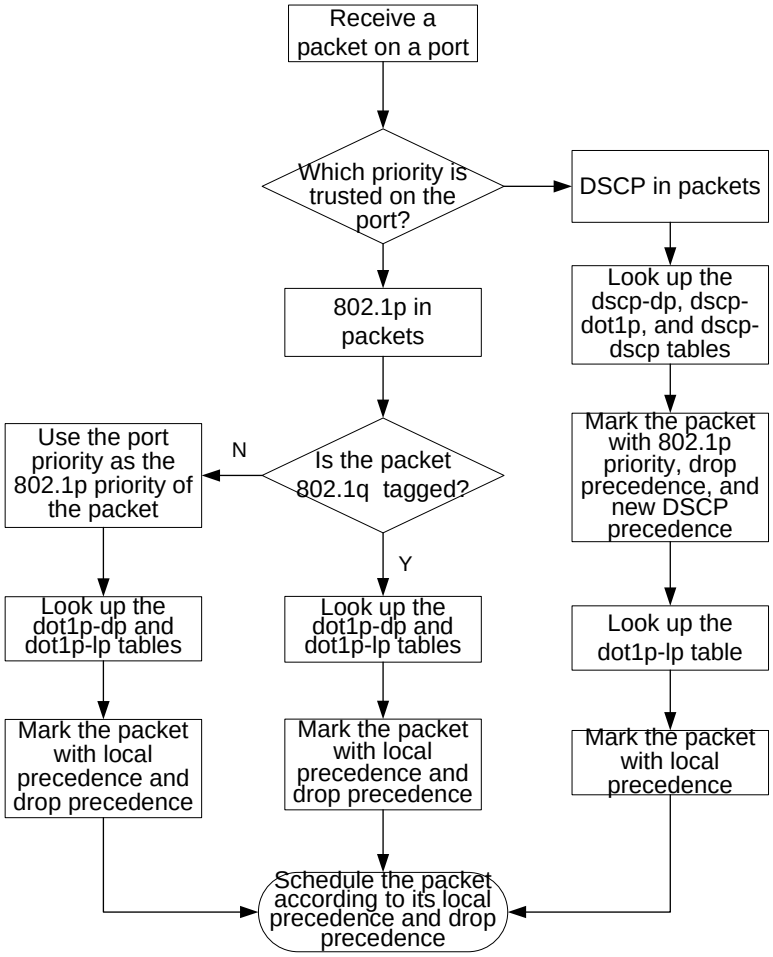
- Using the 802.1p priority carried in packets for priority mapping.
- Using the DSCP carried in packets for priority mapping.

The priority mapping procedure varies with the priority modes. For more information, see Priority mapping procedure.

Priority mapping procedure

On receiving an Ethernet packet on a port, the switch marks the scheduling priorities (local precedence and drop precedence) for the Ethernet packet. This procedure is done according to the priority trust mode of the receiving port and the 802.1q tagging status of the packet, as shown in Figure 5.

Figure 5 Priority mapping procedure for an Ethernet packet



The priority mapping procedure shown in Figure 5 applies in the absence of priority marking. If priority marking is configured, the switch performs priority marking before priority mapping. The switch then uses the re-marked packet-carried priority for priority mapping or directly uses the re-marked scheduling priority for traffic scheduling depending on your configuration. Neither priority trust mode configuration on the port nor port priority configuration takes effect.

Priority mapping configuration tasks

Modify priority mappings by modifying priority mapping tables, priority trust mode on a port, and port priority.

HP recommends planning QoS throughout the network before making your QoS configuration.

To configure priority mapping:

Task	Remarks
Configuring a priority mapping table	Optional
Configuring a port to trust packet priority for priority mapping	Optional

Task	Remarks
Changing the port priority of an interface	Optional

Configuring a priority mapping table

Step…	Command…	Remarks
1. Enter system view.	**system-view**	—
2. Enter priority mapping table view.	**qos map-table** { **dot1p-dp** | **dot1p-lp** | **dscp-dot1p** | **dscp-dp** | **dscp-dscp** }	Required.
3. Configure the priority mapping table.	**import** *import-value-list* **export** *export-value*	Required. Newly configured mappings overwrite the old ones.

Configuring a port to trust packet priority for priority mapping

When configuring the trusted packet priority type on an interface or port group, use the following priority trust modes:

- 802.1p priority of received packets for mapping.
- DSCP precedence of received IP packets for mapping.

To configure the trusted packet priority type on an interface or port group:

Step…		Command…	Remarks
1. Enter system view.		**system-view**	—
2. Enter interface view or port group view.	Enter interface view.	**interface** *interface-type interface-number*	Use either command. Settings in interface view take effect on the current interface. Settings in port group view take effect on all ports in the port group.
	Enter port group view.	**port-group manual** *port-group-name*	
3. Configure the trusted packet priority type for the interface.	Trust the DSCP priority in packets.	**qos trust dscp**	Use either command. By default, the device trusts the 802.1p priority in packets.
	Trust the 802.1p priority in packets.	**qos trust dot1p**	

Changing the port priority of an interface

Step…		Command…	Remarks
1. Enter system view.		**system-view**	—
2. Enter interface view or port group view.	Enter interface view.	**interface** *interface-type interface-number*	Use either command. Settings in interface view take effect on the current interface. Settings in port group view take effect on all ports in the port group.
	Enter port group view.	**port-group manual** *port-group-name*	
3. Set the port priority of the interface.		**qos priority** *priority-value*	Required. The default port priority is 0.

Displaying priority mapping

Step…	Command…	Remarks
Display priority mapping table configuration.	**display qos map-table** [**dot1p-dp** | **dot1p-lp** | **dscp-dot1p** | **dscp-dp** | **dscp-dscp**] [| { **begin** | **exclude** | **include** } *regular-expression*]	Available in any view.
Display the trusted packet priority type on a port.	**display qos trust interface** [*interface-type interface-number*] [| { **begin** | **exclude** | **include** } *regular-expression*]	Available in any view.

Priority mapping configuration examples

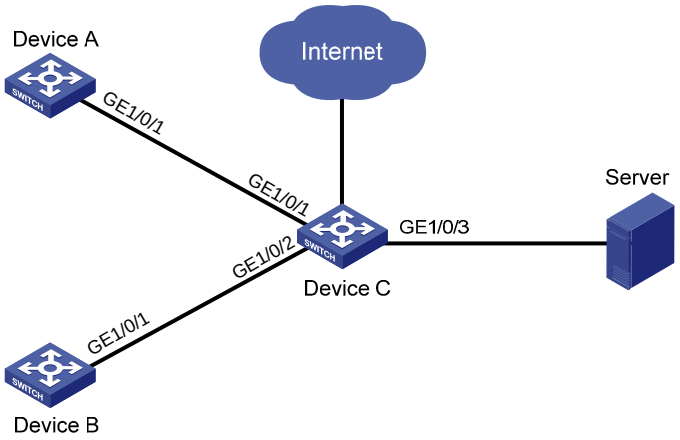
Priority trust mode configuration example

Network requirements

As shown in Figure 6, Device A is connected to GigabitEthernet 1/0/1 of Device C, Device B is connected to GigabitEthernet 1/0/2 of Device C, and the packets from Device A and Device B to Device C are not VLAN tagged.

Set configurations to have Device C preferentially process packets from Device A to Server when GigabitEthernet 1/0/3 of Device C is congested.

Figure 6 Network diagram for priority trust mode configuration



Configuration procedure

Assign port priority to GigabitEthernet 1/0/1 and GigabitEthernet 1/0/2. Make sure that the priority of GigabitEthernet 1/0/1 is higher than that of GigabitEthernet 1/0/2, and no trusted packet priority type is configured on GigabitEthernet 1/0/1 or GigabitEthernet 1/0/2.

```
<DeviceC> system-view
[DeviceC] interface gigabitethernet 1/0/1
[DeviceC-GigabitEthernet1/0/1] qos priority 3
[DeviceC-GigabitEthernet1/0/1] quit
[DeviceC] interface gigabitethernet 1/0/2
[DeviceC-GigabitEthernet1/0/2] qos priority 1
[DeviceC-GigabitEthernet1/0/2] quit
```

Priority mapping table and priority marking configuration example

Network requirements

As shown in Figure 7, the company's enterprise network interconnects all departments through Device. The network is described as follows:

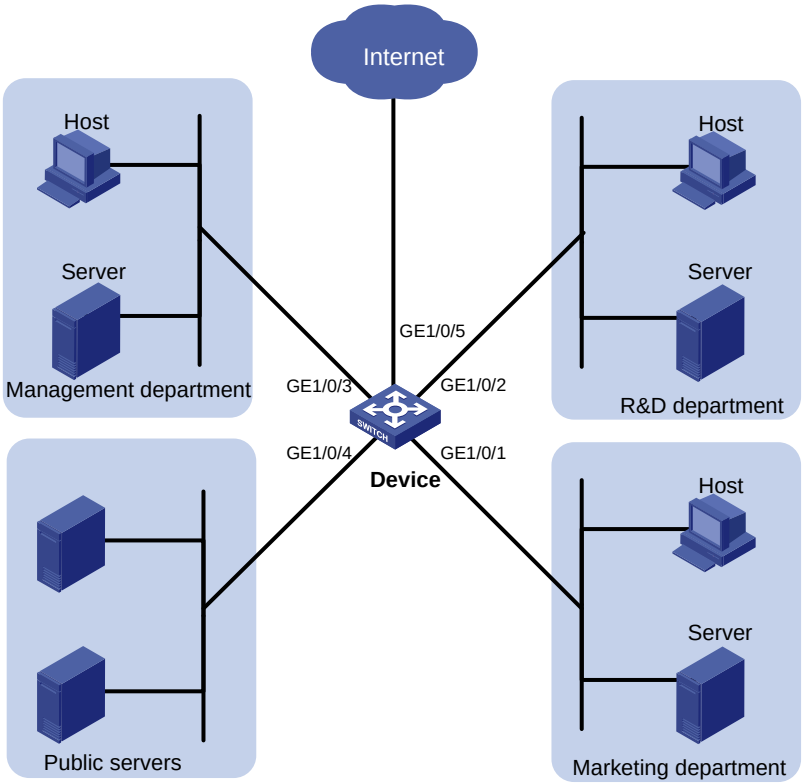
- The marketing department connects to GigabitEthernet 1/0/1 of Device, which sets the 802.1p priority of traffic from the marketing department to 3.
- The R&D department connects to GigabitEthernet 1/0/2 of Device, which sets the 802.1p priority of traffic from the R&D department to 4.
- The management department connects to GigabitEthernet 1/0/3 of Device, which sets the 802.1p priority of traffic from the management department to 5.

Configure port priority, 802.1p-to-local mapping table, and priority marking to implement the plan as described in Table 3.

Table 3 Configuration plan

Traffic destination	Traffic priority order	Queuing plan		
		Traffic source	Output queue	Queue priority
Public servers	R&D department > management department > marketing department	R&D department	6	High
		Management department	4	Medium
		Marketing department	2	Low
Internet	Management department > marketing department > R&D department	R&D department	2	Low
		Management department	6	High
		Marketing department	3	Medium

Figure 7 Network diagram for priority mapping table and priority marking configuration



Configuration procedure

1. Configure trusting port priority.

   # Set the port priority of GigabitEthernet 1/0/1 to 3.

```
<Device> system-view
[Device] interface gigabitethernet 1/0/1
[Device-GigabitEthernet1/0/1] qos priority 3
[Device-GigabitEthernet1/0/1] quit
```

   # Set the port priority of GigabitEthernet 1/0/2 to 4.

```
[Device] interface gigabitethernet 1/0/2
[Device-GigabitEthernet1/0/2] qos priority 4
```

```
[Device-GigabitEthernet1/0/2] quit
```

Set the port priority of GigabitEthernet 1/0/3 to 5.

```
[Device] interface gigabitethernet 1/0/3
[Device-GigabitEthernet1/0/3] qos priority 5
[Device-GigabitEthernet1/0/3] quit
```

2. Configure the priority mapping table.

   # Configure the 802.1p-to-local mapping table to map 802.1p priority values 3, 4, and 5 to local precedence values 2, 6, and 4. This guarantees the R&D department, management department, and marketing department decreased priorities to access the public server.

```
[Device] qos map-table dot1p-lp
[Device-maptbl-dot1p-lp] import 3 export 2
[Device-maptbl-dot1p-lp] import 4 export 6
[Device-maptbl-dot1p-lp] import 5 export 4
[Device-maptbl-dot1p-lp] quit
```

3. Configure priority marking.

   # Mark the HTTP traffic of the management department, marketing department, and R&D department to the Internet with 802.1p priorities 4, 5, and 3, respectively. Use the priority mapping table you have configured to map the 802.1p priorities to local precedence values 6, 4, and 2, respectively, for differentiated traffic treatment.

