Configuring Modular QoS Congestion Management

Congestion management controls congestion after it has occurred on a network. Congestion is managed on Cisco IOS XR software by using packet queuing methods and by shaping the packet flow through use of traffic regulation mechanisms.

The types of traffic regulation mechanisms supported are:

- Traffic shaping:
  - Modified Deficit Round Robin (MDRR)
  - Low-latency queuing (LLQ) with strict priority queuing (PQ)
- Traffic policing:
  - Color blind

Feature History for Configuring Modular QoS Congestion Management on Cisco IOS XR Software

Release	Modification
Release 2.0	The Congestion Avoidance feature was introduced.
Release 3.2	The **police** command was changed to the **police rate** command and the syntax changed.
Release 3.4.0	The **police rate** command enters policy map police configuration mode to configure the conform, exceed and violate actions. The following new commands were added: **conform-action**, **exceed-action** and **violate-action**. The **cos**, **qos-group**, and **transmit** actions were added to the policer.

Release	Modification
Release 3.6.0	Increased Class scale from 32 to 512 classes. Unallocated remaining bandwidth is equally distributed among all the queueing classes that do not have remaining bandwidth configured explicitly. For shape and police percentage parameters in child policy, reference is relative to the maximum rate of the parent. For bandwidth percentage parameters in child policy, reference is relative to the minimum bandwidth of the parent class. If bandwidth is not configured in parent class, guaranteed service rate of parent class is used as reference.
Release 3.8.0	The multi-action set/policer was supported. The **set qos-group** ingress policer marking was supported.
Release 3.9.2	The Policer Granularity andShaper Granularity features were introduced.
Release 4.0.0	Because they are not supported, removed these sections: • QoS-Group-Based Queueing • Traffic Policing on Layer 2 ATM Interfaces • Attaching a Service Policy to the Attachment Circuits (AC) example • Configuring Dual Queue Limit example High Priority Propagation and Layer-all Accounting features were introduced on the Cisco CRS Series Modular Services Card 140G (CRS-MSC-140G). On the CRS-SMC-140G, a police action *must* be configured in the same class as the priority action (configuration change from the Cisco CRS Series Modular Services Card 40G CRS-MSC-40G).
Release 4.2.1	Configured Accounting feature was introduced.

Prerequisites for Configuring QoS Congestion Management

These prerequisites are required for configuring QoS congestion management on your network:

- You must be in a user group associated with a task group that includes the proper task IDs. The command reference guides include the task IDs required for each command. If you suspect user group assignment is preventing you from using a command, contact your AAA administrator for assistance.
- You must be familiar with Cisco IOS XR QoS configuration tasks and concepts.

Information About Configuring Congestion Management

Congestion Management Overview

Congestion management features allow you to control congestion by determining the order in which a traffic flow (or packets) is sent out an interface based on priorities assigned to 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 features in Cisco IOS XR software allow you to specify creation of a different number of queues, affording greater or lesser degree of differentiation of traffic, and to specify the order in which that traffic is sent.

During periods with light traffic flow, 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 queuing method 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.

In addition to queuing methods, QoS congestion management mechanisms, such as policers and shapers, are needed to ensure that a packet adheres to a contract and service. Both policing and shaping mechanisms use the traffic descriptor for a packet.

Policers and shapers usually identify traffic descriptor violations in an identical manner through the token bucket mechanism, but they differ in the way they respond to violations. A policer typically drops traffic flow; whereas, a shaper delays excess traffic flow using a buffer, or queuing mechanism, to hold the traffic for transmission at a later time.

Traffic shaping and policing can work in tandem. For example, a good traffic shaping scheme should make it easy for nodes inside the network to detect abnormal flows.

For Clear Channel ATM SPAs, all queue-based actions are offloaded to the SPA and are performed by the SPA. Clear Channel ATM subinterfaces support eight queues per subinterface. On egress subinterfaces, you can configure a service policy with a maximum of seven non-default classes with queueing actions. Other classes must *not* have queueing actions.

Modified Deficit Round Robin

When MDRR is configured in the queuing strategy, nonempty queues are served one after the other. Each time a queue is served, a fixed amount of data is dequeued. The algorithm then services the next queue. When a queue is served, MDDR keeps track of the number of bytes of data that were dequeued in excess of the configured value. In the next pass, when the queue is served again, less data is dequeued to compensate for the excess data that was served previously. As a result, the average amount of data dequeued per queue is close to the configured value. In addition, MDRR allows for a strict priority queue for delay-sensitive traffic.

Each queue within MDRR is defined by two variables:

- Quantum value—Average number of bytes served in each round.
- Deficit counter—Number of bytes a queue has sent in each round. The counter is initialized to the quantum value.

Packets in a queue are served as long as the deficit counter is greater than zero. Each packet served decreases the deficit counter by a value equal to its length in bytes. A queue can no longer be served after the deficit counter becomes zero or negative. In each new round, the deficit counter for each nonempty queue is incremented by its quantum value.

Note In general, the quantum size for a queue should not be smaller than the maximum transmission unit (MTU) of the interface to ensure that the scheduler always serves at least one packet from each nonempty queue.

The Cisco CRS implements a slight variation of the MDRR scheduling mechanism called packet-by-packet MDRR (P2MDRR). Using P2MDRR, queues are scheduled after every packet is sent compared to MDRR in which queues are scheduled after a queue is emptied. All non-high-priority queues with minimum bandwidth guarantees use P2MDRR.

Low-Latency Queueing with Strict Priority Queueing

The LLQ feature brings strict priority queuing (PQ) to the MDRR scheduling mechanism. PQ in strict priority mode ensures that one type of traffic is 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 the transmission rate of critical traffic is high.

Strict PQ allows delay-sensitive data, such as voice, to be dequeued and sent before packets in other queues are dequeued.

LLQ enables the use of a single, strict priority queue within MDRR at the class level, allowing you to direct traffic belonging to a class. To rank 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.

Through use of the **priority** command, you can assign a strict PQ to any of the valid match criteria used to specify traffic. These methods of specifying traffic for a class include matching on access lists, protocols, IP precedence, and IP differentiated service code point (DSCP) values. Moreover, within an access list you can specify that traffic matches are allowed based on the DSCP value that is set using the first six bits of the IP type of service (ToS) byte in the IP header.

For Clear Channel ATM subinterfaces, the priority queue cannot be configured on the default class.

High-Priority Propagation

The CRS-MSC-140G supports high-priority propagation.

High-priority traffic under all ports is serviced before any low-priority traffic. This means that the scope of priority assignment at the queue level is global. This is referred to as high-priority propagation, which improves low-latency treatment for high-priority traffic, such as real-time voice and video traffic.

Priority is supported only at the queue level, or lowest-level policy map. Priority assignment at the parent level for an egress interface policy is not supported.

High-priority traffic under all ports and groups is serviced before any low-priority traffic. This means that the scope of priority assignment at the queue level is global — it is not limited to the parent group (such as on CRS-MSC-40G) or port. This is referred to as high-priority propagation, which improves low-latency treatment for high-priority traffic, such as real-time voice and video traffic.

Priority is supported only at the queue level, or lowest-level policy map. Priority assignment at the group level for an egress interface policy is not supported.

Policer Requirement

On the CRS-MSC-140G, a policer must be configured to limit the traffic entering priority queues. The policer rate cannot exceed the shape rate configured for the group or port.

Note This requirement does not apply to fabric QoS polices, because police actions in fabric QoS policies are not supported.

On the Cisco CRS Series Modular Services Card 40G (CRS-MSC-40G), a priority action can be configured with or without a police action in the same class. Example 1 shows a valid configuration on the CRS-MSC-40G that includes only a priority action:

Example 1 Class Configured With Priority Action Only (CRS-MSC-40G)

```
policy-map prio_only_policy
 class prec1
  priority level 1
 !
 class class-default
 !
 end-policy-map
!
```

On the Cisco CRS Series Modular Services Card 140G (CRS-MSC-140G), a police action *must* be configured in the same class as the priority action. A class configuration that includes a priority action but no police action is not valid. Such a configuration is rejected.

To use existing CRS-MSC-40G QoS configurations on the CRS-MSC-140G, add a police action to all classes that have a priority action. In Example 2, the class configuration in Example 1 is modified to include a police action:

Example 2 Class Configured With Priority Action and Police Action (CRS-MSC-140G

```
policy-map prio_and_police_policy
```

```
  class prec1
   priority level 1
   police rate percent 20
    !
  !
  class class-default
  !
  end-policy-map
!
```

Note On the CRS-MSC-40G, on egress Layer 3 ATM subinterfaces, if more than one class is configured with priority, a policer must be configured in the same classes.

