Modular QoS Configuration Guide for Cisco NCS 560 Series Routers, Cisco IOS XR Release 7.2.x

First Published: 2020-08-01

Americas Headquarters
Cisco Systems, Inc.
170 West Tasman Drive
San Jose, CA 95134-1706
USA
http://www.cisco.com
Tel: 408 526-4000
800 553-NETS (6387)
Fax: 408 527-0883

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CHAPTER 1

Packet Classification Overview

Packet classification involves categorizing a packet within a specific group (or class) and assigning it a traffic descriptor to make it accessible for QoS handling on the network. The traffic descriptor contains information about the forwarding treatment (quality of service) that the packet should receive. Using packet classification, you can partition network traffic into multiple priority levels or classes of service. The source agrees to adhere to the contracted terms and the network promises a quality of service. Traffic policers and traffic shapers use the traffic descriptor of a packet to ensure adherence to the contract.

Traffic policers and traffic shapers rely on packet classification features, such as IP precedence, to select packets (or traffic flows) traversing a router or interface for different types of QoS service. After you classify packets, you can use other QoS features to assign the appropriate traffic handling policies including congestion management, bandwidth allocation, and delay bounds for each traffic class.

The Modular Quality of Service (QoS) CLI (MQC) defines the traffic flows that must be classified, where each traffic flow is called a class of service, or class. Later, a traffic policy is created and applied to a class. All traffic not identified by defined classes fall into the category of a default class.

You can classify packets at the ingress on L3 subinterfaces for (CoS, DEI) for IPv4, IPv6, and MPLS flows. IPv6 packets are forwarded by paths that are different from those for IPv4. To enable classification of IPv6 packets based on (CoS, DEI) on L3 subinterfaces, run the hw-module profile qos ipv6 short-l2qos-enable command and reboot the line card for the command to take effect.

Restrictions for this Routers

The **hw-module profile qos ingress-model peering** command is not supported.

Traffic Class Elements

The purpose of a traffic class is to classify traffic on your router. Use the **class-map** command to define a traffic class.

A traffic class contains three major elements:

- A name
- A series of **match** commands - to specify various criteria for classifying packets.
- An instruction on how to evaluate these **match** commands (if more than one **match** command exists in the traffic class)

Packets are checked to determine whether they match the criteria that are specified in the **match** commands. If a packet matches the specified criteria, that packet is considered a member of the class and is forwarded according to the QoS specifications set in the traffic policy. Packets that fail to meet any of the matching criteria are classified as members of the default traffic class.

This table shows the details of match types that are supported on the router.

Match Type Supported	Min, Max	Max Entries	Support for Match NOT	Support for Ranges	Direction Supported on Interfaces
IPv4 DSCP IPv6 DSCP DSCP	(0,63)	64	Yes	Yes	Ingress
IPv4 Precedence IPv6 Precedence Precedence	(0,7)	8	Yes	No	Ingress
MPLS Experimental Topmost	(0,7)	8	Yes	No	Ingress
Access-group	Not applicable	8	No	Not applicable	Ingress
QoS-group	(1,7) (1,511) for peering profile	7	No	No	• Egress • Ingress for QoS Policy Propagation Using Border Gateway Protocol (QPPB) • Ingress for peering profile
Traffic-class	(1,7)	7	No	No	• Egress
CoS	(0,7)	8	No	Yes	Ingress

Match Type Supported	Min, Max	Max Entries	Support for Match NOT	Support for Ranges	Direction Supported on Interfaces
DEI	(0,1)	1	No	No	Ingress
Protocol	(0,255)	1	Yes	Not applicable	Ingress

Note Egress queue statistics are displayed only for those classes which have a corresponding match criteria in the egress. Therefore, if you have a **set traffic-class** *x* configured in the ingress, you must have a corresponding **match traffic-class** *x* in the egress, in order to see the statistics in the egress side.

Note A maximum value of up to 64 unique queues is supported. Each unique queue-limit consumes one rate profile in the Traffic manager. Out of 64 unique queues, 4 are reserved and 60 are usable. So, you can program 60 unique queue-limit in the hardware.

Consider the following points while planning for the policy maps:

You need to be cautious of the unique queue-limit while configuring the egress policy-map. Following are some scenarios that can exhaust the 60 configurable rate-profiles.

- Having different shape rate, without configuring queue limits, could exhaust the rate-profiles as 10ms of GSR converts to different value in bytes based on the shape rate.
- Configuring queue limit in time could exhaust the rate-profiles. For example, 20 ms of 50 Mbps and 20 ms of 100 Mbps are two different values in bytes.

Tip You can avoid exhausting the rate-profile using multiple egress policy-maps. By configuring queue limits in absolute unit (bytes/kbytes/mbytes) and sharing between different policy-maps.

Default Traffic Class

Unclassified traffic (traffic that does not meet the match criteria specified in the traffic classes) is treated as belonging to the default traffic class.

If the user does not configure a default class, packets are still treated as members of the default class. However, by default, the default class has no enabled features. Therefore, packets belonging to a default class with no configured features have no QoS functionality. These packets are then placed into a first in, first out (FIFO) queue and forwarded at a rate determined by the available underlying link bandwidth.

For egress classification, match on **traffic-class** (1-7) is supported. Match **traffic-class 0** cannot be configured. The class-default in the egress policy maps to **traffic-class 0**.

This example shows how to configure a traffic policy for the default class:

```
configure
```

```
policy-map ingress_policy1
class class-default
 police rate percent 30
!
```

Create a Traffic Class

To create a traffic class containing match criteria, use the **class-map** command to specify the traffic class name, and then use the **match** commands in class-map configuration mode, as needed.

Guidelines

- Users can provide multiple values for a match type in a single line of configuration; that is, if the first value does not meet the match criteria, then the next value indicated in the match statement is considered for classification.
- Use the **not** keyword with the **match** command to perform a match based on the values of a field that are not specified.
- All **match** commands specified in this configuration task are considered optional, but you must configure at least one match criterion for a class.
- If you specify **match-any**, one of the match criteria must be met for traffic entering the traffic class to be classified as part of the traffic class. This is the default. If you specify **match-all**, the traffic must match all the match criteria.
- From Release 7.7.1 onwards, for the **match access-group** command, QoS classification based on the packet length field in the IPv4 and IPv6 headers is supported. Prior to this, support was not available for packet length and TTL (time to live) fields.
- For the **match access-group** command, when an ACL list is used within a class-map, the deny action of the ACL is ignored and the traffic is classified based on the specified ACL match parameters.

  An empty ACL (contains no rules, only remarks), when used within a class-map permits all traffic by default, and the implicit deny condition doesn't work with an empty ACL. The corresponding **class-map** matches all traffic not yet matched by the preceding traffic classes.
- The **traffic-class** and **discard-class** are supported only in egress direction, and these are the only match criteria supported in egress direction.
- The egress default class implicitly matches **qos-group** 0 for marking policy and **traffic-class** 0 for queuing policy.
- Multicast takes a system path that is different than unicast on router, and they meet later on the egress in a multicast-to-unicast ratio of 20:80 on a per interface basis. This ratio is maintained on the same priority level as that of the traffic.
- When conditional marking policy map is applied, the MPLS EXP value is set to 0 for multicast traffic.
- Egress QoS for multicast traffic treats traffic classes 0-5 as low-priority and traffic classes 6-7 as high priority. Currently, this is not user-configurable.
- Egress shaping does not take effect for multicast traffic in the high priority (HP) traffic classes. It only applies to unicast traffic.

- If you set a traffic class at the ingress policy and do not have a matching class at egress for the corresponding traffic class value, then the traffic at ingress with this class will not be accounted for in the default class at the egress policy map.
- Only traffic class 0 falls in the default class. A non-zero traffic class assigned on ingress but with no assigned egress queue, falls neither in the default class nor any other class.

Configuration Example

You have to accomplish the following to complete the traffic class configuration:

1. Creating a class map
2. Specifying the match criteria for classifying the packet as a member of that particular class

   (For a list of supported match types, see Traffic Class Elements, on page 2.)

```
Router# configure
Router(config)# class-map match-any qos-1
Router(config-cmap)# match qos-group 1
Router(config-cmap)# end-class-map
Router(config-cmap)# commit
```

Use this command to verify the class-map configuration:

```
Router#show class-map qos-1
1) ClassMap: qos-1    Type: qos
    Referenced by 2 Policymaps
```

Also see, Running Configuration, on page 8.

Also see, Verification, on page 9.

Related Topics

- Traffic Class Elements, on page 2
- Traffic Policy Elements, on page 6

Associated Commands

- class-map
- match access-group
- match dscp
- match mpls experimental topmost
- match precedence
- match qos-group

Traffic Policy Elements

A traffic policy contains three elements:

- Name
- Traffic class
- QoS policies

After choosing the traffic class that is used to classify traffic to the traffic policy, the user can enter the QoS features to be applied to the classified traffic.

The MQC does not necessarily require that the users associate only one traffic class to one traffic policy.