   # Create ACL 3000 to match HTTP traffic.

```
[Device] acl number 3000
[Device-acl-adv-3000] rule permit tcp destination-port eq 80
[Device-acl-adv-3000] quit
```

   # Create class **http** and reference ACL 3000 in the class.

```
[Device] traffic classifier http
[Device-classifier-http] if-match acl 3000
[Device-classifier-http] quit
```

   # Configure a priority marking policy for the management department, and apply the policy to the incoming traffic of GigabitEthernet 1/0/3.

```
[Device] traffic behavior admin
[Device-behavior-admin] remark dot1p 4
[Device-behavior-admin] quit
[Device] qos policy admin
[Device-qospolicy-admin] classifier http behavior admin
[Device-qospolicy-admin] quit
[Device] interface gigabitethernet 1/0/3
[Device-GigabitEthernet1/0/3] qos apply policy admin inbound
```

   # Configure a priority marking policy for the marketing department, and apply the policy to the incoming traffic of GigabitEthernet 1/0/1.

```
[Device] traffic behavior market
[Device-behavior-market] remark dot1p 5
[Device-behavior-market] quit
[Device] qos policy market
[Device-qospolicy-market] classifier http behavior market
[Device-qospolicy-market] quit
[Device] interface gigabitethernet 1/0/1
```

```
[Device-GigabitEthernet1/0/1] qos apply policy market inbound
```

Configure a priority marking policy for the R&D department, and apply the policy to the incoming traffic of GigabitEthernet 1/0/2.

```
[Device] traffic behavior rd
[Device-behavior-rd] remark dot1p 3
[Device-behavior-rd] quit
[Device] qos policy rd
[Device-qospolicy-rd] classifier http behavior rd
[Device-qospolicy-rd] quit
[Device] interface gigabitethernet 1/0/2
[Device-GigabitEthernet1/0/2] qos apply policy rd inbound
```

Configuring traffic policing, traffic shaping, and line rate

Overview

Traffic policing, traffic shaping, and rate limit are QoS technologies that help assign network resources, such as assign bandwidth. They increase network performance and user satisfaction. For example, you can configure a flow to use only the resources committed to it in a certain time range. This avoids network congestion caused by burst traffic.

Traffic policing, GTS, and line rate limit the traffic rate and resource usage according to traffic specifications. Once a particular flow exceeds its specifications, such as assigned bandwidth, the flow is shaped or policed to make sure that it is under the specifications. Use token buckets for evaluating traffic specifications.

Traffic evaluation and token buckets

Token bucket features

A token bucket is analogous to a container that holds a certain number of tokens. Each token represents a certain forwarding capacity. The system puts tokens into the bucket at a constant rate. When the token bucket is full, the extra tokens cause the token bucket to overflow.

Evaluating traffic with the token bucket

A token bucket mechanism evaluates traffic by looking at the number of tokens in the bucket. If the number of tokens in the bucket is enough for forwarding the packets, the traffic conforms to the specification, and is called "conforming traffic". Otherwise, the traffic does not conform to the specification, and is called "excess traffic".

A token bucket has the following configurable parameters:

- Mean rate at which tokens are put into the bucket, which is the permitted average rate of traffic. It is usually set to the CIR.
- Burst size or the capacity of the token bucket. It is the maximum traffic size permitted in each burst. It is usually set to the CBS. The set burst size must be greater than the maximum packet size.

Each arriving packet is evaluated. In each evaluation, if the number of tokens in the bucket is enough, the traffic conforms to the specification and the tokens for forwarding the packet are taken away; if the number of tokens in the bucket is not enough, the traffic is excessive.

Complicated evaluation

You can set two token buckets, bucket C and bucket E, to evaluate traffic in a more complicated environment and achieve more policing flexibility. For example, traffic policing uses the following parameters:

- **CIR**: Rate at which tokens are put into bucket C. It sets the average packet transmission or forwarding rate allowed by bucket C.
- **CBS**: Size of bucket C, which specifies the transient burst of traffic that bucket C can forward.

- **PIR**: Rate at which tokens are put into bucket E, which specifies the average packet transmission or forwarding rate allowed by bucket E.
- **EBS**: Size of bucket E, which specifies the transient burst of traffic that bucket E can forward.

CBS is implemented with bucket C, and EBS with bucket E. In each evaluation, packets are measured against the following bucket scenarios:

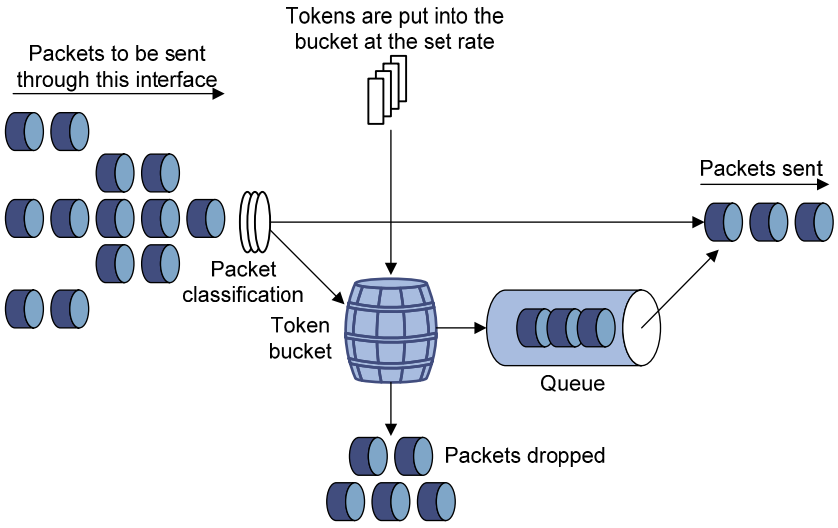
- If bucket C has enough tokens, packets are colored green.
- If bucket C does not have enough tokens but bucket E has enough tokens, packets are colored yellow.
- If neither bucket C nor bucket E has sufficient tokens, packets are colored red.

Traffic policing

Traffic policing supports policing the inbound traffic and the outbound traffic. The outbound traffic is taken for example.

A typical application of traffic policing is to supervise the specification of certain traffic entering a network and limit it within a reasonable range, or to "discipline" the extra traffic. In this way, the network resources and the interests of the carrier are protected. For example, you can limit bandwidth for HTTP packets to less than 50% of the total. If the traffic of a certain session exceeds the limit, traffic policing can drop the packets or reset the IP precedence of the packets.

Figure 8 Schematic diagram for traffic policing



Traffic policing is widely used in policing traffic entering the networks of ISPs. It can classify the policed traffic and take pre-defined policing actions on each packet depending on the evaluation result:

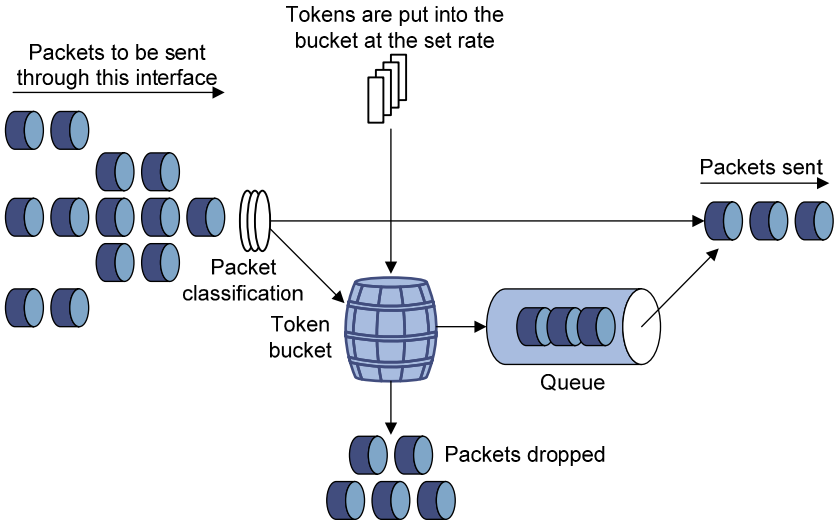
- Forwarding the packet if the evaluation result is “conforming”
- Dropping the packet if the evaluation result is “excess”
- Forwarding the packet with its DSCP precedence re-marked if the evaluation result is “conforming”

Traffic shaping

Traffic shaping shapes the outbound traffic. It provides measures to adjust the rate of outbound traffic actively. A typical traffic shaping application limits the local traffic output rate according to the downstream traffic policing parameters.

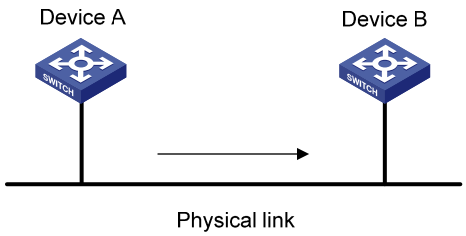
The difference between traffic policing and GTS is that packets to be dropped with traffic policing are retained in a buffer or queue with GTS, as shown in Figure 9. When enough tokens are in the token bucket, the buffered packets are sent at an even rate. Traffic shaping can result in additional delay and traffic policing does not.

Figure 9 Schematic diagram for GTS



For example, in Figure 10, Device A sends packets to Device B. Device B performs traffic policing on packets from Device A and drops packets exceeding the limit.

Figure 10 GTS application



Perform traffic shaping for the packets on the outgoing interface of Device A to avoid unnecessary packet loss. Packets exceeding the limit are cached in Device A. Once resources are released, traffic shaping takes out the cached packets and sends them out. In this way, all of the traffic sent to Device B conforms to the traffic specification defined in Device B.

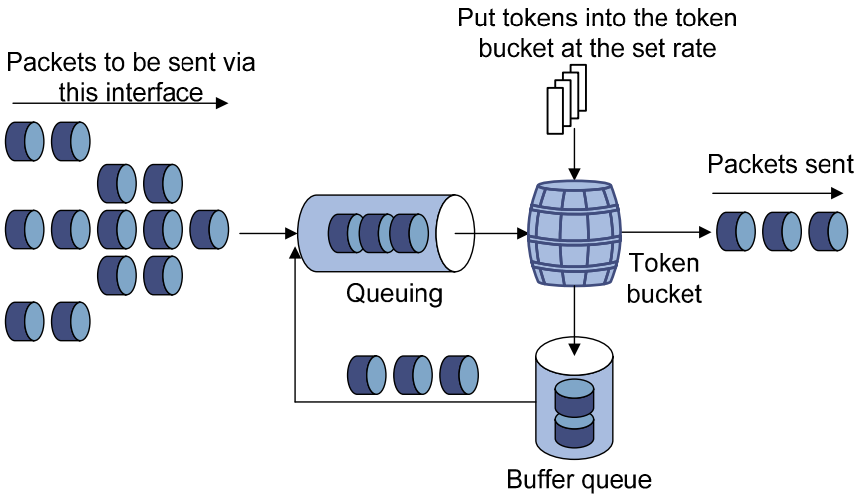
Line rate

Line rate supports rate-limiting the inbound traffic and the outbound traffic. The outbound traffic is taken for example.

The line rate of a physical interface specifies the maximum rate for forwarding packets (including critical packets).

Line rate also uses token buckets for traffic control. With line rate configured on an interface, all packets to be sent through the interface are handled by the token bucket at line rate. If enough tokens are in the token bucket, packets can be forwarded. Otherwise, packets are put into QoS queues for congestion management. In this way, the traffic passing the physical interface is controlled.

Figure 11 Line rate implementation



The token bucket mechanism limits traffic rate when accommodating bursts. It allows bursty traffic to be transmitted if enough tokens are available. If tokens are scarce, packets cannot be transmitted until efficient tokens are generated in the token bucket. It restricts the traffic rate to the rate for generating tokens.

Line rate can only limit traffic rate on a physical interface, and traffic policing can limit the rate of a flow on an interface. To limit the rate of all packets on interfaces, using line rate is easier.

Configuring traffic policing

Step…	Command…	Remarks
1. Enter system view.	**system-view**	—
2. Create a class and enter class view.	**traffic classifier** *tcl-name* [**operator** { **and** | **or** }]	—
3. Configure match criteria.	**if-match** *match-criteria*	—
4. Return to system view.	**quit**	—
5. Create a behavior and enter behavior view.	**traffic behavior** *behavior-name*	—

Step…		Command…	Remarks
6. Configure a traffic policing action.		**car cir** *committed-information-rate* [**cbs** *committed-burst-size* [**ebs** *excess-burst-size*]] [**pir** *peak-information-rate*] [**green** *action*] [**yellow** *action*] [**red** *action*]	Required
7. Return to system view.		**quit**	—
8. Create a policy and enter policy view.		**qos policy** *policy-name*	—
9. Associate the class with the traffic behavior in the QoS policy.		**classifier** *tcl-name* **behavior** *behavior-name*	—
10. Return to system view.		**quit**	—
11. Apply the QoS policy.	To an interface	Applying the QoS policy to an interface.	—
	To a VLAN	Applying the QoS policy to a VLAN.	—
	Globally	Applying the QoS policy globally.	—

Configuring GTS

The device supports queue-based GTS, which shapes traffic of a specific queue.