Ingress and Egress Queuing on the CRS-MSC-140G

- Ingress Queuing Only:

  The smallest step size supported is 32 kbps for groups and 32/3 kbps (10.67 kbps) for queues. Step size increases with the rate value. Rounding error does not exceed 0.4 per cent or 8 kbps, whichever is higher.

- Egress Queuing Only:

  The smallest step size supported is 8 kbps for 10 gigabit interfaces and 64 kbps for 100 gigabit interfaces for queues and groups. Step size increases with the rate value. Rounding error does not exceed 0.4 per cent or 8 kbps, whichever is higher.

Multi-Level Priority Queues

The Multi-Level Priority Queue (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 queue enables the device to place delay-sensitive traffic on the outbound link before delay-insensitive traffic. As a result, high-priority traffic receives the lowest latency possible on the device.

While the oversubscription of priority traffic is allowed, an equal treatment of classes having the same priority level is not guaranteed. During oversubscription, priority level is strictly followed for classes with different priority levels.

Egress Minimum Bandwidth on the CRS-MSC-140G

- Minimum bandwidth of a group must be equal to or greater than the sum of queue minimum bandwidths and the police rates of the high priority classes under the group. If the configured value does not meet these requirements, the minimum group bandwidth is automatically increased to satisfy the requirements. Minimum bandwidth of a parent class must be equal to or greater than the sum of the police rates of the high priority classes in the hierarchy
- Oversubscription of minimum bandwidth is permitted. In the event of oversubscription, the actual minimum bandwidth that a group or queue receives is proportional to its configured value.

Configured Accounting

Configured Accounting controls the type of overhead and packet length for statistics, policing shaping and queuing. The account option can be specified with a service-policy when applying a policy to an interface. For bundle interfaces, the configured accounting option is applied to all member interfaces.

The configured accounting option is available on ingress and egress policing, queuing and statistics for CRS-MSC-140G. In CRS-MSC-40G, the configured accounting option is not available for queuing.

This table shows the packet length used during QoS for various accounting options on the MSC-140:

Configured Accounting Option	Policing	Queuing	Statistics
Default	layer-all	layer 2	layer 2
Layer2	layer 2	layer 2	layer 2
No Layer2	layer 3	layer 3	layer 3

This table shows the packet length used during QoS for various accounting options on the MSC-40:

Configured Accounting Option	Ingress Policing	Ingress Queuing	Ingress Statistics	Egress Policing	Egress Queuing	Egress Statistics
Default	layer 2	layer 3	layer 2	layer 2	layer 2	layer 2
Layer2	layer 2	layer 3	layer 2	layer 2	layer 2	layer 2
No Layer2	layer 3	layer 3	layer 3	layer 3	layer 2	layer 3

Traffic Shaping

Traffic shaping allows you to control the traffic flow exiting an interface to match its transmission to the speed of the remote target interface and ensure that the traffic conforms to policies contracted for it. Traffic adhering to a particular profile can be shaped to meet downstream requirements, thereby eliminating bottlenecks in topologies with data-rate mismatches.

To match the rate of transmission of data from the source to the target interface, you can limit the transfer of data to one of the following:

- A specific configured rate
- A derived rate based on the level of congestion

The rate of transfer depends on these three components that constitute the token bucket: burst size, mean rate, and time (measurement) interval. The mean rate is equal to the burst size divided by the interval.

When traffic shaping is enabled, the bit rate of the interface does not exceed the mean rate over any integral multiple of the interval. In other words, during every interval, a maximum of burst size can be sent. Within the interval, however, the bit rate may be faster than the mean rate at any given time.

Traffic Shaping for ATM on Layer 2 VPN

The **shape** command under the PVC submode is applicable to the attachment circuits (AC) in the virtual circuit (VC) mode and the virtual path (VP) mode.

Layer 2 and Layer 3 ATM VC interfaces support VC shaping. This is not an MQC QoS configuration where shaping is configured in a service policy. Shaping is configured on the ATM interface, directly under the VC.

For ATM Layer 3 subinterfaces, shaping is not supported in the egress direction.

VC shaping cannot be configured, removed, or modified on an interface that already has an egress service policy configured.

Note The default shape is UBR at line rate.

Layer-All Accounting

The CRS-MSC-140G uses "layer-all" accounting. For Ethernet interfaces, this translates to 20 bytes of Layer 1 overhead in addition to the Layer 2 overhead. Cisco CRS Series Modular Services Card 40G (CRS-MSC-40G) does Layer 3 QoS accounting for ingress queueing. CRS-MSC-40G does Layer 2 QoS accounting for egress queueing, egress policing, and ingress policing.

Traffic Policing

In general, traffic policing allows you to control the maximum rate of traffic sent or received on an interface and to partition a network into multiple priority levels or class of service (CoS).

Traffic policing manages the maximum rate of traffic through a token bucket algorithm. The token bucket algorithm uses user-configured values to determine the maximum rate of traffic allowed on an interface at a given moment in time. The token bucket algorithm is affected by all traffic entering or leaving the interface (depending on where the traffic policy with traffic policing is configured) and is useful in managing network bandwidth in cases where several large packets are sent in the same traffic stream.

Traffic entering the interface with traffic policing configured is placed into one of these categories. Within these three categories, users can decide packet treatments. For instance, packets that conform can be configured to be sent, packets that exceed can be configured to be sent with a decreased priority, and packets that violate can be configured to be dropped.

Traffic policing is often configured on interfaces at the edge of a network to limit the rate of traffic entering or leaving the network. In the most common traffic policing configurations, traffic that conforms to the CIR is sent and traffic that exceeds is sent with a decreased priority or is dropped. Users can change these configuration options to suit their network needs.

Note Configured values take into account the Layer 2 encapsulation applied to traffic. This applies to both ingress and egress policing. For POS/SDH transmission, the encapsulation is considered to be 4 bytes. For Ethernet, the encapsulation is 14 bytes; whereas for 802.1Q, the encapsulation is 18 bytes.

Traffic policing also provides a certain amount of bandwidth management by allowing you to set the burst size (Bc) for the committed information rate (CIR). When the peak information rate (PIR) is supported, a second token bucket is enforced and then the traffic policer is called a two-rate policer.

Regulation of Traffic with the Policing Mechanism

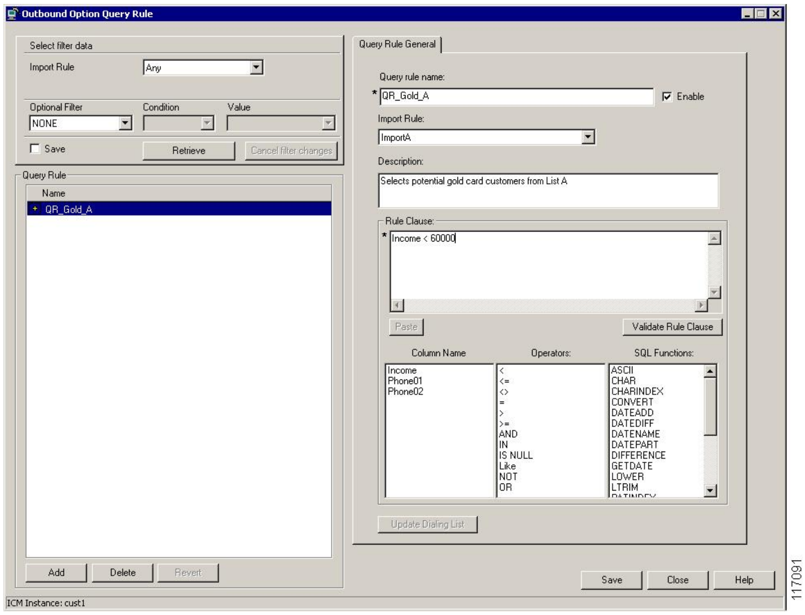
This section describes the single-rate mechanism.

Single-Rate Policer

A single-rate, two-action policer provides one token bucket with two actions for each packet: a conform action and an exceed action.

This figure illustrates how a single-rate token bucket policer marks packets as either conforming or exceeding a CIR, and assigns an action.

