# QoS: Congestion Management Configuration Guide, Cisco IOS XE 17


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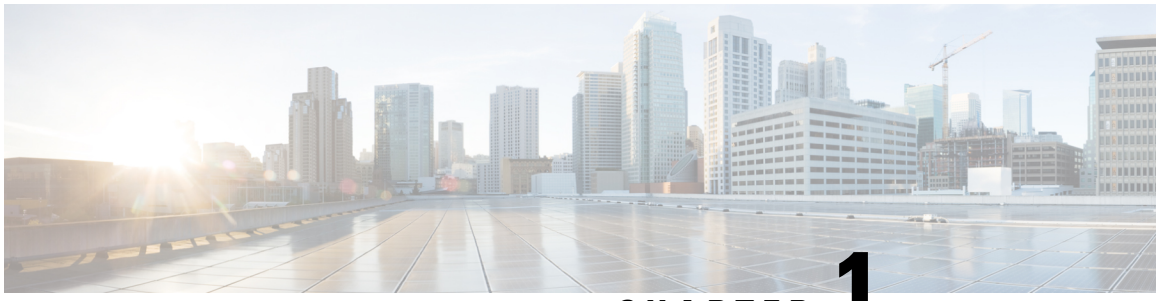

CHAPTER 1

# Read Me First

### Important Information

**Note** For CUBE feature support information in Cisco IOS XE Bengaluru 17.6.1a and later releases, see Cisco Unified Border Element IOS-XE Configuration Guide.

**Note** The documentation set for this product strives to use bias-free language. For purposes of this documentation set, bias-free is defined as language that does not imply discrimination based on age, disability, gender, racial identity, ethnic identity, sexual orientation, socioeconomic status, and intersectionality. Exceptions may be present in the documentation due to language that is hardcoded in the user interfaces of the product software, language used based on standards documentation, or language that is used by a referenced third-party product.

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### Related References

- Cisco IOS Command References, All Releases

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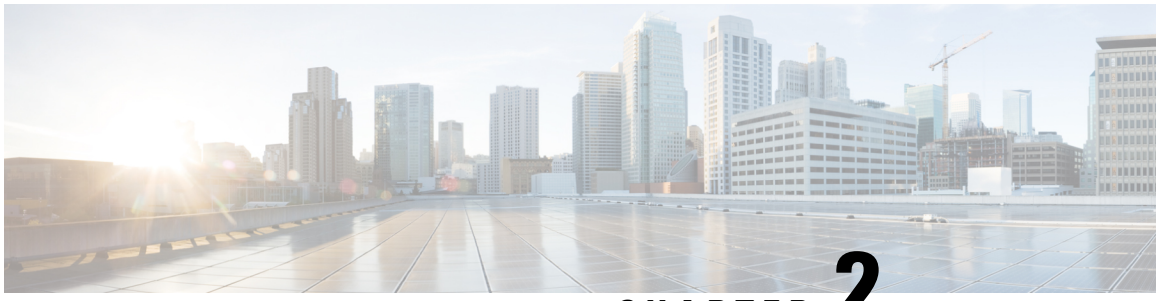
# Short Description



CHAPTER 2

# Congestion Management Overview

Congestion management features allow you to control congestion by determining the order in which packets are sent out an interface based on priorities assigned to those packets. Congestion management entails the creation of queues, assignment of packets to those queues based on the classification of the packet, and scheduling of the packets in a queue for transmission. The congestion management QoS feature offers four types of queueing protocols, each of which allows you to specify creation of a different number of queues, affording greater or lesser degrees of differentiation of traffic, and to specify the order in which that traffic is sent.

During periods with light traffic, that is, when no congestion exists, packets are sent out the interface as soon as they arrive. During periods of transmit congestion at the outgoing interface, packets arrive faster than the interface can send them. If you use congestion management features, packets accumulating at an interface are queued until the interface is free to send them; they are then scheduled for transmission according to their assigned priority and the queueing mechanism configured for the interface. The router determines the order of packet transmission by controlling which packets are placed in which queue and how queues are serviced with respect to each other.

This module discusses the types of queueing and queueing-related features (such as bandwidth management) which constitute the congestion management QoS features:

- Weighted fair queueing (WFQ). Also known as flow-based WFQ in this module.

WFQ offers dynamic, fair queueing that divides bandwidth across queues of traffic based on weights. (WFQ ensures that all traffic is treated fairly, given its weight.) To understand how WFQ works, consider the queue for a series of File Transfer Protocol (FTP) packets as a queue for the collective and the queue for discrete interactive traffic packets as a queue for the individual. Given the weight of the queues, WFQ ensures that for all FTP packets sent as a collective an equal number of individual interactive traffic packets are sent.)

Given this handling, WFQ ensures satisfactory response time to critical applications, such as interactive, transaction-based applications, that are intolerant of performance degradation. For serial interfaces at E1 (2.048 Mbps) and below, flow-based WFQ is used by default.

- Class-based WFQ (CBWFQ)

CBWFQ extends the standard WFQ functionality to provide support for user-defined traffic classes. For CBWFQ, you define traffic classes based on match criteria including protocols, access control lists (ACLs), and input interfaces. Packets satisfying the match criteria for a class constitute the traffic for that class.

- Priority queueing (PQ). With PQ, packets belonging to one priority class of traffic are sent before all lower priority traffic to ensure timely delivery of those packets.

**Note** You can assign only one queueing mechanism type to an interface.

**Note** A variety of queueing mechanisms can be configured using multilink, for example, Multichassis Multilink PPP (MMP). However, if only PPP is used on a tunneled interface--for example, virtual private dialup network (VPND), PPP over Ethernet (PPPoE)--no queueing can be configured on the virtual interface.

- Bandwidth Management

CBWFQ and LLQ (as well as other QoS functionality) can al reserve and consume bandwidth, up to a maximum of the reserved bandwidth on an interface. Specific commands can be used to allocate and fineptune bandwidth as needed. For more information, see the Bandwidth Management, on page 15.



# Finding Feature Information

Your software release may not support all the features documented in this module. For the latest caveats and feature information, see Bug Search Tool and the release notes for your platform and software release. To find information about the features documented in this module, and to see a list of the releases in which each feature is supported, see the feature information table.

Use Cisco Feature Navigator to find information about platform support and Cisco software image support. To access Cisco Feature Navigator, go to https://cfnng.cisco.com/. An account on Cisco.com is not required.

# Why Use Congestion Management

Heterogeneous networks include many different protocols used by applications, giving rise to the need to prioritize traffic in order to satisfy time-critical applications while still addressing the needs of less time-dependent applications, such as file transfer. Different types of traffic sharing a data path through the network can interact with one another in ways that affect their application performance. If your network is designed to support different traffic types that share a single data path between routers, you should consider using congestion management techniques to ensure fairness of treatment across the various traffic types.

Here are some broad factors to consider in determining whether to configure congestion management QoS:

- Traffic prioritization is especially important for delay-sensitive, interactive transaction-based applications--for instance, desktop video conferencing--that require higher priority than do file transfer applications. However, use of WFQ ensures that all traffic is treated fairly, given its weight, and in a

dynamic manner. For example, WFQ addresses the requirements of the interactive application without penalizing the FTP application.

- Prioritization is most effective on WAN links where the combination of bursty traffic and relatively lower data rates can cause temporary congestion.
- Depending on the average packet size, prioritization is most effective when applied to links at T1/E1 bandwidth speeds or lower.
- If users of applications running across your network notice poor response time, you should consider using congestion management features. Congestion management features are dynamic, tailoring themselves to the existing network conditions. However, consider that if a WAN link is constantly congested, traffic prioritization may *not* resolve the problem. Adding bandwidth might be the appropriate solution.
- If there is no congestion on the WAN link, there is no reason to implement traffic prioritization.

The following list summarizes aspects you should consider in determining whether you should establish and implement a queueing policy for your network:

- Determine if the WAN is congested--that is, whether users of certain applications perceive a performance degradation.
- Determine your goals and objectives based on the mix of traffic you need to manage and your network topology and design. In identifying what you want to achieve, consider whether your goal is among the following:
  - To establish fair distribution of bandwidth allocation across all of the types of traffic you identify.
  - To grant strict priority to traffic from special kinds of applications you service--for example, interactive multimedia applications--possibly at the expense of less-critical traffic you also support.
  - To customize bandwidth allocation so that network resources are shared among all of the applications you service, each having the specific bandwidth requirements you have identified.
  - To effectively configure queueing. You must analyze the types of traffic using the interface and determine how to distinguish them. See the "Classification Overview" module for a description of how packets are classified.

After you assess your needs, review the available congestion management queueing mechanisms described in this module and determine which approach best addresses your requirements and goals.

- Configure the interface for the kind of queueing strategy you have chosen, and observe the results.

Traffic patterns change over time, so you should repeat the analysis process described in the second bullet periodically, and adapt the queueing configuration accordingly.

See the following section Deciding Which Queueing Policy to Use for elaboration of the differences among the various queueing mechanisms.

# Deciding Which Queueing Policy to Use

When deciding which queueing policy to use, note the following points:

- PQ guarantees strict priority in that it ensures that one type of traffic will be sent, possibly at the expense of all others. For PQ, a low priority queue can be detrimentally affected, and, in the worst case, never allowed to send its packets if a limited amount of bandwidth is available or if the transmission rate of critical traffic is high.

- WFQ does not require configuration of access lists to determine the preferred traffic on a serial interface. Rather, the fair queue algorithm dynamically sorts traffic into messages that are part of a conversation.
- Low-volume, interactive traffic gets fair allocation of bandwidth with WFQ, as does high-volume traffic such as file transfers.
- Strict priority queueing can be accomplished with WFQ by using low latency queueing (LLQ). Strict PQ allows delay-sensitive data such as voice to be dequeued and sent before packets in other queues are dequeued.

The table below compares the salient features of flow-based WFQ, CBWFQ, and PQ.

***Table 1: Queueing Comparison***

| | **WFQ** | **CBWFQ/** | **PQ** |
|---|---|---|---|
| Number of Queues | Configurable number of queues (256 user queues, by default) | One queue per class, up to 64 classes | 4 queues |
| Kind of Service | • Ensures fairness among all traffic flows based on weights | • Provides class bandwidth guarantee for user-defined traffic classes<br>• Provides flow-based WFQ support for nonuser-defined traffic classes<br>• Strict priority queueing is available through use of the LLQ. | • High priority queues are serviced first |

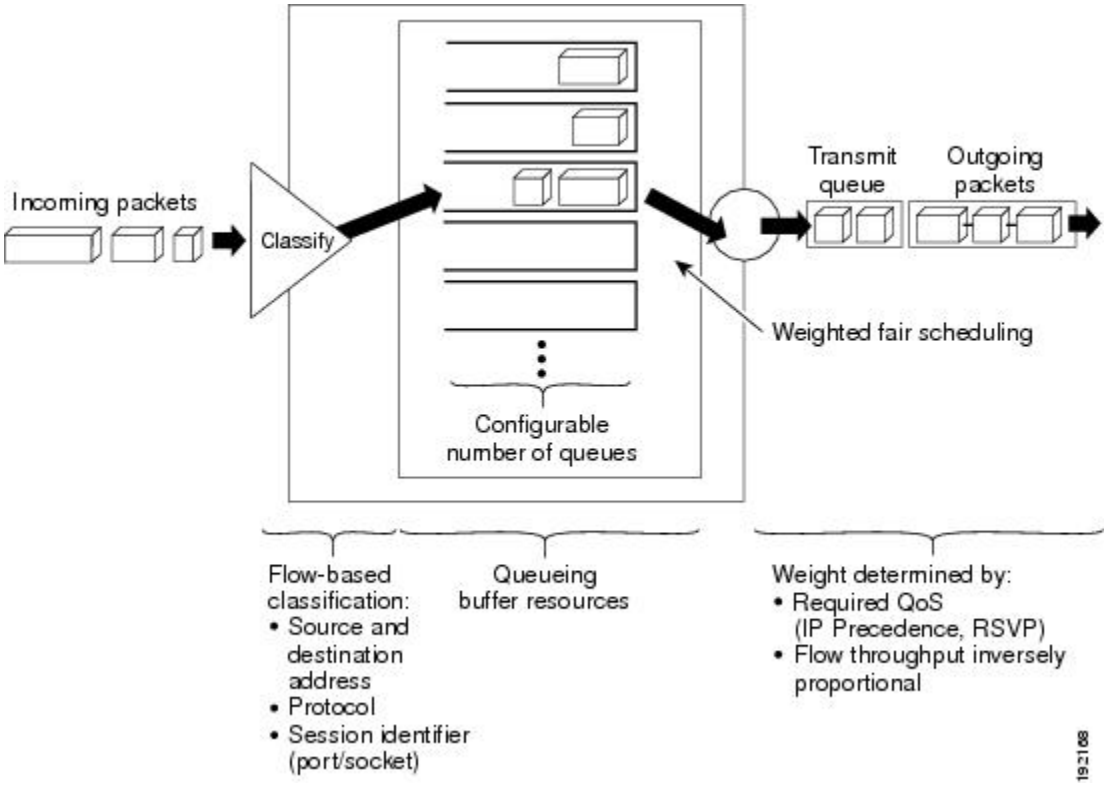
# Weighted Fair Queueing

This section contains overview information about WFQ (often referred to as flow-based WFQ).

### WFQ Functionality

WFQ is a dynamic scheduling method that provides fair bandwidth allocation to all network traffic. WFQ applies priority, or weights, to identified traffic to classify traffic into conversations and determine how much bandwidth each conversation is allowed relative to other conversations. WFQ is a flow-based algorithm that simultaneously schedules interactive traffic to the front of a queue to reduce response time and fairly shares the remaining bandwidth among high-bandwidth flows. In other words, WFQ allows you to give low-volume traffic, such as Telnet sessions, priority over high-volume traffic, such as FTP sessions. WFQ gives concurrent file transfers balanced use of link capacity; that is, when multiple file transfers occur, the transfers are given comparable bandwidth. The figure below shows how WFQ works.

*Figure 1: Weighted Fair Queueing*




WFQ provides traffic priority management that dynamically sorts traffic into messages that make up a conversation. WFQ breaks up the train of packets within a conversation to ensure that bandwidth is shared fairly between individual conversations and that low-volume traffic is transferred in a timely fashion.

WFQ classifies traffic into different flows based on packet header addressing, including such characteristics as source and destination network or MAC address, protocol, source and destination port and socket numbers of the session, Frame Relay data-link connection identifier (DLCI) value, and ToS value. There are two categories of flows: high-bandwidth sessions and low-bandwidth sessions. Low-bandwidth traffic has effective priority over high-bandwidth traffic, and high-bandwidth traffic shares the transmission service proportionally according to assigned weights. Low-bandwidth traffic streams, which comprise the majority of traffic, receive preferential service, allowing their entire offered loads to be sent in a timely fashion. High-volume traffic streams share the remaining capacity proportionally among themselves.

WFQ places packets of the various conversations in the fair queues before transmission. The order of removal from the fair queues is determined by the virtual time of the delivery of the last bit of each arriving packet.

New messages for high-bandwidth flows are discarded after the congestive-messages threshold has been met. However, low-bandwidth flows, which include control-message conversations, continue to enqueue data. As a result, the fair queue may occasionally contain more messages than are specified by the threshold number.

WFQ can manage duplex data streams, such as those between pairs of applications, and simplex data streams such as voice or video.

The WFQ algorithm also addresses the problem of round-trip delay variability. If multiple high-volume conversations are active, their transfer rates and interarrival periods are made much more predictable. WFQ greatly enhances algorithms such as Systems Network Architecture (SNA) Logical Link Control (LLC) and TCP congestion control and slow start features.

WFQ is used as the default queueing mode on most serial interfaces configured to run at E1 speeds (2.048 Mbps) or below.

WFQ provides the solution for situations in which it is desirable to provide consistent response time to heavy and light network users alike without adding excessive bandwidth. WFQ automatically adapts to changing network traffic conditions.

### Restrictions

WFQ is not supported with tunneling and encryption because these features modify the packet content information required by WFQ for classification.

Although WFQ automatically adapts to changing network traffic conditions, it does not offer the degree of precision control over bandwidth allocation that CQ and CBWFQ offer.

### WFQ and IP Precedence

WFQ is IP precedence-aware. It can detect higher priority packets marked with precedence by the IP Forwarder and can schedule them faster, providing superior response time for this traffic. Thus, as the precedence increases, WFQ allocates more bandwidth to the conversation during periods of congestion.

WFQ assigns a weight to each flow, which determines the transmit order for queued packets. In this scheme, lower weights are served first. For standard Cisco IOS WFQ, the IP precedence serves as a divisor to this weighting factor.

Like CQ, WFQ sends a certain number of bytes from each queue. With WFQ, each queue corresponds to a different flow. For each cycle through all flows, WFQ effectively sends a number of bytes equal to the precedence of the flow plus one. This number is only used as a ratio to determine how many bytes per packets to send. However, for the purposes of understanding WFQ, using this number as the byte count is sufficient. For instance, traffic with an IP Precedence value of 7 gets a lower weight than traffic with an IP Precedence value of 3, thus, the priority in transmit order. The weights are inversely proportional to the IP Precedence value.

To determine the bandwidth allocation for each queue, divide the byte count for the flow by the total byte count for all flows. For example, if you have one flow at each precedence level, each flow will get precedence + 1 parts of the link:

$1 + 2 + 3 + 4 + 5 + 6 + 7 + 8 = 36$

Thus, precedence 0 traffic will get 1/36 of the bandwidth, precedence 1 traffic will get 2/36, and precedence 7 traffic will get 8/36.

However, if you have 18 precedence 1 flows and one of each of the rest, the total is now:

$1 + 2(18) + 3 + 4 + 5 + 6 + 7 + 8 = 70$

Precedence 0 traffic will get 1/70, each of the precedence 1 flows will get 2/70, and so on.

As flows are added or ended, the actual allocated bandwidth will continuously change.

### WFQ and RSVP

RSVP uses WFQ to allocate buffer space and schedule packets, and to guarantee bandwidth for reserved flows. WFQ works with RSVP to help provide differentiated and guaranteed QoS services.

RSVP is the Internet Engineering Task Force (IETF) Internet Standard (RFC 2205) protocol for allowing an application to dynamically reserve network bandwidth. RSVP enables applications to request a specific QoS

for a data flow. The Cisco implementation allows RSVP to be initiated within the network using configured proxy RSVP.

RSVP is the only standard signalling protocol designed to guarantee network bandwidth from end to end for IP networks. Hosts and routers use RSVP to deliver QoS requests to the routers along the paths of the data stream and to maintain router and host state to provide the requested service, usually bandwidth and latency. RSVP uses a mean data rate, the largest amount of data the router will keep in queue, and minimum QoS to determine bandwidth reservation.

WFQ or Weighted Random Early Detection (WRED) acts as the preparer for RSVP, setting up the packet classification and scheduling required for the reserved flows. Using WFQ, RSVP can deliver an Integrated Services Guaranteed Service.

# Class-Based Weighted Fair Queueing

CBWFQ extends the standard WFQ functionality to provide support for user-defined traffic classes. For CBWFQ, you define traffic classes based on match criteria including protocols, access control lists (ACLs), and input interfaces. Packets satisfying the match criteria for a class constitute the traffic for that class.

Once a class has been defined according to its match criteria, you can assign it characteristics. To characterize a class, you assign it bandwidth, weight, and maximum packet limit. The bandwidth assigned to a class is the guaranteed bandwidth delivered to the class during congestion.

To characterize a class, you also specify the queue limit for that class, which is the maximum number of packets allowed to accumulate in the queue for the class. Packets belonging to a class are subject to the bandwidth and queue limits that characterize the class.

After a queue has reached its configured queue limit, enqueueing of additional packets to the class causes tail drop or packet drop to take effect, depending on how class policy is configured.

Tail drop is used for CBWFQ classes unless you explicitly configure policy for a class to use WRED to drop packets as a means of avoiding congestion. Note that if you use WRED packet drop instead of tail drop for one or more classes comprising a policy map, you must ensure that WRED is not configured for the interface to which you attach that service policy.

If a default class is configured with the **bandwidth** policy-map class configuration command, all unclassified traffic is put into a single queue and given treatment according to the configured bandwidth. If a default class is configured with the **fair-queue** command, all unclassified traffic is flow classified and given best-effort treatment. If no default class is configured, then by default the traffic that does not match any of the configured classes is flow classified and given best-effort treatment. Once a packet is classified, all of the standard mechanisms that can be used to differentiate service among the classes apply.

Flow classification is standard WFQ treatment. That is, packets with the same source IP address, destination IP address, source TCP or UDP port, or destination TCP or UDP port are classified as belonging to the same flow. WFQ allocates an equal share of bandwidth to each flow. Flow-based WFQ is also called fair queueing because all flows are equally weighted.

For CBWFQ, the weight specified for the class becomes the weight of each packet that meets the match criteria of the class. Packets that arrive at the output interface are classified according to the match criteria filters you define, then each one is assigned the appropriate weight. The weight for a packet belonging to a specific class is derived from the bandwidth you assigned to the class when you configured it; in this sense the weight for a class is user-configurable.

After the weight for a packet is assigned, the packet is enqueued in the appropriate class queue. CBWFQ uses the weights assigned to the queued packets to ensure that the class queue is serviced fairly.

Configuring a class policy--thus, configuring CBWFQ--entails these three processes:

- Defining traffic classes to specify the classification policy (class maps).

This process determines how many types of packets are to be differentiated from one another.

- Associating policies--that is, class characteristics--with each traffic class (policy maps).

This process entails configuration of policies to be applied to packets belonging to one of the classes previously defined through a class map. For this process, you configure a policy map that specifies the policy for each traffic class.

- Attaching policies to interfaces (service policies).

This process requires that you associate an existing policy map, or service policy, with an interface to apply the particular set of policies for the map to that interface.

### CBWFQ Bandwidth Allocation

The sum of all bandwidth allocation on an interface cannot exceed 75 percent of the total available interface bandwidth. The remaining 25 percent is used for other overhead, including Layer 2 overhead, routing traffic, and best-effort traffic. Bandwidth for the CBWFQ class-default class, for instance, is taken from the remaining 25 percent. However, under aggressive circumstances in which you want to configure more than 75 percent of the interface bandwidth to classes, you can override the 75 percent maximum sum allocated to all classes or flows using the **max-reserved-bandwidth** command. If you want to override the default 75 percent, exercise caution and ensure that you allow enough remaining bandwidth to support best-effort and control traffic, and Layer 2 overhead.