The device supports the following types of GTS:

- **Queue-based GTS**—Shapes traffic of a specific queue.
- **GTS applicable to all traffic**—Shapes all traffic.

NOTE:

The A5830AF-48G/A5830AF-48G TAA switch supports the two types of GTS mentioned above. The A5830AF-96G/A5830AF-96G TAA switch supports only GTS applicable to all traffic.

Configuring queue-based GTS

Step…		Command…	Remarks
1. Enter system view.		**system-view**	—
2. Enter interface view or port group view.	Enter interface view.	**interface** *interface-type interface-number*	Use either command. Settings in interface view take effect on the current interface. Settings in port group view take effect on all ports in the port group.
	Enter port group view.	**port-group manual** *port-group-name*	
3. Configure GTS for a queue.		**qos gts queue** *queue-number* **cir** *committed-information-rate*	Required.

Configuring GTS for all traffic

Step…		Command…	Remarks
1. Enter system view.		**system-view**	—
2. Enter interface view or port group view.	Enter interface view.	**interface** *interface-type interface-number*	Use either command. Settings in interface view take effect on the current interface. Settings in port group view take effect on all ports in the port group.
	Enter port group view.	**port-group manual** *port-group-name*	
3. Configure GTS on the interface or port group.		**qos gts any cir** *committed-information-rate*	Required.

Configuring the line rate

The line rate of a physical interface specifies the maximum rate of incoming packets or outgoing packets.

Step…		Command…	Remarks
1. Enter system view.		**system-view**	—
2. Enter interface view or port group view.	Enter interface view.	**interface** *interface-type interface-number*	Use either command. Settings in interface view take effect on the current interface. Settings in port group view take effect on all ports in the port group.
	Enter port group view.	**port-group manual** *port-group-name*	
3. Configure the line rate for the interface or port group.		**qos lr** { **inbound** | **outbound** } **cir** *committed-information-rate* [**cbs** *committed-burst-size*]	Required.

Displaying traffic policing, GTS, and line rate

On the device, you can configure traffic policing in policy-based approach. For more information about the displaying and maintaining commands, see "QoS configuration approaches."

Task…	Command…	Remarks
Display interface GTS configuration information.	**display qos gts interface** [*interface-type interface-number*] [**|** { **begin** | **exclude** | **include** } *regular-expression*]	Available in any view.
Display interface line rate configuration information.	**display qos lr interface** [*interface-type interface-number*] [**|** { **begin** | **exclude** | **include** } *regular-expression*]	Available in any view.

Traffic policing configuration example

Network requirements

As shown in Figure 12:

- GigabitEthernet 1/0/3 of Device A is connected to GigabitEthernet1/0/1 of Device B.
- Server, Host A, and Host B can access the Internet through Device A and Device B.

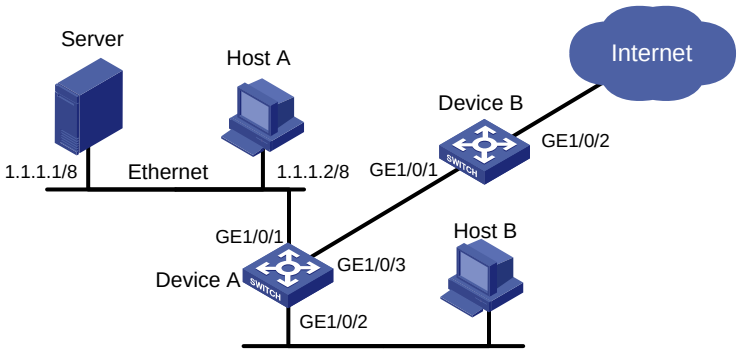
Perform traffic control on GigabitEthernet 1/0/1 of Device A for traffic received from Server and Host A, respectively, to satisfy the following requirements:

- Limit the rate of traffic from Server to 1024 kbps: transmit the conforming traffic normally, and mark the excess traffic with DSCP value 0 and then transmit the traffic.
- Limit the rate of traffic from Host A to 256 kbps: transmit the conforming traffic normally, and drop the excess traffic.

Perform traffic control on GigabitEthernet 1/0/1 and GigabitEthernet 1/0/2 of Device B to satisfy the following requirements:

- Limit the total incoming traffic rate of GigabitEthernet 1/0/1 to 2048 kbps, and drop the excess traffic.
- Limit the outgoing HTTP traffic (traffic accessing the Internet) rate of GigabitEthernet 1/0/2 to 1024 kbps, and drop the excess traffic.

Figure 12 Network diagram for traffic policing configuration



Configuration procedures

1. Configure Device A.

Configure ACL 2001 and ACL 2002 to match traffic from Server and Host A, respectively.

```
<DeviceA> system-view
[DeviceA] acl number 2001
[DeviceA-acl-basic-2001] rule permit source 1.1.1.1 0
[DeviceA-acl-basic-2001] quit
[DeviceA] acl number 2002
[DeviceA-acl-basic-2002] rule permit source 1.1.1.2 0
[DeviceA-acl-basic-2002] quit
```

Create a class named **server**, and use ACL 2001 as the match criterion. Create a class named **host**, and use ACL 2002 as the match criterion.

```
[DeviceA] traffic classifier server
[DeviceA-classifier-server] if-match acl 2001
```

```
[DeviceA-classifier-server] quit
[DeviceA] traffic classifier host
[DeviceA-classifier-host] if-match acl 2002
[DeviceA-classifier-host] quit
```

Create a behavior named **server**, and configure the CAR action for the behavior as follows: set the CIR to 1024 kbps, and mark the excess packets (red packets) with DSCP value 0 and transmit them.

```
[DeviceA] traffic behavior server
[DeviceA-behavior-server] car cir 1024 red remark-dscp-pass 0
[DeviceA-behavior-server] quit
```

Create a behavior named **host**, and configure the CAR action for the behavior as follows: set the CIR to 256 kbps.

```
[DeviceA] traffic behavior host
[DeviceA-behavior-host] car cir 256
[DeviceA-behavior-host] quit
```

Create a QoS policy named **car**, and associate class **server** with behavior **server** and class **host** with behavior **host**.

```
[DeviceA] qos policy car
[DeviceA-qospolicy-car] classifier server behavior server
[DeviceA-qospolicy-car] classifier host behavior host
[DeviceA-qospolicy-car] quit
```

Apply QoS policy **car** to the incoming traffic of port GigabitEthernet 1/0/1.

```
[DeviceA] interface GigabitEthernet 1/0/1
[DeviceA-GigabitEthernet1/0/1] qos apply policy car inbound
```

2. Configure Device B.

Configure advanced ACL 3001 to match HTTP traffic.

```
<DeviceB> system-view
[DeviceB] acl number 3001
[DeviceB-acl-adv-3001] rule permit tcp destination-port eq 80
[DeviceB-acl-adv-3001] quit
```

Create a class named **http**, and use ACL 3001 as the match criterion.

```
[DeviceB] traffic classifier http
[DeviceB-classifier-http] if-match acl 3001
[DeviceB-classifier-http] quit
```

Create a class named **class**, and configure the class to match all packets.

```
[DeviceB] traffic classifier class
[DeviceB-classifier-class] if-match any
[DeviceB-classifier-class] quit
```

Create a behavior named **car_inbound**, and configure the CAR action for the behavior as follows: set the CIR to 2048 kbps.

```
[DeviceB] traffic behavior car_inbound
[DeviceB-behavior-car_inbound] car cir 2048
[DeviceB-behavior-car_inbound] quit
```

Create a behavior named **car_outbound**, and configure a CAR action for the behavior as follows: set the CIR to 1024 kbps.

```
[DeviceB] traffic behavior car_outbound
```

```
[DeviceB-behavior-car_outbound] car cir 1024
[DeviceB-behavior-car_outbound] quit
```

Create a QoS policy named **car_inbound**, and associate class **class** with traffic behavior **car_inbound** in the QoS policy.

```
[DeviceB] qos policy car_inbound
[DeviceB-qospolicy-car_inbound] classifier class behavior car_inbound
[DeviceB-qospolicy-car_inbound] quit
```

Create a QoS policy named **car_outbound**, and associate class **http** with traffic behavior **car_outbound** in the QoS policy.

```
[DeviceB] qos policy car_outbound
[DeviceB-qospolicy-car_outbound] classifier http behavior car_outbound
[DeviceB-qospolicy-car_outbound] quit
```

Apply QoS policy **car_inbound** to the incoming traffic of port GigabitEthernet 1/0/1.

```
[DeviceB] interface GigabitEthernet 1/0/1
[DeviceB-GigabitEthernet1/0/1] qos apply policy car inbound
```

Apply QoS policy **car_outbound** to the outgoing traffic of port GigabitEthernet 1/0/2.

```
[DeviceB] interface GigabitEthernet 1/0/2
[DeviceB-GigabitEthernet1/0/2] qos apply policy car outbound
```

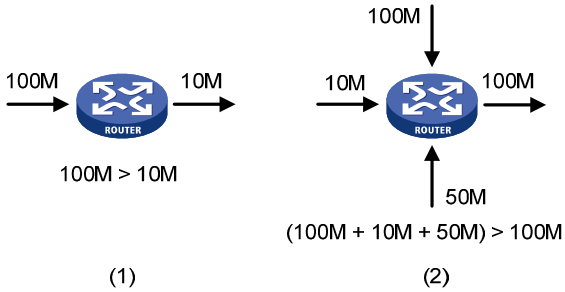
Configuring congestion management

Overview

Network congestion degrades service quality on a traditional network. Congestion is a situation where the forwarding rate decreases due to insufficient resources, resulting in extra delay.

Congestion is more likely to occur in complex packet switching circumstances. Figure 13 shows two common cases:

Figure 13 Traffic congestion causes



Congestion can bring the following negative results:

- Increased delay and jitter during packet transmission
- Decreased network throughput and resource use efficiency
- Network resource (memory, in particular) exhaustion and system breakdown

Congestion is unavoidable in switched networks and multi-user application environments. To improve the service performance of your network, you must take proper measures to address the congestion issues.

The key to congestion management is defining a dispatching policy for resources to decide the order of forwarding packets when congestion occurs.

Techniques

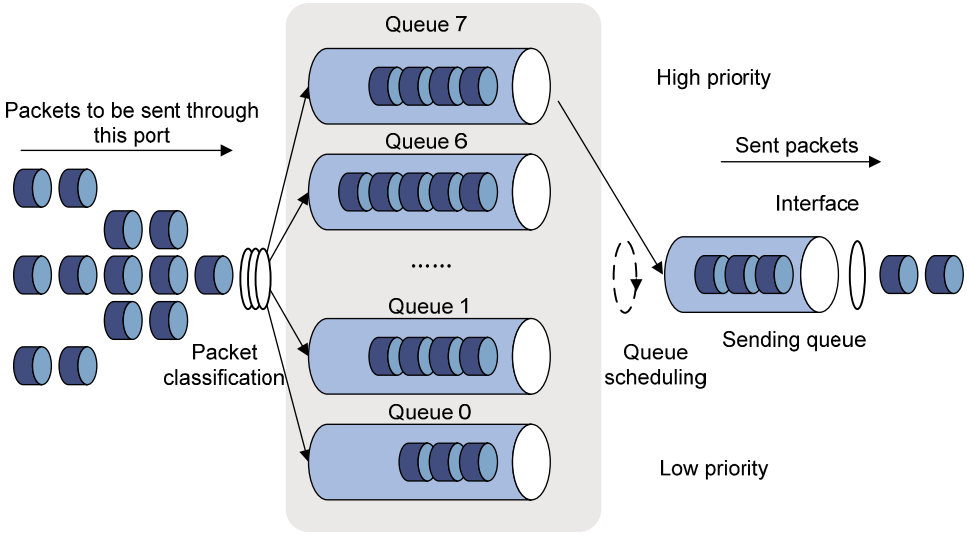
Congestion management uses queuing and scheduling algorithms to classify and sort traffic leaving a port. Each queuing algorithm addresses a particular network traffic problem, and has a different impact on bandwidth resource assignment, delay, and jitter.

Queue scheduling processes packets by their priorities, preferentially forwarding high-priority packets. The following section describes SP, WFQ, WRR, SP+WRR, and SP+WFQ queuing.

SP queuing

SP queuing is designed for mission-critical applications that require preferential service to reduce the response delay when congestion occurs.

Figure 14 Schematic diagram for SP queuing



In Figure 14, SP queuing classifies eight queues on a port into eight classes, numbered 7 to 0 in descending priority order.