The order in which classes are configured in a policy map is important. The match rules of the classes are programmed into the TCAM in the order in which the classes are specified in a policy map. Therefore, if a packet can possibly match multiple classes, only the first matching class is returned and the corresponding policy is applied.

The router supports 32 classes per policy-map in the ingress direction and 8 classes per policy-map in the egress direction.

Note The policer maximum scale value is enhanced to 32K per system from Cisco IOS XR Release 7.1.1 and the scale value supported before this release is 4K per system.

This table shows the supported class-actions on the router.

Supported Action Types	Direction supported on Interfaces
minimum-bandwidth	egress
bandwidth-remaining	egress
mark	(See Packet Marking, on page 10)
police	ingress
priority	egress (level 1 to level 7)
queue-limit	egress
shape	egress
wred	egress

WRED supports **default** and **discard-class** options; the only values to be passed to the discard-class being 0 and 1.

Create a Traffic Policy

The purpose of a traffic policy is to configure the QoS features that should be associated with the traffic that has been classified in a user-specified traffic class or classes.

To configure a traffic class, see Create a Traffic Class, on page 4.

After you define a traffic policy with the **policy-map** command, you can attach it to one, or more interfaces to specify the traffic policy for those interfaces by using the **service-policy** command in interface configuration mode. With dual policy support, you can have two traffic policies, one marking and one queuing attached at the output. See, Attach a Traffic Policy to an Interface, on page 8.

Configuration Example

You have to accomplish the following to complete the traffic policy configuration:

1. Creating a policy map that can be attached to one or more interfaces to specify a service policy
2. Associating the traffic class with the traffic policy
3. Specifying the class-action(s) (see Traffic Policy Elements, on page 6)

```
Router# configure
Router(config)# policy-map  test-shape-1
Router(config-pmap)# class qos-1

/* Configure class-action ('shape' in this example).
Repeat as required, to specify other class-actions */
Router(config-pmap-c)# shape average percent 40
Router(config-pmap-c)# exit

/* Repeat class configuration as required, to specify other classes */

Router(config-pmap)# end-policy-map
Router(config)# commit
```

See, Running Configuration, on page 8.

See, Verification, on page 9.

Related Topics

- Traffic Policy Elements, on page 6
- Traffic Class Elements, on page 2

Associated Commands

- bandwidth
- bandwidth remaining
- class
- police
- policy-map

- priority
- queue-limit
- service-policy
- set discard-class
- set dscp
- set mpls experimental
- set precedence
- set qos-group
- shape

Attach a Traffic Policy to an Interface

After the traffic class and the traffic policy are created, you must attach the traffic policy to interface, and specify the direction in which the policy should be applied.

Configuration Example

You have to accomplish the following to attach a traffic policy to an interface:

1. Creating a traffic class and the associated rules that match packets to the class (see #unique_11)
2. Creating a traffic policy that can be attached to one or more interfaces to specify a service policy (see Create a Traffic Policy, on page 7)
3. Associating the traffic class with the traffic policy
4. Attaching the traffic policy to an interface, in the ingress or egress direction

Running Configuration

```
RP/0/RP0/CPU0:R1# show run interface TwentyFiveGigE0/0/0/26.1

interface TwentyFiveGigE0/0/0/26.1 l2transport
encapsulation dot1q 25
service-policy input cos
!

RP/0/RP0/CPU0:R1# show run policy-map cos

policy-map cos
class cos1
police rate 3 mbps
!
!
class cos2
police rate 2 mbps
!
!
class cos3
police rate 3 mbps
!
```

```
!
class class-default
police rate 4 mbps
!
!
end-policy-map
!

RP/0/RP0/CPU0:R1#
```

```
Router# configure
Router(config)# interface HundredGigE 0/6/0/18
Router(config-int)# service-policy output test-shape-1
Router(config-int)# commit

Running Configuration

/* Class-map configuration */

class-map match-any traffic-class-1
match traffic-class 1
end-class-map
!
- - -
- - -

/* Traffic policy configuration */
policy-map test-shape-1
class traffic-class-1
shape average percent 40
!
class class-default
!
end-policy-map
!
- - -
- - -

/* Attaching traffic policy to an interface in egress direction */
interface HundredGigE0/6/0/18
service-policy output test-shape-1
!
```

Verification

```
Router# show qos interface hundredGigE 0/6/0/18 output

NOTE:- Configured values are displayed within parentheses Interface HundredGigE0/6/0/18 ifh
 0x30001f8  -- output policy
NPU Id:                        3
Total number of classes:       2
Interface Bandwidth:           100000000 kbps
VOQ Base:                      11112
VOQ Stats Handle:              0x88430698
Accounting Type:               Layer1 (Include Layer 1 encapsulation and above)
------------------------------------------------------------------------------
Level1 Class                             =   qos-1
Egressq Queue ID                         =   11113 (LP queue)
Queue Max. BW.                           =   40329846 kbps (40 %)
Queue Min. BW.                           =   0 kbps (default)
Inverse Weight / Weight                  =   1 / (BWR not configured)
Guaranteed service rate                  =   40000000 kbps
TailDrop Threshold                       =   50069504 bytes / 10 ms (default)
```

```
WRED not configured for this class

Level1 Class                              =   class-default
Egressq Queue ID                          =   11112 (Default LP queue)
Queue Max. BW.                            =   101803495 kbps (default)
Queue Min. BW.                            =   0 kbps (default)
Inverse Weight / Weight                   =   1 / (BWR not configured)
Guaranteed service rate                   =   50000000 kbps
TailDrop Threshold                        =   62652416 bytes / 10 ms (default)
WRED not configured for this class
```

Related Topics

- Traffic Policy Elements, on page 6
- Traffic Class Elements, on page 2

Associated Commands

- service-policy

Packet Marking

The packet marking feature provides users with a means to differentiate packets based on the designated markings. The router supports egress packet marking. match on **discard-class** on egress, if configured, can be used for a marking policy only.

The router also supports L2 ingress marking.

For ingress marking:

Ingress traffic— For the ingress pop operation, re-marking the customer VLAN tag (CoS, DEI) is not supported.

Egress traffic— The ingress 'pop VLAN' is translated to a 'push VLAN' for the egress traffic, and (CoS, DEI) marking is supported for newly pushed VLAN tags. If two VLAN tags are pushed to the packet header at the egress side, both inner and outer VLAN tags are marked. For example:

1. rewrite ingress tag pop 1 symmetric

2. rewrite ingress tag pop 2 symmetric

3. rewrite ingress tag translate 2-to-1 dot1q <> symmetric

Packet Marking Guidelines and Limitations

- While marking a packet, ensure you don't set the IP DSCP (using the **set dscp** command) and the MPLS experimental imposition values (using the **set mpls experimental imposition** command) for the same class map. Else, neither the DSCP remarking nor the MPLS EXP values may take effect at the ingress. This will cause, per default QoS behavior, the IP precedence values to be copied to the EXP bits on the imposed packets. Such an action could lead to unintended packets marked as high-priority by your customer being forwarded as high-priority MPLS packets in the network.
- The statistics and counters for the egress marking policy cannot be viewed on the router.
- For QOS EXP-Egress marking applied on a Layer 3 interface on Cisco routers, there is a limit of two unique policy maps per NPU.

You can apply these policies to as many interfaces as your system resources allow. However, if you apply more than the permitted limit of unique policies, you may encounter unexpected failure.

- For QOS egress marking (CoS, DEI) applied on a Layer 2 interface, there is a limit of 13 unique policy-maps per NPU. If you exceed this number, you may encounter unexpected failure.
- Cisco NCS series routers do not support push or translate operations for dot1ad.

Supported Packet Marking Operations

This table shows the supported packet marking operations.

Supported Mark Types	Range	Support for Unconditional Marking	Support for Conditional Marking
set cos	0-7	ingress	No
set dei	0-1	ingress	No
set discard-class	0-3	ingress	No
set dscp	0-63	ingress	No
set mpls experimental topmost	0-7	ingress	No
set precedence	0-7	ingress	No
set QoS-group	0-7	ingress	No
set traffic-class	0-7	ingress	No

Class-based Unconditional Packet Marking

The packet marking feature allows you to partition your network into multiple priority levels or classes of service, as follows:

- Use QoS unconditional packet marking to set the IP precedence or IP DSCP values for packets entering the network. Routers within your network can then use the newly marked IP precedence values to determine how the traffic should be treated.

  On ingress direction, after matching the traffic based on either the IP Precedence or DSCP value, you can set it to a particular discard-class. Weighted random early detection (WRED), a congestion avoidance technique, thereby uses discard-class values to determine the probability that a packet is dropped.

  If however, you set a discard-class of 3, the packet is dropped at ingress itself.

- Use QoS unconditional packet marking to assign MPLS packets to a QoS group. The router uses the QoS group to determine how to prioritize packets for transmission. To set the traffic class identifier on MPLS packets, use the **set traffic-class** command in policy map class configuration mode.

Note Setting the traffic class identifier does not automatically prioritize the packets for transmission. You must first configure an egress policy that uses the traffic class.