Figure 1: Marking Packets and Assigning Actions



Outbound Option Query Rule

Select filter data

Import Rule: Any

Optional Filter: NONE

Condition:

Value:

☐ Save

Query Rule

Name
+ QR_Gold_A

Query Rule General

Query rule name: * QR_Gold_A ☑ Enable

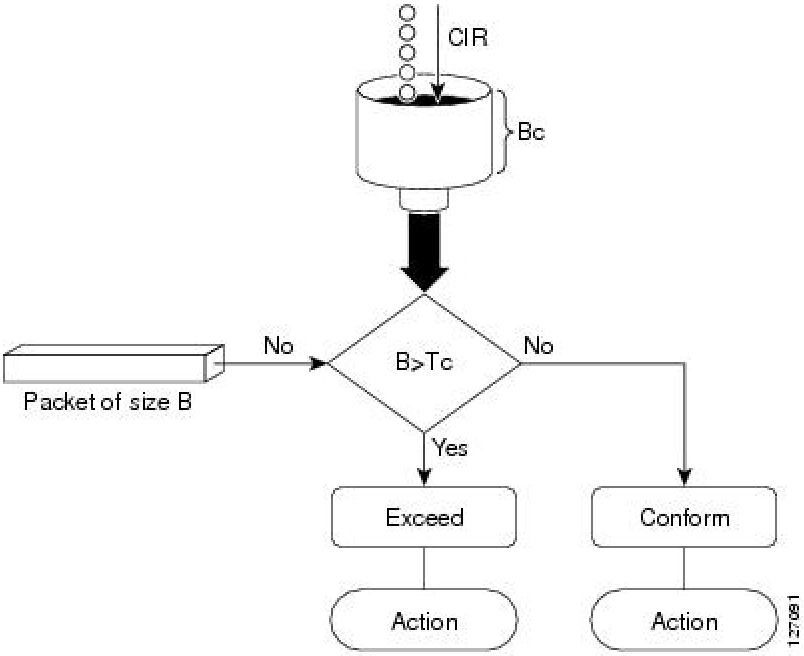
Import Rule: ImportA

Description: Selects potential gold card customers from List A

Rule Clause: * Income < 60000

Column Name	Operators:	SQL Functions:
Income	<	ASCII
Phone01	<=	CHAR
Phone02	<>	CHARINDEX
	=	CONVERT
	>	DATEADD
	>=	DATEDIFF
	AND	DATENAME
	IN	DATEPART
	IS NULL	DIFFERENCE
	Like	GETDATE
	NOT	LOWER
	OR	LTRIM

ICM Instance: cust1



The time interval between token updates (Tc) to the token bucket is updated at the CIR value each time a packet arrives at the traffic policer. The Tc token bucket can contain up to the Bc value, which can be a certain number of bytes or a period of time. If a packet of size B is greater than the Tc token bucket, then the packet exceeds the CIR value and a configured action is performed. If a packet of size B is less than the Tc token bucket, then the packet conforms and a different configured action is performed.

Policing on the CRS-MSC-140G

- Smallest granularity supported is 8 kbps (for rates up to 8 Mbps). The step size is higher for higher rates but is never greater than 0.2% of the rate value. For very high ratios of PIR/CIR the rounding error can be greater than 0.2%.
- The maximum permitted burst size is 2 MB for rates up to 131 Mbps, and 100 ms for higher rates.
- Burst granularity
    - For rates that are less than or equal to 131 Mbps, burst granularity varies from 128 bytes to 16,384 bytes in proportion to the burst value. The worst case rounding error is 1.6%.
    - For rates greater than 131 Mbps, the granularity is 1 ms (with the corresponding rate as reference).

Multiple Action Set

The Multiple Action Set feature allows you to mark packets with multiple action sets (conditional and unconditional) through a class map.

To support multiple action sets, the following combinations are supported of conform and exceed actions:

At least two set actions for each policer action can be configured by using the **conform-action** command, the **exceed-action** command, or the **violate-action** command within a class map for IP, MPLS, or Layer 2 data paths.

Note If partial multiple set actions are used, hierarchical policing is not supported.

This table lists the conditional policer ingress markings for IP, MPLS, or Layer 2 data paths that are applicable.

Layer 3 IP Packets	Layer 3 MPLS Packets	Layer 2 Packets
DSCP or precedence	MPLS experimental imposition	MPLS experimental imposition
tunnel DSCP or tunnel precedence	MPLS experimental topmost	discard-class
MPLS experimental imposition	discard-class	qos-group
discard-class	qos-group	—
qos-group	—	—

Note

- Both DSCP and precedence packets are mutually exclusive.
- Both tunnel DSCP and tunnel packets markings are mutually exclusive.

This table lists the conditional egress policer markings for IP, MPLS, or Layer 2 data paths that are applicable.

Layer 3 IP Packets	Layer 3 MPLS Packets	Layer 2 Packets
DSCP or precedence	MPLS experimental topmost	cos or srp-priority2
cos or srp-priority	cos or srp-priority2	discard-class
discard-class	discard-class	—

Note

- Both cos and srp-priority packets are mutually exclusive; srp-priority is not supported on the Cisco CRS Series Modular Services Card 140G (CRS-MSC-140G).

Packet Marking Through the IP Precedence Value, IP DSCP Value, and the MPLS Experimental Value Setting

In addition to rate-limiting, traffic policing allows you to independently mark (or classify) the packet according to whether the packet conforms or violates a specified rate. Packet marking also allows you to partition your network into multiple priority levels or CoS. Packet marking as a policer action is conditional marking.

Use the traffic policer to set the IP precedence value, IP DSCP value, or Multiprotocol Label Switching (MPLS) experimental value for packets that enter the network. Then networking devices within your network can use this setting to determine how the traffic should be treated. For example, the Weighted Random Early Detection (WRED) feature uses the IP precedence value to determine the probability that a packet is dropped.

If you want to mark traffic but do not want to use traffic policing, see the "Class-based, Unconditional Packet Marking Examples" section to learn how to perform packet classification.

Note Marking IP fields on an MPLS-enabled interface results in non-operation on that particular interface.

Table 4 shows the supported conditional policer marking operations.

Note None of the following class-based conditional policer marking operations are supported on ATM interfaces.

Marking Operation	Layer 2 Ingress			Layer 2 Egress			Layer 3 Ingress			Layer 3 Egress		
	PAC	CAC	p-CFootnote	PAC	CAC	p-C	PhyFootnote	SIfFootnote	P-SIfFootnote	Phy	SIf	P-SIf
prec	N	N	N	N	N	N	Y	Y	Y	Y	Y	Y
prec tunnel	N	N	N	N	N	N	Y	Y	Y	N	N	N
DSCP	N	N	N	N	N	N	Y	Y	Y	Y	Y	Y
DSCP tunnel	N	N	N	N	N	N	Y	Y	Y	N	N	N

Marking Operation	Layer 2 Ingress			Layer 2 Egress			Layer 3 Ingress			Layer 3 Egress		
CoS	N	N	N	Y	Y	Y	N	N	N	Y	Y	Y
discard-class	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
EXP, imposition	Y	Y	Y	N	N	N	Y	Y	Y	N	N	N
EXP, topmost	N	N	N	N	N	N	Y	Y	Y	Y	Y	Y
srp-priority Footnote	N	N	N	Y	Y	Y	N	N	N	Y	Y	Y
qos-group	Y	Y	Y	N	N	N	Y	Y	Y	N	N	N

[1] (1) p-C=physical interface with underlying CACs.
[2] (2) Phy=physical interface.
[3] (3) SIf=subinterface.
[4] (4) P-SIf=physical interface with underlying subinterfaces.
[5] (5) Not supported on the Cisco CRS-MSC-140G.

Note For a list of supported unconditional marking operations, see the *Configuring Modular Quality of Service Packet Classification on Cisco IOS XR Software* module.

Policer Granularity and Shaper Granularity

Table 5 shows the default policer granularity values.

SPA Interface Processor	Policer Granularity Default Value
Cisco 12000 SIP-401	64 kbps
Cisco 12000 SIP-501	64 kbps
Cisco 12000 SIP-601	64 kbps
Cisco CRS Series Modular Services Card 40G	244 kbps

Table 6 shows the default shaper granularity values.

SPA Interface Processor	Shaper Granularity Default Value
Cisco CRS Series Modular Services Card 40G	256 kbps

The Policer Granularity and Shaper Granularity features allow you to override the default policer and shaper granularity values.

Policer granularity can be configured in the ingress and egress directions. The policer granularity is specified as a permissible percentage variation between the user-configured policer rate, and the hardware programmed policer rate.

Shaper granularity can only be configured in the egress direction. The shape rate you set, using the **shape average** command, should be a multiple of the shaper granularity. For example, if the shape rate is set to 320 kbps but the shaper granularity is configured to 256 kbps, the effective shape rate is 512 kbps, that is a multiple of 256 kbps. To get an actual shape rate of 320 kbps, configure the shaper granularity to 64 kbps. Because 320 is a multiple of 64, the shape rate will be exactly 320 kbps.

Policer and shaper granularity values, whether default or configured, apply to the SPA Interface Processor (SIP) and to all shared port adapters (SPAs) that are installed in the SIP.

Bundle QoS Granularity

The Bundle QoS Granularity feature supports shaper and policer rate configuration in units of per-thousand/per-million which provides the ability to provision shape/police rates down to 1 Mbps on link aggregation (LAG) interfaces even with 100 GE bundle members.