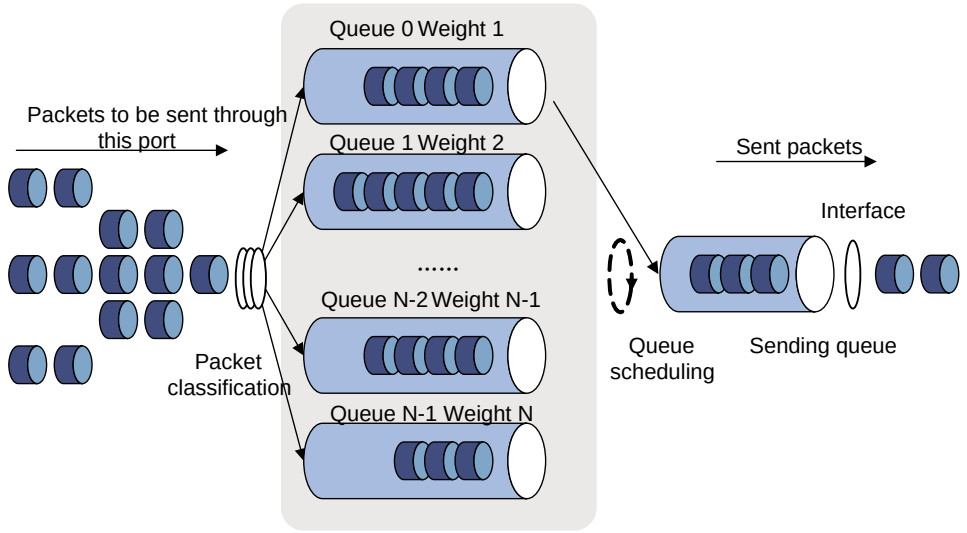
SP queuing schedules the eight queues in the descending order of priority. SP queuing sends packets in the queue with the highest priority first. When the queue with the highest priority is empty, it sends packets in the queue with the second highest priority, and so on. Assign mission-critical packets to the high priority queue to make sure that they are always served first, and assign common service packets to the low priority queues and transmitted when the high priority queues are empty.

The disadvantage of SP queuing is that packets in the lower priority queues cannot be transmitted if packets exist in the higher priority queues. This may cause lower priority traffic to starve to death.

WRR queuing

WRR queuing schedules all queues in turn to make sure every queue is served for a certain time, as shown in Figure 15.

Figure 15 Schematic diagram for WRR queuing



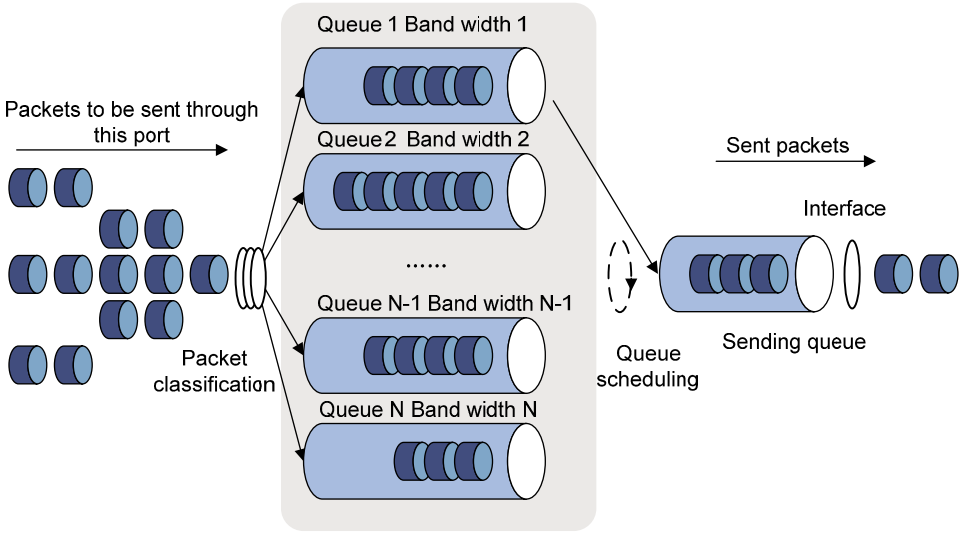
Assume a port provides eight output queues. WRR assigns each queue a weight value (represented by w7, w6, w5, w4, w3, w2, w1, or w0) to decide the proportion of resources assigned to the queue.

The device supports byte-count weight (which determines the weight by the number of bytes scheduled in a cycle) or packet-based weight (which determines the weight by the number of packets scheduled in a cycle). Using the byte-count weight as an example, on a 100 Mbps port, you can configure the weight values of WRR queuing to 5, 5, 3, 3, 1, 1, 1, and 1 (corresponding to w7, w6, w5, w4, w3, w2, w1, and w0, respectively). In this way, the queue with the lowest priority can get a minimum of 5 Mbps of bandwidth. WRR avoids the disadvantage of SP queuing, where packets in low-priority queues can fail to be served for a long time.

Another advantage of WRR queuing is that when the queues are scheduled in turn, the service time for each queue is not fixed. If a queue is empty, the next queue is scheduled immediately. This improves bandwidth resource use efficiency.

WFQ queuing

Figure 16 Schematic diagram for WFQ queuing



WFQ is similar to WRR and can be used as an alternative to WRR.

WFQ works with the minimum guaranteed bandwidth as follows:

- By setting the minimum guaranteed bandwidth, you can make sure that each WFQ queue is assured of certain bandwidth.
- The assignable bandwidth is allocated based on the priority of each queue (assignable bandwidth = total bandwidth – the sum of minimum guaranteed bandwidth of each queue).

For example, assume the total bandwidth of a port is 10 Mbps, and the port has five flows, with the precedence being 0, 1, 2, 3, and 4 and the minimum guaranteed bandwidth being 128 kbps, 128 kbps, 128 kbps, 64 kbps, and 64 kbps, respectively.

- The assignable bandwidth = 10 Mbps – (128 kbps + 128 kbps + 128 kbps + 64 kbps + and 64 kbps) = 9.5 Mbps.
- The total assignable bandwidth quota is the sum of all (precedence value + 1)s, 1 + 2 + 3 + 4 + 5 = 15.
- The bandwidth percentage assigned to each flow is (precedence value of the flow + 1)/total assignable bandwidth quota. The bandwidth percentages for the flows are 1/15, 2/15, 3/15, 4/15, and 5/15, respectively.

- The bandwidth assigned to a queue = the minimum guaranteed bandwidth + the bandwidth allocated to the queue from the assignable bandwidth.

SP+WRR queuing

Assign some queues on a port to the SP scheduling group and the others to the WRR scheduling group (group 1) to implement SP + WRR queue scheduling. The switch schedules packets in the SP scheduling group preferentially, and when the SP scheduling group is empty, schedules the packets in the WRR scheduling group. Queues in the SP scheduling group are scheduled with the SP queue scheduling algorithm. Queues in the WRR scheduling group are scheduled with WRR.

SP+WFQ queuing

SP+WFQ queuing is similar to SP+WRR queuing. Assign some queues on a port to the SP scheduling group and the others to the WFQ scheduling group to implement SP + WFQ queue scheduling. The switch schedules packets of queues in the WFQ group based on their minimum guaranteed bandwidth settings, then uses SP queuing to schedule the queues in the SP scheduling group, and at last uses WFQ to schedule the queues in the WFQ scheduling group in a round robin fashion according to their weights.

Congestion management configuration task list

To configure congestion management:

Task	Remarks
Configuring SP queuing	Use either configuration as needed.
Configuring WRR queuing	
Configuring WFQ queuing	
Configuring SP+WRR queuing	
Configuring SP+WFQ queuing	

Configuring SP queuing

Step…		Command…	Remarks
1. Enter system view.		**system-view**	—
2. Enter interface view or port group view.	Enter interface view.	**interface** *interface-type interface-number*	Use either command. Settings in interface view take effect on the current interface. Settings in port group view take effect on all ports in the port group.
	Enter port group view.	**port-group manual** *port-group-name*	

Step…	Command…	Remarks
3. Configure SP queuing.	**qos sp**	Optional. Default queuing algorithm on an interface is SP queuing.
4. Display SP queuing configuration.	**display qos sp interface** [*interface-type interface-number*] [| { **begin** | **exclude** | **include** } *regular-expression*]	Optional. Available in any view.

Configuration example

Network requirements

Configure GigabitEthernet 1/0/1 to use SP queuing.

Configuration procedure

Enter system view

```
<Sysname> system-view
```

Configure GigabitEthernet1/0/1 to use SP queuing.

```
[Sysname] interface gigabitethernet 1/0/1
[Sysname-GigabitEthernet1/0/1] qos sp
```

Configuring WRR queuing

To guarantee successful WRR configuration, make sure that the scheduling weight type (byte-count or packet-based) is the same as the WRR queuing type (byte-count or packet-based) when configuring the scheduling weight for a WRR queue.

Step…		Command…	Remarks
1. Enter system view.		**system-view**	—
2. Enter interface view or port group view.	Enter interface view.	**interface** *interface-type interface-number*	Use either command. Settings in interface view take effect on the current interface. Settings in port group view take effect on all ports in the port group.
	Enter port group view.	**port-group manual** *port-group-name*	
3. Enable byte-count or packet-based WRR queuing.		**qos wrr** [**byte-count** | **weight**]	Required. Default queuing algorithm on an interface is SP queuing.
4. Configure the scheduling weight for a queue.	For a byte-count WRR queue.	**qos wrr** *queue-id* **group** *group-id* **byte-count** *schedule-value*	Select an approach according to the WRR queuing type. By default, byte-count WRR is used, and the weights of queues 0 through 7 are 1, 2, 3, 4, 5, 6, 7, and 8.
	For a packet-based WRR queue.	**qos wrr** *queue-id* **group** *group-id* **weight** *schedule-value*	
5. Display WRR queuing configuration information on interfaces.		**display qos wrr interface** [*interface-type interface-number*] [| { **begin** | **exclude** | **include** } *regular-expression*]	Optional. Available in any view.

Configuration example

Network requirements

- Enable packet-based WRR on port GigabitEthernet 1/0/1.
- Assign queues 0 through 7 to the WRR group, with the weights being 1, 2, 4, 6, 8, 10, 12, and 14.

Configuration procedure

Enter system view.

```
<Sysname> system-view
```

Configure WRR queuing on port GigabitEthernet 1/0/1.

```
[Sysname] interface GigabitEthernet 1/0/1
[Sysname-GigabitEthernet1/0/1] qos wrr weight
[Sysname-GigabitEthernet1/0/1] qos wrr 0 group 1 weight 1
[Sysname-GigabitEthernet1/0/1] qos wrr 1 group 1 weight 2
[Sysname-GigabitEthernet1/0/1] qos wrr 2 group 1 weight 4
[Sysname-GigabitEthernet1/0/1] qos wrr 3 group 1 weight 6
[Sysname-GigabitEthernet1/0/1] qos wrr 4 group 1 weight 8
[Sysname-GigabitEthernet1/0/1] qos wrr 5 group 1 weight 10
[Sysname-GigabitEthernet1/0/1] qos wrr 6 group 1 weight 12
[Sysname-GigabitEthernet1/0/1] qos wrr 7 group 1 weight 14
```

Configuring WFQ queuing

To guarantee successful WFQ configuration, make sure that the scheduling weight type (byte-count or packet-based) is the same as the WFQ queuing type (byte-count or packet-based) when configuring the scheduling weight for a WFQ queue.

Step…		Command…	Remarks
1. Enter system view.		**system-view**	—
2. Enter interface view or port group view.	Enter interface view.	**interface** *interface-type interface-number*	Use either command. Settings in interface view take effect on the current interface. Settings in port group view take effect on all ports in the port group.
	Enter port group view.	**port-group manual** *port-group-name*	
3. Enable byte-count or packet-based WFQ queuing.		**qos wfq** [**byte-count** | **weight**]	Required. Default queuing algorithm on an interface is SP queuing.
4. Configure the scheduling weight for a queue.	For a byte-count WFQ queue	**qos wfq** *queue-id* **group** *group-id* **byte-count** *schedule-value*	Select a command according to the WFQ type (byte-count or packet-based) you have enabled. If you have enabled WFQ on the port, byte-count WRR applies by default and the default scheduling weight is 1 for each queue.
	For a packet-based WFQ queue	**qos wfq** *queue-id* **group** *group-id* **weight** *schedule-value*	

Step…	Command…	Remarks
5. Configure the minimum guaranteed bandwidth for a WFQ queue.	**qos bandwidth queue** *queue-id* **min** *bandwidth-value*	Optional. No minimum guaranteed bandwidth is configured by default.
6. Display WFQ queuing configuration.	**display qos wfq interface** [*interface-type interface-number*] [**|** { **begin** | **exclude** | **include** } *regular-expression*]	Optional. Available in any view.

Configuration example

Network requirements

Configure WFQ queues on an interface and assign the scheduling weight 2, 5, 10, 10, and 10 to queue 1, queue 3, queue 4, queue 5, and queue 6, respectively.

Configuration procedure

Enter system view.

```
<Sysname> system-view
```

Configure WFQ queues on GigabitEthernet 1/0/1.

```
[Sysname] interface gigabitethernet 1/0/1
[Sysname-GigabitEthernet1/0/1] qos wfq
[Sysname-GigabitEthernet1/0/1] qos wfq 1 weight 2
[Sysname-GigabitEthernet1/0/1] qos wfq 3 weight 5
[Sysname-GigabitEthernet1/0/1] qos wfq 4 weight 10
[Sysname-GigabitEthernet1/0/1] qos wfq 5 weight 10
[Sysname-GigabitEthernet1/0/1] qos wfq 6 weight 10
```

Configuring SP+WRR queuing

To guarantee successful WRR configuration, make sure that the scheduling weight type (byte-count or packet-based) is the same as the WRR queuing type (byte-count or packet-based) when configuring the scheduling weight for a WRR queue.