- Use QoS unconditional packet marking to assign packets to set the priority value of IEEE 802.1p/ Inter-Switch Link (ISL) packets. The router uses the CoS value to determine how to prioritize packets for transmission and can use this marking to perform Layer 2-to-Layer 3 mapping. To set the Layer 2 CoS value of an outgoing packet, use the **set cos** command in policy map configuration mode.
- Use QoS unconditional packet marking to mark a packet based on the drop eligible indicator value (DEI) bit on 802.1ad frames. To set the DEI value, use the **set dei** command to set the drop eligible indicator value (DEI) in policy map class configuration mode.

Note

- Unless otherwise indicated, the class-based unconditional packet marking for Layer 3 physical interfaces applies to bundle interfaces.

Setting QoS-group and DSCP at Ingress

With the introduction of this feature, you can set both qos-group and DSCP values within the same QoS policy that is applied in the ingress direction. You can use any permitted value to set the qos-group value.

Restrictions and Guidelines

The following restrictions and guidelines apply when you are setting qos-group and DSCP values within the same QoS policy that is applied in the ingress direction.

- You can set only up to eight DSCP values (determined by the **hw-module** config) in any QoS policy that contains both **set qos-group** and **set dscp** configurations.
- You cannot configure both set qos-group and set dscp settings in the *same* class. Each configuration must be in a *different* class, but within the same policy.

Configuring QoS-group and DSCP at Ingress

To configure a QoS policy that has both qos-group and set dscp configurations, at ingress you must:

1. Enable the QoS profile to set both qos-group and set dscp configurations.
2. Reload the chassis.
3. Specify class names and define class maps for these class names.
4. Match packets to these classes.
5. Create a policy map and include the class maps you created earlier.
6. Set the qos-group and dscp configurations within this policy map.
7. Attach the policy map to the interface.

Note Starting from Release 7.1.2, you can configure **set qos-group** and **set dscp** packet marking operations within same ingress QoS policy.

To configure static mapping between DSCP and qos-group, use the **hw-module profile qos qosg-dscp-mark-enable** command with only, set dscp values as 0, 8, 16, 24, 32, 40, 48, or 56 in the hardware profile.

```
RP/0/RP0/CPU0:router(config)#hw-module profile qos qosg-dscp-mark-enable 13 16
In order to activate this new qos profile, you must manually reload the chassis/all line
cards
RP/0/RP0/CPU0:router(config)#commit
RP/0/RP0/CPU0:router(config)#
RP/0/RP0/CPU0:router(config)#class-map cm-dscp-cs1
RP/0/RP0/CPU0:router(config-cmap)#match dscp cs1
RP/0/RP0/CPU0:router(config-cmap)#commit
RP/0/RP0/CPU0:router(config)#
RP/0/RP0/CPU0:router(config)# class-map cm-dscp-cs4
RP/0/RP0/CPU0:router(config-cmap)# match dscp cs4
RP/0/RP0/CPU0:router(config-cmap)#commit
RP/0/RP0/CPU0:router(config)#
RP/0/RP0/CPU0:router(config)#policy-map pm-in
RP/0/RP0/CPU0:router(config-pmap)#class cm-dscp-cs1
RP/0/RP0/CPU0:router(config-pmap-c)#set dscp cs2
RP/0/RP0/CPU0:router(config-pmap-c)#exit
RP/0/RP0/CPU0:router(config-pmap)# class cm-dscp-cs4
RP/0/RP0/CPU0:router(config-pmap-c)#set qos-group 2
RP/0/RP0/CPU0:router(config-pmap-c)#commit
RP/0/RP0/CPU0:router(config)#
RP/0/RP0/CPU0:router(config)#interface TenGigE 0/0/0/1
RP/0/RP0/CPU0:router(config-if)#service-policy input pm-in
RP/0/RP0/CPU0:router(config-if)#commit
RP/0/RP0/CPU0:router(config)# exit
```

Running Configuration

```
hw-module profile qos qosg-dscp-mark-enable 13 16

class-map match-any cm-dscp-cs1
match dscp cs1
 end-class-map
!
class-map match-any cm-dscp-cs4
match dscp cs4
 end-class-map
!

policy-map pm-in
class cm-dscp-cs1
  set dscp cs2
!
class cm-dscp-cs4
  set qos-group 2
!
 class class-default
!
 end-policy-map
!

interface TenGigE0/0/0/1
```

```
service-policy input pm-in
shutdown
!
```

Verification

```
RP/0/RP0/CPU0:ios#show policy-map pmap-name pm-in detail
class-map match-any cm-dscp-cs1
match dscp cs1
 end-class-map
!
class-map match-any cm-dscp-cs4
match dscp cs4
 end-class-map
!

policy-map pm-in
class cm-dscp-cs1
  set dscp cs2
!
class cm-dscp-cs4
  set qos-group 2
!
 class class-default
!
 end-policy-map
!
```

Associated Commands

- hw-module profile qos qosg-dscp-mark-enable

QoS Re-marking of IP Packets in Egress Direction

The router support the marking of IP DSCP bits of all IP packets to zero, in the egress direction. This feature helps to re-mark the priority of IP packets, which is mostly used in scenarios like IP over Ethernet over MPLS over GRE. This functionality is achieved using the ingress policy-map with **set dscp 0** option configured in class-default.

Configuration Example

```
Router# configure
Router(config)# policy-map ingress-set-dscp-zero-policy
Router(config-pmap)# class class-default
Router(config-pmap-c)# set dscp 0
Router(config-pmap-c)# end-policy-map
Router(config-pmap)# commit
```

Running Configuration

```
policy-map ingress-set-dscp-zero-policy
class class-default
  set dscp 0
!
end-policy-map
!
```

QoS Re-marking of Ethernet Packets in Egress Direction

The router supports Layer 2 marking of Ethernet packets in the egress direction.

QoS L2 Re-marking of Ethernet Packets in Egress Direction

The router supports Layer 2 marking of Ethernet packets in the egress direction.

To enable this feature, you must:

- Configure the policy maps for queuing and marking at the egress interface.
- Set traffic-class in the ingress and use **match traffic-class** in the egress for queuing.
- Ensure that the **set qos-group** command is configured in ingress policy and the corresponding **match qos-group** command is configured in the egress marking policy. If there is no corresponding QoS group, you will experience traffic failure.

  The ingress ‘push VLAN’ is translated to ‘pop VLAN’ for the egress traffic. In this case, (CoS, DEI) re-marking is not supported for the VLAN tag. For example:

  1. rewrite ingress tag push dot1q/dot1ad <> symmetric
  2. rewrite ingress tag push dot1q/dot1ad <> second-dot1q <> symmetric
  3. rewrite ingress tag translate 1-to-2 dot1q/dot1ad <> second-dot1q <> symmetric

Running Configuration

```
policy-map egress-marking
class qos1
set cos 1
!
class qos2
set cos 2
set dei 1
!
class qos3
set cos 3
!
class class-default
set cos 7
!
end-policy-map
!
```

QoS L2 Re-Marking of Ethernet Packets on L3 Flows in Egress Direction

The router supports Layer 2 marking of Ethernet packets on Layer 3 flows in the egress direction. To enable this feature, you must:

- Configure the policy maps for marking at the egress interface.
- Ensure that the **set qos-group** command is configured in ingress policy and the corresponding **match qos-group** command is configured in the egress marking policy. If there is no corresponding QoS group, you will experience traffic failure.

Restrictions

The following restrictions apply while configuring the Layer 2 marking of Ethernet packets on Layer 3 flows in the egress direction.

- Egress marking statistics are not available.
- Layer 2 (802.1p) Egress marking is supported on Layer 3 flows only for MPLS-to-IP traffic.

Running Configuration

Ingress Policy:

You must first set up the qos-group at ingress.

```
class-map match-any Class0
 match mpls experimental topmost 0

 end-class-map
class-map match-any Class1
 match mpls experimental topmost 1

 end-class-map
class-map match-any Class2
 match mpls experimental topmost 2

 end-class-map
class-map match-any Class3
 match mpls experimental topmost 3

 end-class-map
class-map match-any Class4
 match mpls experimental topmost 4

 end-class-map
class-map match-any Class5
 match mpls experimental topmost 5

 end-class-map
class-map match-any Class6
 match mpls experimental topmost 6
end-class-map
class-map match-any Class7
 match mpls experimental topmost 7

 end-class-map
!

policy-map ncs_input
 class Class7
  set traffic-class 7
    set qos-group 7
!
 class Class6
  set traffic-class 6
  set qos-group 6
!
 class Class5
  set traffic-class 5
    set qos-group 5
!
 class Class4
  set traffic-class 4
  set qos-group 4
 !
 class Class3
  set traffic-class 4
    set qos-group 3
 !
 class Class2
  set traffic-class 2
    set qos-group 2
 !
 class Class1
  set traffic-class 2
    set qos-group 1
 !
 class Class0
  set traffic-class 0
    set qos-group 0
 !
 end-policy-map
!
```

Egress Policy:

At the egress, run these commands to mark the packets.

```
class-map match-any qos7
match gos-group 7
 end-class-map
!
class-map match-any qos6
match gos-group 6
 end-class-map
!
class-map match-any qos5
match qos-group 5
 end-class-map
!
class-map match-any qos4
match gos-group 4
 end-class-map
!
class-map match-any qos3
match gos-group 3
 end-class-map
!
class-map match-any qos2
 match gos-group 2
 end-class-map
!
class-map match-any qos1
match gos-group 1
 end-class-map
!

policy-map ncs_output
 class qos7
  set cos 7
  !
 class qos6
  set cos 6
!
 class qos5
  set cos 5
  !
 class qos4
```

```
  set cos 4
!
 class qos3
  set cos 3
!
 class qos2
  set cos 2

!
 class qos1
  set cos 1
  !
 end-policy-map
!
```

QoS L2 Re-Marking of Ethernet Packets on L3 Flows in Egress Direction on L3 sub-interfaces

The router supports Layer 2 marking of Ethernet packets on Layer 3 flows in the egress direction on L3 subinterfaces.