### Why Use CBWFQ?

Here are some general factors you should consider in determining whether you need to configure CBWFQ:

- Bandwidth allocation. CBWFQ allows you to specify the exact amount of bandwidth to be allocated for a specific class of traffic. Taking into account available bandwidth on the interface, you can configure up to 64 classes and control distribution among them, which is not the case with flow-based WFQ. Flow-based WFQ applies weights to traffic to classify it into conversations and determine how much bandwidth each conversation is allowed relative to other conversations. For flow-based WFQ, these weights, and traffic classification, are dependent on and limited to the seven IP Precedence levels.
- Coarser granularity and scalability. CBWFQ allows you to define what constitutes a class based on criteria that exceed the confines of flow. CBWFQ allows you to use ACLs and protocols or input interface names to define how traffic will be classified, thereby providing coarser granularity. You need not maintain traffic classification on a flow basis. Moreover, you can configure up to 64 discrete classes in a service policy.

### CBWFQ and RSVP

RSVP can be used in conjunction with CBWFQ. When both RSVP and CBWFQ are configured for an interface, RSVP and CBWFQ act independently, exhibiting the same behavior that they would if each were running alone. RSVP continues to work as it does when CBWFQ is not present, even in regard to bandwidth availability assessment and allocation.

### Restrictions

Configuring CBWFQ on a physical interface is only possible if the interface is in the default queueing mode. Serial interfaces at E1 (2.048 Mbps) and below use WFQ by default--other interfaces use FIFO by default. Enabling CBWFQ on a physical interface overrides the default interface queueing method.

If you configure a class in a policy map to use WRED for packet drop instead of tail drop, you must ensure that WRED is not configured on the interface to which you intend to attach that service policy.

# Low Latency Queueing

The LLQ feature brings strict PQ to CBWFQ. Strict PQ allows delay-sensitive data such as voice to be dequeued and sent before packets in other queues are dequeued.

Without LLQ, CBWFQ provides WFQ based on defined classes with no strict priority queue available for real-time traffic. CBWFQ allows you to define traffic classes and then assign characteristics to that class. For example, you can designate the minimum bandwidth delivered to the class during congestion.

For CBWFQ, the weight for a packet belonging to a specific class is derived from the bandwidth you assigned to the class when you configured it. Therefore, the bandwidth assigned to the packets of a class determines the order in which packets are sent. All packets are serviced fairly based on weight; no class of packets may be granted strict priority. This scheme poses problems for voice traffic that is largely intolerant of delay, especially variation in delay. For voice traffic, variations in delay introduce irregularities of transmission manifesting as jitter in the heard conversation.

LLQ provides strict priority queueing for CBWFQ, reducing jitter in voice conversations. Configured by the **priority** command, LLQ enables use of a single, strict priority queue within CBWFQ at the class level, allowing you to direct traffic belonging to a class to the CBWFQ strict priority queue. To enqueue class traffic to the strict priority queue, you specify the named class within a policy map and then configure the **priority** command for the class. (Classes to which the **priority** command is applied are considered priority classes.) Within a policy map, you can give one or more classes priority status. When multiple classes within a single policy map are configured as priority classes, all traffic from these classes is enqueued to the same, single, strict priority queue.

One of the ways in which the strict PQ used within CBWFQ differs from its use outside CBWFQ is in the parameters it takes. Outside CBWFQ, you can use the **ip rtp priority** command to specify the range of UDP ports whose voice traffic flows are to be given priority service. Using the **priority** command, you are no longer limited to a UDP port number to stipulate priority flows because you can configure the priority status for a class within CBWFQ. Instead, all of the valid match criteria used to specify traffic for a class now apply to priority traffic. These methods of specifying traffic for a class include matching on access lists, protocols, and input interfaces. Moreover, within an access list you can specify that traffic matches are allowed based on the IP differentiated services code point (DSCP) value that is set using the first six bits of the ToS byte in the IP header.

Although it is possible to enqueue various types of real-time traffic to the strict priority queue, we strongly recommend that you direct only voice traffic to it because voice traffic is well-behaved, whereas other types of real-time traffic are not. Moreover, voice traffic requires that delay be nonvariable in order to avoid jitter. Real-time traffic such as video could introduce variation in delay, thereby thwarting the steadiness of delay required for successful voice traffic transmission.

For information on how to configure LLQ, see the "Configuring Weighted Fair Queueing" module.

### LLQ Bandwidth Allocation

When you specify the **priority** command for a class, it takes a *bandwidth* argument that gives maximum bandwidth in kbps. You use this parameter to specify the maximum amount of bandwidth allocated for packets belonging to the class configured with the **priority** command. The bandwidth parameter both guarantees bandwidth to the priority class and restrains the flow of packets from the priority class.

In the event of congestion, policing is used to drop packets when the bandwidth is exceeded. Voice traffic enqueued to the priority queue is UDP-based and therefore not adaptive to the early packet drop characteristic of WRED. Because WRED is ineffective, you cannot use the WRED **random-detect** command with the **priority** command.

When congestion occurs, traffic destined for the priority queue is metered to ensure that the bandwidth allocation configured for the class to which the traffic belongs is not exceeded.

Priority traffic metering has the following qualities:

- Priority traffic metering is only performed under congestion conditions. When the device is not congested, the priority class traffic is allowed to exceed its allocated bandwidth. When the device is congested, the priority class traffic above the allocated bandwidth is discarded.
- It is performed on a per-packet basis, and tokens are replenished as packets are sent. If not enough tokens are available to send the packet, it is dropped.
- It restrains priority traffic to its allocated bandwidth to ensure that nonpriority traffic, such as routing packets and other data, is not starved.

With metering, the classes are policed and rate-limited individually. That is, although a single policy map might contain four priority classes, all of which are enqueued in a single priority queue, they are each treated as separate flows with separate bandwidth allocations and constraints.

It is important to note that because bandwidth for the priority class is specified as a parameter to the **priority** command, you cannot also configure the **bandwidth** policy-map class configuration command for a priority class. To do so is a configuration violation that would only introduce confusion in relation to the amount of bandwidth to allocate.

The bandwidth allocated for a priority queue always includes the Layer 2 encapsulation header. However, it does not include other headers. When you calculate the amount of bandwidth to allocate for a given priority class, you must account for the fact that Layer 2 headers are included. You must also allow bandwidth for the possibility of jitter introduced by routers in the voice path.

**Note** The sum of all bandwidth allocation on an interface cannot exceed 75 percent of the total available interface bandwidth. However, under aggressive circumstances in which you want to configure more than 75 percent of the interface bandwidth to classes, you can override the 75 percent maximum sum allocated to all classes or flows using the **max-reserved-bandwidth** command. The **max-reserved-bandwidth** command is intended for use on main interfaces only.

### Why Use LLQ?

Here are some general factors you should consider in determining whether you need to configure LLQ:

- LLQ provides strict priority service serial interfaces.

- LLQ is not limited to UDP port numbers. Because you can configure the priority status for a class within CBWFQ, you are no longer limited to UDP port numbers to stipulate priority flows. Instead, all of the valid match criteria used to specify traffic for a class now apply to priority traffic.
- By configuring the maximum amount of bandwidth allocated for packets belonging to a class, you can avoid starving nonpriority traffic.

### Restrictions

The following restrictions apply to LLQ:

- The **random-detect** command, **shape** command, and **bandwidth** policy-map class configuration command cannot be used in conjunction with **priority** command in the same class-map.
- The **priority** command can be configured in multiple classes, but it should only be used for voice-like, constant bit rate (CBR) traffic.
- The **queue-limit** command can be configured in conjunction with the **priority** command when only one priority queue of a particular level exists in the policy-map.
- You cannot configure the default queue as a priority queue at any level.

# Priority Queueing

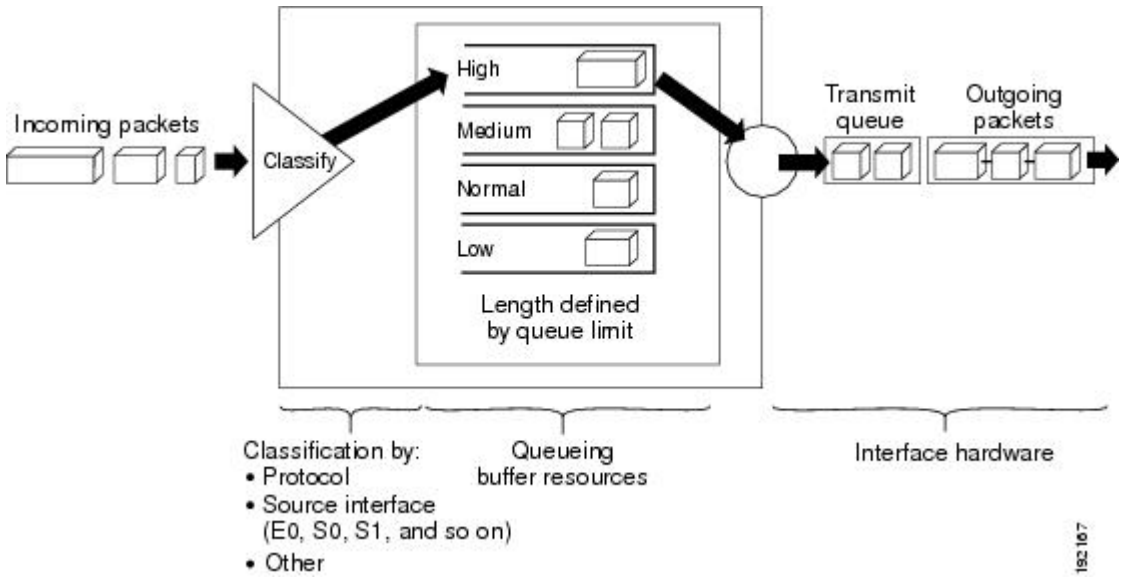
PQ allows you to define how traffic is prioritized in the network. You configure four traffic priorities. You can define a series of filters based on packet characteristics to cause the router to place traffic into these four queues; the queue with the highest priority is serviced first until it is empty, then the lower queues are serviced in sequence.

For information on how to configure PQ, see the "Configuring Priority Queueing" module.

### How It Works

During transmission, PQ gives priority queues absolute preferential treatment over low priority queues; important traffic, given the highest priority, always takes precedence over less important traffic. Packets are classified based on user-specified criteria and placed into one of the four output queues--high, medium, normal, and low--based on the assigned priority. Packets that are not classified by priority fall into the normal queue. The figure below illustrates this process.

*Figure 2: Priority Queueing*




When a packet is to be sent out an interface, the priority queues on that interface are scanned for packets in descending order of priority. The high priority queue is scanned first, then the medium priority queue, and so on. The packet at the head of the highest queue is chosen for transmission. This procedure is repeated every time a packet is to be sent.

The maximum length of a queue is defined by the length limit. When a queue is longer than the queue limit, all additional packets are dropped.

**Note** The priority output queueing mechanism can be used to manage traffic from all networking protocols. Additional fine-tuning is available for IP and for setting boundaries on the packet size.

### How Packets Are Classified for Priority Queueing

A priority list is a set of rules that describe how packets should be assigned to priority queues. A priority list might also describe a default priority or the queue size limits of the various priority queues.

Packets can be classified by the following criteria:

- Protocol or subprotocol type
- Incoming interface
- Packet size
- Fragments
- Access list

Keepalives sourced by the network server are always assigned to the high priority queue; all other management traffic (such as Interior Gateway Routing Protocol (IGRP) updates) must be configured. Packets that are not classified by the priority list mechanism are assigned to the normal queue.

### Why Use Priority Queueing?

PQ provides absolute preferential treatment to high priority traffic, ensuring that mission-critical traffic traversing various WAN links gets priority treatment. In addition, PQ provides a faster response time than do other methods of queueing.

Although you can enable priority output queueing for any interface, it is best used for low-bandwidth, congested serial interfaces.

### Restrictions

When choosing to use PQ, consider that because lower priority traffic is often denied bandwidth in favor of higher priority traffic, use of PQ could, in the worst case, result in lower priority traffic never being sent. To avoid inflicting these conditions on lower priority traffic, you can use traffic shaping to rate-limit the higher priority traffic.

PQ introduces extra overhead that is acceptable for slow interfaces, but may not be acceptable for higher speed interfaces such as Ethernet. With PQ enabled, the system takes longer to switch packets because the packets are classified by the processor card.

PQ uses a static configuration and does not adapt to changing network conditions.

PQ is not supported on any tunnels.

# Bandwidth Management

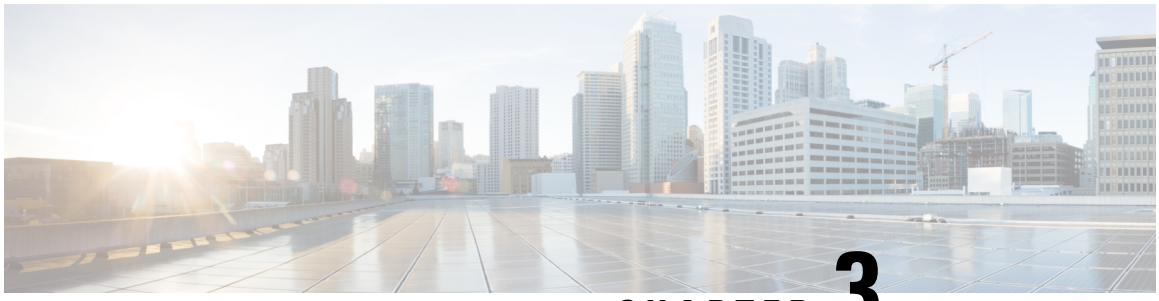
RSVP, CBWFQ and LLQ can all reserve and consume bandwidth, up to a maximum of the reserved bandwidth on an interface.

To allocate bandwidth, you can use one of the following commands:

- For RSVP, use the **ip rsvp bandwidth** command.
- For CBWFQ, use the **bandwidth** policy-map class configuration command.
- For LLQ, you can allocate bandwidth using the **priority** command.

When you configure these commands, be aware of bandwidth limitations and configure bandwidth according to requirements in your network. Remember, the sum of all bandwidths cannot exceed the maximum reserved bandwidth. The default maximum bandwidth is 75 percent of the total available bandwidth on the interface. The remaining 25 percent of bandwidth is used for overhead, including Layer 2 overhead, routing traffic, and best-effort traffic.

If you find that it is necessary to change the maximum reserved bandwidth, you can change the maximum bandwidth by using the **max-reserved-bandwidth** command. The **max-reserved-bandwidth** command can be used only on interfaces; it cannot be used on VCs.



CHAPTER 3

# IPv6 QoS: Queueing

Class-based and flow-based queueing are supported for IPv6.



## Finding Feature Information

Your software release may not support all the features documented in this module. For the latest caveats and feature information, see Bug Search Tool and the release notes for your platform and software release. To find information about the features documented in this module, and to see a list of the releases in which each feature is supported, see the feature information table.

Use Cisco Feature Navigator to find information about platform support and Cisco software image support. To access Cisco Feature Navigator, go to https://cfnng.cisco.com/. An account on Cisco.com is not required.

## Information About IPv6 QoS: Queueing

### Implementation Strategy for QoS for IPv6

IPv6 packets are forwarded by paths that are different from those for IPv4. QoS features supported for IPv6 environments include packet classification, queueing, traffic shaping, weighted random early detection (WRED), class-based packet marking, and policing of IPv6 packets. These features are available at both the process switching and Cisco Express Forwarding switching paths of IPv6.

All of the QoS features available for IPv6 environments are managed from the modular QoS command-line interface (MQC). The MQC allows you to define traffic classes, create and configure traffic policies (policy maps), and then attach those traffic policies to interfaces.

To implement QoS in networks running IPv6, follow the same steps that you would follow to implement QoS in networks running only IPv4. At a very high level, the basic steps for implementing QoS are as follows:

- Know which applications in your network need QoS.

- Understand the characteristics of the applications so that you can make decisions about which QoS features would be appropriate.
- Know your network topology so that you know how link layer header sizes are affected by changes and forwarding.
- Create classes based on the criteria you establish for your network. In particular, if the same network is also carrying IPv4 traffic along with IPv6, decide if you want to treat both of them the same way or treat them separately and specify match criteria accordingly. If you want to treat them the same, use match statements such as **match precedence**, **match dscp**. If you want to treat them separately, add match criteria such as **match protocol ip** and **match protocol ipv6** in a match-all class map.
- Create a policy to mark each class.
- Work from the edge toward the core in applying QoS features.
- Build the policy to treat the traffic.
- Apply the policy.

## Congestion Management in IPv6 Networks

Once you have marked the traffic, you can use the markings to build a policy and classify traffic on the rest of the network segments. If you keep the policy simple (for example approximately four classes), it will be easier to manage. Class-based and flow-based queueing are supported for IPv6. The processes and tasks use the same commands and arguments to configure various queueing options for both IPv4 and IPv6.

## Traffic Policing in IPv6 Environments

Congestion management for IPv6 is similar to IPv4, and the commands used to configure queueing and traffic shaping features for IPv6 environments are the same commands as those used for IPv4. Traffic shaping allows you to limit the packet dequeue rate by holding additional packets in the queues and forwarding them as specified by parameters configured for traffic shaping features. Traffic shaping uses flow-based queueing by default. CBWFQ can be used to classify and prioritize the packets. Class-based policer and generic traffic shaping (GTS) or Frame Relay traffic shaping (FRTS) can be used for conditioning and policing traffic.

# Additional References

### Related Documents

| Related Topic | Document Title |
|---|---|
| IPv6 addressing and connectivity | *IPv6 Configuration Guide* |
| Cisco IOS commands | *Cisco IOS Master Commands List, All Releases* |
| IPv6 commands | *Cisco IOS IPv6 Command Reference* |
| Cisco IOS IPv6 features | *Cisco IOS IPv6 Feature Mapping* |

| Related Topic | Document Title |
|---|---|
| QoS Queuing features | "Congestion Management Overview" module |

### Standards and RFCs

| Standard/RFC | Title |
|---|---|
| RFCs for IPv6 | *IPv6 RFCs* |

### MIBs

| MIB | MIBs Link |
|---|---|
| | To locate and download MIBs for selected platforms, Cisco IOS releases, and feature sets, use Cisco MIB Locator found at the following URL:<br>http://www.cisco.com/go/mibs |

### Technical Assistance

| Description | Link |
|---|---|
| The Cisco Support and Documentation website provides online resources to download documentation, software, and tools. Use these resources to install and configure the software and to troubleshoot and resolve technical issues with Cisco products and technologies. Access to most tools on the Cisco Support and Documentation website requires a Cisco.com user ID and password. | http://www.cisco.com/cisco/web/support/index.html |

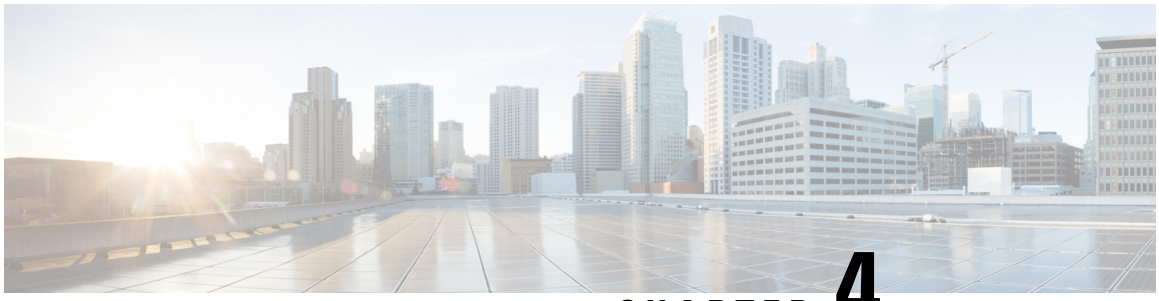
# Feature Information for IPv6 QoS: Queueing

The following table provides release information about the feature or features described in this module. This table lists only the software release that introduced support for a given feature in a given software release train. Unless noted otherwise, subsequent releases of that software release train also support that feature.

Use Cisco Feature Navigator to find information about platform support and Cisco software image support. To access Cisco Feature Navigator, go to www.cisco.com/go/cfn. An account on Cisco.com is not required.

***Table 2: Feature Information for IPv6 QoS: Queueing***

| Feature Name | Releases | Feature Information |
|---|---|---|
| IPv6 QoS: Queueing | Cisco IOS XE Release 2.1 | Class-based and flow-based queueing are supported for IPv6. |



CHAPTER 4

# Low Latency Queueing with Priority Percentage Support

This feature allows you to configure bandwidth as a percentage within low latency queueing (LLQ). Specifically, you can designate a percentage of the bandwidth to be allocated to an entity (such as a physical interface, a shaped ATM permanent virtual circuit (PVC), or a shaped Frame Relay PVC to which a policy map is attached). Traffic associated with the policy map will then be given priority treatment.

This feature also allows you to specify the percentage of bandwidth to be allocated to nonpriority traffic classes. It modifies two existing commands--**bandwidth** and **priority**--and provides additional functionality to the way that bandwidth can be allocated using these two commands.



## Finding Feature Information

Your software release may not support all the features documented in this module. For the latest caveats and feature information, see Bug Search Tool and the release notes for your platform and software release. To find information about the features documented in this module, and to see a list of the releases in which each feature is supported, see the feature information table.

Use Cisco Feature Navigator to find information about platform support and Cisco software image support. To access Cisco Feature Navigator, go to https://cfnng.cisco.com/. An account on Cisco.com is not required.

## Restrictions for LLQ with Priority Percentage Support

### Dropping Excess Traffic

If the incoming high priority traffic exceeds the bandwidth percentage calculated by the **priority percent**command, and there is congestion in the network, the excess traffic is dropped. This is identical to

the behavior demonstrated when the **priority**command uses bandwidth in kbps. In both cases, if the high priority traffic exceeds the bandwidth, and there is congestion in the network, excess traffic is dropped.

#### Exceeding the Configured Bandwidth Percentage Calculated by the bandwidth percent and priority percent Commands

By default, when the **bandwidth percent**and **priority percent** commands are used to allocate bandwidth, the sum of the bandwidth percentage allocated to the high priority traffic and the bandwidth percentage allocated to the nonpriority traffic cannot exceed 99 percent of the total bandwidth available on the interface.

The remaining 1 percent of the total bandwidth available on the interface is kept in reserve for the unclassified traffic and routing traffic, if any, and is proportionally divided among the defined traffic classes.

# Information About LLQ with Priority Percentage Support

## Benefits of LLQ with Priority Percentage Support

This feature allows the Cisco Software to accommodate networks with a large number of interfaces, all with differing bandwidths. This feature is useful when all of those interfaces with differing bandwidths need to be associated with a policy map that allocates proportional bandwidths to multiple classes.

Additionally, configuring bandwidth in percentages is most useful when the underlying link bandwidth is unknown or the relative class bandwidth distributions are known. For interfaces that have adaptive shaping rates (such as available bit rate [ABR] virtual circuits), CBWFQ can be configured by configuring class bandwidths in percentages.