Step…		Command…	Remarks
1. Enter system view.		**system-view**	—
2. Enter interface view or port group view.	Enter interface view.	**interface** *interface-type interface-number*	Use either command. Settings in interface view take effect on the current interface; settings in port group view take effect on all ports in the port group.
	Enter port group view.	**port-group manual** *port-group-name*	
3. Enable byte-count or packet-based WRR queuing.		**qos wrr** [**byte-count** | **weight**]	Required. Default queuing algorithm on an interface is SP queuing.
4. Configure SP queue scheduling.		**qos wrr** *queue-id* **group sp**	Required. By default, all queues of a WRR-enabled port use the WRR queue scheduling algorithm.

Step…		Command…	Remarks
5. Configure the scheduling weight for a queue.	For a byte-count WRR queue	**qos wrr** *queue-id* **group 1 byte-count** *schedule-value*	Select an approach according to the WRR queuing type. By default, byte-count WRR is used, and the weights of queues 0 through 7 are 1, 2, 3, 4, 5, 6, 7, and 8.
	For a packet-based WRR queue	**qos wrr** *queue-id* **group 1 weight** *schedule-value*	

Configuration example

Network requirements

- Configure SP+WRR queue scheduling algorithm on GigabitEthernet 1/0/1.
- Configure queue 0, queue 1, queue 2, and queue 3 on GigabitEthernet 1/0/1 to be in SP queue scheduling group.
- Configure queue 4, queue 5, queue 6, and queue 7 on GigabitEthernet 1/0/1 to use WRR queuing, with the weight 2, 4, 6, and 8 respectively.

Configuration procedure

Enter system view.

```
<Sysname> system-view
```

Enable the SP+WRR queue scheduling algorithm on GigabitEthernet1/0/1.

```
[Sysname] interface GigabitEthernet 1/0/1
[Sysname-GigabitEthernet1/0/1] qos wrr
[Sysname-GigabitEthernet1/0/1] qos wrr 0 group sp
[Sysname-GigabitEthernet1/0/1] qos wrr 1 group sp
[Sysname-GigabitEthernet1/0/1] qos wrr 2 group sp
[Sysname-GigabitEthernet1/0/1] qos wrr 3 group sp
[Sysname-GigabitEthernet1/0/1] qos wrr 4 group 1 weight 2
[Sysname-GigabitEthernet1/0/1] qos wrr 5 group 1 weight 4
[Sysname-GigabitEthernet1/0/1] qos wrr 6 group 1 weight 6
[Sysname-GigabitEthernet1/0/1] qos wrr 7 group 1 weight 8
```

Configuring SP+WFQ queuing

To guarantee successful WFQ configuration, make sure that the scheduling weight type (byte-count or packet-based) is the same as the WFQ queuing type (byte-count or packet-based) when configuring the scheduling weight for a WFQ queue.

Step…		Command…	Remarks
1. Enter system view.		**system-view**	—
2. Enter interface view or port group view.	Enter interface view.	**interface** *interface-type interface-number*	Use either command. Settings in interface view take effect on the current interface. Settings in port group view take effect on all ports in the port group.
	Enter port group view.	**port-group manual** *port-group-name*	
3. Enable byte-count or packet-based WFQ queuing.		**qos wfq** [**byte-count** | **weight**]	Required. By default, SP queuing is enabled.

Step…	Command…	Remarks
4. Configure SP queue scheduling.	**qos wfq** *queue-id* **group sp**	Required. By default, all queues of a WFQ-enabled port use are in the WFQ group.
5. Configure the scheduling weight for a queue.	**qos wfq** *queue-id* **group** *group-id* { **weight** | **byte-count** } *schedule-value*	Required. By default, the scheduling weight is 1 for each queue of a WFQ-enabled port.
6. Configure the minimum guaranteed bandwidth for a queue.	**qos bandwidth queue** *queue-id* **min** *bandwidth-value*	Optional. 64 kbps for each queue by default.

Configuration example

Network requirements

- Configure SP+WFQ queuing on GigabitEthernet 1/0/1, and use packet-based WFQ scheduling weights.
- Configure queue 0, queue 1, queue 2, and queue 3 on GigabitEthernet 1/0/1 to be in SP queue scheduling group.
- Configure queue 4, queue 5, queue 6, and queue 7 on GigabitEthernet 1/0/1 to use WFQ queuing, with the weight 2, 4, 6, and 8 and the minimum guaranteed bandwidth 128 kbps.

Configuration procedure

Enter system view.

```
<Sysname> system-view
```

Enable the SP+WFQ queue scheduling algorithm on GigabitEthernet1/0/1.

```
[Sysname] interface GigabitEthernet 1/0/1
[Sysname-GigabitEthernet1/0/1] qos wfq weight
[Sysname-GigabitEthernet1/0/1] qos wfq 0 group sp
[Sysname-GigabitEthernet1/0/1] qos wfq 1 group sp
[Sysname-GigabitEthernet1/0/1] qos wfq 2 group sp
[Sysname-GigabitEthernet1/0/1] qos wfq 3 group sp
[Sysname-GigabitEthernet1/0/1] qos wfq 4 group 1 weight 2
[Sysname-GigabitEthernet1/0/1] qos bandwidth queue 4 min 128
[Sysname-GigabitEthernet1/0/1] qos wfq 5 group 1 weight 4
[Sysname-GigabitEthernet1/0/1] qos bandwidth queue 5 min 128
[Sysname-GigabitEthernet1/0/1] qos wfq 6 group 1 weight 6
[Sysname-GigabitEthernet1/0/1] qos bandwidth queue 6 min 128
[Sysname-GigabitEthernet1/0/1] qos wfq 7 group 1 weight 8
[Sysname-GigabitEthernet1/0/1] qos bandwidth queue 7 min 128
```

Configuring congestion avoidance

Overview

Avoiding congestion before it occurs is a proactive approach to improving network performance. As a flow control mechanism, congestion avoidance actively monitors network resources (such as queues and memory buffers), and drops packets when congestion is expected to occur or deteriorate.

Compared with end-to-end flow control, this flow control mechanism controls the load of more flows in a device. When dropping packets from a source end, it cooperates with the flow control mechanism (such as TCP flow control) at the source end to regulate the network traffic size. The combination of the local packet drop policy and the source-end flow control mechanism helps maximize throughput and network use efficiency and minimize packet loss and delay.

Tail drop

Congestion management techniques drop all packets that are arriving at a full queue. This tail drop mechanism results in global TCP synchronization. If packets from multiple TCP connections are dropped, these TCP connections go into the state of congestion avoidance and slow start to reduce traffic, but traffic peak occurs later. Consequently, the network traffic jitters all the time.

RED and WRED

Use RED or WRED to avoid global TCP synchronization.

Both RED and WRED avoid global TCP synchronization by randomly dropping packets. When the sending rates of some TCP sessions slow down after their packets are dropped, other TCP sessions remain at high sending rates. Link bandwidth is efficiently used, because TCP sessions at high sending rates always exist.

The RED or WRED algorithm sets an upper threshold and lower threshold for each queue, and processes the packets in a queue as follows:

- When the queue size is shorter than the lower threshold, no packet is dropped.
- When the queue size reaches the upper threshold, all subsequent packets are dropped.
- When the queue size is between the lower threshold and the upper threshold, the received packets are dropped at random. The drop probability in a queue increases along with the queue size under the maximum drop probability.

WRED configuration overview

On this device, WRED is implemented with WRED tables. WRED tables are created globally in system view and then applied to interfaces.

WRED parameters

Before configuring WRED, determine the following parameters:

- **Lower threshold and upper threshold**: Queue buffer usage (in percentage). When the queue buffer usage is below the lower threshold, no packet is dropped; when the queue buffer usage is between the lower threshold and the upper threshold, packets are randomly dropped at a user-configured drop probability; when the queue buffer usage exceeds the upper threshold, all arriving packets are dropped.
- **Drop precedence**: A parameter used in packet drop. Value 0 represents green packets, 1 represents yellow packets, and 2 represents red packets. Red packets are preferentially dropped.
- **Drop probability**: Drop probability in percentage. A higher value means a higher drop probability.

Configuring WRED

In a WRED table, drop parameters are configured on a per queue basis because WRED regulates packets on a per queue basis.

A WRED table can be applied to multiple interfaces. For a WRED table already applied to an interface, you can modify the values of the WRED table, but you cannot remove the WRED table.

To configure and apply a queue-based WRED table:

Step…		Command…	Remarks
1. Enter system view.		**system-view**	—
2. Create a WRED table and enter its view.		**qos wred queue table** *table-name*	—
3. Configure the other WRED parameters.		**queue** *queue-value* [**drop-level** *drop-level*] **low-limit** *low-limit* **high-limit** *high-limit* [**discard-probability** *discard-prob*]	Optional. By default, *low-limit* is 10, *high-limit* is 80, and *discard-prob* is 15.
4. Enter interface view or port group view.	Enter interface view.	**interface** *interface-type interface-number*	Use either command. Settings in interface view take effect on the current interface. Settings in port group view take effect on all ports in the port group.
	Enter port group view.	**port-group manual** *port-group-name*	
5. Apply the WRED table to the interface or port group.		**qos wred apply** *table-name*	Required.

Displaying WRED

Task…	Command…	Remarks
Display WRED configuration information on the interface or all interfaces.	**display qos wred interface** [*interface-type interface-number*] [**|** { **begin** | **exclude** | **include** } *regular-expression*]	Available in any view.
Display configuration information about a WRED table or all WRED tables.	**display qos wred table** [*table-name*] [**|** { **begin** | **exclude** | **include** } *regular-expression*]	Available in any view.

WRED configuration example

Apply a WRED table to Layer 2 port GigabitEthernet 1/0/1. Set *low-limit* to 30, *high-limit* to 70, and *discard-prob* to 20 for queue 1.

Enter system view.

```
<Sysname> system-view
```

Create a queue-based WRED table named **queue-table1**, and configure the drop parameters.

```
[Sysname] qos wred queue table queue-table1
[Sysname-wred-table-queue-table1] queue 1 low-limit 30 high-limit 70 discard-probability
20
[Sysname-wred-table-queue-table1] quit
```

Enter port view.

```
[Sysname] interface gigabitethernet 1/0/1
```

Apply the WRED table to GigabitEthernet 1/0/1.

```
[Sysname-GigabitEthernet1/0/1] qos wred apply queue-table1
```

Configuring traffic filtering

Overview

Filter in or filter out a class of traffic by associating the class with a traffic filtering action. For example, you can filter packets sourced from a specific IP address according to network status.

Configuring traffic filtering

Step…		Command…	Remarks
1. Enter system view.		**system-view**	—
2. Create a class and enter class view.		**traffic classifier** *tcl-name* [**operator** { **and** | **or** }]	—
3. Configure match criteria.		**if-match** *match-criteria*	—
4. Return to system view.		**quit**	—
5. Create a behavior and enter behavior view.		**traffic behavior** *behavior-name*	—
6. Configure the traffic filtering action.		**filter** { **deny** | **permit** }	Required. • **deny**: Drops packets. • **permit**: Permits packets to pass through.
7. Return to system view.		**quit**	—
8. Create a policy and enter policy view.		**qos policy** *policy-name*	—
9. Associate the class with the traffic behavior in the QoS policy.		**classifier** *tcl-name* **behavior** *behavior-name*	—
10. Return to system view.		**quit**	—
11. Apply the QoS policy.	To an interface	Applying the QoS policy to an interface	—
	To a VLAN	Applying the QoS policy to a VLAN	—
	Globally	Applying the QoS policy globally	—
12. Display the traffic filtering configuration.		**display traffic behavior user-defined** [*behavior-name*] [| { **begin** | **exclude** | **include** } *regular-expression*]	Optional. Available in any view.

NOTE:

With **filter deny** configured for a traffic behavior, the other actions (except class-based accounting) in the traffic behavior do not take effect.

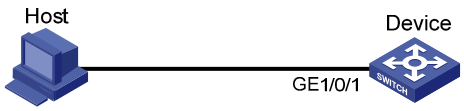
Traffic filtering configuration example

Network requirements

As shown in Figure 17, Host is connected to GigabitEthernet 1/0/1 of Device.

Configure traffic filtering to filter the packets with source port not being 21, and received on GigabitEthernet 1/0/1.