To enable this feature, you must:

- Configure the policy maps for marking at the egress interface.
- Ensure that the **set qos-group** command is configured in ingress policy and the corresponding **match qos-group** command is configured in the egress marking policy. If there is no corresponding QoS group, you experience traffic failure.

Restrictions

The following restrictions apply while configuring the Layer 2 marking of Ethernet packets on Layer 3 flows in the egress direction.

- **set discard-class** is not supported in ingress policy with peering mode.
- Egress marking statistics are not available.
- Layer 2 (CoS, DEI) Egress marking is supported on Layer 3 flows on L3 subinterfaces for these types of traffic: IP-to-IP, IP-to-MPLS, and MPLS-to-IP traffic.

Running Configuration

Ingress Policy:

You must first set up the qos-group at ingress. This is applicable only when you want to mark packets at the egress.

```
class-map match-all COS0_DEI0
 match cos 0
 match dei 0
 end-class-map
class-map match-all COS0_DEI1
 match cos 0
 match dei 1
 end-class-map
class-map match-all COS1_DEI0
 match cos 1
 match dei 0
 end-class-map
class-map match-all COS1_DEI1
```

```
 match cos 1
 match dei 1
 end-class-map
class-map match-all COS2_DEI0
 match cos 2
 match dei 0
 end-class-map
class-map match-all COS2_DEI1
 match cos 2
 match dei 1
 end-class-map
class-map match-all COS3_DEI0
 match cos 3
 match dei 0
 end-class-map
class-map match-all COS3_DEI1
 match cos 3
 match dei 1
 end-class-map
class-map match-all COS4_DEI0
 match cos 4
 match dei 0
 end-class-map
class-map match-all COS4_DEI1
 match cos 4
 match dei 1
 end-class-map
class-map match-all COS5_DEI0
 match cos 5
 match dei 0
 end-class-map
class-map match-all COS5_DEI1
 match cos 5
 match dei 1
 end-class-map
class-map match-all COS6_DEI0
 match cos 6
 match dei 0
 end-class-map
class-map match-all COS6_DEI1
 match cos 6
 match dei 1
 end-class-map
class-map match-all COS7_DEI0
 match cos 7
 match dei 0
 end-class-map
class-map match-all COS7_DEI1
 match cos 7
 match dei 1
 end-class-map

policy-map ncs_input
 class COS7_DEI0
  set qos-group 7
  set discard-class 0
!
 class COS7_DEI1
  set qos-group 7
  set discard-class 1
!
 class COS6_DEI0
  set qos-group 6
  set discard-class 0
```

```
!
 class COS6_DEI1
  set qos-group 6
  set discard-class 1
!
 class COS5_DEI0
  set qos-group 5
  set discard-class 0
!
 class COS5_DEI1
  set qos-group 5
  set discard-class 1
!
 class COS4_DEI0
  set qos-group 4
  set discard-class 0
!
 class COS4_DEI1
  set qos-group 4
  set discard-class 1
!
 class COS3_DEI0
  set qos-group 3
  set discard-class 0
!
 class COS3_DEI1
  set qos-group 3
  set discard-class 1
!
 class COS2_DEI0
  set qos-group 2
  set discard-class 0
!
 class COS2_DEI1
  set qos-group 2
  set discard-class 1
!
 class COS1_DEI0
  set qos-group 1
  set discard-class 0
!
 class COS1_DEI1
  set qos-group 1
  set discard-class 1
!
 class COS0_DEI0
  set qos-group 0
  set discard-class 0
!
 class COS0_DEI1
  set qos-group 0
  set discard-class 1
!
```

Egress Policy:

At the egress, run these commands to mark the packets.

```
class-map match-all qos7_dc0
match qos-group 7
match discard-class 0
 end-class-map
!
class-map match-all qos7_dc1
match qos-group 7
match discard-class 1
 end-class-map
!

class-map match-all qos6_dc0
match qos-group 6
match discard-class 0
 end-class-map
!
class-map match-all qos6_dc1
match qos-group 6
match discard-class 1
 end-class-map
!
class-map match-all qos5_dc0
match qos-group 5
match discard-class 0
 end-class-map
!
class-map match-all qos5_dc1
match qos-group 5
match discard-class 1
 end-class-map
!
class-map match-all qos4_dc0
match qos-group 4
match discard-class 0
 end-class-map
!
class-map match-all qos4_dc1
match qos-group 4
match discard-class 1
 end-class-map
!
class-map match-all qos3_dc0
match qos-group 3
match discard-class 0
 end-class-map
!
class-map match-all qos3_dc1
match qos-group 3
match discard-class 1
 end-class-map
!
class-map match-all qos2_dc0
match qos-group 2
match discard-class 0
 end-class-map
!
class-map match-all qos2_dc1
match qos-group 2
match discard-class 1
 end-class-map
!
class-map match-all qos1_dc0
match qos-group 1
match discard-class 0
 end-class-map
!
class-map match-all qos1_dc1
match qos-group 1
match discard-class 1
 end-class-map
!
```

```
class-map match-all qos0_dc0
match qos-group 0
match discard-class 0
 end-class-map
!
class-map match-all qos0_dc1
match qos-group 0
match discard-class 1
 end-class-map
!


policy-map ncs_output
 class qos7_dc0
  set cos 7
  set dei 0
  set mpls experimental imposition 7
!
 class qos7_dc1
  set cos 7
  set dei 1
  set mpls experimental imposition 7
!
 class qos6_dc0
  set cos 6
  set dei 0
  set mpls experimental imposition 6
!
 class qos6_dc1
  set cos 6
  set dei 1
  set mpls experimental imposition 6
!
 class qos5_dc0
  set cos 5
  set dei 0
  set mpls experimental imposition 5
!
 class qos5_dc1
  set cos 5
  set dei 1
  set mpls experimental imposition 5
!
 class qos4_dc0
  set cos 4
  set dei 0
  set mpls experimental imposition 4
!
 class qos4_dc1
  set cos 4
  set dei 1
  set mpls experimental imposition 4
!
 class qos3_dc0
  set cos 3
  set dei 0
  set mpls experimental imposition 3
!
 class qos3_dc1
  set cos 3
  set dei 1
  set mpls experimental imposition 3
!
 class qos2_dc0
```

```
  set cos 2
  set dei 0
  set mpls experimental imposition 2
!
 class qos2_dc1
  set cos 2
  set dei 1
  set mpls experimental imposition 2
!
 class qos1_dc0
  set cos 1
  set dei 0
  set mpls experimental imposition 1
!
 class qos1_dc1
  set cos 1
  set dei 1
  set mpls experimental imposition 1
!
 class qos0_dc0
  set cos 0
  set dei 0
  set mpls experimental imposition 0
!
 class qos0_dc1
  set cos 0
  set dei 1
  set mpls experimental imposition 0
!
 end-policy-map
!
```

Bundle Traffic Policies

A policy can be bound to bundles. When a policy is bound to a bundle, the same policy is programmed on every bundle member (port). For example, if there is a policer or shaper rate, the same rate is configured on every port. Traffic is scheduled to bundle members based on the load balancing algorithm.

Both ingress and egress traffic is supported. Percentage-based policies , absolute rate-based policies, and time-based policies are supported.

Note Egress marking is not supported on BVI interfaces.

For details, see Configure QoS on Link Bundles, on page 79.

Ingress Short-Pipe

When QoS traffic leaves an MPLS network, the MPLS label stack is removed on the penultimate ingress Label Switch Router (LSR), leaving an IPv4 or IPv6 packet to be forwarded. MPLS experimental bits (or EXP or pipe mode) carries out this disposition process and the packet is marked with a Differentiated Services Code Point (DSCP) or precedence value (also called DSCP or Precedence-based classification).

Usually, QoS traffic supports DSCP and precedence-based classifications only when there is no MPLS label in the packet. Using the ingress short-pipe feature, however, you can classify a packet that contains one MPLS label using the type-of-service (ToS) field of the IPv4 or IPv6 header. This classification method is called ingress short-pipe. To classify an IP packet this way, you must:

1. Create a child class map.
2. Specify a ToS value in the child class map.
3. Attach the child class map to a parent class map.
4. Create a policy map containing the parent class map.
5. Set any ingress action such as traffic class or QoS group. From Release 7.1.1 onwards, you can also set ingress action DSCP (or precedence value).