## Changes to the bandwidth Command for LLQ with Priority Percentage Support

This feature adds a new keyword to the **bandwidth** command--**remaining percent**. The feature also changes the functionality of the existing **percent** keyword. These changes result in the following commands for bandwidth: **bandwidth percent**and **bandwidth remaining percent**.

The **bandwidth percent** command configures bandwidth as an absolute percentage of the total bandwidth on the interface.

The **bandwidth remaining percent**command allows you to allocate bandwidth as a relative percentage of the total bandwidth available on the interface. This command allows you to specify the relative percentage of the bandwidth to be allocated to the classes of traffic. For instance, you can specify that 30 percent of the available bandwidth be allocated to class1, and 60 percent of the bandwidth be allocated to class2. Essentially, you are specifying the ratio of the bandwidth to be allocated to the traffic class. In this case, the ratio is 1 to 2 (30 percent allocated to class1 and 60 percent allocated to class2). The sum of the numbers used to indicate this ratio cannot exceed 100 percent. This way, you need not know the total amount of bandwidth available, just the relative percentage you want to allocate for each traffic class.

Each traffic class gets a minimum bandwidth as a relative percentage of the remaining bandwidth. The remaining bandwidth is the bandwidth available after the priority queue, if present, is given its required bandwidth, and after any Resource Reservation Protocol (RSVP) flows are given their requested bandwidth.

Because this is a relative bandwidth allocation, the packets for the traffic classes are given a proportionate weight only, and no admission control is performed to determine whether any bandwidth (in kbps) is actually

available. The only error checking that is performed is to ensure that the total bandwidth percentages for the classes do not exceed 100 percent.

## Changes to the priority Command for LLQ with Priority Percentage Support

This feature also adds the **percent** keyword to the **priority** command. The **priority percent** command indicates that the bandwidth will be allocated as a percentage of the total bandwidth of the interface. You can then specify the percentage (that is, a number from 1 to 100) to be allocated by using the *percentage* argument with the **priority percent**command.

Unlike the **bandwidth** command, the **priority** command provides a strict priority to the traffic class, which ensures low latency to high priority traffic classes.

## Bandwidth Calculations in LLQ with Priority Percentage Support

When the **bandwidth** and **priority** commands calculate the total amount of bandwidth available on an entity, the following guidelines are invoked:

- If the entity is a physical interface, the total bandwidth is the bandwidth on the physical interface.
- If the entity is a shaped ATM PVC, the total bandwidth is calculated as follows:
  - For a variable bit rate (VBR) VC, the average shaping rate is used in the calculation.
  - For an available bit rate (ABR) VC, the minimum shaping rate is used in the calculation.

# How to Configure LLQ with Priority Percentage Support

## Specifying the Bandwidth Percentage

### SUMMARY STEPS

1. **enable**
2. **configure terminal**
3. **policy-map** *policy-map*
4. **class** {*class-name* | **class-default**}
5. **priority** {*bandwidth-kbps* | **percent** *percentage*}[*burst*]
6. **bandwidth** {*bandwidth-kbps* | **percent** *percentage* | **remaining percent** *percentage*}
7. **end**

### DETAILED STEPS

| | Command or Action | Purpose |
|---|---|---|
| **Step 1** | **enable**<br>**Example:**<br>`Router> enable` | Enables privileged EXEC mode.<br>• Enter your password if prompted. |

| | Command or Action | Purpose |
|---|---|---|
| **Step 2** | **configure terminal**<br>**Example:**<br>`Router# configure terminal` | Enters global configuration mode. |
| **Step 3** | **policy-map** *policy-map*<br>**Example:**<br>`Router(config)# policy-map policy1` | Specifies the name of the policy map to be created or modified. Enters policy-map configuration mode.<br>• Enter the policy map name. Names can be a maximum of 40 alphanumeric characters. |
| **Step 4** | **class** {*class-name* **\| class-default**}<br>**Example:**<br>`Router(config-pmap)# class class1` | Specifies the class so that you can configure or modify its policy. Enters policy-map class configuration mode.<br>• Enter the class name. |
| **Step 5** | **priority** {*bandwidth-kbps* **\| percent** *percentage*}[*burst*]<br>**Example:**<br>`Router(config-pmap-c)#`<br>`priority percent 10` | Gives priority to a class of traffic belonging to the policy map.<br>• Enter the priority percentage. |
| **Step 6** | **bandwidth** {*bandwidth-kbps* **\| percent** *percentage* **\| remaining percent** *percentage*}<br>**Example:**<br>`Router(config-pmap-c)#`<br>`bandwidth percent 30` | Specifies the bandwidth for a class of traffic belonging to the policy map.<br>• Enter the bandwidth percentage. |
| **Step 7** | **end**<br>**Example:**<br>**Example:**<br>`Router(config-pmap-c)#`<br>`end` | (Optional) Exits policy-map class configuration mode and returns to privileged EXEC mode. |

# Verifying the Bandwidth Percentage

### SUMMARY STEPS

1. **enable**
2. **show policy-map** *policy-map*
3. **show policy-map** *policy-map* **class** *class-name*

4. **show policy-map interface** *type number*
5. **exit**

**DETAILED STEPS**

| | Command or Action | Purpose |
|---|---|---|
| **Step 1** | **enable**<br>**Example:**<br>`Router> enable` | Enables privileged EXEC mode.<br>• Enter your password if prompted. |
| **Step 2** | **show policy-map** *policy-map*<br>**Example:**<br>`Router#`<br>`show policy-map policy1` | (Optional) Displays the configuration of all classes for a specified service policy map or the configuration of all classes for all existing policy maps<br>• Enter the name of the policy map whose complete configuration is to be displayed. |
| **Step 3** | **show policy-map** *policy-map* **class** *class-name*<br>**Example:**<br>`Router#`<br>`show policy-map policy1 class class1` | (Optional) Displays the configuration for the specified class of the specified policy map.<br>• Enter the policy map name and the class name. |
| **Step 4** | **show policy-map interface** *type number*<br>**Example:**<br>`Router#`<br>`show policy-map interface serial4/0/0` | (Optional) Displays the packet statistics of all classes that are configured for all service policies either on the specified interface or subinterface or on a specific PVC on the interface.<br>• Enter the interface type and number. |
| **Step 5** | **exit**<br>**Example:**<br>`Router# exit` | (Optional) Exits privileged EXEC mode. |

# Configuration Examples for LLQ with Priority Percentage Support

## Example Specifying the Bandwidth Percentage

The following example uses the **priority percent** command to specify a bandwidth percentage of 10 percent for the class called voice-percent. Then the **bandwidth remaining percent** command is used to specify a bandwidth percentage of 30 percent for the class called data1, and a bandwidth percentage of 20 percent for the class called data2.

```
Router> enable
Router# configure terminal
Router(config)# policy-map policy1
Router(config-pmap)# class voice-percent
Router(config-pmap-c)# priority percent 10
Router(config-pmap-c)# exit
Router(config-pmap)# class data1
Router(config-pmap-c)# bandwidth remaining percent 30
Router(config-pmap-c)# exit
Router(config-pmap)# class data2
Router(config-pmap-c)# bandwidth remaining percent 20
Router(config-pmap-c)# end
```

As a result of this configuration, 10 percent of the interface bandwidth is guaranteed for the class called voice-percent. The classes called data1 and data2 get 30 percent and 20 percent of the remaining bandwidth, respectively.

# Example Mixing the Units of Bandwidth for Nonpriority Traffic

If a particular unit (that is, kbps or percentages) is used when specifying the bandwidth for a specific class of nonpriority traffic, the same bandwidth unit must be used when specifying the bandwidth for the other nonpriority classes in that policy map. The bandwidth units within the same policy map must be identical. However, the unit for the **priority** command in the priority class can be different from the bandwidth unit of the nonpriority class. The same configuration can contain multiple policy maps, however, which in turn can use different bandwidth units.

The following sample configuration contains three policy maps--policy1, policy2, and policy3. In the policy map called policy1 and the policy map called policy2, the bandwidth is specified by percentage. However, in the policy map called policy3, bandwidth is specified in kbps.

```
Router> enable
Router# configure terminal
Router(config)# policy-map policy1
Router(config-pmap)# class voice-percent
Router(config-pmap-c)# priority percent 10
Router(config-pmap-c)# exit
Router(config-pmap)# class data1
Router(config-pmap-c)# bandwidth percent 30
Router(config-pmap-c)# exit
Router(config-pmap)# class data2
Router(config-pmap-c)# bandwidth percent 20
Router(config-pmap-c)# exit
Router(config-pmap)# exit
Router(config)# policy-map policy2
Router(config-pmap)# class voice-percent
Router(config-pmap-c)# priority percent 10
Router(config-pmap-c)# exit
Router(config-pmap)# class data1
Router(config-pmap-c)# bandwidth remaining percent 30
Router(config-pmap-c)# exit
Router(config-pmap)# class data2
Router(config-pmap-c)# bandwidth remaining percent 20
Router(config-pmap-c)# exit
Router(config-pmap)# exit
Router(config)# policy-map policy3
Router(config-pmap)# class voice-percent
Router(config-pmap-c)# priority 500
Router(config-pmap-c)# exit
```

```
Router(config-pmap)# class data1
Router(config-pmap-c)# bandwidth 30
Router(config-pmap-c)# exit
Router(config-pmap)# class data2
Router(config-pmap-c)# bandwidth 20
Router(config-pmap-c)# end
```

# Example Verifying the Bandwidth Percentage

The following sample output from the **show policy-map interface**command shows that 50 percent of the interface bandwidth is guaranteed for the class called class1 and that 25 percent is guaranteed for the class called class2. The output displays the amount of bandwidth as both a percentage and a number of kbps.

```
Router# show policy-map interface
 serial3/2/0
 Serial3/2/0
  Service-policy output:policy1
    Class-map:class1 (match-all)
      0 packets, 0 bytes
      5 minute offered rate 0 bps, drop rate 0 bps
      Match:none
      Weighted Fair Queueing
        Output Queue:Conversation 265
        Bandwidth 50 (%)
        Bandwidth 772 (kbps) Max Threshold 64 (packets)
        (pkts matched/bytes matched) 0/0
        (depth/total drops/no-buffer drops) 0/0/0
Class-map:class2 (match-all)
      0 packets, 0 bytes
      5 minute offered rate 0 bps, drop rate 0 bps
      Match:none
      Weighted Fair Queueing
        Output Queue:Conversation 266
        Bandwidth 25 (%)
        Bandwidth 386 (kbps) Max Threshold 64 (packets)
        (pkts matched/bytes matched) 0/0
        (depth/total drops/no-buffer drops) 0/0/0
    Class-map:class-default (match-any)
      0 packets, 0 bytes
      5 minute offered rate 0 bps, drop rate 0 bps
      Match:any
```

In this example, serial interface s3/2/0 has a total bandwidth of 1544 kbps. During periods of congestion, 50 percent (or 772 kbps) of the link bandwidth is guaranteed to the class called class1, and 25 percent (or 386 kbps) of the link bandwidth is guaranteed to the class called class2.

# Additional References

### Related Documents

| Related Topic | Document Title |
|---|---|
| QoS commands: complete command syntax, command modes, command history, defaults, usage guidelines, and examples | *Cisco IOS Quality of Service Solutions Command Reference* |

| Related Topic | Document Title |
|---|---|
| LLQ | "Applying QoS Features Using the MQC" module |

### Standards

| Standards | Title |
|---|---|
| No new or modified standards are supported, and support for existing standards has not been modified. | -- |

### MIBs

| MIBs | MIBs Link |
|---|---|
| No new or modified MIBs are supported, and support for existing MIBs has not been modified by this feature. | To locate and download MIBs for selected platforms, Cisco IOS XE Software releases, and feature sets, use Cisco MIB Locator found at the following URL:<br>http://www.cisco.com/go/mibs |

### RFCs

| RFCs | Title |
|---|---|
| No new or modified RFCs are supported, and support for existing RFCs has not been modified. | -- |

### Technical Assistance

| Description | Link |
|---|---|
| The Cisco Support and Documentation website provides online resources to download documentation, software, and tools. Use these resources to install and configure the software and to troubleshoot and resolve technical issues with Cisco products and technologies. Access to most tools on the Cisco Support and Documentation website requires a Cisco.com user ID and password. | http://www.cisco.com/cisco/web/support/index.html |

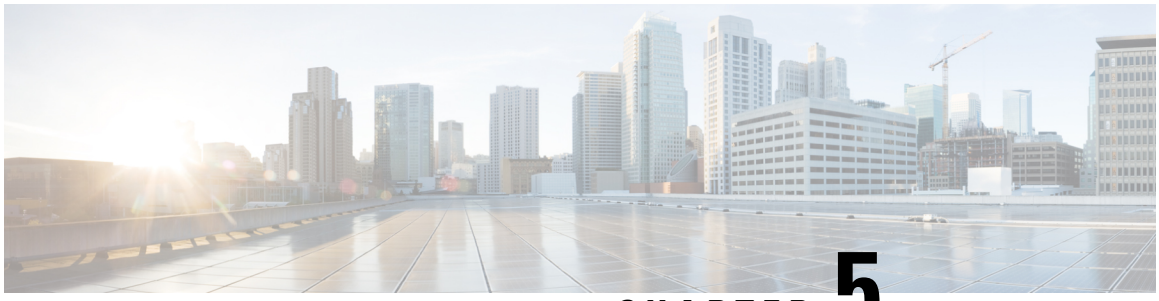
# Feature Information for LLQ with Priority Percentage Support

The following table provides release information about the feature or features described in this module. This table lists only the software release that introduced support for a given feature in a given software release train. Unless noted otherwise, subsequent releases of that software release train also support that feature.

Use Cisco Feature Navigator to find information about platform support and Cisco software image support. To access Cisco Feature Navigator, go to www.cisco.com/go/cfn. An account on Cisco.com is not required.

*Table 3: Feature Information for Low Latency Queueing with Priority Percentage Support*

| Feature Name | Releases | Feature Information |
|---|---|---|
| Low Latency Queueing with Priority Percentage Support | Cisco IOS XE Release 2.1 | This feature allows you to configure bandwidth as a percentage within low latency queueing (LLQ). Specifically, you can designate a percentage of the bandwidth to be allocated to an entity (such as a physical interface, a shaped ATM permanent virtual circuit [PVC], or a shaped Frame Relay PVC to which a policy map is attached). Traffic associated with the policy map will then be given priority treatment.<br><br>This feature was implemented on the Cisco ASR 1000 Series Routers.<br><br>The following commands were introduced or modified: **bandwidth**(policy-map class), **priority**. |



CHAPTER 5

# Low Latency Queueing for IPsec Encryption Engines

This feature module describes the LLQ for IPsec encryption engines feature and includes the following sections:



## Finding Feature Information

Your software release may not support all the features documented in this module. For the latest caveats and feature information, see Bug Search Tool and the release notes for your platform and software release. To find information about the features documented in this module, and to see a list of the releases in which each feature is supported, see the feature information table.

Use Cisco Feature Navigator to find information about platform support and Cisco software image support. To access Cisco Feature Navigator, go to https://cfnng.cisco.com/. An account on Cisco.com is not required.

## Feature Overview

Low Latency Queueing (LLQ) for IPSec encryption engines helps reduce packet latency by introducing the concept of queueing before crypto engines. Prior to this, the crypto processing engine gave data traffic and voice traffic equal status. Administrators now designate voice traffic as priority. Data packets arriving at a router interface are directed into a data packet inbound queue for crypto engine processing. This queue is called the best effort queue. Voice packets arriving on a router interface are directed into a priority packet inbound queue for crypto engine processing. This queue is called the priority queue. The crypto engine undertakes packet processing in a favorable ratio for voice packets. Voice packets are guaranteed a minimum processing bandwidth on the crypto engine.

# Benefits of the LLQ for IPSec Encryption Engines

The LLQ for IPsec encryption engines feature guarantees a certain level of crypto engine processing time for priority designated traffic.

### Better Voice Performance

Voice packets can be identified as priority, allowing the crypto engine to guarantee a certain percentage of processing bandwidth. This feature impacts the end user experience by assuring voice quality if voice traffic is directed onto a congested network.

### Improved Latency and Jitters

Predictability is a critical component of network performance. The LLQ for IPsec encryption engines feature delivers network traffic predictability relating to VPN. With this feature disabled, an end user employing an IP phone over VPN might experience jitter or latency, both symptoms of overall network latency and congestion. With this feature enabled, these undesirable characteristics are dissipated.

# Restrictions

- No per-tunnel QoS policy. An interface QoS policy represents all tunnels.
- Assume the same IP precedence/DSCP marking for inbound and outbound voice packets.
- Assume the IP precedence/DSCP marking for voice packets are done at the source.
- Limited match criteria for voice traffic in the interface QoS policy.
- Assume call admission control is enforced within the enterprise.
- No strict error checking when aggregate policy’s bandwidth exceeds crypto engine bandwidth. Only a warning is displayed but configuration is allowed.
- Assume voice packets are either all encrypted or unencrypted.

# Related Documents

- Cisco IOS Quality of Service Solutions Command Reference
- "Applying QoS Features Using the MQC" module

# Supported Standards MIBs and RFCs

### Standards

No new or modified standards are supported by this feature.

### MIBs

No new or modified standards are supported by this feature.

To locate and download MIBs for selected platforms, Cisco IOS XE Software releases, and feature sets, use Cisco MIB Locator found at the following URL:

http://www.cisco.com/go/mibs

### RFCs

No new or modified RFCs are supported by this feature.

# Prerequisites

To use this feature, you should be familiar with the following:

- Access control lists
- Bandwidth management
- CBWFQ

# Configuration Tasks

## Defining Class Maps

### SUMMARY STEPS

1. Router(config)# **class-map**class-map-name
2. Do one of the following:
   - Router(config-cmap)# **match access-group** {*access-group* | *name access-group-name*}

### DETAILED STEPS

| | Command or Action | Purpose |
|---|---|---|
| **Step 1** | Router(config)# **class-map**class-map-name | Specifies the name of the class map to be created. |
| **Step 2** | Do one of the following:<br>• Router(config-cmap)# **match access-group** {*access-group* \| *name access-group-name*}<br>**Example:**<br>`Router(config-cmap)# match input-interface interface-name`<br>**Example:**<br>`or`<br>**Example:** | Specifies the name of the access control list (ACL) against whose contents packets are checked to determine if they belong to the class. Specifies the name of the input interface used as a match criterion against which packets are checked to determine if they belong to the class. Specifies the name of the protocol used as a match criterion against which packets are checked to determine if they belong to the class. |

| | Command or Action | Purpose |
|---|---|---|
| | `Router(config-cmap)# match protocol protocol` | |

# Configuring Class Policy in the Policy Map

To configure a policy map and create class policies that make up the service policy, begin with the **policy-map** command to specify the policy map name. Then use one or more of the following commands to configure the policy for a standard class or the default class:

- **priority**
- **bandwidth**
- **queue-limit** or **random-detect**
- **fair-queue** (for class-default class only)

For each class that you define, you can use one or more of the commands listed to configure the class policy. For example, you might specify bandwidth for one class and both bandwidth and queue limit for another class.

The default class of the policy map (commonly known as the class-default class) is the class to which traffic is directed if that traffic does not satisfy the match criteria of the other classes defined in the policy map.

You can configure class policies for as many classes as are defined on the router, up to the maximum of 64. However, the total amount of bandwidth allocated for all classes in a policy map must not exceed the minimum committed information rate (CIR) configured for the virtual circuit (VC) minus any bandwidth reserved by the **frame-relay voice bandwidth** and **frame-relay ip rtp priority** commands. If the minimum CIR is not configured, the bandwidth defaults to one half of the CIR. If all of the bandwidth is not allocated, the remaining bandwidth is allocated proportionally among the classes on the basis of their configured bandwidth.

To configure class policies in a policy map, perform the tasks described in the following sections. The task in the first section is required; the tasks in the remaining sections are optional.

# Configuring Class Policy for a Priority Queue

### SUMMARY STEPS

1. Router(config)# **policy-map** policy-map
2. Router(config-cmap)# **class** class-name
3. Router(config-pmap-c)# **priority** bandwidth-kbps

### DETAILED STEPS

| | Command or Action | Purpose |
|---|---|---|
| **Step 1** | Router(config)# **policy-map** policy-map | Specifies the name of the policy map to be created or modified. |
| **Step 2** | Router(config-cmap)# **class** class-name | Specifies the name of a class to be created and included in the service policy. |

| | Command or Action | Purpose |
|---|---|---|
| **Step 3** | Router(config-pmap-c)# **priority** bandwidth-kbps | Creates a strict priority class and specifies the amount of bandwidth, in kbps, to be assigned to the class. |

# Configuring Class Policy Using a Specified Bandwidth

### SUMMARY STEPS

1. Router(config)# **policy-map** policy-map
2. Router(config-cmap)# **class** class-name
3. Router(config-pmap-c)# **bandwidth** bandwidth-kbps

### DETAILED STEPS

| | Command or Action | Purpose |
|---|---|---|
| **Step 1** | Router(config)# **policy-map** policy-map | Specifies the name of the policy map to be created or modified. |
| **Step 2** | Router(config-cmap)# **class** class-name | Specifies the name of a class to be created and included in the service policy. |
| **Step 3** | Router(config-pmap-c)# **bandwidth** bandwidth-kbps | Specifies the amount of bandwidth to be assigned to the class, in kbps, or as a percentage of the available bandwidth. Bandwidth must be specified in kbps or as a percentage consistently across classes. (Bandwidth of the priority queue must be specified in kbps.) |

# Configuring the Class-Default Class Policy

### SUMMARY STEPS

1. Router(config)# **policy-map** policy-map
2. Router(config-cmap)# **class class-default** *default-class-name*
3. Router(config-pmap-c)# **bandwidth** bandwidth-kbps

### DETAILED STEPS

| | Command or Action | Purpose |
|---|---|---|
| **Step 1** | Router(config)# **policy-map** policy-map | Specifies the name of the policy map to be created or modified. |
| **Step 2** | Router(config-cmap)# **class class-default** *default-class-name* | Specifies the default class so that you can configure or modify its policy. |

| | Command or Action | Purpose |
|---|---|---|
| | | **Note** The class-default class is used to classify traffic that does not fall into one of the defined classes. Even though the class-default class is predefined when you create the policy map, you still have to configure it. If a default class is not configured, then traffic that does not match any of the configured classes is given best-effort treatment, which means that the network will deliver the traffic if it can, without any assurance of reliability, delay prevention, or throughput. |
| **Step 3** | Router(config-pmap-c)# **bandwidth** bandwidth-kbps<br>**Example:**<br>**Example:**<br>or<br>**Example:**<br>**Example:**<br>Router(config-pmap-c)# **fair-queue** [*number-of-dynamic-queues*] | Specifies the amount of bandwidth, in kbps, to be assigned to the class. Specifies the number of dynamic queues to be reserved for use by flow-based WFQ running on the default class. The number of dynamic queues is derived from the bandwidth of the interface. |

# Attaching the Service Policy

### SUMMARY STEPS

1. Router(config)# **interface**type number
2. Router(config-if)# **service-policy output**policy-map

### DETAILED STEPS

| | Command or Action | Purpose |
|---|---|---|
| **Step 1** | Router(config)# **interface**type number | Specifies the interface using the LLQ for IPSec encryption engines. |
| **Step 2** | Router(config-if)# **service-policy output**policy-map | Attaches the specified service policy map to the output interface and enables LLQ for IPSec encryption engines. |

## Verifying Configuration of Policy Maps and Their Classes

### SUMMARY STEPS

1. Router# **show frame-relay pvc dlci**
2. Router# **show policy-map interface** *interface-name*
3. Router# **show policy-map interface** *interface-name dlci* **dlci**

### DETAILED STEPS

| | Command or Action | Purpose |
|---|---|---|
| **Step 1** | Router# **show frame-relay pvc dlci** | Displays statistics about the PVC and the configuration of classes for the policy map on the specified data-link connection identifier (DLCI). |
| **Step 2** | Router# **show policy-map interface** *interface-name* | When LLQ is configured, displays the configuration of classes for all policy maps. |
| **Step 3** | Router# **show policy-map interface** *interface-name dlci* **dlci** | When LLQ is configured, displays the configuration of classes for the policy map on the specified DLCI. |

# Monitoring and Maintaining LLQ for IPSec Encryption Engines

### SUMMARY STEPS

1. Router# **show crypto eng qos**

### DETAILED STEPS

| | Command or Action | Purpose |
|---|---|---|
| **Step 1** | Router# **show crypto eng qos** | Displays quality of service queueing statistics for LLQ for IPSec encryption engines. |

# Configuration Examples

## LLQ for IPsec Encryption Engines Example

In the following example, a strict priority queue with a guaranteed allowed bandwidth of 50 kbps is reserved for traffic that is sent from the source address 10.10.10.10 to the destination address 10.10.10.20, in the range of ports 16384 through 20000 and 53000 through 56000.