Figure 17 Network diagram for traffic filtering configuration



Configuration procedure

Create advanced ACL 3000, and configure a rule to match packets whose source port number is not 21.

```
<DeviceA> system-view
[DeviceA] acl number 3000
[DeviceA-acl-adv-3000] rule 0 permit tcp source-port neq 21
[DeviceA-acl-adv-3000] quit
```

Create a class named **classifier_1**, and use ACL 3000 as the match criterion in the class.

```
[DeviceA] traffic classifier classifier_1
[DeviceA-classifier-classifier_1] if-match acl 3000
[DeviceA-classifier-classifier_1] quit
```

Create a behavior named **behavior_1**, and configure the traffic filtering action to drop packets.

```
[DeviceA] traffic behavior behavior_1
[DeviceA-behavior-behavior_1] filter deny
[DeviceA-behavior-behavior_1] quit
```

Create a policy named **policy**, and associate class **classifier_1** with behavior **behavior_1** in the policy.

```
[DeviceA] qos policy policy
[DeviceA-qospolicy-policy] classifier classifier_1 behavior behavior_1
[DeviceA-qospolicy-policy] quit
```

Apply the policy named **policy** to the incoming traffic of GigabitEthernet 1/0/1.

```
[DeviceA] interface gigabitethernet 1/0/1
[DeviceA-GigabitEthernet1/0/1] qos apply policy policy inbound
```

Configuring priority marking

Overview

Priority marking can be used together with priority mapping. For more information, see "Configuring priority mapping."

Priority marking sets the priority fields or flag bits of packets to modify the priority of traffic. For example, you can use priority marking to set IP precedence or DSCP for a class of IP traffic to change its transmission priority in the network.

To configure priority marking, you can associate a class with a behavior configured with the priority marking action to set the priority fields or flag bits of the class of packets.

Configuring a priority marking

Step…	Command…	Remarks
1. Enter system view.	**system-view**	—
2. Create a class and enter class view.	**traffic classifier** *tcl-name* [**operator** { **and** | **or** }]	—
3. Configure match criteria.	**if-match** *match-criteria*	—
4. Return to system view.	**quit**	—
5. Create a behavior and enter behavior view.	**traffic behavior** *behavior-name*	—
6. Set the DSCP value for packets.	**remark dscp** *dscp-value*	Optional.
7. Set the 802.1p priority for packets or configure the inner-to-outer tag priority copying function.	**remark dot1p** { *8021p* | **customer-dot1p-trust** }	Optional.
8. Set the drop precedence for packets.	**remark drop-precedence** *drop-precedence-value*	Optional. Applicable to only the outbound direction.
9. Set the IP precedence for packets.	**remark ip-precedence** *ip-precedence-value*	Optional.
10. Set the local precedence for packets.	**remark local-precedence** *local-precedence*	Optional.
11. Set the QoS-local ID for packets.	**remark qos-local-id** *local-id-value*	Optional. QoS-local-ID is used for identifying services and has only local significance. By marking different classes of traffic with the same QoS local ID, you can re-classify them to apply a uniform set of QoS actions on them.

Step…		Command…	Remarks
12. Return to system view.		**quit**	—
13. Create a policy and enter policy view.		**qos policy** *policy-name*	—
14. Associate the class with the traffic behavior in the QoS policy.		**classifier** *tcl-name* **behavior** *behavior-name*	—
15. Return to system view.		**quit**	—
16. Apply the QoS policy.	To an interface	Applying the QoS policy to an interface	—
	To a VLAN	Applying the QoS policy to a VLAN	—
	Globally	Applying the QoS policy globally	—
17. Display the priority marking configuration.		**display traffic behavior user-defined** [*behavior-name*] [| { **begin** | **exclude** | **include** } *regular-expression*]	Optional. Available in any view.

The following table shows the support for priority marking actions in the inbound and outbound directions.

Table 4 Support for priority marking actions in the inbound and outbound directions

Action	inbound	outbound
802.1p priority marking	Supported	Supported
Drop precedence marking	Supported	Not supported
DSCP marking	Supported	Supported
IP precedence marking	Supported	Supported
Local precedence marking	Supported	Not supported
QoS-local ID marking	Supported	Supported

Priority marking configuration example

Network requirements

As shown in Figure 18, the company's enterprise network interconnects hosts with servers through Device. The network is described as follows:

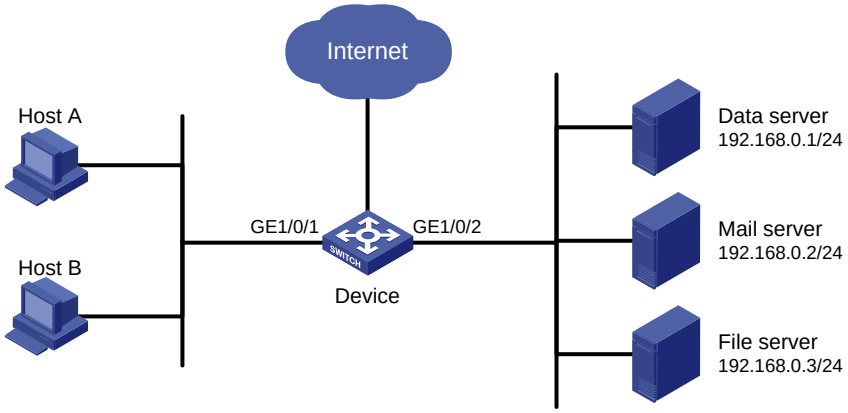
- Host A and Host B are connected to GigabitEthernet 1/0/1 of Device.
- The data server, mail server, and file server are connected to GigabitEthernet 1/0/2 of Device.

Configure priority marking on the device to satisfy the following requirements:

Traffic source	Destination	Processing priority
Host A, B	Data server	High
Host A, B	Mail server	Medium

Traffic source	Destination	Processing priority
Host A, B	File server	Low

Figure 18 Network diagram for priority marking configuration



Configuration procedure

Create advanced ACL 3000, and configure a rule to match packets with destination IP address 192.168.0.1.

```
<Device> system-view
[Device] acl number 3000
[Device-acl-adv-3000] rule permit ip destination 192.168.0.1 0
[Device-acl-adv-3000] quit
```

Create advanced ACL 3001, and configure a rule to match packets with destination IP address 192.168.0.2.

```
[Device] acl number 3001
[Device-acl-adv-3001] rule permit ip destination 192.168.0.2 0
[Device-acl-adv-3001] quit
```

Create advanced ACL 3002, and configure a rule to match packets with destination IP address 192.168.0.3.

```
[Device] acl number 3002
[Device-acl-adv-3002] rule permit ip destination 192.168.0.3 0
[Device-acl-adv-3002] quit
```

Create a class named **classifier_dbserver**, and use ACL 3000 as the match criterion in the class.

```
[Device] traffic classifier classifier_dbserver
[Device-classifier-classifier_dbserver] if-match acl 3000
[Device-classifier-classifier_dbserver] quit
```

Create a class named **classifier_mserver**, and use ACL 3001 as the match criterion in the class.

```
[Device] traffic classifier classifier_mserver
[Device-classifier-classifier_mserver] if-match acl 3001
[Device-classifier-classifier_mserver] quit
```

Create a class named **classifier_fserver**, and use ACL 3002 as the match criterion in the class.

```
[Device] traffic classifier classifier_fserver
[Device-classifier-classifier_fserver] if-match acl 3002
[Device-classifier-classifier_fserver] quit
```

Create a behavior named **behavior_dbserver**, and configure the action of setting the local precedence value to 4.

```
[Device] traffic behavior behavior_dbserver
[Device-behavior-behavior_dbserver] remark local-precedence 4
[Device-behavior-behavior_dbserver] quit
```

Create a behavior named **behavior_mserver**, and configure the action of setting the local precedence value to 3.

```
[Device] traffic behavior behavior_mserver
[Device-behavior-behavior_mserver] remark local-precedence 3
[Device-behavior-behavior_mserver] quit
```

Create a behavior named **behavior_fserver**, and configure the action of setting the local precedence value to 2.

```
[Device] traffic behavior behavior_fserver
[Device-behavior-behavior_fserver] remark local-precedence 2
[Device-behavior-behavior_fserver] quit
```

Create a policy named **policy_server**, and associate classes with behaviors in the policy.

```
[Device] qos policy policy_server
[Device-qospolicy-policy_server] classifier classifier_dbserver behavior
behavior_dbserver
[Device-qospolicy-policy_server] classifier classifier_mserver behavior behavior_mserver
[Device-qospolicy-policy_server] classifier classifier_fserver behavior behavior_fserver
[Device-qospolicy-policy_server] quit
```

Apply the policy named **policy_server** to the incoming traffic of GigabitEthernet 1/0/1.

```
[Device] interface gigabitethernet 1/0/1
[Device-GigabitEthernet1/0/1] qos apply policy policy_server inbound
[Device-GigabitEthernet1/0/1] quit
```

QoS-local-ID marking configuration example

QoS-local-ID marking is mainly used for re-classifying packets of multiple classes to perform a uniform set of actions on them as a re-classified class.

Consider the case of limiting the total rate of packets with source MAC address 0001-0001-0001 and packets with source IP address 1.1.1.1 to 128 kbps. Without QoS local ID marking, you can only assign fixed bandwidth to the two classes by associating each of them with a rate-limit traffic behavior. With QoS local ID marking, however, traffic limit applies to the two classes as a whole, allowing the switch to dynamically assign the bandwidth to the two classes depending on their traffic size.

To configure QoS-local-ID marking to limit the total rate of the two classes, you must mark packets of the two classes with the same QoS-local-ID, create a class to match the QoS local ID, and associate this class with the traffic policing action.

Create ACL 2000 to match packets with source IP address 1.1.1.1.

```
<Sysname> system-view
[Sysname] acl number 2000
[Sysname-acl-basic-2000] rule permit source 1.1.1.1 0
[Sysname-acl-basic-2000] quit
```

Create a class **class_a** to match both packets with source MAC address 0001-0001-0001 and packets with source IP 1.1.1.1.

```
<Sysname> system-view
[Sysname] traffic classifier class_a operator or
[Sysname-classifier-class_a] if-match source-mac 1-1-1
[Sysname-classifier-class_a] if-match acl 2000
[Sysname-classifier-class_a] quit
```

Create a behavior **behavior_a**, and configure the action of marking packets with QoS-local-ID 100 for the behavior.

```
[Sysname] traffic behavior behavior_a
[Sysname-behavior-behavior_a] remark qos-local-id 100
[Sysname-behavior-behavior_a] quit
```

Create a class **class_b** to match packets with QoS-local-ID 100.

```
[Sysname] traffic classifier class_b
[Sysname-classifier-class_b] if-match qos-local-id 100
[Sysname-classifier-class_b] quit
```

Create a behavior **behavior_b**, and configure the action of limiting traffic rate to 128 kbps for the behavior.

```
[Sysname] traffic behavior behavior_b
[Sysname-behavior-behavior_b] car cir 128
[Sysname-behavior-behavior_b] quit
```

Create a QoS policy **car_policy**. In the QoS policy, associate class **class_a** with behavior **behavior_a**, and associate class **class_b** with behavior **behavior_b**.

```
[Sysname] qos policy car_policy
[Sysname-qospolicy-car_policy] classifier class_a behavior behavior_a
[Sysname-qospolicy-car_policy] classifier class_b behavior behavior_b
```

Apply the QoS policy **car_policy** to the interface, satisfying the network requirements.

Configuring traffic redirection

Overview

Traffic redirecting is the action of redirecting the packets matching the specific match criteria to a certain location for processing.

The following redirect actions are supported:

- **Redirecting traffic to the CPU**: redirects packets that require processing by the CPU to the CPU.
- **Redirecting traffic to an interface**: redirects packets that require processing by an interface to the interface. This action applies to only Layer 2 packets, and the target interface must be a Layer 2 interface.
- **Redirecting traffic to the next hop**: redirects packets that require processing by an interface to the interface. This action only applies to Layer 3 packets.

Configuring traffic redirecting

The actions of redirecting traffic to the CPU, redirecting traffic to an interface, and redirecting traffic to the next hop are mutually exclusive with each other in the same traffic behavior.

A QoS policy with traffic redirecting actions can be applied to only the inbound direction of a port, VLAN, or all ports.

Use **display traffic behavior user-defined** to view the traffic redirecting configuration.