With the ingress short-pipe feature, you get an increased visibility into traffic packets. Plus, the feature also removes the limitation of classifying MPLS packets that come into IPv4 or IPv6 networks.

Restrictions and Other Important Points

Ensure that you read these points before you configure the ingress short-pipe feature.

- This feature works only when there is one MPLS header in the traffic packet. If there are two or more MPLS headers, the ingress-short pipe feature fails. For example, in case of Explicit Null where there are two labels at the disposition, this feature will not work.
- You can carry out ingress classification using either the MPLS experimental bits (or EXP or pipe mode) classification OR the DSCP/precedence (or short-pipe) classification. Ensure that you do not mix the classification methods, else it may result in an unknown behavior, and the classification may not work at all.
- This feature is supported only on L3VPN, and not supported on L2VPN.
- This feature works for regular IPv4/IPv6 traffic, but will not work for IPv6 VPN Provider Edge over MPLS (6VPE).
- You can add only one child class map to a parent class map.
- This feature supports the invocation of short-pipe and legacy DSCP classification for the same parent class map.
- The child class map can contain only match precedence and match dscp commands.
- This feature is not supported in peering mode.

Configure Ingress Short-Pipe

This section details a sample configuration for the ingress short-pipe feature and another sample to configure classification for labeled and non-labeled packets under the same parent class.

Sample configuration to classify a packet that contains one MPLS label using the type-of-service (ToS) field of the IPv4 or IPv6 header (or the ingress short-pipe method):

```
class-map match-any in_pipe
 match mpls disposition class-map child_pipe
end-class-map
!
class-map match-any child_pipe
```

```
 match precedence 1
match dscp ipv4 af11
 end-class-map
!
class-map match-any ingress-business-high
match dscp af21 af22
end-class-map

class-map match-any ingress-business-low
match dscp af11 af12
end-class-map

policy-map ingress-classifier
class in_pipe
set traffic-class 5
set dscp af31
class ingress-business-high
set traffic-class 4
class ingress-business-low
set traffic-class 2
class class-default
set traffic-class 0
!
```

Note The **set dscp** option is available from Release 7.1.1 onwards.

You can configure classification for both labeled and non-labeled packets under the same parent class as in the following sample configuration. In this example, for MPLS labeled packets, DSCP configured under the child class is classified, while for non-labeled packets, DSCP/ToS configured in the **match dscp <value>** statement is classified.

DSCP value range is from 0 through 63. The range option is not supported. Up to 8 items per class are supported. Up to 64 **match dscp** values in total.

```
class-map match-any in_pipe
match mpls disposition class-map child_pipe  (labeled case)
match dscp af11 (non-labeled case)
end-class-map
!
class-map match-any child_pipe
match precedence 1
match dscp ipv4 af11
end-class-map
!
class-map match-any ingress-business-high
match dscp af21 af22
end-class-map

class-map match-any ingress-business-low
match dscp af11 af12
end-class-map

policy-map ingress-classifier
class in_pipe
set traffic-class 5
set dscp af31
class ingress-business-high
set traffic-class 4
class ingress-business-low
set traffic-class 2
```

```
class class-default
set traffic-class 0
!
```

Note The **set dscp** option is available from Release 7.1.1 onwards. A maximum of one set dscp command is supported per class-map.

Associated Commands

- match mpls disposition class-map

Selective Egress Policy-Based Queue Mapping

With selective egress policy-based queue mapping, you can combine traffic class (TC) maps in various permutations at the egress.

The primary aim of introducing the egress TC (traffic class) mapping is to classify the traffic in the ingress using a single policy and place the classified traffic into queues, by assigning the traffic classes. At the egress, you can support different grouping of TCs.

Based on different Service Level Agreements (SLAs) that each customer has signed up for, you can group some TCs into priority queues for real time (RT) traffic, other TCs into guaranteed bandwidth (BW) traffic, and the rest into best effort (BE) traffic delivery.

Let us consider an example where three customers have purchased these services, based on their requirements:

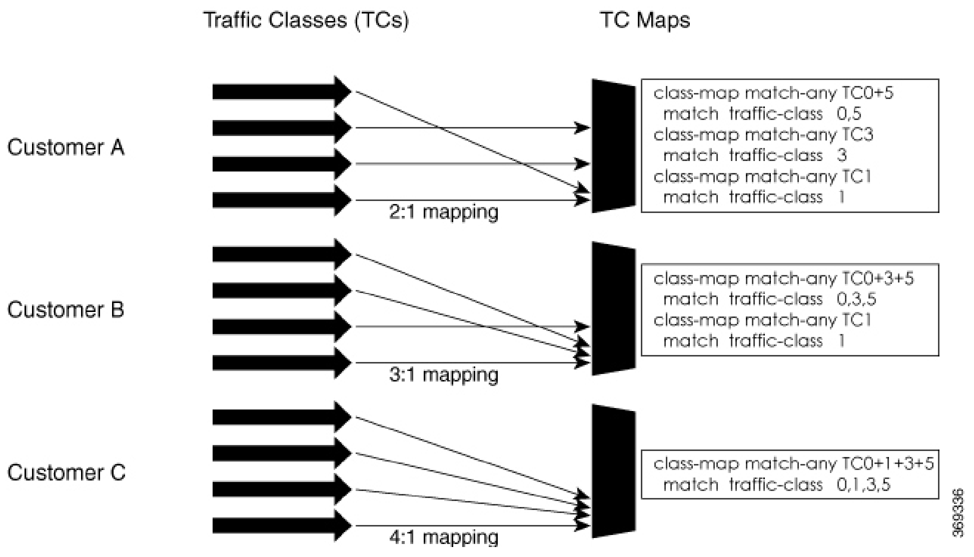
- Customer A - Requires RT traffic, reserved BW traffic and BE traffic delivery.
- Customer B – Requires reserved BW traffic and BE traffic delivery.
- Customer C – Needs only BE traffic delivery.

Using the selective egress policy-based queue mapping, you can create three profiles this way:

- Customer A – Priority queue RT traffic (TC1), Guaranteed BW traffic (TC3), Best effort traffic (TC0, TC5)
- Customer B – Guaranteed BW traffic (TC1), Best effort traffic (TC0, TC3, TC5)
- Customer C - Best effort traffic (TC0, TC1, TC3, TC5)

Using the egress TC-mapping, you can create three different profiles that you can use for each customer based on their SLAs with the provider.

Figure 1: Selective Egress Policy-Based Queue Mapping Helps Create Customer Profiles Based on Their SLAs



Restrictions and Other Important Points

Ensure that you read these points before you configure the selective egress policy-based queue-mapping feature.

- There can be only one TC (Traffic Class) mapped class to a PM (Policy Map).
- You cannot use a TC that you used in a mapped class, in a non-mapped class under the same PM.
- You can have a maximum of three unique TC mapped PMs or profiles per platform.
- Every TC mapped class must include **traffic-class 0** in the range values.
- The TC-mapping range is from 0 through 5.
- When a TC-mapped class is present in a PM, the class default becomes a dummy class. This means that the class default statistics and QoS values are not applicable.
- All the class default limitations apply to the TC-mapped class; for example, you cannot configure **priority** command under the TC mapped class.

Note A TC-mapped PM or profile is a PM that contains a TC-mapped class.

Example of a TC-mapped class:

match traffic-class 0 1 2 3

Example of a TC non-mapped class:

match traffic-class 1

Configure Selective Egress Policy-Based Queue Mapping

This section details a sample configuration for the selective egress policy-based queue-mapping feature and a use case to show how this feature works.

Sample configuration

```
class-map match-any <name>
 match traffic-class <value>
commit

policy-map tc_pmap
 class tc035
  shape average percent 1
 !
 class class-default
!
 end-policy-map
!
 class-map match-any tc035
match traffic-class 0 3 5
 end-class-map
!
```

Verification

Run the **show qos interface** and **show policy-map interface** commands.