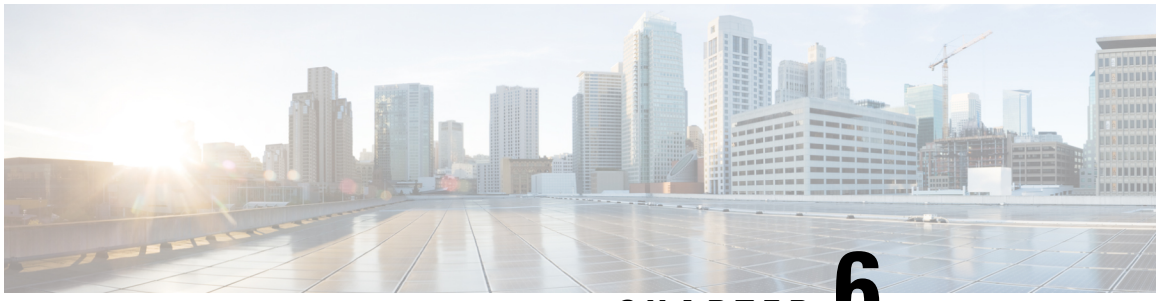
First, the following commands configure access list 102 to match the desired voice traffic:

```
Router(config)# access-list 102 permit udp host 10.10.10.10 host 10.10.10.20 range 16384
20000
```

```
Router(config)# access-list 102 permit udp host 10.10.10.10 host 10.10.10.20 range 53000
56000
```

Next, the class map voice is defined, and the policy map called policy1 is created; a strict priority queue for the class voice is reserved, a bandwidth of 20 kbps is configured for the class bar, and the default class is configured for WFQ. The service-policy command then attaches the policy map to the fas0/0.

```
Router(config)# class-map voice
Router(config-cmap)# match access-group 102
Router(config-cmap)# exit
Router(config)# policy-map policy1
Router(config-pmap)# class voice
Router(config-pmap-c)# priority 50
Router (config-cmap-c)# exit
Router(config-pmap)# class bar
Router(config-pmap-c)# bandwidth 20
Router(config-cmap-c)# exit
Router(config-pmap)# class class-default
Router(config-pmap-c)# fair-queue
Router(config-cmap-c)# exit
Router(config-cmap)# exit
Router(config)# interface fastethernet0/0/0
Router(config-if)# service-policy output policy1
```



CHAPTER 6

# Configurable Queue Depth

This feature allows you to configure (resize) the depth of the packet queues on your network. That is, you can set the maximum number (the depth) of packets that a class queue can hold, which in turn controls when the router drops packets. Configuring the depth of the packet queues helps alleviate packet queue congestion.



# Finding Feature Information

Your software release may not support all the features documented in this module. For the latest caveats and feature information, see Bug Search Tool and the release notes for your platform and software release. To find information about the features documented in this module, and to see a list of the releases in which each feature is supported, see the feature information table.

Use Cisco Feature Navigator to find information about platform support and Cisco software image support. To access Cisco Feature Navigator, go to https://cfnng.cisco.com/. An account on Cisco.com is not required.

# Information About Configuring Queue Depth

## Queue Limit

Each queue has a limit on the number of packets that the router can place into the queue. This limit, referred to as the depth, is a user-configurable limit. During periods of high traffic, a queue fills with packets that are waiting for transmission. When a queue reaches its queue limit and becomes full, by default, the router drops packets until the queue is no longer full.

For the Cisco ASR 1000 Series Router in Cisco IOS XE Software Release 2.1, the packets-per-queue range is 1 to 2,000,000.

When a packet queue temporarily experiences congestion, increasing the depth of the queue using the queue-limit command reduces the number of packets dropped. However, setting the queue limit to a high value might reduce the number of packet buffers available to other interfaces.

If you do not specify a queue limit, the router calculates the default buffer size for each class queue as follows:

- Class queues --The router uses 50 ms of 1500-byte packets but never less than 64 packets.
- Class queues on ESP40--The router uses 25 ms of 1500-byte packets but never less than 64 packets.
- Priority queues --The router uses a queue limit of 512 packets.

**Note** When setting the queue limit, decide how many users will be active at any given time and tune the queue limits accordingly. This will allow individual interfaces to handle traffic bursts and not deplete the available memory. For assistance, contact the Cisco Support website at http://www.cisco.com/techsupport.

# How to Configure Queue Depth

This section contains the following tasks:

## Setting the Depth of a Traffic Class Queue

### Before you begin

The traffic classes, class maps, and policy maps must exist.

### SUMMARY STEPS

1. **enable**
2. **configure terminal**
3. **policy-map** *policy-map-name*
4. **class** *class-map-name*
5. **bandwidth** {*bandwidth-kbps* | **percent** *percent*
6. **queue-limit** *number-of-packets*
7. **end**

### DETAILED STEPS

| | Command or Action | Purpose |
|---|---|---|
| **Step 1** | **enable**<br>**Example:**<br>`Router> enable` | Enables privileged EXEC mode.<br>• Enter your password if prompted. |
| **Step 2** | **configure terminal**<br>**Example:** | Enters global configuration mode. |

| | Command or Action | Purpose |
|---|---|---|
| | `Router# configure terminal` | |
| **Step 3** | **policy-map** *policy-map-name*<br>**Example:**<br>`Router(config)# policy-map Policy1` | Specifies the name of the policy map and enters policy-map configuration mode.<br>• Enter the policy map name. |
| **Step 4** | **class** *class-map-name*<br>**Example:**<br>`Router(config-pmap)# class Class1` | Assigns the traffic class you specify to the policy map. Enters policy-map class configuration mode.<br>• Enter the name of a previously configured class map. This is the traffic class for which you want to enable QoS features. |
| **Step 5** | **bandwidth** {*bandwidth-kbps* \| **percent** *percent*<br>**Example:**<br>`Router(config-pmap-c)# bandwidth 3000` | Specifies the amount of bandwidth (in kbps or as a percentage of available bandwidth) to be assigned to the class.<br>• Enter the amount of bandwidth. The amount of bandwidth configured should be large enough to also accommodate Layer 2 overhead. |
| **Step 6** | **queue-limit** *number-of-packets*<br>**Example:**<br>`Router(config-pmap-c)# queue-limit 32`<br>**Example:** | Specifies or modifies the maximum number of packets that the queue can hold for this class.<br>• Enter the maximum number of packets as applicable. |
| **Step 7** | **end**<br>**Example:**<br>`Router(config-pmap-c)# end` | (Optional) Exits policy-map class mode. |

# Verifying the Depth of the Traffic Class Queue

### SUMMARY STEPS

1. **enable**
2. **show policy-map interface** *type number*
3. **exit**

### DETAILED STEPS

| | Command or Action | Purpose |
|---|---|---|
| **Step 1** | **enable** | Enables privileged EXEC mode. |

| | Command or Action | Purpose |
|---|---|---|
| | **Example:**<br><br>`Router> enable` | • Enter your password if prompted. |
| **Step 2** | **show policy-map interface** *type number*<br>**Example:**<br><br>`Router#`<br>`show policy-map interface serial4/0/0` | Displays the packet statistics of all classes that are configured for all service policies either on the specified interface or subinterface or on a specific PVC on the interface.<br>• Enter the interface type and number. |
| **Step 3** | **exit**<br>**Example:**<br><br>`Router# exit` | (Optional) Exits privileged EXEC mode. |

# Configuration Examples for Configuring Queue Depth

## Example Setting the Queue Size

The following example shows how to create a policy map named Policy1 that contains two classes named Class1 and Class2. The Class1 configuration enable a specific bandwidth allocation and specifies the maximum number of packets that can be queued for the class. Because Class1 limits the number of packets that can be held in the queue to 32, the router uses tail drop to drop packets when that limit is reached. Class2 enables bandwidth allocation only.

```
Router(config)# policy-map Policy1
Router(config-pmap)# class Class1
Router(config-pmap-c)# bandwidth 3000
Router(config-pmap-c)# queue-limit 32
Router(config-pmap-c)# exit
Router(config-pmap)# class Class2
Router(config-pmap-c)# bandwidth 2000
Router(config-pmap-c)# end
```

## Example Verifying the Queue Size

Use the **show policy-map interface** command to display traffic statistics for the class maps, policy maps, and traffic queues on your network.

The following is sample output for the show policy-map interface command. In this example, the policy map named Traffic-5-PR is attached to serial interface 1/0/0 and includes three traffic classes. The Voice-5-PR class has a configured queue limit of 32 packets with 0 packets dropped. The Gold-5-PR class also indicates that no packets dropped. The Silver-5-PR class has a configured queue limit of 64 packets with 0 packets dropped.

```
Router# show policy-map interface serial 1/0/0
 Serial1/0/0
```

```
Service-policy output: Traffic-Parent (1051)
  Class-map: class-default (match-any) (1068/0)
    2064335 packets, 120273127 bytes
    5 minute offered rate 1000 bps, drop rate 0 bps
    Match: any  (1069)
      126970 packets, 3982597 bytes
      5 minute rate 0 bps
    Shape : 6000 kbps
    Service-policy : Traffic-5-PR (1052)
      Class-map: Voice-5-PR (match-all) (1053/1)
        82310 packets, 4938600 bytes
        5 minute offered rate 0 bps, drop rate 0 bps
        Match: ip precedence 5  (1054)
        Output queue: 0/32; 82310/4938600 packets/bytes output, 0 drops
        Absolute priority
        Queue-limit: 32 packets
        Police:
          304000 bps, 1536 limit, 0 extended limit
          conformed 82312 packets, 4938720 bytes; action: transmit
          exceeded 0 packets, 0 bytes; action: drop
          violated 0 packets, 0 bytes; action: drop
      Class-map: Gold-5-PR (match-any) (1058/2)
        1125476 packets, 67528560 bytes
        5 minute offered rate 0 bps, drop rate 0 bps
        Match: ip precedence 3  4  (1059)
          1125476 packets, 67528560 bytes
          5 minute rate 0 bps
        Output queue: 0/128; 1125503/67530180 packets/bytes output, 0 drops
        Bandwidth : 188 kbps (Weight 3)
      Class-map: Silver-5-PR (match-any) (1061/3)
        697908 packets, 41874480 bytes
        5 minute offered rate 0 bps, drop rate 0 bps
        Match: ip precedence 0  1  2  (1062)
          697908 packets, 41874480 bytes
          5 minute rate 0 bps
        Output queue: 0/64; 697919/41875140 packets/bytes output, 0 drops
        Bandwidth : 71 kbps (Weight 1)
        Random-detect (precedence-based):
          Exponential weight: 9 (1/512)
          Current average queue length: 0 packets
          ------------------------------------------------
                    Min   Max Prob    Rand-Drops Tail-Drops
          ------------------------------------------------
                0    16    32 1/10             0          0
                1    18    32 1/10             0          0
                2    20    32 1/10             0          0
                3    22    32 1/10             0          0
                4    24    32 1/10             0          0
                5    26    32 1/10             0          0
                6    28    32 1/10             0          0
                7    30    32 1/10             0          0
        Queue-limit: 64 packets
      Class-map: class-default (match-any) (1066/0)
        158641 packets, 5931487 bytes
        5 minute offered rate 0 bps, drop rate 0 bps
        Match: any  (1067)
          158641 packets, 5931487 bytes
          5 minute rate 0 bps
        Output queue: 0/128; 31672/1695625 packets/bytes output, 0 drops
```

# Additional References

### Related Documents

| Related Topic | Document Title |
|---|---|
| QoS commands: complete command syntax, command modes, command history, defaults, usage guidelines, and examples | *Cisco IOS Quality of Service Solutions Command Reference* |
| Packet classification | "Classifying Network Traffic" module |
| Creating classes, class maps, and policy maps | "Applying QoS Features Using the MQC" module |

### Standards

| Standard | Title |
|---|---|
| No new or modified standards are supported by this feature, and support for existing standards has not been modified by this feature. | -- |

### MIBs

| MIB | MIBs Link |
|---|---|
| No new or modified MIBs are supported by this feature, and support for existing MIBs has not been modified by this feature. | To locate and download MIBs for selected platforms, Cisco IOS XE Software releases, and feature sets, use Cisco MIB Locator found at the following URL:<br>http://www.cisco.com/go/mibs |

### RFCs

| RFC | Title |
|---|---|
| No new or modified RFCs are supported by this feature, and support for existing RFCs has not been modified by this feature. | -- |

### Technical Assistance

| Description | Link |
|---|---|
| The Cisco Support and Documentation website provides online resources to download documentation, software, and tools. Use these resources to install and configure the software and to troubleshoot and resolve technical issues with Cisco products and technologies. Access to most tools on the Cisco Support and Documentation website requires a Cisco.com user ID and password. | http://www.cisco.com/cisco/web/support/index.html |

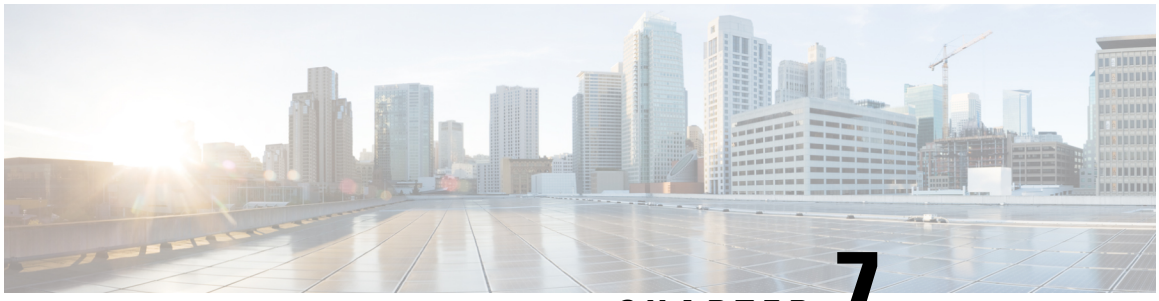
# Feature Information for Configuring Queue Depth

The following table provides release information about the feature or features described in this module. This table lists only the software release that introduced support for a given feature in a given software release train. Unless noted otherwise, subsequent releases of that software release train also support that feature.

Use Cisco Feature Navigator to find information about platform support and Cisco software image support. To access Cisco Feature Navigator, go to www.cisco.com/go/cfn. An account on Cisco.com is not required.

*Table 4: Feature Information for Configuring Queue Depth*

| Feature Name | Releases | Feature Information |
|---|---|---|
| Configurable Queue Depth | Cisco IOS XE Release 2.1 | This feature allows you to configure (resize) the depth of the packet queues on your network. That is, you can set the maximum number (the depth) of packets that a class queue can hold, which in turn controls when the router drops packets. Configuring the depth of the packet queues helps alleviate packet queue congestion.<br>The following command was introduced or modified: **queue-limit**. |



CHAPTER 7

# Multi-Level Priority Queues

The Multi-Level Priority Queues (MPQ) feature allows you to configure multiple priority queues for multiple traffic classes by specifying a different priority level for each of the traffic classes in a single service policy map. You can configure multiple service policy maps per device. Having multiple priority queues enables the device to place delay-sensitive traffic (for example, voice) on the outbound link before delay-insensitive traffic. As a result, high-priority traffic receives the lowest latency possible on the device.



## Finding Feature Information

Your software release may not support all the features documented in this module. For the latest caveats and feature information, see Bug Search Tool and the release notes for your platform and software release. To find information about the features documented in this module, and to see a list of the releases in which each feature is supported, see the feature information table.

Use Cisco Feature Navigator to find information about platform support and Cisco software image support. To access Cisco Feature Navigator, go to https://cfnng.cisco.com/. An account on Cisco.com is not required.

## Prerequisites for Multi-Level Priority Queues

You must configure traffic classes using the **class-map** command.

## Restrictions for Multi-Level Priority Queues

- The Bandwidth kbps and percent command cannot co-exist with strict priority or priority level in the same policy-map. So, a check is added to ensure only a policer with drop action, along with priority is allowed as a conditional priority.

- You cannot configure both the **priority** command and the **priority level** command for two different classes in the same policy map. For example, the device does not accept the following configuration:

```
Device> enable
Device# configure terminal
Device(config)# policy-map Map1
Device(config-pmap)# class Bronze
Device(config-pmap-c)# priority level 1
Device(config-pmap-c)# exit
Device(config-pmap)# class Gold
Device(config-pmap-c)# priority 1000
Device(config-pmap-c)# end
```

**Note** The **priority** *rate* command is not supported, instead you can use proirity *cir* command on the Cisco RSP3 Module.

- You cannot specify the same priority level for two different classes in the same policy map. For example, the device does not accept the following configuration:
- You cannot configure the default queue as a priority queue at any level.
- You cannot configure the **bandwidth** command and multi-level priority queues on the same class. For example, the device rejects the following configuration:

```
policy-map P1
 class C1
  priority level 1
  bandwidth 200
```

- You cannot configure the **shape** command and multi-level priority queues on the same class. For example, the device rejects the following configuration:

```
policy-map P1
 class C1
  priority level 1
  shape average 56000
```

- To convert a one-level (flat) service policy with multiple priority queues configured to a hierarchical multi-level priority queues service policy, you must first detach the flat service policy from the interface using the **no service-policy** command and then add a child policy map to it.
- We recommend not to use MPQ at the logical level, that is, under the class-map containing match for the VLANs .

# Information About Multi-Level Priority Queues

## Benefits of Multi-Level Priority Queues

The MPQ feature allows you to configure multiple priority queues for multiple traffic classes by specifying a different priority level for each of the traffic classes in a single service policy map. You can configure multiple service policy maps per device.

Previously, devices could have only one strict priority queue per policy map for all delay-sensitive traffic—the device associated all priority traffic with this one single priority queue. However, having only one priority queue can cause significant delay in delivering traffic, especially if the device sends high-priority traffic (for example, voice) behind low-priority traffic (for example, video). Using class-based weighted fair queueing (CBWFQ) to reduce delay by heavily weighting one queue can affect the granularity of bandwidth allocations to the other queues. The MPQ feature addresses these issues and improves latency.

# Functionality of Multi-Level Priority Queues

The **priority** command is used to specify that a class of traffic has latency requirements with respect to other classes. For multiple priority queues, you can use the **priority level** command to configure a level of priority service on a class in a policy map. The device places traffic with a high-priority level on the outbound link ahead of traffic with a low-priority level. High-priority packets, therefore, are not delayed behind low-priority packets.

The device services the high-level priority queues until empty before servicing the next-level priority queues and non-priority queues. While the device services a queue, the service rate is as fast as possible and is constrained only by the rate of the underlying link or parent node in a hierarchy. If a rate is configured and the device determines that a traffic stream has exceeded the configured rate, the device drops the exceeding packets during periods of congestion. If the link is currently not congested, the device places the exceeding packets onto the outbound link.

When configuring MPQ on different traffic classes in a policy map, you must specify different priority levels for the traffic classes. For example, configure one traffic class to have priority level 2 and another class to have priority level 1.

**Note** In a hierarchical MPQ configuration in which *all* traffic is sent through the level-2 priority queue only, the traffic sent through the level-2 priority queue receives the same treatment as the traffic sent through the level-1 priority queue.

You cannot configure the **priority** command and the **priority level** command on different classes in the same policy map.

# Traffic Policing and Multi-Level Priority Queues

Bandwidth guarantees can be given to other classes only if traffic policing is enabled on the priority queue.

Using the **priority** and **police** commands, multi-level priority queues can be configured to police traffic in one of the following ways:

- Conditional traffic policing, for example:

```
policy-map my_policy
  class voice
   priority 400000   <<< Priority queue conditionally policed to 400M
  class gold
   bandwidth 400000 <<< 400M minimum guaranteed to class gold
```

With conditional traffic policing on the queue, you run the risk of sudden degradation in priority service when an interface becomes congested. You can go from an instance of a priority class using the entire link to suddenly traffic being policed to the configured value. You need to know the available bandwidth

and use some form of admission control to ensure that your offered loads do not exceed the available bandwidth.

**Note** With the conditional policing, traffic policing does not engage unless the interface is congested.

- Unconditional traffic policing, for example:

```
policy-map my_policy
  class voice
   priority           <<< Indicates priority scheduling
   police 400000000   <<< Traffic policed to 400M
  class gold
   bandwidth 400000  <<<400M minimum guaranteed to class gold
```

The priority class is configured with an "always on" (unconditional) policer. The priority class is always policed to the configured value regardless of whether the interface is congested. The advantage of an unconditional policer is that you always know how much priority traffic will be offered to the downstream devices, thus making your bandwidth planning much simpler. This is the recommended choice.