To configure traffic redirecting:

Step…	Command…	Remarks
1. Enter system view.	**system-view**	—
2. Create a class and enter class view.	**traffic classifier** *tcl-name* [**operator** { **and** | **or** }]	—
3. Configure match criteria.	**if-match** *match-criteria*	—
4. Return to system view.	**quit**	—
5. Create a behavior and enter behavior view.	**traffic behavior** *behavior-name*	Required
6. Configure a traffic redirecting action.	**redirect** { **cpu** | **interface** *interface-type interface-number* | **next-hop** { *ipv4-add1* [*ipv4-add2*] | *ipv6-add1* [*interface-type interface-number*] [*ipv6-add2* [*interface-type interface-number*]] } }	Required
7. Return to system view.	**quit**	—
8. Create a policy and enter policy view.	**qos policy** *policy-name*	—

Step…		Command…	Remarks
9. Associate the class with the traffic behavior in the QoS policy.		**classifier** *tcl-name* **behavior** *behavior-name*	—
10. Return to system view.		**quit**	—
11. Apply the QoS policy.	To an interface	Applying the QoS policy to an interface	—
	To a VLAN	Applying the QoS policy to a VLAN	—
	Globally	Applying the QoS policy globally	—

Traffic redirecting configuration example

Redirecting traffic to the next hop example

Network requirements

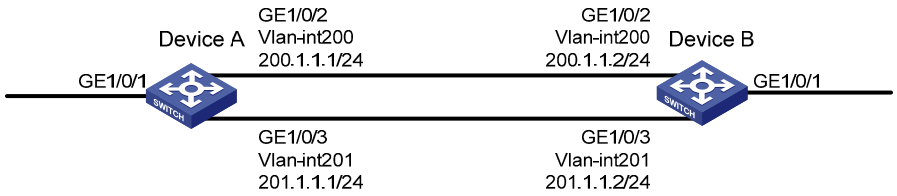
As shown in Figure 19, the network is described as follows:

- Device A is connected to Device through two links. At the same time, Device A and Device B are each connected to other devices.
- GigabitEthernet 1/0/2 of Device A and GigabitEthernet 1/0/2 of Device B belong to VLAN 200.
- Ethernet 1/3 of Device A and Ethernet 1/3 of Device B belong to VLAN 201.
- On Device A, the IP address of VLAN-interface 200 is 200.1.1.1/24, and that of VLAN-interface 201 is 201.1.1.1/24.
- On Device B, the IP address of VLAN-interface 200 is 200.1.1.2/24, and that of VLAN-interface 201 is 201.1.1.2/24.

Configure the actions of redirecting traffic to the next hop to implement policy-based routing and satisfy the following requirements:

- Packets with source IP address 2.1.1.1 received on GigabitEthernet 1/0/1 of Device A are forwarded to IP address 200.1.1.2.
- Packets with source IP address 2.1.1.2 received on GigabitEthernet 1/0/1 of Device A are forwarded to IP address 201.1.1.2.
- Other packets received on Ethernet 1/1 of Device A are forwarded according to the routing table.

Figure 19 Network diagram for redirecting traffic to the next hop



Configuration procedure

Create basic ACL 2000, and configure a rule to match packets with source IP address 2.1.1.1.

```
<DeviceA> system-view
[DeviceA] acl number 2000
[DeviceA-acl-basic-2000] rule permit source 2.1.1.1 0
[DeviceA-acl-basic-2000] quit
```

Create basic ACL 2001, and configure a rule to match packets with source IP address 2.1.1.2.

```
[DeviceA] acl number 2001
[DeviceA-acl-basic-2001] rule permit source 2.1.1.2 0
[DeviceA-acl-basic-2001] quit
```

Create a class named **classifier_1**, and use ACL 2000 as the match criterion in the class.

```
[DeviceA] traffic classifier classifier_1
[DeviceA-classifier-classifier_1] if-match acl 2000
[DeviceA-classifier-classifier_1] quit
```

Create a class named **classifier_2**, and use ACL 2001 as the match criterion in the class.

```
[DeviceA] traffic classifier classifier_2
[DeviceA-classifier-classifier_2] if-match acl 2001
[DeviceA-classifier-classifier_2] quit
```

Create a behavior named **behavior_1**, and configure the action of redirecting traffic to the next hop 200.1.1.2.

```
[DeviceA] traffic behavior behavior_1
[DeviceA-behavior-behavior_1] redirect next-hop 200.1.1.2
[DeviceA-behavior-behavior_1] quit
```

Create a behavior named **behavior_2**, and configure the action of redirecting traffic to the next hop 200.1.1.2.

```
[DeviceA] traffic behavior behavior_2
[DeviceA-behavior-behavior_2] redirect next-hop 201.1.1.2
[DeviceA-behavior-behavior_2] quit
```

Create a policy named **policy**, associate class **classifier_1** with behavior **behavior_1**, and associate class **classifier_2** with behavior **behavior_2** in the policy.

```
[DeviceA] qos policy policy
[DeviceA-qospolicy-policy] classifier classifier_1 behavior behavior_1
[DeviceA-qospolicy-policy] classifier classifier_2 behavior behavior_2
[DeviceA-qospolicy-policy] quit
```

Apply the policy named **policy** to the incoming traffic of GigabitEthernet 1/0/1.

```
[DeviceA] interface gigabitethernet 1/0/1
[DeviceA-GigabitEthernet1/0/1] qos apply policy policy inbound
```

Configuring class-based accounting

Overview

Class-based accounting collects statistics (in packets or bytes) on a per-traffic class basis. For example, you can define the action to collect statistics for traffic sourced from a certain IP address. By analyzing the statistics, you can determine whether anomalies have occurred and what action to take.

Configuring class-based accounting

Step…		Command…	Remarks
1. Enter system view.		**system-view**	—
2. Create a class and enter class view.		**traffic classifier** *tcl-name* [**operator** { **and** | **or** }]	—
3. Configure match criteria.		**if-match** *match-criteria*	—
4. Return to system view.		**quit**	—
5. Create a behavior and enter behavior view.		**traffic behavior** *behavior-name*	Required
6. Configure the accounting action.		**accounting** { **byte** | **packet** }	Optional • **byte**: Counts traffic in bytes • **packet**: Counts traffic in packets
7. Return to system view.		**quit**	—
8. Create a policy and enter policy view.		**qos policy** *policy-name*	—
9. Associate the class with the traffic behavior in the QoS policy.		**classifier** *tcl-name* **behavior** *behavior-name*	—
10. Return to system view.		**quit**	—
11. Apply the QoS policy.	To an interface	Applying the QoS policy to an interface	—
	To a VLAN	Applying the QoS policy to a VLAN	—
	Globally	Applying the QoS policy globally	—

Displaying and maintaining traffic accounting

Task…	Command…	Remarks
Verify the configuration.	**display qos policy global** **display qos policy interface** **display qos vlan-policy**	Use the appropriate display qos policy command for the specific QoS policy application.

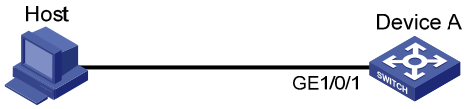
Class-based accounting configuration example

Network requirements

As shown in Figure 20, Host is connected to GigabitEthernet 1/0/1 of Device A.

Configure class-based accounting to collect statistics for traffic sourced from 1.1.1.1/24 and received on GigabitEthernet 1/0/1.

Figure 20 Network diagram for traffic accounting configuration



Configuration procedure

Create basic ACL 2000, and configure a rule to match packets with source IP address 1.1.1.1.

```
<DeviceA> system-view
[DeviceA] acl number 2000
[DeviceA-acl-basic-2000] rule permit source 1.1.1.1 0
[DeviceA-acl-basic-2000] quit
```

Create a class named **classifier_1**, and use ACL 2000 as the match criterion in the class.

```
[DeviceA] traffic classifier classifier_1
[DeviceA-classifier-classifier_1] if-match acl 2000
[DeviceA-classifier-classifier_1] quit
```

Create a behavior named **behavior_1**, and configure the traffic accounting action.

```
[DeviceA] traffic behavior behavior_1
[DeviceA-behavior-behavior_1] accounting
[DeviceA-behavior-behavior_1] quit
```

Create a policy named **policy**, and associate class **classifier_1** with behavior **behavior_1** in the policy.

```
[DeviceA] qos policy policy
[DeviceA-qospolicy-policy] classifier classifier_1 behavior behavior_1
[DeviceA-qospolicy-policy] quit
```

Apply the policy named **policy** to the incoming traffic of GigabitEthernet 1/0/1.

```
[DeviceA] interface gigabitethernet 1/0/1
[DeviceA-GigabitEthernet1/0/1] qos apply policy policy inbound
```

```
[DeviceA-GigabitEthernet1/0/1] quit
```

Display traffic statistics to verify the configuration.

```
[DeviceA] display qos policy interface gigabitethernet 1/0/1

  Interface: GigabitEthernet1/0/1

  Direction: Inbound

  Policy: policy
   Classifier: classifier_1
     Operator: AND
     Rule(s) : If-match acl 2000
     Behavior: behavior_1
      Accounting Enable:
        28529 (Packets)
```

Configuring QPPB

The term *router* refers to both routers and Layer 3 switches.

Overview

The QPPB feature enables you to classify IP packets based on BGP community lists, prefix lists, and BGP AS paths.

The idea of QPPB is that the BGP route sender pre-classifies routes before advertising them and the BGP route receiver sets the IP precedence and QoS-local ID for the routes and takes appropriate QoS actions on the packets that match the routes.

QPPB minimizes the QoS policy configuration and management efforts on the BGP route receiver when the network topology changes. It is suitable for large-scaled complex network that classifies packets based on source or destination IP addresses for QoS.

QPPB applies to IBGP and EBGP. Use it within an autonomous system or cross multiple autonomous systems.

QPPB fundamentals

QPPB works on the BGP receiver. It depends on the BGP route sender to pre-classify routes.

The BGP route sender uses a routing policy to set route attributes for BGP routes before advertising them.

The BGP receiver uses a routing policy to match routes based on these route attributes, and sets IP precedence and QoS-local ID for the matching routes:

1. Compares the routes with the incoming route policy based on their BGP AS path, prefix, or community attributes.
2. Applies the IP precedence and QoS-local ID to the matching routes.
3. Adds the BGP routes and their associated IP precedence and QoS-local ID to the routing table.
4. Applies the IP precedence and QoS-local ID to the packets sourced from or destined to the IP address in the route.
5. Takes QoS actions on the packets according to the QoS priority settings.

QPPB configuration task list

Complete the following tasks to configure QPPB:

Task		Remarks
Configuring the route sender	Configuring basic BGP functions	Required
	Creating a routing policy	Optional
Configuring the route	Configuring basic BGP functions	Required

Task		Remarks
	Configuring a routing policy	Required
	Configuring a QoS policy	Required
	Applying the QoS policy to VLANs	Required

Configuring the route sender

Configure the BGP route sender to set route attributes for routes before advertising them.

Configuring basic BGP functions

For more information, see *Layer 3—IP Routing Configuration Guide*.

Creating a routing policy

Configure a routing policy to classify routes and set route attributes for the route classes. For more information, see *Layer 3—IP Routing Configuration Guide*.

Configuring the route receiver

Configure the route receiver to match the route attributes set by the sender and set IP precedence and QoS-local ID for the matching routes.

Configuring basic BGP functions

For more information, see *Layer 3—IP Routing Configuration Guide*.

Configuring a routing policy

Configure a routing policy to match the route attributes set by the sender and set the IP precedence, QoS-local ID, or both for the matching routes. For more information, see *Layer 3—IP Routing Configuration Guide*.

Configuring a QoS policy

The classes in the QoS policy use the IP precedence and QoS-local ID set by the routing policy as match criteria. If the match criteria contain QoS-local IDs, you must specify that the class-behavior association is used together with QPPB.

Applying the QoS policy to VLANs

To apply the QoS policy to VLANs:

Step…	Command…	Remarks
1. Enter system view.	**system-view**	—
2. Apply the policy to the specified VLANs.	**qos vlan-policy** *policy-name* **vlan** *vlan-id-list* { **inbound** | **outbound** }	Required

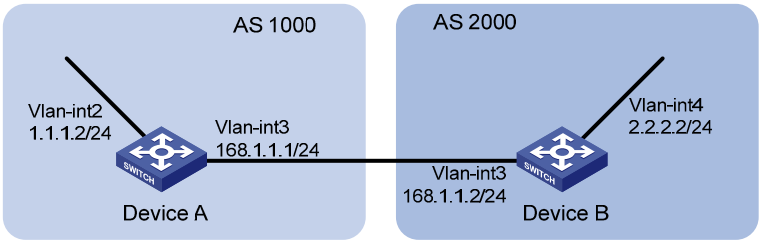
QPPB configuration examples

QPPB configuration example in an IPv4 network

Network requirements

As shown in Figure 21, all switches run BGP. Device B receives routes, sets the QPPB IP precedence and QoS-local IDs, and uses the QoS policy to limit the traffic from Device B to Device A to 512 kbps.