Bundle QoS granularity supports both, ingress and egress policy-maps. The supported bundle-member types are, 100GE, 10GE, 40GE, OC768, OC192.

Limitations for Bundle QoS Granularity

These are the limitations for Bundle QoS Granularity:

- The maximum number of bundle members allowed are 64.
- No support for non-bundle interfaces.
- Policer or shaper can be only up to 16G per class on 40G linecard, and 128G for 140G linecard.
- Maximum number of supported classes across all service-policy instances for each linecard is 32000, depending on the use of the Ternary Content Addressable Memory (TCAM) memory.
- On 140G linecard, the number of classes supported for each policy map in bundle interfaces is 512/The number of members in the bundle).

How to Configure QoS Congestion Management

Configuring Guaranteed and Remaining Bandwidths

The **bandwidth** command allows you to specify the minimum guaranteed bandwidth to be allocated for a specific class of traffic. MDRR is implemented as the scheduling algorithm.

The **bandwidth remaining** command specifies a weight for the class to the MDRR. The MDRR algorithm derives the weight for each class from the bandwidth remaining value allocated to the class. If you do not configure the **bandwidth remaining** command for any class, the leftover bandwidth is allocated equally to all classes for which **bandwidth remaining** is not explicitly specified.

Guaranteed Service rate of a queue is defined as the bandwidth the queue receives when all the queues are congested. It is defined as:

Guaranteed Service Rate = minimum bandwidth + excess share of the queue

On ATM interfaces, if there are other bandwidth commands configured in the same class, the **bandwidth remaining** command cannot be configured.

Restrictions

The amount of bandwidth configured should be large enough to also accommodate Layer 2 overhead.

A policy map can have all class bandwidths specified in kilobits per second or percentages but not a mixture of both in the same class.

The **bandwidth** command is supported only on policies configured on outgoing interfaces.

Note In the ingress direction, bandwidth calculations do not include Layer 2 overhead because Layer 2 headers are stripped off when a packet is received. In other instances, the bandwidth calculations include the Layer 2 encapsulation. In the case of PoS/SDH, the encapsulation is 4 bytes; for Ethernet, the encapsulation is 14 bytes; and for Dot1Q, the encapsulation is 18 bytes.

SUMMARY STEPS

1. **configure**
2. **policy-map** *policy-name*
3. **class** *class-name*
4. **bandwidth** {*rate* [*units*]| **percent** *value*}
5. **bandwidth remaining percent** *value*
6. **exit**
7. **class** *class-name*
8. **bandwidth** {*rate* [*units*] | **percent** *value*}
9. **bandwidth remaining percent** *value*
10. **exit**
11. **exit**
12. **interface** *type interface-path-id*
13. **service-policy** {**input** | **output**} *policy-map*
14. **commit**
15. **show policy-map interface** *type interface-path-id* [**input** | **output**]

DETAILED STEPS

	Command or Action	Purpose
Step 1	**configure**	
Step 2	**policy-map** *policy-name* **Example:** `RP/0/RP0/CPU0:router(config)# policy-map policy1`	Creates or modifies a policy map that can be attached to one or more interfaces to specify a service policy and enters the policy map configuration mode.
Step 3	**class** *class-name* **Example:**	Specifies the name of the class whose policy you want to create or change.

	Command or Action	Purpose
	`RP/0/RP0/CPU0:router(config-pmap)# class class1`	

Step 4	**bandwidth** {*rate* [*units*]| **percent** *value*}
	Example:
	`RP/0/RP0/CPU0:router(config-pmap-c)# bandwidth percent 50`
		Specifies the bandwidth allocated for a class belonging to a policy map and enters the policy map class configuration mode. In this example, class class1 is guaranteed 50 percent of the interface bandwidth.

Step 5	**bandwidth remaining percent** *value* **Example:** `RP/0/RP0/CPU0:router(config-pmap-c)# bandwidth remaining percent 20`	Specifies how to allocate leftover bandwidth to various classes. **Note** The remaining bandwidth of 40 percent is shared by class class1 and class2 (see Steps 8 and 9) in a 20:80 ratio: class class1 receives 20 percent of the 40 percent, and class class2 receives 80 percent of the 40 percent.
Step 6	**exit** **Example:** `RP/0/RP0/CPU0:router(config-pmap-c)# exit`	Returns the router to policy map configuration mode.

Step 7	**class** *class-name*
	Example:
	`RP/0/RP0/CPU0:router(config-pmap)# class class2`
		Specifies the name of a different class whose policy you want to create or change.

Step 8	**bandwidth** {*rate* [*units*] | **percent** *value*}
	Example:
	`RP/0/RP0/CPU0:router(config-pmap-c)# bandwidth percent 10`
		Specifies the bandwidth allocated for a class belonging to a policy map. In this example, class class2 is guaranteed 10 percent of the interface bandwidth.

Step 9	**bandwidth remaining percent** *value* **Example:** `RP/0/RP0/CPU0:router(config-pmap-c)# bandwidth remaining percent 80`	Specifies how to allocate leftover bandwidth to various classes. **Note** The remaining bandwidth of 40 percent is shared by class class1 and class2 (see Steps 8 and 9) in a 20:80 ratio: class class1 receives 20 percent of the 40 percent, and class class2 receives 80 percent of the 40 percent.
Step 10	**exit** **Example:** `RP/0/RP0/CPU0:router(config-pmap-c)# exit`	Returns the router to policy map configuration mode.
Step 11	**exit** **Example:**	Returns the router to global configuration mode.

	Command or Action	Purpose
	`RP/0/RP0/CPU0:router(config-pmap)# exit`	
Step 12	**interface** *type interface-path-id* **Example:** `RP/0/RP0/CPU0:router(config)# interface POS 0/2/0/0`	Enters interface configuration mode and configures an interface.
Step 13	**service-policy** {**input** | **output**} *policy-map* **Example:** `RP/0/RP0/CPU0:router(config-if)# service-policy output policy1`	Attaches a policy map to an input or output interface to be used as the service policy for that interface. In this example, the traffic policy evaluates all traffic leaving that interface.
Step 14	**commit**	
Step 15	**show policy-map interface** *type interface-path-id* [**input** | **output**] **Example:** `RP/0/RP0/CPU0:router# show policy-map interface POS 0/2/0/0`	(Optional) Displays policy configuration information for all classes configured for all service policies on the specified interface.

Configuring Low-Latency Queueing with Strict Priority Queueing

The **priority** command configures LLQ with strict priority queuing (PQ) that allows delay-sensitive data such as voice to be dequeued and sent before packets in other queues are dequeued. When a class is marked as high priority using the **priority** command, you must configure a policer to limit the priority traffic. This configuration ensures that the priority traffic does not constrain all the other traffic on the line card, which protects low priority traffic from limitations. Use the **police** command to explicitly configure the policer.

Note Eight levels of priorities are supported: priority level 1, priority level 2, priority level 3, priority level 4, priority level 5, priority level 6, priority level 7 and the priority level normal. If no priority level is configured, the default is priority level normal.

Restrictions

- Unused priority queues cannot be used for a different priority level.
- The eight priority levels can be configured only on egress of main physical interface or main bundle interface.
- Eight priority levels work on Cisco ASR 9000 High Density 100GE Ethernet line cards only.
- The policy-map with eight priorities must have only one queuing class at the parent level of the priority class.
- If the policy-map has a parent class, the parent class cannot have bandwidth configured.

- 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 queued to the same single priority queue.
- The **shape average**,**bandwidth**, and **random-detect**commands cannot be configured in the same class with the **priority** command.
- On the CRS-MSC-140G, a policer must be configured to limit the traffic entering priority queues. The policer rate cannot exceed the shape rate configured for the group or port.

SUMMARY STEPS

1. **configure**
2. **policy-map** *policy-name*
3. **class** *class-name*
4. **police rate** {[*units*] | **percent** *percentage*}} [**burst** *burst-size* [*burst-units*]] [**peak-burst** *peak-burst* [*burst-units*]] [**peak-rate** *value* [*units*]] | **percent** *percentage*]
5. **exceed-action** *action*
6. **exit**
7. **priority**[**level** *priority_level*]
8. **exit**
9. **exit**
10. **interface** *type interface-path-id*
11. **service-policy** {**input** | **output**} *policy-map*
12. **commit**
13. **show policy-map interface** *type interface-path-id* [**input** | **output**]

DETAILED STEPS

	Command or Action	Purpose
Step 1	**configure**	
Step 2	**policy-map** *policy-name* **Example:** `RP/0/RP0/CPU0:router(config)# policy-map voice`	Creates or modifies a policy map that can be attached to one or more interfaces to specify a service policy and enters the policy map configuration mode.