- Absolute priority queue (no traffic policing)

  If traffic policing is not configured, the priority traffic may consume the entire interface bandwidth.

# How to Configure Multi-Level Priority Queues

## Configuring Multi-Level Priority Queues in a Policy Map

### Before you begin

The traffic classes, class maps, and policy maps must exist.

### SUMMARY STEPS

1. **enable**
2. **configure terminal**
3. **policy-map** *policy-name*
4. **class** *class-name*
5. **priority level** *level*
6. **police cir** *bps*
7. **police cir percent** *percent*
8. **end**

## DETAILED STEPS

| | Command or Action | Purpose |
|---|---|---|
| **Step 1** | **enable**<br>**Example:**<br>`Device> enable` | Enables privileged EXEC mode.<br>• Enter your password if prompted. |
| **Step 2** | **configure terminal**<br>**Example:**<br>`Device# configure terminal` | Enters global configuration mode. |
| **Step 3** | **policy-map** *policy-name*<br>**Example:**<br>`Device(config)# policy-map Premium` | Creates or modifies a policy map and enters policy-map configuration mode.<br>• Enter the name of the policy map. |
| **Step 4** | **class** *class-name*<br>**Example:**<br>`Device(config-pmap)# class business` | Specifies a traffic class and enters policy-map class configuration mode.<br>• Enter the name of a previously configured traffic class. |
| **Step 5** | **priority level** *level*<br>**Example:**<br>`Device(config-pmap-c)# priority level 2` | Assigns priority to a traffic class at the priority level specified.<br>• Enter the level of priority assigned to the priority class. Valid values are 1 (high priority) and 2 (low priority). The default is 1.<br>**Note** Do not specify the same priority level for two different classes in the same policy map. |
| **Step 6** | **police cir** *bps*<br>**Example:**<br>`Device(config-pmap-c)# police cir 8000` | (Optional) Configures traffic policing based on a bits per second (bps) rate.<br>• **cir** is the committed information rate and is based on the interface shape rate. This keyword indicates an average rate at which the policer meters traffic.<br>• *bps* specifies the average rate in bits per second (bps). Valid values are from 8000 to 2488320000 bps. |
| **Step 7** | **police cir percent** *percent*<br>**Example:**<br>`Device(config-pmap-c)# police cir percent 20` | (Optional) Configures traffic policing based on a percentage of bandwidth available on the interface.<br>• **cir** is the committed information rate and is based on the interface shape rate. This keyword indicates an average rate at which the policer meters traffic. |

| | Command or Action | Purpose |
|---|---|---|
| | | • **percent** *percent* indicates to use the percentage of available bandwidth specified in percent to calculate the CIR. Valid values are from 1 to 100. |
| **Step 8** | **end**<br>**Example:**<br>`Device(config-pmap-c)# end` | (Optional) Exits policy-map class mode. |

# Verifying Multi-Level Priority Queues

**Step 1** **enable**

**Example:**

```
Device> enable
```

Enables privileged EXEC mode.

- Enter your password if prompted.

**Step 2** **show policy-map interface** *type number*

**Example:**

Displays the packet statistics of all classes that are configured for all service policies either on the specified interface or subinterface or on a specific PVC on the interface.

- Enter the interface type and number.

**Step 3** **exit**

**Example:**

```
Device# exit
```

(Optional) Exits privileged EXEC mode.

# Configuration Examples for Multi-Level Priority Queues

## Example: Configuring Multi-Level Priority Queues

The following example shows how to configure multiple priority queues with 2 level priority. The policy map named Business has two traffic classes: Bronze and Gold. Bronze traffic has a level 2 (low) priority, whereas Gold traffic has a level 1 (high) priority. To prevent bandwidth starvation of Bronze traffic, the Gold traffic is policed at 30 percent of the interface bandwidth.

**Note** Although a policer is not required, configure policing for priority traffic to prevent bandwidth starvation of low-priority traffic. When policing is configured, the traffic rate is policed at the police rate for each of the priority queues.

The following example shows how to configure multiple priority queues with 7 level priority. The policy map named Business has seven traffic classes: Platinum, Gold, Silver, Bronze, Iron, Aluminium, and Steel. Steel traffic has a level 7 (lowest) priority, whereas Platinum traffic has a level 1 (highest) priority. To prevent bandwidth starvation, the Platinum and Gold traffic is policed at 30 percent and 20 percent respectively, of the interface bandwidth.

## Example: Verifying Multi-Level Priority Queues

The following is partial sample output from the **show policy-map interface** command.

```
Device# show policy-map interface serial2/1/0

Serial2/1/0
Service-policy output: P1
Queue statistics for all priority classes:
.
.
.
Class-map: Gold (match-all)
0 packets, 0 bytes    /*Updated for each priority level configured.*/
5 minute offered rate 0 bps, drop rate 0 bps
Match: ip precedence 2
Priority: 0 kbps, burst bytes 1500, b/w exceed drops: 0
Priority Level 2:
0 packets, 0 bytes
```

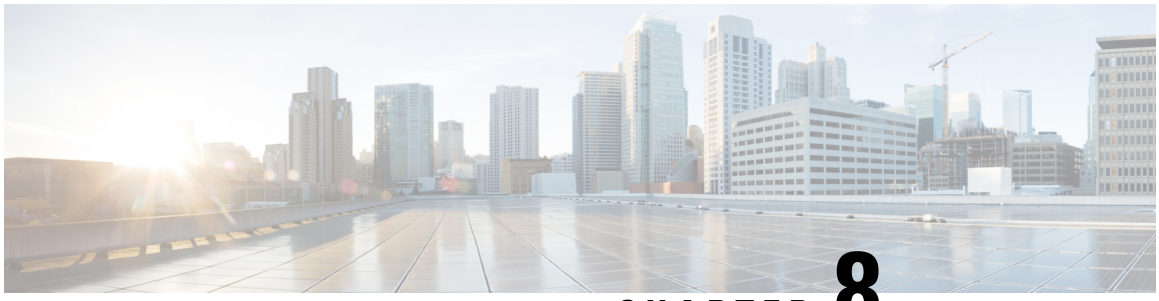
# Additional References for Multi-Level Priority Queues

### Related Documents

| Related Topic | Document Title |
|---|---|
| QoS commands: complete command syntax, command modes, command history, defaults, usage guidelines, and examples | *Cisco IOS Quality of Service Solutions Command Reference* |
| Priority queues, creating classes, class maps, and policy maps | "Applying QoS Features Using the MQC" module |

### Technical Assistance

| Description | Link |
|---|---|
| The Cisco Support and Documentation website provides online resources to download documentation, software, and tools. Use these resources to install and configure the software and to troubleshoot and resolve technical issues with Cisco products and technologies. Access to most tools on the Cisco Support and Documentation website requires a Cisco.com user ID and password. | http://www.cisco.com/cisco/web/support/index.html |



CHAPTER 8

# Configuring Custom Queueing

This module describes the tasks for configuring QoS custom queueing (CQ) on a router.

**Note** CQ is not supported on any tunnels.



## Finding Feature Information

Your software release may not support all the features documented in this module. For the latest caveats and feature information, see Bug Search Tool and the release notes for your platform and software release. To find information about the features documented in this module, and to see a list of the releases in which each feature is supported, see the feature information table.

Use Cisco Feature Navigator to find information about platform support and Cisco software image support. To access Cisco Feature Navigator, go to https://cfnng.cisco.com/. An account on Cisco.com is not required.

## Custom Queueing Configuration Task List

You must follow certain required, basic steps to enable CQ for your network. In addition, you can choose to assign packets to custom queues based on protocol type, interface where the packets enter the router, or other criteria you specify.

CQ allows a fairness not provided with priority queueing (PQ). With CQ, you can control the available bandwidth on an interface when it is unable to accommodate the aggregate traffic enqueued. Associated with each output queue is a configurable byte count, which specifies how many bytes of data should be delivered from the current queue by the system before the system moves on to the next queue. When a particular queue is being processed, packets are sent until the number of bytes sent exceeds the queue byte count defined by the **queue-list queue byte-count** command (see the following section Specifying the Maximum Size of the Custom Queues, on page 56), or until the queue is empty.

To configure CQ, perform the tasks described in the following sections.

# Specifying the Maximum Size of the Custom Queues

| Command | Purpose |
|---|---|
| `Router(config)# queue-list list-number queue queue-number limit limit-number` | Specifies the maximum number of packets allowed in each of the custom queues. The *limit-numbe r* argument specifies the number of packets that can be queued at any one time. The range is from 0 to 32767. The default is 20. |
| `Router(config)# queue-list list-number queue queue-number byte-count byte-count-number` | Designates the average number of bytes forwarded per queue. The *byte-count-number* argument specifies the average number of bytes the system allows to be delivered from a given queue during a particular cycle. |

# Assigning Packets to Custom Queues

| Command | Purpose |
|---|---|
| `Router(config)# queue-list list-number protocol protocol-name queue-number queue-keyword keyword-value` | Establishes queueing priorities based on the protocol type.<br>**Note** All protocols supported by Cisco are allowed. The *queue-keyword* variable provides additional options, including byte count, TCP service and port number assignments, and AppleTalk, IP, IPX, VINES, or XNS access list assignments.<br>**Note** When you use multiple rules, remember that the system reads the **queue-list** commands in order of appearance. |
| `Router(config)# queue-list list-number interface interface-type interface-number queue-number` | Establishes CQ based on packets entering from a given interface. |
| `Router(config)# queue-list list-number default queue-number` | Assigns a queue number for those packets that do not match any other rule in the custom queue list. |

# Defining the Custom Queue List

### SUMMARY STEPS

1. Router(config)# **interface***interface-type interface-number*
2. Router(config-if)# **custom-queue-list***list*

**DETAILED STEPS**

| | Command or Action | Purpose |
|---|---|---|
| **Step 1** | Router(config)# **interface***interface-type interface-number* | Specifies the interface, and then enters interface configuration mode. |
| **Step 2** | Router(config-if)# **custom-queue-list***list* | Assigns a custom queue list to the interface. The list argument is any number from 1 to 16. There is no default assignment.<br>**Note** Use the **custom-queue-list**command in place of the **priority-list** command. Only one queue list can be assigned per interface. |

# Monitoring Custom Queue Lists

| Command | Purpose |
|---|---|
| `Router# show queue interface-type interface-number` | Displays the contents of packets inside a queue for a particular interface or virtual circuit (VC). |
| `Router# show queueing custom` | Displays the status of the CQ lists. |
| `Router# show interfaces interface-type interface-number` | Displays the current status of the custom output queues when CQ is enabled. |

# Custom Queueing Configuration Examples

## Example Custom Queue List Defined

The following example illustrates how to assign custom queue list number 3 to serial interface 0:

```
interface serial 0
custom-queue-list 3
```

## Examples Maximum Specified Size of the Custom Queues

The following example specifies the maximum number of packets allowed in each custom queue. The queue length of queue 10 is increased from the default 20 packets to 40 packets.

```
queue-list 3 queue 10 limit 40
```

The queue length limit is the maximum number of packets that can be enqueued at any time, with the range being from 0 to 32767 queue entries.

The following example decreases queue list 9 from the default byte count of 1500 to 1400 for queue number 10:

```
queue-list 9 queue 10 byte-count 1400
```

The byte count establishes the lowest number of bytes the system allows to be delivered from a given queue during a particular cycle.

# Examples Packets Assigned to Custom Queues

The following examples assign packets to custom queues by either protocol type or interface type, and the default assignment for unmatched packets.

## Protocol Type

The following example assigns traffic that matches IP access list 10 to queue number 1:

```
queue-list 1 protocol ip 1 list 10
```

The following example assigns Telnet packets to queue number 2:

```
queue-list 4 protocol ip 2 tcp 23
```

The following example assigns User Datagram Protocol (UDP) Domain Name Service (DNS) packets to queue number 3:

```
queue-list 4 protocol ip 3 udp 53
```

## Interface Type

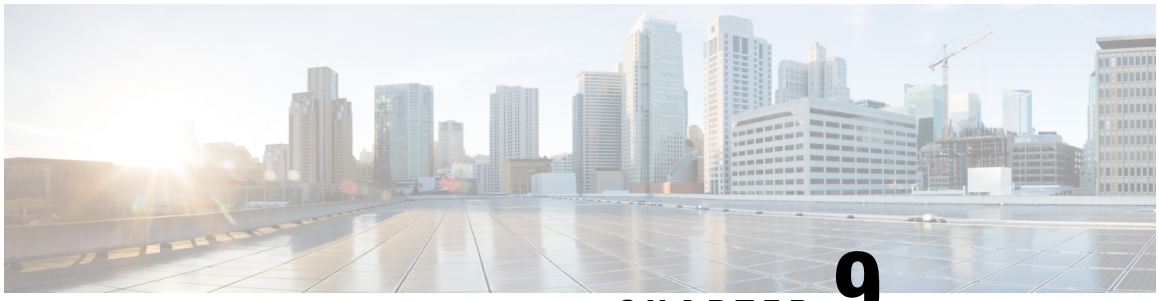
In this example, queue list 4 establishes queueing priorities for packets entering on serial interface 0. The queue number assigned is 10.

```
queue-list 4 interface serial 0 10
```

## Default Queue

You can specify a default queue for packets that do not match other assignment rules. In this example, the default queue for list 10 is set to queue number 2:

```
queue-list 10 default 2
```



CHAPTER 9

# QoS Hierarchical Queueing for Ethernet DSLAMs

This feature module describes how to configure quality of service (QoS) hierarchical queueing policy maps on sessions and subinterfaces in Ethernet Digital Subscriber Line Access Multiplexer (E-DSLAM) applications on a Cisco ASR 1000 series router. The QoS Hierarchical Queueing for Ethernet DSLAMs feature supports IEEE 802.1 QinQ VLAN tag termination to configure inner VLAN identifiers on E-DSLAMs.



## Finding Feature Information

Your software release may not support all the features documented in this module. For the latest caveats and feature information, see Bug Search Tool and the release notes for your platform and software release. To find information about the features documented in this module, and to see a list of the releases in which each feature is supported, see the feature information table.

Use Cisco Feature Navigator to find information about platform support and Cisco software image support. To access Cisco Feature Navigator, go to https://cfnng.cisco.com/. An account on Cisco.com is not required.

## Prerequisites for QoS Hierarchical Queueing for Ethernet DSLAMs

You must configure traffic classes using the class-map command.

# Restrictions for QoS Hierarchical Queueing for Ethernet DSLAMs

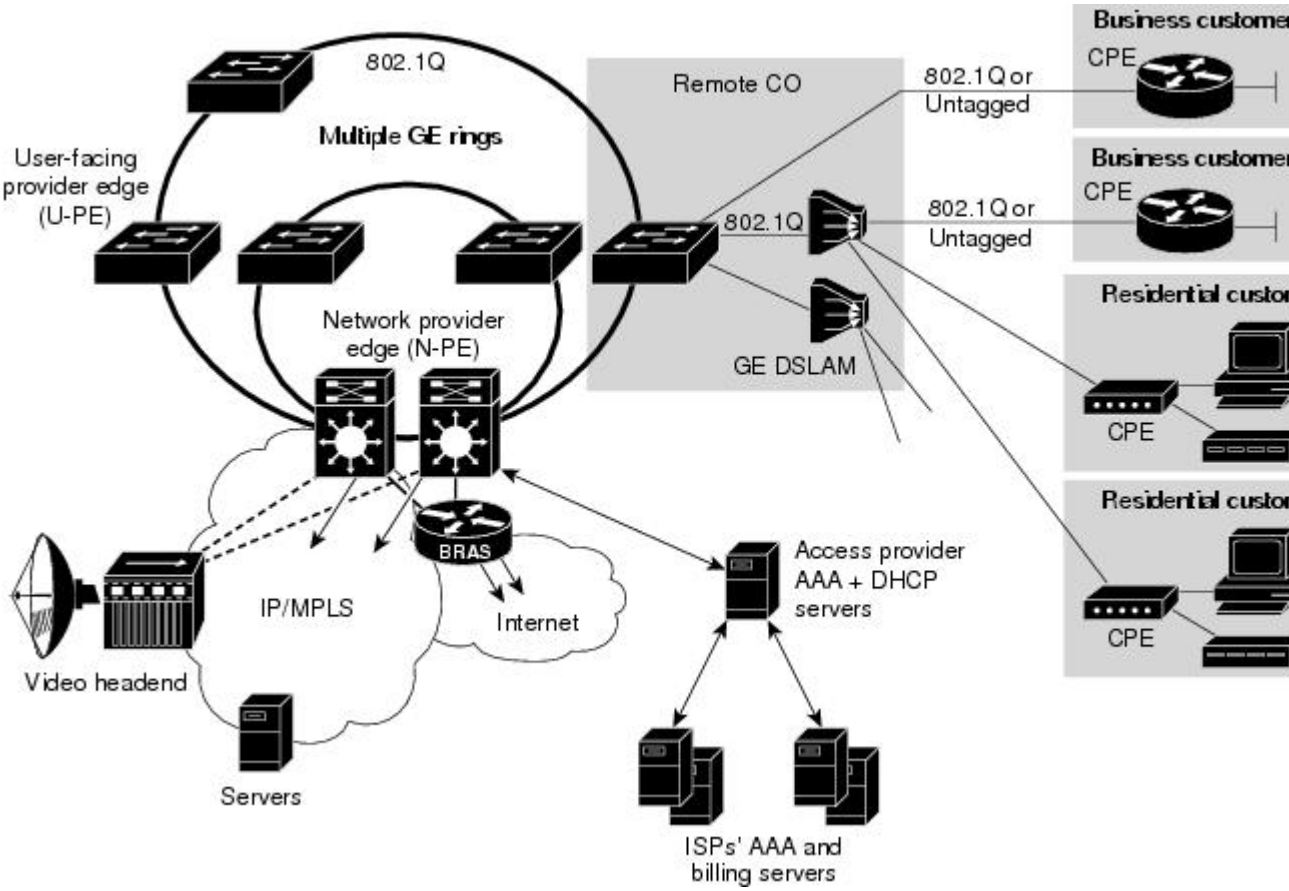
This feature is not supported in combination with load balancing when a session service policy is routed to a Layer 2 Tunnel Protocol (L2TP) tunnel. Do not configure load balancing on an L2TP tunnel if per-session queueing is enabled.

# Information About QoS Hierarchical Queueing for Ethernet DSLAMs

## Different Levels of QoS Provisioning

Traffic downstream from a Broadband Router Access Server (BRAS) requires different levels of QoS provisioning (for example, traffic shaping) depending on the network architecture between the BRAS and the subscriber. The figure below illustrates an Ethernet DSL access network. The sample network includes multiple entities where QoS provisioning is required for different reasons.

***Figure 3: Ethernet DSL Access Network***



The following entities may require different traffic shaping:

- A VLAN that is shaped to a certain aggregate traffic rate to limit the traffic to a group of subscribers (different 802.1Q interfaces in the figure above).
- Individual sessions that is shaped with certain QoS services for different classes of traffic (individual PCs in the figure above).

## Integrated Queueing Hierarchy

Different traffic shaping requirements result in QoS provisioning at multiple levels at the same time. The QoS-Hierarchical Queueing for Ethernet DSLAMs feature provides the ability to form one integrated queueing hierarchy that provides QoS provisioning at multiple levels with support for features such as bandwidth distribution at any of these levels.

The integrated queueing hierarchy is formed on the physical interface. When a service policy is instantiated on a session, the Subscriber Service Switch (SSS) infrastructure invokes the MQC and a common queueing control plane sets up and enables the queueing features.

Session-to-interface associations are resolved to determine the physical interface on which to form the integrated queueing hierarchy for all levels of QoS provisioning. As subinterface session-based policies are added, the respective queues are created and integrated into the queueing hierarchy.

When a subinterface is provisioned followed by session-based policy provisioning, the integrated queueing hierarchy is formed on top of the physical interface as a result of queueing policies provisioned at two different levels. When a session is provisioned before subinterface-based policy provisioning, the queueing hierarchy has a placeholder logical level between the physical queue and the session queue. The placeholder queue becomes the default queue at that level, and all other sessions are parented to that queue.

# Configuration Guidelines for Hierarchical Queueing on Ethernet DSLAMs

When configuring the QoS Hierarchical Queueing for Ethernet DSLAMs feature, note the following guidelines:

- An individual subscriber is always identified by a PPP or IP session. A group of subscribers is identified by a particular VLAN by means of the outer tag ISP, E-DSLAM, or user-facing provider edge (U-PE).
- When a subinterface is used to aggregate a number of sessions with queueing policies, a queueing policy at a subinterface level must be a one-level policy map that is configured as class-default with only the shape and bandwidth remaining ratio feature enabled.
- Both subinterfaces and sessions can be oversubscribed and controlled by shaper and bandwidth remaining ratio.