Figure 21 Network diagram for QPPB configuration example in an IPv4 network



Configuration procedure

1. Configure IP addresses for each interface (omitted).
2. Configure Device A.

   # Configure a BGP connection.

```
<DeviceA> system-view
[DeviceA] bgp 1000
[DeviceA-bgp] peer 168.1.1.2 as-number 2000
[DeviceA-bgp] network 1.1.1.0 255.0.0.0
[DeviceA-bgp] quit
```

3. Configure Device B.

   # Configure a BGP connection.

```
<DeviceB> system-view
[DeviceB] bgp 2000
[DeviceB-bgp] peer 168.1.1.1 as-number 1000
[DeviceB-bgp] peer 168.1.1.1 route-policy qppb import
[DeviceB-bgp] network 2.2.2.0 255.0.0.0
[DeviceB-bgp] quit
```

   # Configure a routing policy.

```
[DeviceB] route-policy qppb permit node 0
[DeviceB-route-policy] apply qos-local-id 3
[DeviceB-route-policy] quit
```

   # Configure a QoS policy.

```
[DeviceB] traffic classifier qppb
[DeviceB-classifier-qppb] if-match qos-local-id 3
[DeviceB-classifier-qppb] quit
[DeviceB] traffic behavior qppb
[DeviceB-behavior-qppb] car cir 512 green pass red discard
[DeviceB-behavior-qppb] quit
```

```
[DeviceB] qos policy qppb
[DeviceB-qospolicy-qppb] classifier qppb behavior qppb mode qppb-manipulation
[DeviceB-qospolicy-qppb] quit
```

Apply the QoS policy to the incoming traffic of VLAN 4.

```
[DeviceB] qos vlan-policy qppb vlan 4 inbound
```

4. Verify the configuration.

Check whether the related route on Device B takes effect.

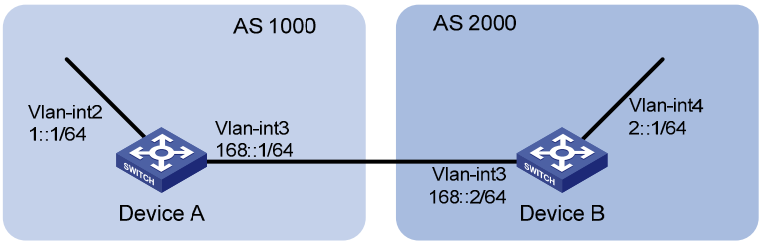
```
[DeviceB] display ip routing-table 1.1.1.0 24 verbose
Routing Table : Public
Summary Count : 1

  Destination: 1.1.1.0/24
     Protocol: BGP             Process ID: 0
   Preference: 255                   Cost: 0
 IpPrecedence:                   QosLcId: 3
      NextHop: 168.1.1.1        Interface: Vlan-interface3
    BkNextHop: 0.0.0.0        BkInterface:
  RelyNextHop: 0.0.0.0          Neighbor : 168.1.1.1
    Tunnel ID: 0x0                  Label: NULL
        State: Active Adv GotQ        Age: 00h00m45s
          Tag: 0
```

QPPB configuration example in an IPv6 network

Network requirements

As shown in Figure 22, all routers run BGP. Device B receives routes, and sets the QPPB IP precedence.

Figure 22 Network diagram for QPPB configuration in an IPv6 network



Configuration procedure

1. Enable IPv6 globally, and configure IP addresses for each interface (omitted).
2. Configure Device A.

Configure BGP.

```
<DeviceA> system-view
[DeviceA] bgp 1000
[DeviceA-bgp] ipv6-family
[DeviceA-bgp-af-ipv6] peer 168::2 as-number 2000
[DeviceA-bgp-af-ipv6] network 1:: 64
[DeviceA-bgp-af-ipv6] quit
```

```
[DeviceA-bgp] quit
```

3. Configure Device B.

   # Configure BGP.

```
<DeviceB> system-view
[DeviceB] bgp 2000
[DeviceB-bgp] ipv6-family
[DeviceB-bgp-af-ipv6] peer 168::1 as-number 1000
[DeviceB-bgp-af-ipv6] peer 168::1 route-policy qppb import
[DeviceB-bgp-af-ipv6] network 2:: 64
[DeviceB-bgp-af-ipv6] quit
[DeviceB-bgp] quit
```

   # Configure a routing policy.

```
[DeviceB] route-policy qppb permit node 0
[DeviceB-route-policy] apply ip-precedence 4
[DeviceB-route-policy] quit
```

   # Enable QPPB on interface VLAN-interface 4.

```
[DeviceB] interface vlan-interface 4
[DeviceB-Vlan-interface4] bgp-policy destination ip-prec-map
```

4. Verify the configuration.

   # Check whether the related routes on Device A take effect.

```
[DeviceA]display ipv6 routing-table
Routing Table :
         Destinations : 7        Routes : 7

Destination: ::1/128                                    Protocol   : Direct
NextHop    : ::1                                        Preference: 0
Interface  : InLoop0                                    Cost       : 0

Destination: 1::/64                                     Protocol   : Direct
NextHop    : 1::1                                       Preference: 0
Interface  : Vlan2                                      Cost       : 0

Destination: 1::1/128                                   Protocol   : Direct
NextHop    : ::1                                        Preference: 0
Interface  : InLoop0                                    Cost       : 0

Destination: 2::/64                                     Protocol   : BGP4+
NextHop    : 168::2                                     Preference: 255
Interface  : Vlan3                                      Cost       : 0

Destination: 168::/64                                   Protocol   : Direct
NextHop    : 168::1                                     Preference: 0
Interface  : Vlan3                                      Cost       : 0

Destination: 168::1/128                                 Protocol   : Direct
NextHop    : ::1                                        Preference: 0
```

```
Interface  : InLoop0                                    Cost      : 0

Destination: FE80::/10                                  Protocol  : Direct
NextHop    : ::                                         Preference: 0
Interface  : NULL0                                      Cost      : 0
```

Check whether the related routes on Device B take effect.

```
[DeviceB] display ipv6 routing-table
Routing Table :
         Destinations : 7        Routes : 7

Destination: ::1/128                                    Protocol  : Direct
NextHop    : ::1                                        Preference: 0
Interface  : InLoop0                                    Cost      : 0

Destination: 1::/64                                     Protocol  : BGP4+
NextHop    : 168::1                                     Preference: 255
Interface  : Vlan3                                      Cost      : 0

Destination: 2::/64                                     Protocol  : Direct
NextHop    : 2::1                                       Preference: 0
Interface  : Vlan4                                      Cost      : 0

Destination: 2::1/128                                   Protocol  : Direct
NextHop    : ::1                                        Preference: 0
Interface  : InLoop0                                    Cost      : 0

Destination: 168::/64                                   Protocol  : Direct
NextHop    : 168::2                                     Preference: 0
Interface  : Vlan3                                      Cost      : 0

Destination: 168::2/128                                 Protocol  : Direct
NextHop    : ::1                                        Preference: 0
Interface  : InLoop0                                    Cost      : 0

Destination: FE80::/10                                  Protocol  : Direct
NextHop    : ::                                         Preference: 0
Interface  : NULL0                                      Cost      : 0
```

Appendix

Appendix A Default priority mapping tables

For the default **dscp-dscp** mapping tables, an input value yields a target value equal to it.

Table 5 Default dot1p-lp and dot1p-dp priority mapping tables

Input priority value	dot1p-lp mapping	dot1p-dp mapping
802.1p priority (dot1p)	Local precedence (lp)	Drop precedence (dp)
0	2	0
1	0	0
2	1	0
3	3	0
4	4	0
5	5	0
6	6	0
7	7	0

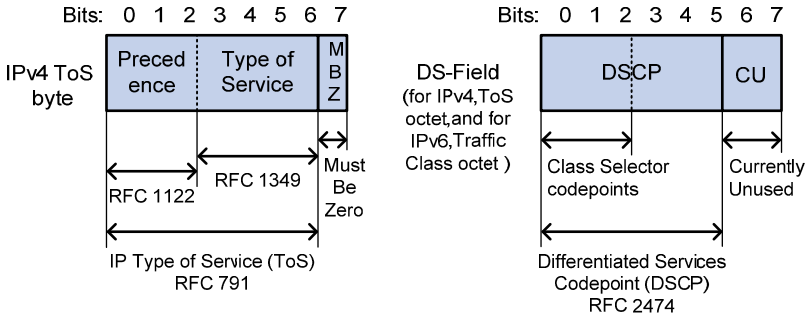
Table 6 Default dscp-dp and dscp-dot1p priority mapping tables

Input priority value	dscp-dp mapping	dscp-dot1p mapping
DSCP	Drop precedence (dp)	802.1p priority (dot1p)
0 to 7	0	0
8 to 15	0	1
16 to 23	0	2
24 to 31	0	3
32 to 39	0	4
40 to 47	0	5
48 to 55	0	6
56 to 63	0	7

Appendix B Introduction to packet precedence

IP precedence and DSCP values

Figure 23 ToS and DS fields



As shown in Figure 23, the ToS field in the IP header contains eight bits. The first three bits (0 to 2) represent IP precedence from 0 to 7. According to RFC 2474, the ToS field is redefined as the DS field, where a DSCP value is represented by the first six bits (0 to 5), ranging from 0 to 63. The remaining two bits (6 and 7) are reserved.

Table 7 Description on IP precedence

IP precedence (decimal)	IP precedence (binary)	Description
0	000	Routine
1	001	priority
2	010	immediate
3	011	flash
4	100	flash-override
5	101	critical
6	110	internet
7	111	network

Table 8 Description on DSCP values

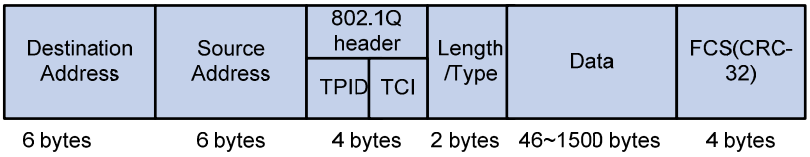
DSCP value (decimal)	DSCP value (binary)	Description
46	101110	ef
10	001010	af11
12	001100	af12
14	001110	af13
18	010010	af21
20	010100	af22
22	010110	af23

DSCP value (decimal)	DSCP value (binary)	Description
26	011010	af31
28	011100	af32
30	011110	af33
34	100010	af41
36	100100	af42
38	100110	af43
8	001000	cs1
16	010000	cs2
24	011000	cs3
32	100000	cs4
40	101000	cs5
48	110000	cs6
56	111000	cs7
0	000000	be (default)

802.1p priority

802.1p priority lies in the Layer 2 header and applies to occasions where Layer 3 header analysis is not needed and QoS must be assured at Layer 2.

Figure 24 An Ethernet frame with an 802.1Q tag header



As shown in Figure 24, the four-byte 802.1Q tag header consists of the TPID, two bytes in length, whose value is 0x8100, and the TCI, two bytes in length. Figure 25 shows the format of the 802.1Q tag header. The Priority field in the 802.1Q tag header is called the "802.1p priority", because its use is defined in IEEE 802.1p. Table 9 shows the values for 802.1p priority.

Figure 25 802.1Q tag header

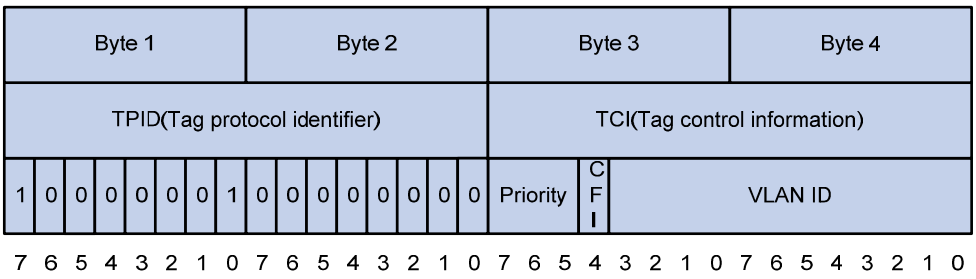


Table 9 Description on 802.1p priority

802.1p priority (decimal)	802.1p priority (binary)	Description
0	000	best-effort
1	001	background
2	010	spare
3	011	excellent-effort
4	100	controlled-load
5	101	video
6	110	voice
7	111	network-management

Support and other resources

Contacting HP

For worldwide technical support information, see the HP support website:

http://www.hp.com/support

Before contacting HP, collect the following information:

- Product model names and numbers
- Technical support registration number (if applicable)
- Product serial numbers
- Error messages
- Operating system type and revision level
- Detailed questions

Subscription service

HP recommends that you register your product at the Subscriber's Choice for Business website:

http://www.hp.com/go/wwalerts

After registering, you will receive email notification of product enhancements, new driver versions, firmware updates, and other product resources.

Related information

Documents

To find related documents, browse to the Manuals page of the HP Business Support Center website:

http://www.hp.com/support/manuals

- For related documentation, navigate to the Networking section, and select a networking category.
- For a complete list of acronyms and their definitions, see *HP A-Series Acronyms*.

Websites

- HP.com http://www.hp.com
- HP Networking http://www.hp.com/go/networking
- HP manuals http://www.hp.com/support/manuals
- HP download drivers and software http://www.hp.com/support/downloads
- HP software depot http://www.software.hp.com

Conventions

This section describes the conventions used in this documentation set.

Command conventions

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

GUI conventions

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

Symbols

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

Network topology icons

	Represents a generic network device, such as a router, switch, or firewall.
	Represents a routing-capable device, such as a router or Layer 3 switch.
	Represents a generic switch, such as a Layer 2 or Layer 3 switch, or a router that supports Layer 2 forwarding and other Layer 2 features.

Port numbering in examples

The port numbers in this document are for illustration only and might be unavailable on your device.

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