Step 3	**class** *class-name*
	Example:
	`RP/0/RP0/CPU0:router(config-pmap)# class voice`
		Specifies the name of the class whose policy you want to create or change and enters the policy map class configuration mode.

Step 4	**police rate** {[*units*] | **percent** *percentage*}} [**burst** *burst-size* [*burst-units*]] [**peak-burst** *peak-burst* [*burst-units*]] [**peak-rate** *value* [*units*]] | **percent** *percentage*] **Example:**	Configures traffic policing and enters policy map police configuration mode. In this example, the low-latency queue is restricted to 250 kbps to protect low-priority traffic from starvation and to release bandwidth.

	Command or Action	Purpose
	`RP/0/RP0/CPU0:router(config-pmap-c)# police rate 250`	
Step 5	**exceed-action** *action* **Example:** `RP/0/RP0/CPU0:router(config-pmap-c-police)# exceed-action drop`	Configures the action to take on packets that exceed the rate limit.
Step 6	**exit** **Example:** `RP/0/RP0/CPU0:router(config-pmap)# exit`	Returns the router to policy map class configuration mode.
Step 7	**priority**[**level** *priority_level*] **Example:** `RP/0/RP0/CPU0:router(config-pmap-c)# priority level 1`	Specifies priority to a class of traffic belonging to a policy map. If no priority level is configured, the default is priority 1.
Step 8	**exit** **Example:** `RP/0/RP0/CPU0:router(config-pmap-c)# exit`	Returns the router to policy map configuration mode.
Step 9	**exit** **Example:** `RP/0/RP0/CPU0:router(config-pmap)# exit`	Returns the router to Global Configuration mode.
Step 10	**interface** *type interface-path-id* **Example:** `RP/0/RP0/CPU0:router(config)# interface POS 0/2/0/0`	Enters interface configuration mode, and configures an interface.
Step 11	**service-policy** {**input** | **output**} *policy-map* **Example:** `RP/0/RP0/CPU0:router(config-if)# service-policy output policy1`	Attaches a policy map to an input or output interface to be used as the service policy for that interface. In this example, the traffic policy evaluates all traffic leaving that interface.
Step 12	**commit**	
Step 13	**show policy-map interface** *type interface-path-id* [**input** | **output**] **Example:**	(Optional) Displays policy configuration information for all classes configured for all service policies on the specified interface.

	Command or Action	Purpose
	`RP/0/RP0/CPU0:router# show policy-map interface POS 0/2/0/0`	

Configuring Traffic Shaping

Traffic shaping allows you to control the traffic exiting an interface to match its transmission to the speed of the remote target interface and ensure that the traffic conforms to policies contracted for it.

Shaping performed on outgoing interfaces is done at the Layer 2 level and includes the Layer 2 header in the rate calculation. Shaping performed on incoming interfaces is done at the Layer 3 level and does not include the Layer 2 header in the rate calculation.

Restrictions

- The bandwidth, priority and shape average commands should not be configured together in the same class.
- A flat port-level shaper requires a child policy with 100% bandwidth explicitly allocated to the class-default.

SUMMARY STEPS

1. **configure**
2. **policy-map** *policy-name*
3. **class** *class-name*
4. **shape average** {**percent** *value* | *rate* [*units*]}
5. **exit**
6. **exit**
7. Specifies the name of the class whose policy you want to create or change.**interface** *type interface-path-id*
8. **service-policy** {**input** | **output**} *policy-map*
9. **commit**
10. **show policy-map interface** *type interface-path-id* [**input** | **output**]

DETAILED STEPS

	Command or Action	Purpose
Step 1	**configure**	
Step 2	**policy-map** *policy-name* **Example:** `RP/0/RP0/CPU0:router(config)# policy-map policy1`	Creates or modifies a policy map that can be attached to one or more interfaces to specify a service policy and enters the policy map configuration mode.

Step 3	**class** *class-name*
	Example:
	`RP/0/RP0/CPU0:router(config-pmap)# class class1`
		Specifies the name of the class whose policy you want to create or change and enters the policy map class configuration mode.

	Command or Action	Purpose

Step 4	**shape average** {**percent** *value* | *rate* [*units*]}
	Example:
	`RP/0/RP0/CPU0:router(config-pmap-c)# shape average percent 50`
		Shapes traffic to the indicated bit rate according to average rate shaping in the specified units or as a percentage of the bandwidth.

Step 5	**exit** **Example:** `RP/0/RP0/CPU0:router(config-pmap-c)# exit`	Returns the router to policy map configuration mode.
Step 6	**exit** **Example:** `RP/0/RP0/CPU0:router(config-pmap)# exit`	Returns the router to global configuration mode.
Step 7	Specifies the name of the class whose policy you want to create or change.**interface** *type interface-path-id* **Example:** `RP/0/RP0/CPU0:router(config)# interface POS 0/2/0/0`	Enters interface configuration mode and configures an interface.
Step 8	**service-policy** {**input** | **output**} *policy-map* **Example:** `RP/0/RP0/CPU0:router(config-if)# service-policy output policy1`	Attaches a policy map to an input or output interface to be used as the service policy for that interface. In this example, the traffic policy evaluates all traffic leaving that interface.
Step 9	**commit**	
Step 10	**show policy-map interface** *type interface-path-id* [**input** | **output**] **Example:** `RP/0/RP0/CPU0:router# show policy-map interface POS 0/2/0/0`	(Optional) Displays policy configuration information for all classes configured for all service policies on the specified interface.

Configuring Traffic Policing (Two-Rate Color-Blind)

Traffic policing allows you to control the maximum rate of traffic sent or received on an interface.

Restrictions

set cos is not allowed as an ingress policer action.

SUMMARY STEPS

1. **configure**

2. **policy-map** *policy-name*
3. **class** *class-name*
4. **police rate** {[*units*] | **percent** *percentage*} [**burst** *burst-size* [burst-*units*]] [**peak-burst** *peak-burst* [burst-*units*]] [**peak-rate** *value* [*units*] | **percent** *percentage*]
5. **conform-action** *action*
6. **exceed-action** *action*
7. **exit**
8. **exit**
9. **exit**
10. **interface** *type interface-path-id*
11. **service-policy** {**input** | **output**} *policy-map*
12. **commit**
13. **show policy-map interface** *type interface-path-id* [**input** | **output**]

DETAILED STEPS

	Command or Action	Purpose
Step 1	**configure**	
Step 2	**policy-map** *policy-name* **Example:** `RP/0/RP0/CPU0:router(config)# policy-map policy1`	Creates or modifies a policy map that can be attached to one or more interfaces to specify a service policy and enters the policy map configuration mode.

Step 3	**class** *class-name*
	Example:
	`RP/0/RP0/CPU0:router(config-pmap)# class class1`
		Specifies the name of the class whose policy you want to create or change and enters the policy map class configuration mode.

Step 4	**police rate** {[*units*] | **percent** *percentage*} [**burst** *burst-size* [burst-*units*]] [**peak-burst** *peak-burst* [burst-*units*]] [**peak-rate** *value* [*units*] | **percent** *percentage*] **Example:** `RP/0/RP0/CPU0:router(config-pmap-c)# police rate 250000`	Configures traffic policing and enters policy map police configuration mode. The traffic policing feature works with a token bucket algorithm.
Step 5	**conform-action** *action* **Example:** `RP/0/RP0/CPU0:router(config-pmap-c-police)# conform-action set mpls experimental topmost 3`	Configures the action to take on packets that conform to the rate limit. The *action* argument is specified by one of these keywords: • **drop**—Drops the packet. • **set**—Has these keywords and arguments: **atm-clp** *value*—Sets the cell loss priority (CLP) bit. **cos** *value*—Sets the class of service value. Range is 0 to 7.

	Command or Action	Purpose
		discard-class *value*—Sets the discard class on IP Version 4 (IPv4) or Multiprotocol Label Switching (MPLS) packets. Range is 0 to 7. **dscp** [**tunnel**] *value*—Sets the differentiated services code point (DSCP) value and sends the packet. **mpls experimental** {**topmost** | **imposition**} *value*—Sets the experimental (EXP) value of the Multiprotocol Label Switching (MPLS) packet topmost label or imposed label. Range is 0 to 7. **precedence** [**tunnel**] *precedence*—Sets the IP precedence and sends the packet. - **transmit**—Transmits the packets.
Step 6	**exceed-action** *action* **Example:** `RP/0/RP0/CPU0:router(config-pmap-c-police)# exceed-action set mpls experimental topmost 4`	Configures the action to take on packets that exceed the rate limit. The *action* argument is specified by one of the keywords specified in Step 5 .
Step 7	**exit** **Example:** `RP/0/RP0/CPU0:router(config-pmap-c-police)# exit`	Returns the router to policy map class configuration mode.
Step 8	**exit** **Example:** `RP/0/RP0/CPU0:router(config-pmap-c)# exit`	Returns the router to policy map configuration mode.
Step 9	**exit** **Example:** `RP/0/RP0/CPU0:router(config-pmap)# exit`	Returns the router to global configuration mode.
Step 10	**interface** *type interface-path-id* **Example:** `RP/0/RP0/CPU0:router(config)# interface pos 0/5/0/0`	Enters configuration mode and configures an interface.
Step 11	**service-policy** {**input** | **output**} *policy-map* **Example:** `RP/0/RP0/CPU0:router(config-if)# service-policy output policy1`	Attaches a policy map to an input or output interface to be used as the service policy for that interface. In this example, the traffic policy evaluates all traffic leaving that interface.