# How to Configure QoS Hierarchical Queueing for Ethernet DSLAMs

## Configuring and Applying QoS Hierarchical Queueing Policy Maps to Sessions

### SUMMARY STEPS

1. **enable**
2. **configure terminal**
3. **policy-map** *policy-map-name*
4. **class** class-map-name
5. bandwidth {*bandwidth-kbps* | **percent***percentage*| **remainingpercent***percentage*}
6. **precedence** *precedence min-threshold max-threshold mark-probability-denominator*
7. **set cos** *cos-value*
8. **exit**
9. **exit**
10. **policy-map** *policy-map-name*
11. **class class-default**
12. **shape** average *cir*
13. **bandwidth remaining ratio** *ratio*
14. **service-polic** y*policy-map-name*
15. **exit**
16. **exit**
17. **interface virtual-template** *number*
18. **service-policy output** *policy-map-name*
19. **end**

### DETAILED STEPS

| | Command or Action | Purpose |
|---|---|---|
| **Step 1** | **enable**<br>**Example:**<br>`Router> enable` | Enables privileged EXEC mode.<br>• Enter your password if prompted. |
| **Step 2** | **configure terminal**<br>**Example:**<br>`Router# configure terminal` | Enters global configuration mode. |
| **Step 3** | **policy-map** *policy-map-name*<br>**Example:** | Creates a child policy and enters policy-map configuration mode.<br>• Enter the policy-map name. |

| | Command or Action | Purpose |
|---|---|---|
| | `Router(config)# policy-map session_a_child` | |
| **Step 4** | **class** class-map-name<br>**Example:**<br>`Router(config-pmap)# class voip` | Configures the traffic class that you specify and enters policy-map class configuration mode.<br>• Enter the name of a previously configured class map . |
| **Step 5** | bandwidth {*bandwidth-kbps* \| **percent***percentage*\| **remainingpercent***percentage*}<br>**Example:**<br>`Router(config-pmap-c)# bandwidth 10000`<br>**Example:** | (Optional) Enables class-based weighted fair queueing based on the keywords and arguments specified, as described below.<br>• bandwidth-kbps--Specifies the minimum bandwidth allocated for a class belonging to a policy map. Valid values are from 8 to 2,488,320, which represents from 1 to 99 percent of the link bandwidth.<br>• percent percentage--Specifies the minimum percentage of the link bandwidth allocated for a class belonging to a policy map. Valid values are from 1 to 99.<br>• remaining percent percentage--Specifies the minimum percentage of unused link bandwidth allocated for a class belonging to a policy map. Valid values are from 1 to 99. |
| **Step 6** | **precedence** *precedence min-threshold max-threshold mark-probability-denominator*<br>**Example:**<br>`Router(config-pmap-c)# precedence 0 32 256 100` | (Optional) Configures a precedence level for the traffic class based on the arguments specified, as described below.<br>• precedence--Specifies the IP precedence number. Valid values are from 0 to 7.<br>• min-threshold--Specifies the minimum threshold in number of packets. Valid values are from 1 to 4096.<br>• max-threshold--Specifies the maximum threshold in number of packets. Valid values are from the minimum threshold to 4096.<br>• mark-probability-denominator--Specifies the denominator for the fraction of packets dropped when the average queue depth is equal to the maximum threshold. For example, if the denominator is 512, 1 out of every 512 packets is dropped when the average queue is at the maximum threshold. Valid values are from 1 to 65536. The default value is 10 (1 out of every 10 packets is dropped at the maximum threshold). |

| | Command or Action | Purpose |
|---|---|---|
| **Step 7** | **set cos** *cos-value*<br>**Example:**<br>`Router(config-pmap-c)# set cos 1` | (Optional) Sets the Layer 2 class of service (CoS) value of an outgoing packet.<br>• Enter the IEEE 802.1Q CoS value from 0 to 7.<br>**Note** Use the set cos command only in service policies that are attached in the output direction of an interface; packets that enter an interface cannot be set with a CoS value. You can configure a CoS value on an Ethernet interface that is configured for 802.1Q or on a virtual access interface that is using an 802.1Q interface. |
| **Step 8** | **exit**<br>**Example:**<br>`Router(config-pmap-c)# exit` | Exits policy-map class configuration mode. |
| **Step 9** | **exit**<br>**Example:**<br>`Router(config-pmap)# exit` | Exits policy-map configuration mode. |
| **Step 10** | **policy-map** *policy-map-name*<br>**Example:**<br>`Router(config)# policy-map session_a_parent` | Creates a parent policy and enters policy-map configuration mode.<br>• Enter the policy-map name. |
| **Step 11** | **class class-default**<br>**Example:**<br>`Router(config-pmap)# class class-default` | Configures the traffic class as class-default and enters policy-map class configuration mode.<br>**Note** Do not configure any other traffic class. |
| **Step 12** | **shape** average *cir*<br>**Example:**<br>`Router(config-pmap-c)# shape average 10000000` | Specifies average-rate traffic shaping for all traffic that does not match any other traffic class.<br>• Enter the **average** keyword followed by the committed information rate (CIR), in bits per second (bps). |
| **Step 13** | **bandwidth remaining ratio** *ratio*<br>**Example:**<br>`Router(config-pmap-c)# bandwidth remaining ratio 10` | Specifies the weight (ratio) for the subinterface.<br>• Enter the relative weight of this subinterface (or class queue). This number (ratio) indicates the proportional relationship between the other subinterfaces or class queues. |

| | Command or Action | Purpose |
|---|---|---|
| **Step 14** | **service-polic** *ypolicy-map-name*<br>**Example:**<br>`Router(config-pmap-c)# service-policy session_a_child` | Applies the child policy map to the parent class-default class.<br>• Enter the name of a previously configured child policy map. |
| **Step 15** | **exit**<br>**Example:**<br>`Router(config-pmap-c)# exit` | Exits policy-map class configuration mode. |
| **Step 16** | **exit**<br>**Example:**<br>`Router(config-pmap)# exit` | Exits policy-map configuration mode. |
| **Step 17** | **interface virtual-template** *number*<br>**Example:**<br>`Router(config)# interface virtual-template 1` | Creates a virtual template and enters interface configuration mode.<br>• Enter the virtual template number. Valid range is from 1 to 4095. |
| **Step 18** | **service-policy output** *policy-map-name*<br>**Example:**<br>`Router(config-if)# service-policy output session_a_parent` | Applies the service policy to the virtual interface.<br>• Enter the name of the previously configured parent policy map.<br>**Note** You must specify the output keyword to apply the service policy to outbound traffic on the interface. |
| **Step 19** | **end**<br>**Example:**<br>`Router(config-if)# end` | (Optional) Returns to privileged EXEC mode. |

### Examples

The following is an example of how to configure and apply a QoS hierarchical queueing policy map to PPP/IP sessions by using a virtual template:

```
Router> enable
Router# configure terminal
Router(config)# policy-map session_a_child
Router(config-pmap)# class voip
Router(config-pmap-c)# police 1000000
Router(config-pmap-c)# priority level 1
Router(config-pmap-c)# exit
Router(config-pmap)# class video
```

```
Router(config-pmap-c)# police 100000
Router(config-pmap-c)# priority level 2
Router(config-pmap-c)# exit
Router(config-pmap)# class precedence_0
Router(config-pmap-c)# bandwidth remaining ratio 10
Router(config-pmap-c)# exit
Router(config-pmap)# class precedence_1
Router(config-pmap-c)# bandwidth remaining ratio 20
Router(config-pmap-c)# exit
Router(config-pmap)# exit
Router(config)# policy-map session_a_parent
Router(config-pmap-c)# exit
Router(config-pmap)# class class-default
Router(config-pmap-c)# shape average 10000000
Router(config-pmap-c)# bandwidth remaining ratio 10
Router(config-pmap-c)# service-policy session_a_child
Router(config-pmap-c)# exit
Router(config-pmap)# exit
Router(config)# interface virtual-template 20
Router(config-if)# service-policy output session_a_parent
Router(config-if)# end
```

# Configuring and Applying QoS Hierarchical Queueing Policy Maps to Subinterfaces

### SUMMARY STEPS

1. **enable**
2. **configure terminal**
3. **policy-map** *policy-map-name*
4. **class class-default**
5. **shape average** *cir*
6. **exit**
7. **exit**
8. interface type slot/subslot/port**.**subinterface
9. **encapsulation dot1q** *outer-vlan-id* [**second-dot1q***inner-vlan-id*]
10. **service-policy output** *policy-map-name*
11. **end**

### DETAILED STEPS

| | Command or Action | Purpose |
|---|---|---|
| **Step 1** | **enable**<br>**Example:**<br>`Router> enable` | Enables privileged EXEC mode.<br>• Enter your password if prompted. |
| **Step 2** | **configure terminal**<br>**Example:**<br>`Router# configure terminal` | Enters global configuration mode. |

| | Command or Action | Purpose |
|---|---|---|
| **Step 3** | **policy-map** *policy-map-name*<br>**Example:**<br>`Router(config)# policy-map subint_1` | Creates a policy map and enters policy-map configuration mode.<br>• policy-map-name--The name of the policy map. |
| **Step 4** | **class class-default**<br>**Example:**<br>`Router(config-pmap)# class class-default` | Configures the traffic class as class-default and enters policy-map class configuration mode. Do not configure any other traffic class.<br>**Note** When a subinterface aggregates a number of sessions with queueing policies, a queueing policy at a subinterface level must be a one-level policy map configured as class-default. |
| **Step 5** | **shape average** *cir*<br>**Example:**<br>`Router(config-pmap-c)# shape average 10000000` | Specifies average-rate traffic shaping for all traffic that does not match any other traffic class.<br>• Enter the **average** keyword followed by the CIR, in bps.<br>**Note** When a subinterface aggregates a number of sessions with queueing policies, a queueing policy at a subinterface level must be a one-level policy map with only the shape feature enabled. |
| **Step 6** | **exit**<br>**Example:**<br>`Router(config-pmap-c)# exit` | Exits policy-map class configuration mode. |
| **Step 7** | **exit**<br>**Example:**<br>`Router(config-pmap)# exit` | Exits policy-map configuration mode. |
| **Step 8** | interface type slot/subslot/port**.**subinterface<br>**Example:**<br>`Router(config)# interface GigabitEthernet3/1/1.1` | Specifies the subinterface on which you are attaching the policy map and enters subinterface configuration mode.<br>• Enter the interface type and slot number, subslot number, port number, and subinterface number. |
| **Step 9** | **encapsulation dot1q** *outer-vlan-id* [**second-dot1q***inner-vlan-id*]<br>**Example:**<br>`Router(config-subif)# encapsulation dot1q 100` | Enables IEEE 802.1Q encapsulation of traffic on the subinterface.<br>The **second-dot1q**keywordsupports the IEEE 802.1 QinQ VLAN Tag Termination feature to configure an inner VLAN ID. |

| | Command or Action | Purpose |
|---|---|---|
| | | • outer-vlan-id--The outer VLAN identifier. The range is from 1 to 4095.<br>• inner-vlan-id--The inner VLAN identifier. The range is from 1 to 4095. |
| **Step 10** | **service-policy output** *policy-map-name*<br>**Example:**<br>`Router(config-subif)# service-policy output subint_1` | Attaches the service policy to the subinterface.<br>• policy-map-name--The name of the previously configured policy map.<br>**Note** You must specify the output keyword to apply the service policy to outbound traffic on the subinterface. |
| **Step 11** | **end**<br>**Example:**<br>`Router(config-subif)# end` | (Optional) Returns to privileged EXEC mode. |

### Examples

The following is an example of how to configure and apply a QoS hierarchical queueing policy map to a subinterface (and provide aggregate shaping for a large number of subscribers):

```
Router> enable
Router# configure terminal
Router(config)# policy-map subint_1
Router(config-pmap)# class class-default
Router(config-pmap-c)# shape average 10000000
Router(config-pmap-c)# exit
Router(config-pmap)# exit
Router(config)# interface GigabitEthernet3/1/1.1
Router(config-subif)# encapsulation dot1q 100
Router(config-subif)# service-policy output subint_1
Router(config-subif)# end
```

# Displaying Policy-Map Information for Hierarchical Queueing

### SUMMARY STEPS

1. **enable**
2. **show policy-map**
3. **show policy-map interface** *type number*
4. **show policy-map session**
5. **exit**

**DETAILED STEPS**

| | Command or Action | Purpose |
|---|---|---|
| **Step 1** | **enable**<br>**Example:**<br>`Router> enable` | Enables privileged EXEC mode.<br>• Enter your password if prompted. |
| **Step 2** | **show policy-map**<br>**Example:**<br>`Router# show policy-map` | (Optional) Displays all information for all class maps. |
| **Step 3** | **show policy-map interface** *type number*<br>**Example:**<br>`Router#`<br>`show policy-map interface GigabitEthernet4/0/0.1` | (Optional) Displays the packet statistics of all classes that are configured for all service policies either on the specified interface or subinterface or on a specific PVC on the interface.<br>• Enter the interface type and number. |
| **Step 4** | **show policy-map session**<br>**Example:**<br>`Router#`<br>`show policy-map session` | (Optional) Displays the QoS policy map in effect for the SSS session. |
| **Step 5** | **exit**<br>**Example:**<br>`Router# exit` | (Optional) Exits privileged EXEC mode. |

# Configuration Examples for QoS Hierarchical Queueing for Ethernet DSLAMs

## Example Policy Maps on VLANs or QinQ Subinterfaces

The following example shows how to configure and apply QoS hierarchical queueing policy maps on VLANs or QinQ subinterfaces. A child queueing policy is applied to each parent subscriber line level policy. In this example, the policy maps are applied to create subscriber groups on subinterfaces.

```
Router> enable
Router# configure terminal
Router(config)# policy-map service_a_out
Router(config-pmap)# class voip
Router(config-pmap-c)# priority
Router(config-pmap-c)# police cir percent 20 bc 300 ms pir precent 40
Router(config-pmap-c)# set cos 1
```

```
Router(config-pmap-c)# exit
Router(config-pmap)# class video
Router(config-pmap-c)# police cir percent 20 bc 300 ms pir prectent 40
Router(config-pmap-c)# set cos 2
Router(config-pmap-c)# exit
Router(config-pmap)# class gaming
Router(config-pmap-c)# bandwidth remaining percent 80
Router(config-pmap-c)# set cos 3
Router(config-pmap-c)# exit
Router(config-pmap)# class class-default
Router(config-pmap-c)# bandwidth remaining percent 20
Router(config-pmap-c)# set cos 4
Router(config-pmap-c)# exit
Router(config-pmap)# exit
!
Router(config)# policy-map service_z_out
Router(config-pmap)# exit
!
Router(config)# policy-map rate_1_service_a_in
Router(config-pmap)# class voip
Router(config-pmap-c)# police cir percent 25 4 ms 1 ms
Router(config-pmap-c)# exit
Router(config-pmap)# class gaming
Router(config-pmap-c)# police cir percent 50 2 ms 1 ms
Router(config-pmap-c)# exit
Router(config-pmap)# class class-default
Router(config-pmap-c)# police percent 20 bc 300 ms pir 40
Router(config-pmap-c)# exit
Router(config-pmap)# exit
!
Router(config)# policy-map rate_x_service_z_in
Router(config-pmap)# exit
!
Router(config)# policy-map rate_1_service_a_out
Router(config-pmap)# class class-default
Router(config-pmap-c)# bandwidth remaining ratio 10
Router(config-pmap-c)# shape average 100000
Router(config-pmap-c)# service policy service_a_out
Router(config-pmap-c)# exit
Router(config-pmap)# exit
!
Router(config)# policy-map rate_x_service_z_out
Router(config-pmap)# class class-default
Router(config-pmap-c)# bandwidth remaining ratio 10
Router(config-pmap-c)# shape average 100000
Router(config-pmap-c)# service policy service_z_out
Router(config-pmap-c)# exit
Router(config-pmap)# exit
Router(config)# interface GigabitEthernet1/0/0.1
Router(config-subif)# encapsulation dot1q 5 second dot1q 20
Router(config-subif)# service-policy output rate_1_service_a_out
Router(config-subif)# service-policy input rate_1_service_a_in
Router(config-subif)# exit
Router(config)# interface GigabitEthernet1/0/0.2
Router(config-subif)# encapsulation dot1q 5 second dot1q 25
Router(config-subif)# service-policy output rate_x_service_z_out
Router(config-subif)# service-policy input rate_x_service_z_in
Router(config-subif)# end
```

# Example Policy Maps on VLANs with Arbitrary QinQ

The following example shows how to configure and apply QoS hierarchical queueing policy maps on VLANs with subscriber lines grouped by arbitrary QinQ. A child queueing policy is applied to each parent subscriber line level policy. This example includes the configuration of multiple class maps.

```
Router> enable
Router# configure terminal
Router(config)# class-map match-all user_1
Router(config-cmap)# match vlan 10
Router(config-cmap)# exit
Router(config)# class-map match-all user_2
Router(config-cmap)# match vlan 11
Router(config-cmap)# exit
Router(config)# class-map match-all user_3
Router(config-cmap)# match vlan 10
Router(config-cmap)# exit
Router(config)# class-map match-any user_4
Router(config-cmap)# match vlan 11
Router(config-cmap)# exit
Router(config)# class-map match-all user_n
Router(config-cmap)# exit
Router(config)# class-map match-any isp_A
Router(config-cmap)# match class user_1
Router(config-cmap)# match class user_2
Router(config-cmap)# exit
Router(config)# class-map match-any isp_Z
Router(config-cmap)# match class user_3
Router(config-cmap)# match class user_4
Router(config-cmap)# exit
!
Router(config)# policy-map service_a_out
Router(config-pmap)# class voip
Router(config-pmap-c)# priority
Router(config-pmap-c)# police cir percent 20 bc 300 ms pir precent 40
Router(config-pmap-c)# set cos 1
Router(config-pmap-c)# exit
Router(config-pmap)# class video
Router(config-pmap-c)# police cir percent 20 bc 300 ms pir precent 40
Router(config-pmap-c)# set cos 2
Router(config-pmap-c)# exit
Router(config-pmap)# class gaming
Router(config-pmap-c)# bandwidth remaining percent 80
Router(config-pmap-c)# set cos 3
Router(config-pmap-c)# exit
Router(config-pmap)# class class-default
Router(config-pmap-c)# bandwidth remaining percent 20
Router(config-pmap-c)# set cos 4
Router(config-pmap-c)# exit
Router(config-pmap)# exit
!
Router(config)# policy-map service_z_out
Router(config)# policy-map service_a_in
Router(config-pmap)# class voip
Router(config-pmap-c)# police cir percent 25 4 ms 1 ms
Router(config-pmap-c)# exit
Router(config-pmap)# class gaming
Router(config-pmap-c)# police cir percent 50 2 ms 1 ms
Router(config-pmap-c)# exit
Router(config-pmap)# class class-default
Router(config-pmap-c)# police cir percent 20 bc 300 ms pir precent 40
Router(config-pmap-c)# exit
```

```
Router(config-pmap)# exit
!
Router(config)# policy-map service_z_in
Router(config-pmap)# exit
!
Router(config)# policy-map isp_A_out
Router(config-pmap)# class user_1
Router(config-pmap-c)# bandwidth remaining ratio 10
Router(config-pmap-c)# shape average 100000
Router(config-pmap-c)# service policy service_a_out
Router(config-pmap-c)# exit
Router(config-pmap)# class user_n
Router(config-pmap-c)# bandwidth remaining ratio 20
Router(config-pmap-c)# shape average 100000
Router(config-pmap-c)# service policy service_z_out
Router(config-pmap-c)# exit
Router(config-pmap)# exit
!
Router(config)# policy-map isp_Z_out
Router(config-pmap)# exit
!
Router(config)# policy-map isp_A_in
Router(config-pmap)# class user_1
Router(config-pmap-c)# service policy service_a_in
Router(config-pmap-c)# class user_n
Router(config-pmap-c)# service policy service_z_in
Router(config-pmap-c)# exit
Router(config-pmap)# exit
!
Router(config)# policy-map isp_Z_in
Router(config-pmap)# exit
!
Router(config)# policy-map interface_policy_out
Router(config-pmap)# class isp_A
Router(config-pmap-c)# shape average 100000
Router(config-pmap-c)# service policy isp_A_out
Router(config-pmap-c)# exit
Router(config-pmap)# class isp_Z
Router(config-pmap-c)# shape average 100000
Router(config-pmap-c)# service policy isp_Z_out
Router(config-pmap-c)# exit
Router(config-pmap)# exit
!
Router(config)# policy-map interface_policy_in
Router(config-pmap)# class isp_A
Router(config-pmap-c)# service policy isp_A_in
Router(config-pmap-c)# exit
Router(config-pmap)# class isp_Z
Router(config-pmap-c)# service policy isp_Z_in
Router(config-pmap-c)# exit
Router(config-pmap)# exit
!
Router(config)# interface GigabitEthernet1/0/0.1
Router(config-subif)# encapsulation dot1q 5 second dot1q any
Router(config-subif)# service-policy output interface_policy_out
Router(config-subif)# service-policy input interface_policy_in
Router(config-subif)# end
```

# Example CPolicy Maps on Sessions

The following example shows how to configure and apply QoS hierarchical queueing policy maps on sessions. A child queueing policy is applied to each parent subscriber line level policy.

```
Router> enable
Router# configure terminal
Router(config)# policy-map service_a_out
Router(config-pmap)# class voip
Router(config-pmap-c)# priority
Router(config-pmap-c)# set cos 1
Router(config-pmap-c)# exit
Router(config-pmap)# class video
Router(config-pmap-c)# set cos 2
Router(config-pmap-c)# exit
Router(config-pmap)# class gaming
Router(config-pmap-c)# bandwidth remaining percent 80
Router(config-pmap-c)# set cos 3
Router(config-pmap-c)# exit
Router(config-pmap)# class class-default
Router(config-pmap-c)# bandwidth remaining percent 20
Router(config-pmap-c)# set cos 4
Router(config-pmap-c)# exit
Router(config-pmap)# exit
!
Router(config)# policy-map service_z_out
Router(config-pmap)# exit
!
Router(config)# policy-map rate_1_service_a_out
Router(config-pmap)# class class-default
Router(config-pmap-c)# bandwidth remaining ratio 10
Router(config-pmap-c)# shape average 100000
Router(config-pmap-c)# service-policy service_a_out
Router(config-pmap-c)# exit
Router(config-pmap)# exit
!
Router(config)# policy-map rate_x_service_z_out
Router(config-pmap)# class class-default
Router(config-pmap-c)# bandwidth remaining ratio 10
Router(config-pmap-c)# shape average 100000
Router(config-pmap-c)# service-policy service_z_out
Router(config-pmap-c)# exit
Router(config-pmap)# exit
!
Router(config)# policy-map rate_1_service_a_in
Router(config-pmap)# class voip
Router(config-pmap-c)# police cir percent 25 4 ms 1 ms
Router(config-pmap-c)# exit
Router(config-pmap)# class gaming
Router(config-pmap-c)# police cir percent 50 2 ms 1 ms
Router(config-pmap-c)# exit
Router(config-pmap)# class class-default
Router(config-pmap-c)# police cir percent 20 bc 300 ms pir precent 40
Router(config-pmap-c)# exit
Router(config-pmap)# exit
!
Router(config)# policy-map rate_x_service_z_in
Router(config-pmap)# exit
!
Router(config)# policy-map isp_A_out
Router(config-pmap)# class class-default
Router(config-pmap-c)# shape average 100000
Router(config-pmap-c)# bandwidth remaining ratio 10
Router(config-pmap-c)# exit
Router(config-pmap)# exit
Router(config)# exit
Router(config)# policy-map isp_Z_out
Router(config-pmap-c)# exit
```

```
Router(config-pmap)# class class-default
Router(config-pmap-c)# shape average 200000
Router(config-pmap-c)# bandwidth remaining ratio 30
Router(config-pmap-c)# exit
Router(config-pmap)# exit
Router(config)# interface GigabitEthernet1/0/0.1
Router(config-subif)# encapsulation dot1q 1
Router(config-subif)# service-policy output isp_A_out
Router(config-subif)# exit
Router(config)# interface GigabitEthernet2/0/0.2
Router(config-subif)# encapsulation dot1q 2
Router(config-subif)# service-policy output isp_Z_out
Router(config-subif)# end
```