When TC mapping class is present in a policy map, the class default does not have any values calculated.

show qos interface bundle-Ether 44 output sample

```
NOTE:- Configured values are displayed within parentheses
NPU Id:                      0
Total number of classes:     3
Interface Bandwidth:         100000000 kbps
Policy Name:                 tc_pmap
Accounting Type:             Layer1 (Include Layer 1 encapsulation and above)
------------------------------------------------------------------------------
Level1 Class                           =   tc1

Level1 Class                           =   tc035

Level1 Class                           =   class-default

Interface HundredGigE0/0/0/30 Ifh 0xf000208 (Member) -- output policy
NPU Id:                      0
Total number of classes:     3
Interface Bandwidth:         100000000 kbps
Policy Name:                 tc_pmap
VOQ Base:                    1264
Accounting Type:             Layer1 (Include Layer 1 encapsulation and above)
------------------------------------------------------------------------------
Level1 Class                           =   tc1
Egressq Queue ID                       =   1265 (LP queue)
Queue Max. BW.                         =   10063882 kbps (10 %)
Queue Min. BW.                         =   0 kbps (default)
Inverse Weight / Weight                =   1 / (BWR not configured)
Guaranteed service rate                =   10000000 kbps
TailDrop Threshold                     =   12517376 bytes / 10 ms (default)
WRED not configured for this class
```

```
Level1 Class                             =   tc035
Egressq Queue ID                         =   1264 (LP queue)
Queue Max. BW.                           =   1011732 kbps (1 %)
Queue Min. BW.                           =   0 kbps (default)
Inverse Weight / Weight                  =   1 / (BWR not configured)
Guaranteed service rate                  =   1000000 kbps
TailDrop Threshold                       =   1253376 bytes / 10 ms (default)
WRED not configured for this class

Level1 Class                             =   class-default
Queue Max. BW.                           =   no max (default)
Queue Min. BW.                           =   0 kbps (default)
Inverse Weight / Weight                  =   0 / (BWR not configured)
```

show policy-map interface bundle-Ether 44 output sample

```
Bundle-Ether44 output: tc_pmap

Class tc1
  Classification statistics          (packets/bytes)     (rate - kbps)
    Matched             :              429444/53823648            0
    Transmitted         :              429444/53823648            0
    Total Dropped       :                   0/0                   0
  Queueing statistics
    Queue ID                                : None (Bundle)
    Taildropped(packets/bytes)              : 0/0
Class tc035
  Classification statistics          (packets/bytes)     (rate - kbps)
    Matched             :             1288331/161470820           0
    Transmitted         :             1288331/161470820           0
    Total Dropped       :                   0/0                   0
  Queueing statistics
    Queue ID                                : None (Bundle)
    Taildropped(packets/bytes)              : 0/0
Class class-default
  Classification statistics          (packets/bytes)     (rate - kbps)
    Matched             :                   0/0                   0
    Transmitted         :                   0/0                   0
    Total Dropped       :                   0/0                   0
  Queueing statistics
    Queue ID                                : None (Bundle)
    Taildropped(packets/bytes)              : 0/0
Policy Bag Stats time: 1557216940000  [Local Time: 05/07/19 08:15:40.000]
RP/0/RP0/CPU0:BB1#
```

Use Case

With the ingress traffic matching the same match criteria, you can group the egress traffic up to three unique TC mapped profiles. Using this feature, you can provide differentiated services to customers based on the SLAs they have signed up for.

In the example that follows, the ingress policy-map sets the ingress match criteria for the traffic class from 0 through 5. Based on the SLAs, you can group the TC values at the egress PM to deliver differentiated services.

After you group the TC values, you can apply specific egress actions under that class.

Ingress match:

```
class EXP1
  set traffic-class 1
!
class EXP2
  set traffic-class 2
```

```
!
class EXP3
  set traffic-class 3
!
class EXP4
  set traffic-class 4
!
class EXP5
  set traffic-class 5
!
class class-default
!
end-policy-map
!
```

Egress match:

Sample TC mapped class for policy-map PM1

```
class-map match-any TC2:1
match traffic-class 0 1
end-class-map
```

Sample TC mapped class for policy-map PM2

```
class-map match-any TC3:1
match traffic-class 0 1 2
end-class-map
```

Sample TC mapped class for policy-map PM3

```
class-map match-any TC6:1
match traffic-class 0 1 2 3 4 5
end-class-map
```

Configuring QoS Groups with an ACL

You can create QoS groups and configure ACLs to classify traffic into the groups based on a specified match condition. In this example, we match by the QoS group value (0-511).

Prerequisites

Before you can configure QoS groups with an ACL, the QoS peering profile must be enabled on the router or the line card. After enabling QoS peering, the router or line card must be reloaded, as shown in the following configuration.

Enabling QoS Peering Profile on the Router

Enter the global configuration mode and enable the QoS peering profile for the router as shown:

```
RP/0/RP0/CPU0:router(config)# hw-module profile qos ingress-model peering
RP/0/RP0/CPU0:router(config)# exit
RP/0/RP0/CPU0:router# reload
```

Enabling QoS Peering Profile on the Line Card

Enter the global configuration mode and enable the QoS peering profile for the line card as shown:

```
RP/0/RP0/CPU0:router(config)# hw-module profile qos ingress-model peering location 0/0/CPU0
RP/0/RP0/CPU0:router(config)# exit
RP/0/RP0/CPU0:router# reload location 0/0/CPU0
```

Configuration

Use the following set of configuration statements to configure an ACL with QoS groups.

```
/*
 Enter the global configuration mode, and configure an ACL with the required QoS groups.
*/
RP/0/RP0/CPU0:router# configure
RP/0/RP0/CPU0:router(config)# ipv4 access-list qos-acl
RP/0/RP0/CPU0:router(config-ipv4-acl)# 10 permit ipv4 host 5.0.0.1 any set qos-group 1
RP/0/RP0/CPU0:router(config-ipv4-acl)# 11 permit ipv4 host 6.0.0.1 any set qos-group 2
RP/0/RP0/CPU0:router(config-ipv4-acl)# 12 permit ipv4 host 7.0.0.1 any set qos-group 3
RP/0/RP0/CPU0:router(config-ipv4-acl)# 13 deny ipv4 any any


/* Create a policy map with the required classes.
In this example, we also create a default class for traffic that does not belong to any of
 the specified
classes. */
RP/0/RP0/CPU0:router(config)# policy-map qos-acl-map
RP/0/RP0/CPU0:router(config-pmap)# class qos1
RP/0/RP0/CPU0:router(config-pmap-c)# set dscp af43
RP/0/RP0/CPU0:router(config-pmap-c)# set traffic-class 2
RP/0/RP0/CPU0:router(config-pmap-c)# exit

RP/0/RP0/CPU0:router(config-pmap)# class qos2
RP/0/RP0/CPU0:router(config-pmap-c)# set precedence critical
RP/0/RP0/CPU0:router(config-pmap-c)# set traffic-class 7
RP/0/RP0/CPU0:router(config-pmap-c)# exit

RP/0/RP0/CPU0:router(config-pmap)# class qos3
RP/0/RP0/CPU0:router(config-pmap-c)# set precedence 2
RP/0/RP0/CPU0:router(config-pmap-c)# set traffic-class 2
RP/0/RP0/CPU0:router(config-pmap-c)# exit

RP/0/RP0/CPU0:router(config-pmap)# class qos4
RP/0/RP0/CPU0:router(config-pmap-c)# set traffic-class 4
RP/0/RP0/CPU0:router(config-pmap-c)# set dscp cs4
RP/0/RP0/CPU0:router(config-pmap-c)# exit

RP/0/RP0/CPU0:router(config-pmap)# class class-default
RP/0/RP0/CPU0:router(config-pmap-c)# police rate percent 20
RP/0/RP0/CPU0:router(config-pmap-c-police)# exit


/* Create the class maps for specifying the match conditions. */
RP/0/RP0/CPU0:router(config)# class-map match-any qos1
RP/0/RP0/CPU0:router(config-cmap)# match qos-group 1
RP/0/RP0/CPU0:router(config-cmap)# end-class-map

RP/0/RP0/CPU0:router(config)# class-map match-any qos2
RP/0/RP0/CPU0:router(config-cmap)#  match qos-group 2
RP/0/RP0/CPU0:router(config-cmap)# end-class-map

RP/0/RP0/CPU0:router(config)# class-map match-any qos3
RP/0/RP0/CPU0:router(config-cmap)# match qos-group 3
RP/0/RP0/CPU0:router(config-cmap)# end-class-map

RP/0/RP0/CPU0:router(config)# class-map match-any qos4
RP/0/RP0/CPU0:router(config-cmap)# match qos-group 4
RP/0/RP0/CPU0:router(config-cmap)# end-class-map
```

```
/* Apply the access list and the QoS map to the Gigabit interface, and commit your
configuration. */
RP/0/RP0/CPU0:router(config)# interface TenGigE0/0/0/1
RP/0/RP0/CPU0:router(config-if)# ipv4 address 12.0.0.1/24
RP/0/RP0/CPU0:router(config-if)# no shut
RP/0/RP0/CPU0:router(config-if)# service-policy input qos-acl-map
RP/0/RP0/CPU0:router

RP/0/RP0/CPU0:router(config-if)# commit
Tue Mar 28 10:23:34.106 IST

RP/0/0/CPU0:Mar 28 10:37:48.570 : ifmgr[397]: %PKT_INFRA-LINK-3-UPDOWN : Interface
TenGigE0/0/0/1, changed state to Down
RP/0/0/CPU0:Mar 28 10:37:48.608 : ifmgr[397]: %PKT_INFRA-LINK-3-UPDOWN : Interface
TenGigE0/0/0/1, changed state to Up

RP/0/RP0/CPU0:router(config-if)# exit
```

Running Configuration

Confirm your configuration.

```
RP/0/RP0/CPU0:router(config)# show run
Tue Mar 28 10:37:55.737 IST

Building configuration...
!! IOS XR Configuration 0.0.0

ipv4 access-list qos-acl
10 permit ipv4 host 5.0.1.1 any set qos-group 1
11 permit ipv4 host 6.0.1.1 any set qos-group 2
12 permit ipv4 host 7.0.1.1 any set qos-group 3
13 deny ipv4 any any

class-map match-any qos1
match qos-group 1
end-class-map
!
class-map match-any qos2
match qos-group 2
end-class-map
!
class-map match-any qos3
match qos-group 3
end-class-map
!
class-map match-any qos4
match qos-group 4
end-class-map
!

policy-map qos-acl-map
class qos1
  set dscp af43
  set traffic-class 2
!
class qos2
  set precedence critical
  set traffic-class 7
!
class qos3
```

```
  set precedence 2
  set traffic-class 2
!
class qos4
  set traffic-class 4
  set dscp cs4
!
class class-default
  police rate percent 20
  !
!
end-policy-map
!

interface TenGigE0/0/0/1
service-policy input qos-acl-map
ipv4 address 12.0.0.1 255.255.255.0
ipv4 access-group qos-acl ingress compress level 3

!
```

You have successfully configured an ACL with QoS groups.