	Command or Action	Purpose
Step 12	**commit**	
Step 13	**show policy-map interface** *type interface-path-id* [**input** | **output**] **Example:** `RP/0/RP0/CPU0:router# show policy-map interface POS 0/2/0/0`	(Optional) Displays policy configuration information for all classes configured for all service policies on the specified interface.

Configuring Traffic Policing (2R3C)

SUMMARY STEPS

1. **configure**
2. **class-map** [**match-all**][**match-any**] *class-map-name*
3. **match [not] fr-de***fr-de-bit-value*
4. **policy-map** *policy-name*
5. **class** *class-name*
6. **police rate** {[*units*] | **percent** *percentage*} [**burst** *burst-size* [burst-*units*]] [**peak-burst** *peak-burst* [burst-*units*]] [**peak-rate** *value* [*units*]
7. **conform-color** *class-map-name*
8. **exceed-color** *class-map-name*
9. **conform-action** *action*
10. **exceed-action** *action*
11. **exit**
12. **exit**
13. **exit**
14. **interface** *type interface-path-id*
15. **service-policy** *policy-map*
16. **commit**
17. **show policy-map interface** *type interface-path-id*

DETAILED STEPS

	Command or Action	Purpose
Step 1	**configure**	

Step 2	**class-map** [**match-all**][**match-any**] *class-map-name*
	Example:
	`RP/0/RP0/CPU0:router(config)# class-map match-all match-not-frde`
		(Use with SIP 700 line card, ingress only)
		Creates or modifies a class map that can be attached to one or more interfaces to specify a matching policy and enters the class map configuration mode.

Step 3	**match [not] fr-de***fr-de-bit-value* **Example:**	(Use with SIP 700 line card, ingress only) Specifies the matching condition:

	Command or Action	Purpose
	`RP/0/RP0/CPU0:router(config)# match not  fr-de 1`	• Match *not* fr-de 1 is typically used to specify a conform-color packet. • Match fr-de 1 is typically used to specify an exceed-color packet.
Step 4	**policy-map** *policy-name* **Example:** `RP/0/RP0/CPU0:router(config)# policy-map policy1`	Creates or modifies a policy map that can be attached to one or more interfaces to specify a service policy and enters the policy map configuration mode.

Step 5	**class** *class-name*
	Example:
	`RP/0/RP0/CPU0:router(config-pmap)# class class1`
		Specifies the name of the class whose policy you want to create or change and enters the policy map class configuration mode.

Step 6	**police rate** {[*units*] | **percent** *percentage*} [**burst** *burst-size* [burst-*units*]] [**peak-burst** *peak-burst* [burst-*units*]] [**peak-rate** *value* [*units*] **Example:** `RP/0/RP0/CPU0:router(config-pmap-c)# police rate 768000 burst 288000 peak-rate 1536000 peak-burst 576000`	Configures traffic policing and enters policy map police configuration mode. The traffic policing feature works with a token bucket algorithm.
Step 7	**conform-color** *class-map-name* **Example:** `RP/0/RP0/CPU0:router(config-pmap-c-police)# conform-color match-not-frde`	(Use with SIP 700 line card, ingress only) Configures the class-map name to assign to conform-color packets.
Step 8	**exceed-color** *class-map-name* **Example:** `RP/0/RP0/CPU0:router(config-pmap-c-police)# exceed-color match-frde`	(Use with SIP 700 line card, ingress only) Configures the class-map name to assign to exceed-color packets.
Step 9	**conform-action** *action* **Example:** `RP/0/RP0/CPU0:router(config-pmap-c-police)# conform-action set mpls experimental topmost 3`	Configures the action to take on packets that conform to the rate limit. The *action* argument is specified by one of these keywords: • **drop**—Drops the packet. • **set**—Has these keywords and arguments: **dscp** *value*—Sets the differentiated services code point (DSCP) value and sends the packet. **mpls experimental** {**topmost** | **imposition**} *value*—Sets the experimental (EXP) value of the

	Command or Action	Purpose
		Multiprotocol Label Switching (MPLS) packet topmost label or imposed label. Range is 0 to 7. **precedence** *precedence*—Sets the IP precedence and sends the packet. • **transmit**—Transmits the packets.
Step 10	**exceed-action** *action* **Example:** `RP/0/RP0/CPU0:router(config-pmap-c-police)# exceed-action set mpls experimental topmost 4`	Configures the action to take on packets that exceed the rate limit. The *action* argument is specified by one of the keywords specified in Step 5.
Step 11	**exit** **Example:** `RP/0/RP0/CPU0:router(config-pmap-c-police)# exit`	Returns the router to policy map class configuration mode.
Step 12	**exit** **Example:** `RP/0/RP0/CPU0:router(config-pmap-c)# exit`	Returns the router to policy map configuration mode.
Step 13	**exit** **Example:** `RP/0/RP0/CPU0:router(config-pmap)# exit`	Returns the router to global configuration mode.
Step 14	**interface** *type interface-path-id* **Example:** `RP/0/RP0/CPU0:router(config)# interface`	Enters configuration mode and configures an interface.
Step 15	**service-policy** *policy-map* **Example:** `RP/0/RP0/CPU0:router(config-if)# service-policy policy1`	Attaches a policy map to an input interface to be used as the service policy for that interface.
Step 16	**commit**	
Step 17	**show policy-map interface** *type interface-path-id* **Example:** `RP/0/RP0/CPU0:router# show policy-map interface`	(Optional) Displays policy configuration information for all classes configured for all service policies on the specified interface.

Configuring Shaper Granularity

Use the Shaper Granularity feature to configure the shaper granularity value so that the shape rate you specify is a multiple of the shaper granularity.

Restrictions

The Shaper Granularity feature has these limitations:

- Supported on Cisco CRS Series Modular Services Card 40G.
- Shaper granularity values apply to the SIP and to all SPAs that are installed on the SIP.
- The line card must be reloaded, for the configured shape granularity to take effect.
- Effective shape rate is a multiple of the shaper granularity.

SUMMARY STEPS

1. **configure**
2. **hw-module qos output shape granularity** *granularity* **location** *interface-path-id*
3. **commit**

DETAILED STEPS

	Command or Action	Purpose
Step 1	**configure**	
Step 2	**hw-module qos output shape granularity** *granularity* **location** *interface-path-id* **Example:** `RP/0/RP0/CPU0:router(config)# hw-module qos output shape granularity 128 location 0/4/CPU0`	Configures the specified shaper granularity on the output interface.
Step 3	**commit**	

Configuring Police Rate for LAG Granularity

Granularity of police rate for link aggregation (LAG) bundles can be defined using the following keywords:

- **police rate per-thousand**(equals to 0.1%)
- **police rate per-million** (equals to 0.001%)

SUMMARY STEPS

1. **configure**
2. **policy-map** *policy-name*
3. **class** *class-name*
4. **police rate** { *rate* | **per-thousand** *rate-per-thousand* | **per-million** *rate-per-million* | **percent** *value* }

5. **exit**
6. **commit**

DETAILED STEPS

	Command or Action	Purpose
Step 1	**configure** **Example:** `RP/0/RP0/CPU0:router# configure`	Enters global configuration mode.
Step 2	**policy-map** *policy-name* **Example:** `RP/0/RP0/CPU0:router(config)# policy-map p1`	Enters policy map configuration mode. • Creates or modifies a policy map that can be attached to one or more interfaces to specify a service policy.

Step 3	**class** *class-name*
	Example:
	`RP/0/RP0/CPU0:router(config-pmap)# class class1`
		Enters policy map class configuration mode.
		• Specifies the name of the class whose policy you want to create or change.

Step 4	**police rate** { *rate* | **per-thousand** *rate-per-thousand* | **per-million** *rate-per-million* | **percent** *value* }
	Example:
	`RP/0/RP0/CPU0:router (config-pmap-class) # police rate per-thousand 1000`
		Specifies the police rate. The configured value is the committed information rate per-million/ per-thousand (as the case may be) of the link bandwidth.