# Example Policy Maps on Sessions with Aggregate Shaping

The following example shows how to configure and apply QoS hierarchical queueing policy maps on sessions with multiple PPP/IP sessions per subscriber line. In this example, the same policies are applied to all sessions using the same virtual interface.

```
Router> enable
Router# configure terminal
Router(config)# policy-map service_a_out
Router(config-pmap)# class voip
Router(config-pmap-c) priority
Router(config-pmap-c)# police cir percent 25 4 ms 1 ms
Router(config-pmap-c)# set cos 1
Router(config-pmap-c)# exit
Router(config-pmap)# class video
Router(config-pmap-c)# police cir percent 30 5 ms 1 ms
Router(config-pmap-c)# set cos 2
Router(config-pmap-c)# exit
Router(config-pmap)# class class-default
Router(config-pmap-c)# bandwidth remaining percent 20
Router(config-pmap-c)# set cos 3
Router(config-pmap-c)# exit
Router(config-pmap)# exit
!
Router(config)# policy-map service_z_out
Router(config-pmap)# exit
!
Router(config)# policy-map rate_1_service_a_in
Router(config-pmap)# class voip
Router(config-pmap-c)# police cir percent 25 4 ms 1 ms
Router(config-pmap-c)# exit
Router(config-pmap)# class video
Router(config-pmap-c)# police cir percent 30 2 ms 1 ms
Router(config-pmap-c)# exit
Router(config-pmap)# class class-default
Router(config-pmap-c)# police cir percent 40 2 ms 1 ms
Router(config-pmap-c)# exit
Router(config-pmap)# exit
!
Router(config)# policy-map rate_x_service_z_in
Router(config-pmap)# exit
!
Router(config)# policy-map rate_1_service_a_out
Router(config-pmap)# class class-default
Router(config-pmap-c)# bandwidth remaining ratio 10
Router(config-pmap-c)# shape average 100000
```

```
Router(config-pmap-c)# service policy service_a_out
Router(config-pmap-c)# exit
Router(config-pmap)# exit
!
Router(config)# policy-map rate_x_service_z_out
Router(config-pmap)# class class-default
Router(config-pmap-c)# bandwidth remaining ratio 10
Router(config-pmap-c)# shape average 100000
Router(config-pmap-c)# service policy service_z_out
Router(config-pmap-c)# exit
Router(config-pmap)# exit
Router(config)# interface GigabitEthernet1/0/0
Router(config-if)# encapsulation dot1q 1
Router(config-if)# service-policy output isp_A_out
Router(config-if)# exit
Router(config)# interface GigabitEthernet2/0/0
Router(config-if)# encapsulation dot1q 2
Router(config-if)# service-policy output isp_Z_out
Router(config-if)# end
```

# Additional References

### Related Documents

| Related Topic | Document Title |
|---|---|
| QoS commands: complete command syntax, command modes, command history, defaults, usage guidelines, and examples | *Cisco IOS Quality of Service Solutions Command Reference* |
| Traffic shaping | "Regulating Traffic Flow Using Traffic Shaping" module |
| MQC | "Applying QoS Features Using the MQC" module |

### Standards

| Standard | Title |
|---|---|
| No new or modified standards are supported by this feature, and support for existing standards has not been modified by this feature. | -- |

### MIBs

| MIB | MIBs Link |
|---|---|
| No new or modified MIBs are supported by this feature, and support for existing MIBs has not been modified by this feature. | To locate and download MIBs for selected platforms, Cisco IOS XE Software releases, and feature sets, use Cisco MIB Locator found at the following URL:<br>http://www.cisco.com/go/mibs |

### RFCs

| RFC | Title |
|---|---|
| No new or modified RFCs are supported by this feature, and support for existing RFCs has not been modified by this feature. | -- |

### Technical Assistance

| Description | Link |
|---|---|
| The Cisco Support and Documentation website provides online resources to download documentation, software, and tools. Use these resources to install and configure the software and to troubleshoot and resolve technical issues with Cisco products and technologies. Access to most tools on the Cisco Support and Documentation website requires a Cisco.com user ID and password. | http://www.cisco.com/cisco/web/support/index.html |

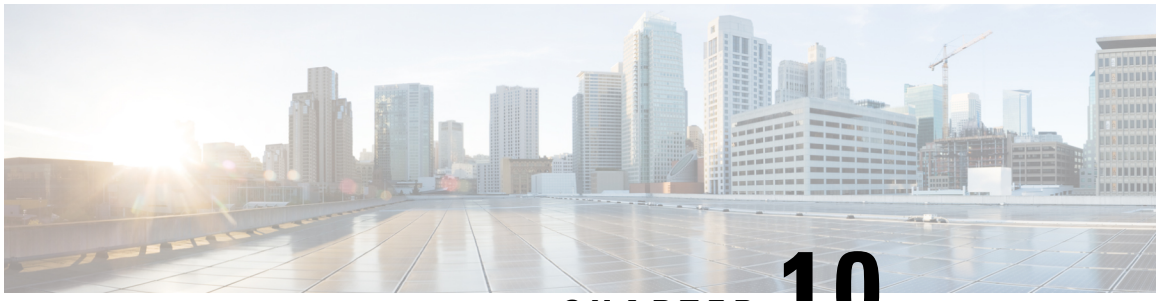
# Feature Information for QoS Hierarchical Queueing for Ethernet DSLAMs

The following table provides release information about the feature or features described in this module. This table lists only the software release that introduced support for a given feature in a given software release train. Unless noted otherwise, subsequent releases of that software release train also support that feature.

Use Cisco Feature Navigator to find information about platform support and Cisco software image support. To access Cisco Feature Navigator, go to www.cisco.com/go/cfn. An account on Cisco.com is not required.

***Table 5: Feature Information for QoS Hierarchical Queueing for Ethernet DSLAMs***

| Feature Name | Releases | Feature Information |
|---|---|---|
| QoS Hierarchical Queueing for Ethernet DSLAMs | Cisco IOS XE Release 2.4 | This feature module describes how to configure QoS hierarchical queueing policy maps on sessions and subinterfaces in Ethernet Digital Subscriber Line Access Multiplexer (E-DSLAM) applications.<br>This feature was implemented on Cisco ASR 1000 Series Routers. |



CHAPTER 10

# QoS Hierarchical Queueing for ATM DSLAMs

This feature module describes how to configure quality of service (QoS) hierarchical queueing policy maps on sessions and ATM VCs in ATM Digital Subscriber Line Access Multiplexer (A-DSLAM) applications on a Cisco ASR 1000 Series Aggregation Services Router.



## Finding Feature Information

Your software release may not support all the features documented in this module. For the latest caveats and feature information, see Bug Search Tool and the release notes for your platform and software release. To find information about the features documented in this module, and to see a list of the releases in which each feature is supported, see the feature information table.

Use Cisco Feature Navigator to find information about platform support and Cisco software image support. To access Cisco Feature Navigator, go to https://cfnng.cisco.com/. An account on Cisco.com is not required.

## Prerequisites for QoS Hierarchical Queueing for ATM DSLAMs

You must configure traffic classes using the class-map command.

## Restrictions for QoS Hierarchical Queueing for ATM DSLAMs

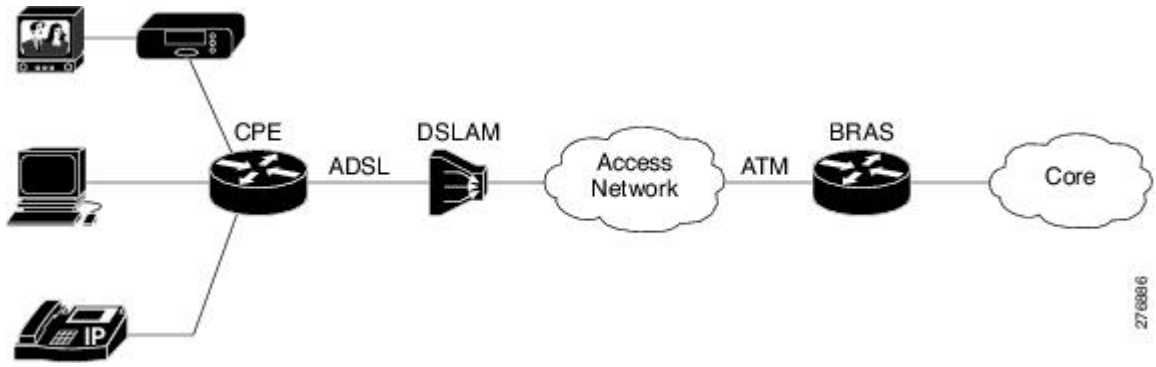
The QoS Hierarchical Queueing for ATM DSLAMs feature is not supported in combination with load balancing when a session service policy is routed to a Layer 2 Tunnel Protocol (L2TP) tunnel. This feature is supported only with shaped ATM VCs, which means ATM VCs that are defined as constant bit rate (CBR), Variable bit rate (VBR) or shaped unspecified bit rate (UBR), (that is, UBR with a peak cell rate).

# Information About QoS Hierarchical Queueing for ATM DSLAMs

## Different Levels of QoS Provisioning

Traffic downstream from a Broadband Router Access Server (BRAS) requires different levels of QoS provisioning (for example, traffic shaping) depending on the network architecture between the BRAS and the subscriber. The figure below illustrates an ATM DSL access network. The sample network includes multiple entities where QoS provisioning is required for different reasons.

***Figure 4: ATM DSL Access Network***




### Integrated Queueing Hierarchy

Different traffic shaping requirements result in QoS provisioning at multiple levels at the same time. The QoS-Hierarchical Queueing for ATM DSLAMs feature provides the ability to form one integrated queueing hierarchy that provides QoS provisioning at multiple levels with support for features such as bandwidth distribution at any of these levels.

The integrated queueing hierarchy is formed on the physical interface. When a service policy is instantiated on a session, the Subscriber Service Switch (SSS) infrastructure invokes the Modular QoS CLI (MQC) and a common queueing control plane sets up and enables the queueing features.

Session-to-ATM associations are resolved to determine the ATM VC on which the session QoS queues are built. QoS policies consisting of a shaper may also be applied simultaneously at the VC level.

## Configuration Guidelines for Hierarchical Queueing on ATM DSLAMs

When configuring the QoS Hierarchical Queueing for ATM DSLAMs feature, note the following guidelines:

- When an ATM VC is used to aggregate a number of sessions with queueing policies, a queueing policy at an ATM VC level must be a one-level policy map that is configured as class-default with only the shape feature enabled.
- Both ATM VCs and sessions can be oversubscribed and controlled by shapers.

# How to Configure QoS Hierarchical Queueing for ATM DSLAMs

## Configuring and Applying QoS Hierarchical Queueing Policy Maps to Sessions

### SUMMARY STEPS

1. **enable**
2. **configure terminal**
3. **policy-map** *policy-map-name*
4. **class** class-map-name
5. bandwidth {*bandwidth-kbps* | **percent***percentage*| **remainingpercent***percentage*}
6. **exit**
7. **exit**
8. **policy-map** *policy-map-name*
9. **class class-default**
10. **shape** average {*cir*| **percent***percentage*}
11. **bandwidth remaining ratio** *ratio*
12. **service-polic** y*policy-map-name*
13. **exit**
14. **exit**
15. **interface virtual-template** *number*
16. **service-policy output** *policy-map-name*
17. **end**

### DETAILED STEPS

| | Command or Action | Purpose |
|---|---|---|
| **Step 1** | **enable**<br>**Example:**<br>`Router> enable` | Enables privileged EXEC mode.<br>• Enter your password if prompted. |
| **Step 2** | **configure terminal**<br>**Example:**<br>`Router# configure terminal` | Enters global configuration mode. |
| **Step 3** | **policy-map** *policy-map-name*<br>**Example:**<br>`Router(config)# policy-map session-a-child` | Creates a child policy and enters policy-map configuration mode.<br>• Enter the policy-map name. |
| **Step 4** | **class** class-map-name<br>**Example:** | Configures the traffic class that you specify and enters policy-map class configuration mode. |

| | Command or Action | Purpose |
|---|---|---|
| | `Router(config-pmap)# class voip` | • Enter the name of a previously configured class map . |
| **Step 5** | bandwidth {*bandwidth-kbps* \| **percent***percentage*\| **remainingpercent***percentage*}<br>**Example:**<br>`Router(config-pmap-c)# bandwidth 10000`<br>**Example:** | (Optional) Enables class-based weighted fair queueing based on the keywords and arguments specified.<br>• bandwidth-kbps--Specifies the minimum bandwidth allocated for a class belonging to a policy map. Valid values are from 1 to 2,000,000.<br>• percent percentage--Specifies the minimum percentage of the link bandwidth allocated for a class belonging to a policy map. Valid values are from 1 to 100.<br>• remaining percent percentage--Specifies the minimum percentage of unused link bandwidth allocated for a class belonging to a policy map. Valid values are from 1 to 99. |
| **Step 6** | **exit**<br>**Example:**<br>`Router(config-pmap-c)# exit` | Exits policy-map class configuration mode. |
| **Step 7** | **exit**<br>**Example:**<br>`Router(config-pmap)# exit` | Exits policy-map configuration mode. |
| **Step 8** | **policy-map** *policy-map-name*<br>**Example:**<br>`Router(config)# policy-map session_a_parent` | Creates a parent policy and enters policy-map configuration mode.<br>• Enter the policy-map name. |
| **Step 9** | **class class-default**<br>**Example:**<br>`Router(config-pmap)# class class-default` | Configures the traffic class as class-default and enters policy-map class configuration mode.<br>**Note** Do not configure any other traffic class. |
| **Step 10** | **shape** average {*cir*\| **percent***percentage*}<br>**Example:**<br>`Router(config-pmap-c)# shape average 10000000` | Specifies average-rate traffic shaping for all traffic that does not match any other traffic class.<br>• Enter the **average** keyword followed by the committed information rate (CIR), in bits per second (bps), or enter the **average** keyword followed by **percentage** keyword to specify a percentage of the interface bandwidth for the CIR. Valid values are from 1 to 100. |

| | Command or Action | Purpose |
|---|---|---|
| **Step 11** | **bandwidth remaining ratio** *ratio*<br>**Example:**<br>`Router(config-pmap-c)# bandwidth remaining ratio 10` | Specifies the weight (ratio) for the ATM VC.<br>• Enter the relative weight of this ATM VC (or class queue). This number (ratio) indicates the proportional relationship between the other ATM VCs or class queues. |
| **Step 12** | **service-polic** *ypolicy-map-name*<br>**Example:**<br>`Router(config-pmap-c)# service-policy session-a-child` | Applies the child policy map to the parent class-default class.<br>• Enter the name of a previously configured child policy map. |
| **Step 13** | **exit**<br>**Example:**<br>`Router(config-pmap-c)# exit` | Exits policy-map class configuration mode. |
| **Step 14** | **exit**<br>**Example:**<br>`Router(config-pmap)# exit` | Exits policy-map configuration mode. |
| **Step 15** | **interface virtual-template** *number*<br>**Example:**<br>`Router(config)# interface virtual-template 1` | Creates a virtual template and enters interface configuration mode.<br>• Enter the virtual template number. Valid range is from 1 to 4095. |
| **Step 16** | **service-policy output** *policy-map-name*<br>**Example:**<br>`Router(config-if)# service-policy output session_a_parent` | Applies the service policy to the virtual interface.<br>• Enter the name of the previously configured parent policy map.<br>**Note** You must specify the output keyword to apply the service policy to outbound traffic on the interface. |
| **Step 17** | **end**<br>**Example:**<br>`Router(config-if)# end` | (Optional) Returns to privileged EXEC mode. |

### Examples

The following is an example of how to configure and apply a QoS hierarchical queueing policy map to PPP/IP sessions by using a virtual template:

```
Router> enable
Router# configure terminal
Router(config)# policy-map session-a-child
Router(config-pmap)# class voip
Router(config-pmap-c)# police 1000000
Router(config-pmap-c)# priority level 1
Router(config-pmap-c)# exit
Router(config-pmap)# class video
Router(config-pmap-c)# police 100000
Router(config-pmap-c)# priority level 2
Router(config-pmap-c)# exit
Router(config-pmap)# class precedence_0
Router(config-pmap-c)# bandwidth remaining ratio 10
Router(config-pmap-c)# exit
Router(config-pmap)# class precedence_1
Router(config-pmap-c)# bandwidth remaining ratio 20
Router(config-pmap-c)# exit
Router(config-pmap)# exit
Router(config)# policy-map session_a_parent
Router(config-pmap-c)# exit
Router(config-pmap)# class class-default
Router(config-pmap-c)# shape average 10000000
Router(config-pmap-c)# bandwidth remaining ratio 10
Router(config-pmap-c)# service-policy session-a-child
Router(config-pmap-c)# exit
Router(config-pmap)# exit
Router(config)# interface virtual-template 20
Router(config-if)# service-policy output session_a_parent
Router(config-if)# end
```

# Configuring and Applying QoS Hierarchical Queueing Policy Maps to ATM VCs

## SUMMARY STEPS

1. **enable**
2. **configure terminal**
3. **policy-map** *policy-map-name*
4. **class class-default**
5. **shape average** {*cir*| **percent***percentage*}
6. **exit**
7. **exit**
8. interface type slot/subslot/port**.**subinterface
9. pvc [*name*] *vpi*/*vci* [**ces** | **ilmi** | **qsaal** | **smds**| **l2transport**]
10. **vbr-nrt** *peak-cell-rate average-cell-rate*
11. **service-policy output** *policy-map-name*
12. **end**

## DETAILED STEPS

| | Command or Action | Purpose |
|---|---|---|
| **Step 1** | **enable** | Enables privileged EXEC mode. |

| | Command or Action | Purpose |
|---|---|---|
| | **Example:**<br>`Router> enable` | • Enter your password if prompted. |
| **Step 2** | **configure terminal**<br>**Example:**<br>`Router# configure terminal` | Enters global configuration mode. |
| **Step 3** | **policy-map** *policy-map-name*<br>**Example:**<br>`Router(config)# policy-map subint-1` | Creates a policy map and enters policy-map configuration mode.<br>• policy-map-name--The name of the policy map. |
| **Step 4** | **class class-default**<br>**Example:**<br>`Router(config-pmap)# class class-default` | Configures the traffic class as class-default and enters policy-map class configuration mode.<br>• Do not configure any other traffic class.<br>**Note** When an ATM VC aggregates a number of sessions with queueing policies, a queueing policy at an ATM VC level must be a one-level policy map that is configured as class-default. |
| **Step 5** | **shape average** {*cir*\| **percent***percentage*}<br>**Example:**<br>`Router(config-pmap-c)# shape average 10000000` | Specifies average-rate traffic shaping for all traffic that does not match any other traffic class.<br>• Enter the **average** keyword followed by the CIR, in bps or enter the **average** keyword followed by **percentage** keyword to specify a percentage of the interface bandwidth for the CIR. Valid values are from 1 to 100.<br>**Note** When an ATM VC aggregates a number of sessions with queueing policies, a queueing policy at an ATM VC level must be a one-level policy map with only the shape feature enabled. |
| **Step 6** | **exit**<br>**Example:**<br>`Router(config-pmap-c)# exit` | Exits policy-map class configuration mode. |
| **Step 7** | **exit**<br>**Example:**<br>`Router(config-pmap)# exit` | Exits policy-map configuration mode. |

| | Command or Action | Purpose |
|---|---|---|
| **Step 8** | interface type slot/subslot/port.subinterface<br>**Example:**<br>`Router(config)# interface ATM 3/1/1.1` | Specifies the ATM VC on which you are attaching the policy map and enters ATM VC configuration mode.<br>• Enter the interface type and slot number, subslot number, port number, and ATM VC number. |
| **Step 9** | pvc [*name*] *vpi*/*vci* [**ces** \| **ilmi** \| **qsaal** \| **smds**\| **l2transport**]<br>**Example:**<br>`Router(config-if-atm-vc)# pvc 2/100` | Selects the ATM VC to which the service policy is to be applied. |
| **Step 10** | **vbr-nrt** *peak-cell-rate average-cell-rate*<br>**Example:**<br>`Router(config-if-atm-vc)# vbr-nrt 800000 800000` | Sets the VC type to VBR with a peak and average cell rate. |
| **Step 11** | **service-policy output** *policy-map-name*<br>**Example:**<br>`Router(config-subif)# service-policy output subint-1` | Attaches the service policy to the ATM VC.<br>• policy-map-name--The name of the previously configured policy map.<br>**Note** You must specify the output keyword to apply the service policy to outbound traffic on the ATM VC. |
| **Step 12** | **end**<br>**Example:**<br>`Router(config-subif)# end` | (Optional) Returns to privileged EXEC mode. |

### Examples

The following is an example of how to configure and apply a QoS hierarchical queueing policy map to an ATM VC (and provide aggregate shaping for a large number of subscribers):

```
Router> enable
Router# configure terminal
Router(config)# policy-map subint-1
Router(config-pmap)# class class-default
Router(config-pmap-c)# shape average 10000000
Router(config-pmap-c)# exit
Router(config-pmap)# exit
Router(config)# interface ATM 3/1/1.1
Router(config-if-atm-vc)# pvc 2/100
Router (config-if-atm-vc)# vbr-nrt 800000 800000
Router(config-subif)# service-policy output subint-1
Router(config-subif)# end
```

# Displaying Policy-Map Information for Hierarchical Queueing

## SUMMARY STEPS

1. **enable**
2. **show policy-map**
3. **show policy-map interface** *type number*
4. **show policy-map session**
5. **exit**

## DETAILED STEPS

| | Command or Action | Purpose |
|---|---|---|
| **Step 1** | **enable**<br>**Example:**<br>`Router> enable` | Enables privileged EXEC mode.<br>• Enter your password if prompted. |
| **Step 2** | **show policy-map**<br>**Example:**<br>`Router# show policy-map` | (Optional) Displays all information for all class maps. |
| **Step 3** | **show policy-map interface** *type number*<br>**Example:**<br>`Router#`<br>`show policy-map interface ATM 4/0/0.1` | (Optional) Displays the packet statistics of all classes that are configured for all service policies either on the specified interface or ATM VC or on a specific PVC on the interface.<br>• Enter the interface type and number. |
| **Step 4** | **show policy-map session**<br>**Example:**<br>`Router#`<br>`show policy-map session` | (Optional) Displays the QoS policy map in effect for the SSS session. |
| **Step 5** | **exit**<br>**Example:**<br>`Router# exit` | (Optional) Exits privileged EXEC mode. |