QoS Egress Marking and Queuing Using Dual Policy-Map

To achieve QoS Egress marking/queuing, the router utilizes the dual policy model on the Egress with independent policies for marking and queuing.

Egress marking can be achieved by applying a policy-map on the ingress interface by setting qos-group/discard-class. Then the qos-group which is set by the ingress policy-map is used by the egress-policy map along with DP (drop-precedence or discard class) value to remark the cos/dei bits of the outgoing L2 packet. Similarly Egress queuing can be achieved by applying a policy-map on the ingress interface by setting the traffic-class. Then the traffic-class is used by the egress-policy map to perform queuing actions.

Benefits

- This feature enables the users to make the marking decision based on the DP (drop precedence) field.
- In case of MPLS-to-Layer 2 traffic stream, the Layer 2 packet is within the MPLS data packet; therefore marking of the Layer 2 header is possible only at Egress after data transmission.
- In case of Egress rewrite operations, where the VLAN tags are modified or added, the cos or the dei fields can be marked with Egress marking.

QoS Egress Marking and Queueing can be summarized in the following three steps—

1. Configure a Ingress Policy-Map— classifying the incoming packet and setting the qos-group/discard-class or the traffic class.
2. Configure a Egress Policy-Map:
    - Configure Egress Marking Policy—
        - Create class-map to classify on qos-group/discard-class.
        - Create policy-map to mark cos/dei field in the L2 header.

- Configure Egress Queuing Policy—
  - Create class-map to classify on traffic-class.
  - Create policy-map to perform the queuing actions (for example, bandwidth, shaping, priority).

3. Attaching the policies to the Interfaces.

Note While marking QinQ traffic, only outer dot1q header is effected and the inner header remains as is. However, in case of few rewrite operations where the new QinQ tags are added, the inner header is marked.

Example— Ingress Policy-Map Configuration:

```
/*Create class-map/*
Router#config
Router(config)#class-map match-any cos2
Router(config-cmap)#match cos 2
Router(config-cmap)#commit
Router(config)#class-map match-any cos3
Router(config-cmap)#match cos 3
Router(config-cmap)#commit
Router(config)#class-map match-any cos4
Router(config-cmap)#match cos 4
Router(config-cmap)#commit

/*Create classification policies*/
Router#config
Router(config)#policy-map ingress-classification
Route(config-pmap)#class cos2
Router(config-pmap-c)#set qos-group 1
Router(config-pmap-c)#set traffic-class 3
Router(config-pmap-c)#class cos3
Router(config-pmap-c)#set qos-group 2
Router(config-pmap-c)#set traffic-class 5
Router(config-pmap-c)#class cos4
Router(config-pmap-c)#set qos-group 3
Router(config-pmap-c)#set traffic-class 4
Router(config-pmap-c)#class class-default
Router(config-pmap-c)#set qos-group 7
Router(config-pmap-c)#set traffic-class 6
Router(config-pmap-c)#commit
```

Example— Egress Policy-Map Configuration:

```
*/Egress Marking Policy/*
Router#config
Router(config)#class-map match-any qos1
Router(config-cmap)#match qos-group 1
Router(config-cmap)#commit
Router(config)#class-map match-any qos2
Router(config-cmap)#match qos-group 2
Router(config-cmap)#commit
Router(config)#class-map match-any qos3
Router(config-cmap)#match qos-group 3
Router(config-cmap)#commit
Router#config
Router(config)#policy-map egress-marking
Route(config-pmap)#class qos1
```

```
Router(config-pmap-c)#set cos 1
Router(config-pmap-c)#class qos2
Router(config-pmap-c)#set cos 2
Router(config-pmap-c)#set dei 1
Router(config-pmap-c)#class qos3
Router(config-pmap-c)#set cos 3
Router(config-pmap-c)#class class-default
Router(config-pmap-c)#set cos 7
Router(config-pmap-c)#commit

*/Egress Queuing Policy/*
Router#config
Router(config)#class-map match-any tc3
Router(config-cmap)#match traffic-class 3
Router(config-cmap)#commit
Router(config)#class-map match-any tc4
Router(config-cmap)#match traffic-class 3
Router(config-cmap)#commit
Router(config)#class-map match-any tc5
Router(config-cmap)#match traffic-class 3
Router(config-cmap)#commit
Router#config
Router(config)#policy-map egress-queuing
Route(config-pmap)#class tc3
Router(config-pmap-c)#shape average 2 mbps
Router(config-pmap-c)#class tc4
Router(config-pmap-c)#shape average 5 mbps
Router(config-pmap-c)#class tc5
Router(config-pmap-c)#shape average 7 mbps
Router(config-pmap-c)#class class-default
Router(config-pmap-c)#commit
```

Example— Attaching the policies to the Interface

```
Router#config
Router(config)#interface tenGigE 0/0/0/1
Router(config-if)#service-policy input ingress-classification
Router(config-if)#service-policy output egress-marking
Router(config-if)#service-policy output egress-queuing
Router(config-if)#commit
```

Restrictions

- Statistics for marking policy is not supported, that is, the show policy-map interface command does not display any output.
- Statistics output is displayed only when the queuing policy is applied.
- Egress marking policy can classify only on qos-group/discard-class.
- Egress queueing policy can classify only on traffic-class.
- Egress marking policy can mark only the cos/dei field in L2 header.

Restrictions

The following table lists Ingress QoS Scale limitation for these variants of the NCS 540 Series Routers.

- N540-24Z8Q2C-M

- N540X-ACC-SYS
- N540-ACC-SYS
- N540-28Z4C-SYS

Table 1: Ingress QoS Scale Limitation

	Class-Map Size	Maximum number of Interfaces with Ingress QoS Applied	
		Per Core	Per NPU
	4	767	767
	8	383	383
	16	191	191
	32	95	95

The table below lists Ingress QoS Scale limitation for these variants of the NCS 540 Series Routers.

- N540-28Z4C-SYS-A
- N540-28Z4C-SYS-D
- N540X-16Z4G8Q2C-A
- N540X-16Z4G8Q2C-D
- N540-12Z20G-SYS-A
- N540-12Z20G-SYS-D
- N540X-12Z16G-SYS-A
- N540X-12Z16G-SYS-D

Table 2: Ingress QoS Scale Limitation

	Class-Map Size	Maximum number of Interfaces with Ingress QoS Applied	
		Per Core	Per NPU
	4	767	767
	8	383	383
	16	191	191
	32	95	95

Note If you apply an ingress policy map to a bundle that has bundle members only from a single core of an NPU, the QoS resources are consumed on both cores of that NPU.

Other restrictions to follow:

- If you have a **set traffic class** statement explicitly configured in ingress service policy, it is mandatory to have a corresponding **match traffic class** on egress for the traffic to be correctly matched and the stats to be accounted in **show policy-map interface <> output** command. To match the ingress traffic to egress class-default, traffic class should be set to 0 on ingress.
- If you have a **set traffic class that is configured** in ingress service policy, and no corresponding **match traffic class** on egress, the traffic will not go to class default and the stats for this traffic flow will not be seen in **show policy-map interface <> output** command.
- If you do not have any **set traffic class** statement in ingress, then traffic will hit the default-class on egress.
- If you have a **set discard-class** statement configured in ingress service policy, it is mandatory to have a corresponding **match discard-class** on egress for the traffic to be correctly matched and the stats to be accounted in **show policy-map interface <> output** command.
- If you have a **set discard-class** statement configured in ingress service policy and do not have a corresponding **match discard-class** on egress, the traffic will not hit the class-default and the stats for this flow will not be accounted in **show policy-map interface <> output** command.
- The system does not support class-map size on peering mode.
- Depending on the packet size, the traffic shaped value for low shaper rates, such as 10mbps, have greater deviation than 5% of tolerance from the shaper value. For higher shaper rates, the deviation is within the limit of 5% of tolerance from the shaper value for all packet sizes.