Step 5	**exit** **Example:** `RP/0/RP0/CPU0:router(config-pmap)# exit`	Returns the router to global configuration mode.
Step 6	**commit**	

Configuring Shape Average for LAG Granularity

The granularity of shape average for link aggregation (LAG) bundles is defined using these keywords:

- **shape average per-thousand**(equals 0.01%)
- **shape average per-million**(equals 0.001%)

SUMMARY STEPS

1. **configure**
2. **policy-map** *policy-name*
3. **class** *class-name*
4. **shape average** { *rate* | **per-thousand** *rate-per-thousand* | **per-million** *rate-per-million* | **percent** *value* }

5. **exit**
6. **commit**

DETAILED STEPS

	Command or Action	Purpose
Step 1	**configure**	
Step 2	**policy-map** *policy-name* **Example:** `RP/0/RP0/CPU0:router(config)# policy-map p1`	Enters policy map configuration mode. • Creates or modifies a policy map that can be attached to one or more interfaces to specify a service policy.

Step 3	**class** *class-name*
	Example:
	`RP/0/RP0/CPU0:router(config-pmap)# class class1`
		Enters policy map class configuration mode.
		• Specifies the name of the class whose policy is to be created or changed.

Step 4	**shape average** { *rate* | **per-thousand** *rate-per-thousand* | **per-million** *rate-per-million* | **percent** *value* }
	Example:
	`RP/0/RP0/CPU0:router (config-pmap-class) #  shape average per-thousand 1000`
		Specifies the shape average rate. The configured value is the committed information rate per-million or per-thousand (as the case may be) of the link bandwidth.

Step 5	**exit** **Example:** `RP/0/RP0/CPU0:router(config-pmap)# exit`	Returns the router to global configuration mode.
Step 6	**commit**	

Configuring Accounting

The steps that follow describe how to configure accounting.

Note NoLayer2 accounting option is not supported on layer 2 interfaces.

SUMMARY STEPS

1. **configure**
2. **interface** *interface-path-id*
3. **service-policy**{**input | output | type** } *service-policy-name* **account**{**layer2** | **no layer2**}
4. **commit**

DETAILED STEPS

	Command or Action	Purpose
Step 1	**configure** **Example:** `RP/0/RP0/CPU0:router configure`	Enters global configuration mode.
Step 2	**interface** *interface-path-id* **Example:** `RP/0/RP0/CPU0:router(config)# interface gig 0/6/5/5`	Configures the interface.

Step 3	**service-policy**{**input** | **output** | **type** } *service-policy-name* **account**{**layer2** | **no layer2**}
	Example:
	`RP/0/RP0/CPU0:router(config-if)# service-policy input p1 account layer2`
		Configures accounting.

Step 4	**commit**	

Configuration Examples for Configuring Congestion Management

Traffic Shaping for an Input Interface: Example

This example shows how to configure a policy map on an input interface:

```
policy-map p2
 class voip
 shape average percent 20

!
interface bundle-pos 1
 service-policy input p2
 commit
RP/0/RP0/CPU0:Jun 8 16:55:11.819 : config[65546]: %MGBL-LIBTARCFG-6-COMMIT : Configuration
 committed by user 'cisco'. Use 'show configuration commit changes 1000006140' to view the
 changes.
```

This example shows the display output for the previous policy map configuration:

```
RP/0/RP0/CPU0:router# show policy-map interface bundle-pos 1 input

Bundle-POS1 input: p2
  Class voip
    Classification statistics                      (packets/bytes)      (rate - kbps)
            Matched                               : 0/0      0
            Transmitted                          : 0/0      0
            Total Dropped                        : 0/0      0
    Queueing statistics
            Vital           (packets)            : 0
    Queueing statistics
            Queue ID                             : 38
            High watermark  (packets)            : 0
            Inst-queue-len  (bytes)              : 0
            Avg-queue-len   (bytes)              : 0
            TailDrop Threshold(bytes)            : 47923200
            Taildropped(packets/bytes)           : 0/0
Class default
    Classification statistics                      (packets/bytes)      (rate - kbps)
            Matched                              : 0/0      0
            Transmitted                          : 0/0      0
            Total Dropped                        : 0/0      0
    Queueing statistics
            Vital           (packets)            : 0
    Queueing statistics
            Queue ID                             : 36
            High watermark  (packets)            : 0
            Inst-queue-len  (bytes)              : 0
            Avg-queue-len   (bytes)              : 0
            TailDrop Threshold(bytes)            : 239616000
            Taildropped(packets/bytes)           : 0/0
```

Traffic Policing for a Bundled Interface: Example

This example shows how to configure a policy map for a bundled interface. Note that for bundled interfaces, policing can be configured only as a percentage and not a specific rate per second:

```
policy-map p2
 class voip
 police rate 23425
!
interface bundle-pos 1
 service-policy input p2
 commit
RP/0/RP0/CPU0:Jun  8 16:51:36.623 : qos_ma[286]: %QOS-QOS_RC_QOSMGR-3-RC_BUNDLE_BW_NOPCT :
 Absolute bw specified for bundle interfaces, use percentage values instead
RP/0/RP0/CPU0:Jun  8 16:51:36.624 : qos_ma[286]: %QOS-QOS-3-MSG_SEND_FAIL : Failed to send
 message to feature rc while adding class. Error code - Invalid argument

% Failed to commit one or more configuration items during an atomic operation, no changes
have been made. Please use 'show configuration failed' to view the errors
!
```

An error occurred after the attempted commit of an invalid configuration.

```
!
!
policy-map p2
 class voip
 police rate percent 20
 commit
RP/0/RP0/CPU0:Jun  8 16:51:51.679 : config[65546]: %MGBL-LIBTARCFG-6-COMMIT : Configuration
 committed by user 'cisco'.   Use 'show configuration commit changes 1000006135' to view
the changes.
 exit
exit
interface bundle-pos 1
```

```
 service-policy input p2
 commit
RP/0/RP0/CPU0:Jun  8 16:52:02.650 : config[65546]: %MGBL-LIBTARCFG-6-COMMIT : Configuration
 committed by user 'cisco'.   Use 'show configuration commit changes 1000006136' to view
the changes.
```

This example shows the display output for the successful policy map configuration in which policing was configured as a percentage:

```
RP/0/RP0/CPU0:router#show policy-map interface bundle-e 1 in
Sat Feb 28 07:20:03.269 UTC

Bundle-Ether1 input: ingress

Class prec-1
  Classification statistics          (packets/bytes)     (rate - kbps)
    Matched             :           545449301/52363132896         5215354
    Transmitted         :           189729675/18214048800         1811636
    Total Dropped       :           355719626/34149084096         3403718
  Policing statistics                (packets/bytes)     (rate - kbps)
    Policed(conform)    :           189729675/18214048800         1811636
    Policed(exceed)     :           355719626/34149084096         3403718
    Policed(violate)    :                   0/0                   0
    Policed and dropped :           355719626/34149084096
Class class-default
  Classification statistics          (packets/bytes)     (rate - kbps)
    Matched             :                   0/0                   0
    Transmitted         :                   0/0                   0
    Total Dropped       :                   0/0                   0
```

Service Fragment Configurations: Example

This example shows the service-fragment premium being created.

```
policy-map tsqos-port-policy
    class class-default
        shape 500 mbps
    class dscp1
        shape 1 Gbps
        service-fragment premium
        end-policy
      exit
```

This example shows the service-fragment premium being referred (at the sub-interface):

```
policy-map tsqos-subif-policy-premium
    class class-default
        fragment premium
        shape 20 mbps
        bandwidth remaining ratio 20
        service-policy subif-child
        end-policy
       exit
```

Policer Granularity: Example

Policer granularity can be configured in the ingress and egress directions. The policer granularity is specified as a permissible percentage variation between the user-configured police rate and the hardware programmed police rate. The configured value will be applied only for all future traffic policies configured on the interface.

This example shows how to set the police rate deviation tolerance to 4%, on an input interface:

```
hw-module qos input police granularity 4 location 0/1/CPU0
```

Use the show hw-module qos {input | output} police granularity location commands to verify the policer granularity.

```
show hw-module qos input police granularity location 0/1/CPU0

===========================
    QOS POLICE GRANULARITY
===========================

 Location     Rate Deviation
              Tolerance (%)
==========    ==============
 0/1/CPU0           4
----------------------------
```

Shaper Granularity: Example

The shape rate you set, using the **shape average** command, should be a multiple of the shaper granularity. For example, if the shape rate is set to 320 kbps but the shaper granularity is configured to 256 kbps, the effective shape rate is 256 kbps. To get an actual shape rate of 320 kbps, configure the shaper granularity to 64 kbps. Because 320 is a multiple of 64, the shape rate will be exactly 320 kbps.