# Configuration Examples for QoS Hierarchical Queueing for ATM DSLAMs

## Example Policy Maps on Sessions

The following example shows how to configure and apply QoS hierarchical queueing policy maps on sessions. A child queueing policy is applied to each parent subscriber line level policy.

```
Router> enable
Router# configure terminal
Router(config)# policy-map service-a-out
Router(config-pmap)# class voip
Router(config-pmap-c)# priority
Router(config-pmap-c)# set cos 1
Router(config-pmap-c)# exit
Router(config-pmap)# class video
Router(config-pmap-c)# set cos 2
Router(config-pmap-c)# exit
Router(config-pmap)# class gaming
Router(config-pmap-c)# bandwidth remaining percent 80
Router(config-pmap-c)# set cos 3
Router(config-pmap-c)# exit
Router(config-pmap)# class class-default
Router(config-pmap-c)# bandwidth remaining percent 20
Router(config-pmap-c)# set cos 4
Router(config-pmap-c)# exit
Router(config-pmap)# exit
!
Router(config)# policy-map rate-1-service-a-out
Router(config-pmap)# class class-default
Router(config-pmap-c)# bandwidth remaining ratio 10
Router(config-pmap-c)# shape average 100000
Router(config-pmap-c)# service-policy service-a-out
Router(config-pmap-c)# exit
Router(config-pmap)# exit
!
Router(config)# policy-map rate-1-service-a-in
Router(config-pmap)# class voip
Router(config-pmap-c)# police percent 25
Router(config-pmap-c)# exit
Router(config-pmap)# class gaming
Router(config-pmap-c)# police percent 50
Router(config-pmap-c)# exit
Router(config-pmap)# class class-default
Router(config-pmap-c)# police percent 20
Router(config-pmap-c)# exit
Router(config-pmap)# exit
!
Router(config)# interface virtual-template 20
Router(config-if)# service-policy output rate-1-service-a-out
Router(config-if)# service-policy input rate-1-service-a-in
Router(config-if)# end
```

## Example Policy Maps on Sessions with Aggregate Shaping

The following example shows how to configure and apply QoS hierarchical queueing policy maps on sessions with multiple PPP/IP sessions per subscriber line. In this example, queueing is configured as in previous example. The VC is configured as follows:

```
Router(config)# policy-map isp_A_out
Router(config-pmap)# class class-default
Router(config-pmap-c)# shape average 500000
Router(config-pmap-c)# exit
Router(config-pmap)# exit
Router(config)# interface ATM 1/0/0.1
Router(config-subif)# pvc 10/100
Router(config-if-atm-vc)# vbr-nrt 800000 800000
Router(config-if-atm-vc)# service-policy output isp-A-out
Router(config-if-atm-vc)# exit
Router(config-subif)# exit
```

# Additional References

### Related Documents

| Related Topic | Document Title |
|---|---|
| QoS commands: complete command syntax, command modes, command history, defaults, usage guidelines, and examples | *Cisco IOS Quality of Service Solutions Command Reference* |
| Traffic shaping | "Regulating Traffic Flow Using Traffic Shaping" module |
| MQC | "Applying QoS Features Using the MQC" module |

### Standards

| Standard | Title |
|---|---|
| No new or modified standards are supported by this feature, and support for existing standards has not been modified by this feature. | -- |

### MIBs

| MIB | MIBs Link |
|---|---|
| No new or modified MIBs are supported by this feature, and support for existing MIBs has not been modified by this feature. | To locate and download MIBs for selected platforms, Cisco IOS XE Software releases, and feature sets, use Cisco MIB Locator found at the following URL:<br>http://www.cisco.com/go/mibs |

### RFCs

| RFC | Title |
|---|---|
| No new or modified RFCs are supported by this feature, and support for existing RFCs has not been modified by this feature. | -- |

### Technical Assistance

| Description | Link |
|---|---|
| The Cisco Support and Documentation website provides online resources to download documentation, software, and tools. Use these resources to install and configure the software and to troubleshoot and resolve technical issues with Cisco products and technologies. Access to most tools on the Cisco Support and Documentation website requires a Cisco.com user ID and password. | http://www.cisco.com/cisco/web/support/index.html |

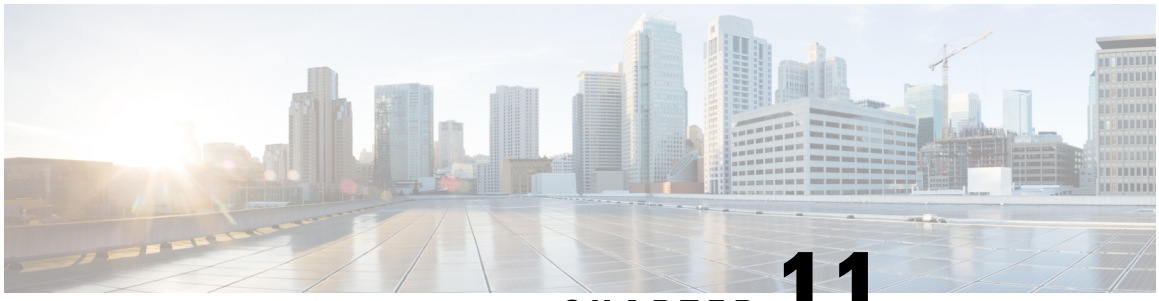
# Feature Information for QoS Hierarchical Queueing for ATM DSLAMs

The following table provides release information about the feature or features described in this module. This table lists only the software release that introduced support for a given feature in a given software release train. Unless noted otherwise, subsequent releases of that software release train also support that feature.

Use Cisco Feature Navigator to find information about platform support and Cisco software image support. To access Cisco Feature Navigator, go to www.cisco.com/go/cfn. An account on Cisco.com is not required.

***Table 6: Feature Information for QoS Hierarchical Queueing for ATM DSLAMs***

| Feature Name | Releases | Feature Information |
|---|---|---|
| QoS Hierarchical Queueing for ATM DSLAMs | Cisco IOS XE Release 2.4 Cisco IOS XE Release 2.5 | This feature module describes how to configure QoS hierarchical queueing policy maps on sessions and ATM VCs in ATM Digital Subscriber Line Access Multiplexer (A-DSLAM) applications.<br><br>This feature was implemented on Cisco ASR 1000 Series Aggregation Services Routers. |



CHAPTER 11

# Per-Flow Admission

The Per-Flow Admission feature provides explicit controls to limit packet flow into a WAN edge in order to protect already admitted flows on the routing/WAN edge.



## Finding Feature Information

Your software release may not support all the features documented in this module. For the latest caveats and feature information, see Bug Search Tool and the release notes for your platform and software release. To find information about the features documented in this module, and to see a list of the releases in which each feature is supported, see the feature information table.

Use Cisco Feature Navigator to find information about platform support and Cisco software image support. To access Cisco Feature Navigator, go to https://cfnng.cisco.com/. An account on Cisco.com is not required.

## Prerequisites for Per-Flow Admission

A class must have bandwidth or priority defined before configuring the Per-Flow Admission feature.

## Restrictions for Per-Flow Admission

Per-flow admission is currently supported only on Ethernet and serial interfaces, and Dynamic Multipoint Virtual Private Network (DMVPN) tunnels.

# Information About Per-Flow Admission

## Overview of Per-Flow Admission

Application (mainly voice and video) quality drops when they are connected from a branch to head quarters and data centers over a WAN because the WAN interface bandwidth is limited and always comes at a premium cost. There are no well-defined controls to restrict flows through a WAN link and no explicit controls to limit the flows to protect already admitted flows. This limitation leads to quality degradation of already admitted flows.

The Per-Flow Admission feature allows operators to understand the number of flows that can be accommodated into an interface without quality degradation. In most deployments, the N+1st flow affects the quality of all existing valid first N flows. The Per-Flow Admission feature enables nodes to automatically learn about flows and their bandwidth as they get accommodated into the interface where bandwidth is at a premium. The network node accommodates only flows that the interface can handle, and it drops flows thereafter.

## Benefits of Per-Flow Admission

The following are benefits of integrating the Per-Flow Admission feature to Quality of Service (QoS):

- Makes QoS networks more predictable and robust.
- Requires no end-to-end coordination because per-flow admission is a per-hop decision and each hop makes decision independently.
- Does not require the source to predict the flow rate.
- Ensures a higher probability of getting a reservation in the network.
- Works well with rate adaption because certain parts of the flow may be elastic.
- Promotes better selection of admitted traffic.
- Works at the IP layer.
- Works transparently with other network technologies such as Network Address Translation (NAT).
- Does not allow the source to hog the network.
- Provides benefits for certain endpoints by selecting only certain parts of the flow as admitted.

# How to Configure Per-Flow Admission

## Configuring a Class Map

### SUMMARY STEPS

1. **enable**
2. **configure terminal**
3. **metadata flow**
4. **class-map** [**match-all** | **match-any**] *class-map-name*
5. exit
6. **class-map** [**match-all** | **match-any**] *class-map-name*

7. **match dscp** *dscp-value*
8. **end**

**DETAILED STEPS**

| | Command or Action | Purpose |
|---|---|---|
| **Step 1** | **enable**<br>**Example:**<br>`Device> enable` | Enables privileged EXEC mode.<br>• Enter your password if prompted. |
| **Step 2** | **configure terminal**<br>**Example:**<br>`Device# configure terminal` | Enters global configuration mode. |
| **Step 3** | **metadata flow**<br>**Example:**<br>`Device(config)# metadata flow` | Enables metadata on all interfaces. |
| **Step 4** | **class-map** [**match-all** \| **match-any**] *class-map-name*<br>**Example:**<br>`Device(config)# class-map match-all admitted` | Creates a class map for matching traffic to a specified class, and enters class-map configuration mode.<br>• Enter the class map name. |
| **Step 5** | exit<br>**Example:**<br>`Device(config-cmap)# exit` | Exits the class-map configuration mode and returns to global configuration mode. |
| **Step 6** | **class-map** [**match-all** \| **match-any**] *class-map-name*<br>**Example:**<br>`Device(config-cmap)# class-map match-all af4` | Creates a class map to be used for matching traffic to a specified class.<br>• Enter the class map name. |
| **Step 7** | **match dscp** *dscp-value*<br>**Example:**<br>`Device(config-cmap)# match dscp af41 af42 af43` | Identifies a specific IP Differentiated Services Code Point (DSCP) value as a match criterion. |
| **Step 8** | **end**<br>**Example:**<br>`Device(config-cmap)#end` | Exits class-map configuration mode and returns to privilged EXEC mode. |

# Configuring a Child Policy Map

### SUMMARY STEPS

1. **enable**
2. **configure terminal**
3. **policy-map** *policy-map-name*
4. **class** {*class-name* | **class-default**}
5. **set dscp** *dscp-value*
6. **class** {*class-name* | **class-default**}
7. **set dscp** *dscp-value*
8. **end**

### DETAILED STEPS

| | Command or Action | Purpose |
|---|---|---|
| **Step 1** | **enable**<br>**Example:**<br>`Device> enable` | Enables privileged EXEC mode.<br>• Enter your password if prompted. |
| **Step 2** | **configure terminal**<br>**Example:**<br>`Device# configure terminal` | Enters global configuration mode. |
| **Step 3** | **policy-map** *policy-map-name*<br>**Example:**<br>`Device(config)# policy-map child` | Creates a policy map using the specified name and enters policy-map configuration mode.<br>• Enter the name of the policy map that you want to create. |
| **Step 4** | **class** {*class-name* | **class-default**}<br>**Example:**<br>`Device(config-pmap)# class admitted` | Specifies the name of the class whose policy you want to create and enters policy-map class configuration mode.<br>• This class is associated with the class map created earlier. |
| **Step 5** | **set dscp** *dscp-value*<br>**Example:**<br>`Device(config-pmap-c)# set dscp af41` | Sets the differentiated services code point (DSCP) value in the type of service (ToS) byte and assigns higher priority to admitted traffic by marking up the admitted flow and marking down the un-admitted flow.<br>• Enter the DSCP value. |
| **Step 6** | **class** {*class-name* | **class-default**}<br>**Example:**<br>`Device(config-pmap-c)# class un-admitted` | Specifies the name of the class whose policy you want to create or change or specifies the default class (commonly known as the class default class) before you configure its policy. |

| | Command or Action | Purpose |
|---|---|---|
| | | • Enter the name of the class or enter the **class-default** keyword.<br>This class will be matched against the **match metadata cac status un-admitted** command. |
| **Step 7** | **set dscp** *dscp-value*<br>**Example:**<br>`Device(config-pmap-c)# set dscp af42` | Sets the DSCP value in the ToS byte. Sets higher priority to admitted traffic by marking up the admitted flow and marking down the un-admitted flow.<br>• Enter the DSCP value. |
| **Step 8** | **end**<br>**Example:**<br>`Device(config-pmap-c)# end` | Exits policy-map class configuration mode and returns to privileged EXEC mode. |

# Configuring Per-Flow Admission for a Class

### Before you begin

A class must have bandwidth or priority defined before configuring per-flow admission.

### SUMMARY STEPS

1. **enable**
2. **configure terminal**
3. **policy-map** *policy-map-name*
4. **class** {*class-name* | **class-default**}
5. **bandwidth** {*kilobits* | **percent** *percentage*}
6. **admit cac local**
7. **rate** {*kbps* | **percent** *percentage*}
8. **flow rate fixed** *kbps flow-bit-rate*
9. **end**

### DETAILED STEPS

| | Command or Action | Purpose |
|---|---|---|
| **Step 1** | **enable**<br>**Example:**<br>`Device> enable` | Enables privileged EXEC mode.<br>• Enter your password if prompted. |
| **Step 2** | **configure terminal**<br>**Example:**<br>`Device# configure terminal` | Enters global configuration mode. |

| | Command or Action | Purpose |
|---|---|---|
| **Step 3** | **policy-map** *policy-map-name*<br>**Example:**<br>`Device(config)# policy-map test` | Creates a policy map using the specified name and enters policy-map configuration mode.<br>• Enter the name of the policy map that you want to create. |
| **Step 4** | **class** {*class-name* \| **class-default**}<br>**Example:**<br>`Device(config-pmap)# class af4`<br>**Note** To divide packets into admitted and un-admitted buckets, you must assign the policy map created earlier, under the **class** command that is defined here as a child policy. | Specifies the name of the class whose policy you want to create and enters policy-map class configuration mode.<br>• This class is associated with the class map created earlier. |
| **Step 5** | **bandwidth** {*kilobits* \| **percent** *percentage*}<br>**Example:**<br>`Device(config-pmap-c)# bandwidth 200` | Specifies the bandwidth for a class of traffic belonging to the policy map.<br>• Enter the bandwidth in kbps. |
| **Step 6** | **admit cac local**<br>**Example:**<br>`Device(config-pmap-c)# admit cac local` | Enables per-flow admission for this class and enters per-flow admission configuration mode. |
| **Step 7** | **rate** {*kbps* \| **percent** *percentage*}<br>**Example:**<br>`Device(config-pmap-admit-cac)# rate percent 80` | Configures the size of the bandwidth pool in kbps or as a percentage of output class bandwidth. |
| **Step 8** | **flow rate fixed** *kbps flow-bit-rate*<br>**Example:**<br>`Device(config-pmap-admit-cac)# flow rate fixed 100` | Specifies how much bandwidth to allocate for each flow. |
| **Step 9** | **end**<br>**Example:**<br>`Device(config-pmap-admit-cac)# end` | Exits per-flow admission configuration mode and returns to privileged EXEC mode. |

# Attaching a Per-Flow Admission Policy to an Interface

### SUMMARY STEPS

1. **enable**
2. **configure terminal**
3. **policy-map** *policy-map-name*
4. **class** {*class-name* | **class-default**}

5. **service-policy** *policy-map*
6. **end**
7. **configure terminal**
8. **interface** *type number*
9. **ip address** *ip-address mask*
10. **load-interval** *seconds*
11. **service-policy output** *policy-map-name*
12. **no shutdown**
13. end

**DETAILED STEPS**

| | Command or Action | Purpose |
|---|---|---|
| **Step 1** | **enable**<br>**Example:**<br>`Device> enable` | Enables privileged EXEC mode.<br>• Enter your password if prompted. |
| **Step 2** | **configure terminal**<br>**Example:**<br>`Device# configure terminal` | Enters global configuration mode. |
| **Step 3** | **policy-map** *policy-map-name*<br>**Example:**<br>`Device(config)# policy-map test` | Creates a policy map using the specified name and enters policy-map configuration mode.<br>• Enter the name of the policy map that you want to create. |
| **Step 4** | **class** {*class-name* \| **class-default**}<br>**Example:**<br>`Device(config-pmap)# class af4` | Specifies the name of the class whose policy you want to create and enters policy-map class configuration mode.<br>• This class is associated with the class map created earlier. |
| **Step 5** | **service-policy** *policy-map*<br>**Example:**<br>`Device(config-pmap-c)# service-policy child` | Attaches the policy map to a class. |
| **Step 6** | **end**<br>**Example:**<br>`Device(config-pmap-c)# end` | Exits policy-map class configuration mode and returns to privileged EXEC mode. |
| **Step 7** | **configure terminal**<br>**Example:**<br>`Device# configure terminal` | Enters global configuration mode. |

| | Command or Action | Purpose |
|---|---|---|
| **Step 8** | **interface** *type number*<br>**Example:**<br>`Device(config)# interface Serial2/0` | Configures the specified interface and enters interface configuration mode.<br>• Enter the interface type and number. |
| **Step 9** | **ip address** *ip-address mask*<br>**Example:**<br>`Device(config-if)# ip address 10.10.100.1 255.255.255.0` | Sets an IP address for an interface. |
| **Step 10** | **load-interval** *seconds*<br>**Example:**<br>`Device(config-if)# load-interval 30` | Specifies the interval for load calculation of an interface. |
| **Step 11** | **service-policy output** *policy-map-name*<br>**Example:**<br>`Device(config-if)# service-policy output test` | Attaches a policy map to an interface. |
| **Step 12** | **no shutdown**<br>**Example:**<br>`Device(config-if)# no shutdown` | Enables the interface. |
| **Step 13** | end<br>**Example:**<br>`Device(config-if)# end` | Exits interface configuration mode and returns to privileged EXEC mode. |

# Verifying Per-flow Admission

### SUMMARY STEPS

1. **enable**
2. **show policy-map interface** *interface-name*

### DETAILED STEPS

| | Command or Action | Purpose |
|---|---|---|
| **Step 1** | **enable**<br>**Example:**<br>`Device> enable` | Enables privileged EXEC mode.<br>• Enter your password if prompted. |

| | Command or Action | Purpose |
|---|---|---|
| **Step 2** | **show policy-map interface** *interface-name*<br>**Example:**<br>`Device# show policy-map interface serial2/0` | Displays the configuration of all classes configured for all service policies on the specified interface.<br>• Enter the name of the policy map whose complete configuration is to be displayed. |

# Configuration Examples for Per-Flow Admission

## Example: Configuring a Class Map

```
Device> enable
Device# configure terminal
Device(config)# metadata flow
Device(config)# class-map match-all admitted
Device(config-cmap)# match metadata cac status admitted
Device(config-cmap)# class-map match-all af4
Device(config-cmap)# match dscp af41 af42 af43
Device(config-cmap)# end
```

## Example: Configuring a Policy Map

```
Device> enable
Device# configure terminal
Device(config)# policy-map child
Device(config-pmap)# class admitted
Device(config-pmap-c)# set dscp af41
Device(config-pmap-c)# class class-default
Device(config-pmap-c)# set dscp af42
Device(config-pmap-c)# end
```

## Example: Configuring Per-Flow Admission for a Class

```
Device> enable
Device# configure terminal
Device(config)# policy-map test
Device(config-pmap)# class af4
Device(config-pmap-c)# bandwidth 200
Device(config-pmap-c)# admit cac local
Device(config-pmap-admit-cac)# rate percent 80
Device(config-pmap-admit-cac)# flow rate fixed 100
Device(config-pmap-c)# exit
```

# Example: Attaching a Per-Flow Admission Policy to an Interface

```
Device> enable
Device# configure terminal
Device(config-pmap-c)# service-policy child
Device(config-pmap-c)# end
Device# configure terminal
Device(config)# interface Serial2/0
Device(config-if)# bandwidth 384
Device(config-if)# ip address 10.10.100.1 255.255.255.0
Device(config-if)# load-interval 30
Device(config-if)# service-policy output test
Device(config-if)# no shutdown
Device(config-if)# end
```

# Example: Verifying Per-Flow Admission

```
Device# show policy-map interface


  Service-policy output: test

    Class-map: af4 (match-all)
      269 packets, 336250 bytes
      30 second offered rate 90000 bps, drop rate 13000 bps
      Match:  dscp af41 (34) af42 (36) af43 (38)
      Queueing
      queue limit 100 ms/ 2500 bytes


      (queue depth/total drops/no-buffer drops) 2500/39/0
      (pkts output/bytes output) 230/287500
      bandwidth 200 kbps

      cac local rate 200 kbps, reserved 200 kbps
      flow rate fixed 100 kbps

      All flows:
        Number of admitted flows: [2]
        Number of non-admitted flows: [1]

      Service-policy : child

        Class-map: admitted (match-all)
          178 packets, 222500 bytes
          30 second offered rate 60000 bps, drop rate 0000 bps
          Match:  metadata cac status admitted
          QoS Set
            dscp af41
              Packets marked 194

        Class-map: unadmitted (match-all)
          88 packets, 110000 bytes
          30 second offered rate 30000 bps, drop rate 0000 bps
          Match:  metadata cac status un-admitted
          QoS Set
            dscp af42
```

```
          Packets marked 96

      Class-map: class-default (match-any)
        3 packets, 3750 bytes
        30 second offered rate 1000 bps, drop rate 0000 bps
        Match: any

Class-map: class-default (match-any)
  181 packets, 115396 bytes
  30 second offered rate 31000 bps, drop rate 0000 bps
  Match: any

  queue limit 64 packets
  (queue depth/total drops/no-buffer drops) 0/0/0
  (pkts output/bytes output) 181/115396
```

# Additional References for Per-Flow Admission

### Related Documents

| Related Topic | Document Title |
|---|---|
| Cisco IOS commands | Cisco IOS Master Commands List, All Releases |
| QoS commands: complete command syntax, command modes, command history, defaults, usage guidelines, and examples. | Cisco IOS Quality of Service Solutions Command Reference |

### Technical Assistance

| Description | Link |
|---|---|
| The Cisco Support website provides extensive online resources, including documentation and tools for troubleshooting and resolving technical issues with Cisco products and technologies.<br>To receive security and technical information about your products, you can subscribe to various services, such as the Product Alert Tool (accessed from Field Notices), the Cisco Technical Services Newsletter, and Really Simple Syndication (RSS) Feeds.<br>Access to most tools on the Cisco Support website requires a Cisco.com user ID and password. | http://www.cisco.com/cisco/web/support/index.html |

# Feature Information for Per-Flow Admission

The following table provides release information about the feature or features described in this module. This table lists only the software release that introduced support for a given feature in a given software release train. Unless noted otherwise, subsequent releases of that software release train also support that feature.

Use Cisco Feature Navigator to find information about platform support and Cisco software image support. To access Cisco Feature Navigator, go to www.cisco.com/go/cfn. An account on Cisco.com is not required.

***Table 7: Feature Information for Per-Flow Admission***