This example shows how to set the shaper granularity to 128 kbps:

```
hw-module qos output shape granularity 128 location 0/1/CPU0
```

Use the show hw-module qos output shape granularity location command to verify theshaper granularity. The Configured Shape Granularity is the user-configured shaper granularity. The LC reload value indicates if a line card reload will be required in order to bring the configured shaper granularity rate into effect. If a configured shaper granularity is not applied, the HW Programmed Granularity is applied.

```
show hw-module qos output shape granularity location 0/1/CPU0

============  ====================================
               QOS SHAPING GRANULARITY
              ====================================
              Configured    HW            LC
 Location     Shape         Programmed    reload
              Granularity   Granularity   (Y / N)
============  ===========   ============ ========
 0/1/CPU0         ---         256Kbps        N
--------------------------------------------------
```

Configuring granularity for LAG bundles: Examples

This example shows how to configure police-rate:

```
config
     policy-map p1
     class c1
      police-rate per-thousand 100
     end-policy-map
     exit
   !
```

The **show run policy-map** command displays police-rate details:

```
show run policy-map p1
policy-map Police8
 class Pre5
  priority level 1
  police rate per-thousand 100
  !
 !
 class Pre1
   !
 class class-default
 !
 end-policy-map

!
```

This example shows how to configure shape average:

```
config
     policy-map p1
     class c1
      shape average per-million 1000
     end-policy-map
     exit
    !
```

The **show run policy-map** command displays shape average details:

```
show run policy-map p1
policy-map p3
 class class-default
  shape average per-million 1000
!
end-policy-map
!
```

Multiple Action Set: Examples

These examples show how to configure multiple action sets for both conditional and unconditional markings in both the ingress and egress directions:

Conditional Policer Markings in the Ingress Direction: Example

This example shows how to configure conditional policer markings in the ingress direction:

```
configure
 policy-map p1
  class c1
   police rate percent 30 peak-rate percent 50
    conform-action set precedence 2
    conform-action set mpls experimental imposition 3
    conform-action set mpls experimental topmost 4
    exceed-action set precedence 4
    exceed-action set mpls experimental imposition 5
    exceed-action set mpls experimental topmost 6
    violate-action set discard-class 3
    violate-action set qos-group 4
  !
 !
  class class-default
 !
 end-policy-map
!
end
```

If policy map p1 is applied as an ingress policy, the following action sets are applied:

- By using the **conform-action** command, IP packets are marked with the precedence value of 2 and the MPLS experimental value for the imposition label is set to 3; whereas, MPLS packets are marked with the MPLS experimental value for the imposition label that is set to 3 and the topmost label is set to 4.
- By using the **exceed-action** command, IP packets are marked with the precedence value of 4 and the MPLS experimental value for the imposition label is set to 5; whereas, MPLS packets are marked with the MPLS experimental value for the imposition label that is set to 5 and the topmost label is set to 6.
- By using the **violate-action** command, IP packets are marked with the discard class value of 3 and the QoS group value of 4; whereas, MPLS packets are marked with the discard class value of 3 and the QoS group value of 4.

Unconditional Quality-of-Service Markings in the Ingress Direction: Examples

These examples show how to configure unconditional QoS markings in the ingress direction.

Example One

```
configure
 policy-map p4
  class c1
   set discard-class 2
   set qos-group 4
   set precedence 5
   set mpls experimental imposition 3
   set mpls experimental topmost 4
   !
  class class-default
  !
 end-policy-map
!
```

If policy map p4 is applied as an ingress policy, the following sets are applied:

- IP packets are marked with the precedence value of 5 by using the **set precedence** command. The MPLS experimental value for the imposition label is marked by using the **set mpls experimental** command.
- MPLS packets are marked with MPLS experimental value of the imposition label is set to 3 and topmost label is set to 4 by using the **set mpls experimental** command.

  For both IP and MPLS packets, the discard class value is set by using the **set discard-class** command. The QoS group is set by using the **set qos-group** command.

Example Two

```
configure
 policy-map p5
  class c1
   set discard-class 2
   set qos-group 4
   set precedence 5
   set dscp tunnel 3
   set mpls experimental topmost 4
   !
  class class-default
  !
 end-policy-map
!
```

If policy map p5 is applied as an ingress policy, the following sets are applied:

- IP packets are marked with the precedence value by using the **set precedence** command. If the packets are sent out of MDT tunnel interface, they are marked with the DSCP value in the tunnel header by using the **set dscp** command.
- MPLS packets are marked with the MPLS experimental value for the topmost label by using the **set mpls experimental** command.

Example Three

```
configure
 policy-map hp
  class prec123
   service-policy child
   set discard-class 4
   set qos-group 4
   set precedence 3
   set dscp tunnel 2
   !
  class class-default
  !
 end-policy-map
!

configure
 policy-map child
  class prec1
   set discard-class 3
   set qos-group 3
   set precedence 2
   set dscp tunnel 4
   !
  class class-default
  !
 end-policy-map
!
```

If policy map hp (hierarchical policy) is applied as an ingress policy, the following sets are applied:

- IP packets with the precedence value set to 1 are marked with discard class value set to 3 by using the **set discard-class** command, qos-group value set to 3 by using the **set qos-group** command, and the precedence value set to 2 by using the **set precedence** command. If the packets are sent out of the MDT tunnel interface, they are marked with the DSVP value of 4 in the tunnel header by using the **set dscp** command.
- IP packets with precedence values of 2 and 3 are marked with discard class value set to 4, qos-group value set to 4, precedence value set to 3, and the dscp tunnel set to 2.

Conditional Policer Markings in the Egress Direction: Example

This example shows how to configure conditional policer markings in the egress direction:

```
configure
 policy-map p3
  class c1
  police rate percent 30 peak-rate percent 50
   conform-action set precedence 2
   conform-action set cos 3
   conform-action set mpls experimental topmost 3
   exceed-action set precedence 4
   exceed-action set cos 4
   exceed-action set mpls experimental topmost 4
   violate-action set discard-class 3
   violate-action set cos 5
   !
  !
 class class-default
 !
 end-policy-map
!
```

If policy map p3 is applied as an egress policy, the following action sets are applied:

- By using the **conform-action** command, IP packets are marked with the precedence value of 2 and the CoS value of 3; whereas, MPLS packets are marked with the MPLS experimental value of the topmost label that is set to 3 and the CoS value of 3.
- By using the **exceed-action** command, IP packets are marked with the precedence value of 4 and the CoS value of 4; whereas, MPLS packets are marked with the MPLS experimental value of the topmost label that is set to 4 and the CoS value of 4.
- By using the **violate-action** command, IP packets are marked with the discard class value of 3 and the CoS value of 5; whereas, MPLS packets are marked with the discard class value of 3 and the CoS value of 5.

Unconditional Quality-of-Service Markings in the Egress Direction: Example

This example shows how to configure the unconditional QoS markings in the egress direction:

```
configure
 policy-map p6
  class c1
   set cos 2
   set precedence 5
   set mpls experimental topmost 4
   !
  class class-default
  !
 end-policy-map
!
```

If policy map p6 is applied as an egress policy, the following sets are applied:

- IP packets are marked with the CoS value of 2 from the **set cos** command and the precedence value of 5 from the **set precedence** command.
- MPLS packets are marked with CoS and the MPLS experimental value for the topmost label.

Additional References

These sections provide references related to implementing QoS congestion management.

Related Documents

Related Topic	**Document Title**
Initial system bootup and configuration	*Cisco IOS XR Getting Started Guide for the* Cisco CRS Router
Master command reference	Cisco CRS Router Master Command Listing
QoS commands	Cisco IOS XR Modular Quality of Service Command Reference for the Cisco CRS Router
User groups and task IDs	*"Configuring AAA Services on Cisco IOS XR Software"* module of *Cisco IOS XR System Security Configuration Guide*

Standards

Standards	**Title**
No new or modified standards are supported by this feature, and support for existing standards has not been modified by this feature.	—

MIBs

MIBs	**MIBs Link**
—	To locate and download MIBs using Cisco IOS XR software, use the Cisco MIB Locator found at the following URL and choose a platform under the Cisco Access Products menu: http://cisco.com/public/sw-center/netmgmt/cmtk/mibs.shtml

RFCs

RFCs	**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 Technical Support website contains thousands of pages of searchable technical content, including links to products, technologies, solutions, technical tips, and tools. Registered Cisco.com users can log in from this page to access even more content.	http://www.cisco.com/cisco/web/support/index.html
For information about fabric scheduling, virtual output queuing (VOQ), and more, search for “voq” on community.cisco.com.	community.cisco.com
For information about session id BRKSPG-2904 and BRKARC-2003, search on Cisco Live on-demand library.	https://www.ciscolive.com/c/r/ciscolive/global/on-demand-library.html#/