Restrictions for Peering QoS Profile

- After enabling the QoS peering feature using the **hw-module profile qos ingress-model peering** command, you can set the Layer 2 class of service (CoS) or drop eligible indicator (DEI) values at the egress using the **set cos** or **set dei** commands, respectively. However, at the egress, ensure you don’t set the MPLS experimental imposition (EXP) values (using the **set mpls experimental imposition** command). Otherwise, when committing the policy map with these configurations at the egress, you will encounter an error. This error occurs because the internal fields required for egress EXP marking are not available with peering enabled.
- **explicit set discard-class** statement is not supported.
- This feature is supported only on L3 interfaces and is limited to 1000 L3 interfaces per system.
- **set mpls exp topmost** statement is not supported within QoS in peering mode.
- **access group** statement is not supported.
- (Only in Release 6.2.x and Release 6.3.x) **set mpls exp imposition** statement is not supported on ingress interface.
- 2-Level ingress policer is not supported.

- (From Release 6.5.x) Egress H-QOS with peering profile support is enabled, but ingress H-QOS with peering profile is not supported.
- Depending on the packet size, the traffic shaped value for low shaper rates, such as 10mbps, have greater deviation than 5% of tolerance from the shaper value. For higher shaper rates, the deviation is within the limit of 5% of tolerance from the shaper value for all packet sizes.

Restrictions for QoS on BVI

- The system does not support the egress policy on Bridge-Group Virtual Interface (BVI), but BVI (CoS, DEI) marking is supported by applying the policy to its corresponding Layer 2 interface, which is part of the same bridge domain.
- If you apply L3 ingress QoS policy on L2 interface, which is a part of the same bridge-domain as BVI, the classification might not work if packets are destined to the BVI MAC address.
- If a QoS policy is attached to BVI, the policy is inherited by the L2 interfaces, which are part of the same bridge-domain. Hence, any other policy cannot be applied on the L2 interfaces. Similarly, if a QoS policy is attached to any of the L2 interfaces, any QoS policy cannot be applied on the BVI, which is part of the same bridge-domain.

Restrictions for Egress Drop Action

- A maximum of 8 interfaces can have the drop action configured and a maximum of 8 classes in any single policy can have the drop action.
- A drop action in any particular class cannot be combined with other actions.
- Drop action in a policy applied on the main interface is not inherited onto sub-interfaces.
- Match condition for drop action PM can only based on qos-group, discard class based match is not supported.

In-Place Policy Modification

The In-Place policy modification feature allows you to modify a QoS policy even when the QoS policy is attached to one or more interfaces. A modified policy is subjected to the same checks that a new policy is subject to when it is bound to an interface. If the policy-modification is successful, the modified policy takes effect on all the interfaces to which the policy is attached. However, if the policy modification fails on any one of the interfaces, an automatic rollback is initiated to ensure that the pre-modification policy is in effect on all the interfaces.

You can also modify any class map used in the policy map. The changes made to the class map take effect on all the interfaces to which the policy is attached.

Note

- The QoS statistics for the policy that is attached to an interface are lost (reset to 0) when the policy is modified.
- When a QoS policy attached to an interface is modified, there might not be any policy in effect on the interfaces in which the modified policy is used for a short period of time.
- The system does not support the show policy-map statistics for marking policies.
- An in-place modification of an ACL does not reset the policy-map statistics counter.

Note

- For QOS EXP-Egress marking applied on a Layer 3 interface on Cisco routers, there is a limit of two unique policy-maps per NPU. When the maximum limit for policy-maps is reached and you try to modify a policy-map which is shared between different interfaces, you may get an error.
- For QOS egress marking (CoS, DEI) applied on a Layer 2 interface, there is a limit of 13 unique policy-maps per NPU. When the maximum limit for policy-maps is reached and you try to modify a policy-map which is shared between different interfaces, you may get an error.

Verification

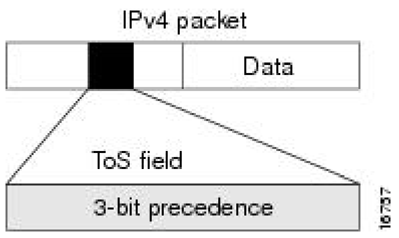
If unrecoverable errors occur during in-place policy modification, the policy is put into an inconsistent state on target interfaces. No new configuration is possible until the configuration session is unblocked. It is recommended to remove the policy from the interface, check the modified policy and then re-apply accordingly.

References for Modular QoS Service Packet Classification

Specification of the CoS for a Packet with IP Precedence

Use of IP precedence allows you to specify the CoS for a packet. You can create differentiated service by setting precedence levels on incoming traffic and using them in combination with the QoS queuing features. So that, each subsequent network element can provide service based on the determined policy. IP precedence is usually deployed as close to the edge of the network or administrative domain as possible. This allows the rest of the core or backbone to implement QoS based on precedence.

Figure 2: IPv4 Packet Type of Service Field



You can use the three precedence bits in the type-of-service (ToS) field of the IPv4 header for this purpose. Using the ToS bits, you can define up to eight classes of service. Other features configured throughout the network can then use these bits to determine how to treat the packet in regard to the ToS to grant it. These other QoS features can assign appropriate traffic-handling policies, including congestion management strategy and bandwidth allocation. For example, queuing features such as LLQ can use the IP precedence setting of the packet to prioritize traffic.

IP Precedence Bits Used to Classify Packets

Use the three IP precedence bits in the ToS field of the IP header to specify the CoS assignment for each packet. You can partition traffic into a maximum of eight classes and then use policy maps to define network policies in terms of congestion handling and bandwidth allocation for each class.

Each precedence corresponds to a name. IP precedence bit settings 6 and 7 are reserved for network control information, such as routing updates. These names are defined in RFC 791.

IP Precedence Value Settings

By default, the routers leave the IP precedence value untouched. This preserves the precedence value set in the header and allows all internal network devices to provide service based on the IP precedence setting. This policy follows the standard approach stipulating that network traffic should be sorted into various types of service at the edge of the network and that those types of service should be implemented in the core of the network. Routers in the core of the network can then use the precedence bits to determine the order of transmission, the likelihood of packet drop, and so on.

Because traffic coming into your network can have the precedence set by outside devices, we recommend that you reset the precedence for all traffic entering your network. By controlling IP precedence settings, you prohibit users that have already set the IP precedence from acquiring better service for their traffic simply by setting a high precedence for all of their packets.

The class-based unconditional packet marking and LLQ features can use the IP precedence bits.

IP Precedence Compared to IP DSCP Marking

If you need to mark packets in your network and all your devices support IP DSCP marking, use the IP DSCP marking to mark your packets because the IP DSCP markings provide more unconditional packet marking options. If marking by IP DSCP is undesirable, however, or if you are unsure if the devices in your network support IP DSCP values, use the IP precedence value to mark your packets. The IP precedence value is likely to be supported by all devices in the network.

You can set up to 8 different IP precedence markings and 64 different IP DSCP markings.

Conditional Marking of MPLS Experimental bits for L2VPN Traffic

This feature is supported on Virtual Private Wire Service (VPWS), and Virtual Private LAN Service (VPLS) traffic in the L2VPN network, and currently not supported for Ethernet Virtual Private Network (EVPN).

The conditional marking of MPLS experimental bits is achieved for Layer 2 Virtual Private Network (L2VPN) traffic by applying a combination of ingress and egress policy-maps on the Provider Edge (PE) router. In the ingress policy-map, the qos-group or discard-class is set either based on the result of the policing action or implicitly. The egress policy-map matches on qos-group or on a combination of qos-group and discard-class and sets the mpls experiment bits to the corresponding value.

Conditional marking can be used to mark the MPLS experimental bits differently for in-contract and out-of-contract packets. In-contract packets are the confirmed packets with the color green and discard-class set to 0. Out-of-contract packets are the packets which have exceeded the limit and have the color yellow and discard-class set to 1.

Conditional marking of MPLS experimental bits for L2VPN traffic is supported on both physical and bundle main interfaces as well as sub-interfaces.

Restrictions for Conditional Marking of MPLS Experimental bits on L2VPN

1. In the case of two PE routers connected back-to-back and the only label that the traffic between the routers have is the BGP label, then the explicit null label should be configured.
2. A maximum of two policy-maps which perform conditional marking of MPLS experimental bits can be configured per Network Processor Unit (NPU) of the Cisco NCS 560 Series Routers. However, the same policy can be applied on multiple interfaces on the same NPU.
3. In the ingress policy-map if qos-group is being set for the incoming traffic packets, then setting of dscp and mpls experimental bits will not work.
4. Both the ingress and egress policy-maps must be applied in order to attain the expected behaviour. If either one of them is not applied then it may lead to undefined behaviour.
5. If the egress policy-map does not match on qos-group or discard-class and set the mpls experiment bits to the required value, then the mpls experimental bits will be set to a value of zero, by default.

Policy-map for conditional marking of incoming traffic

The incoming packets on the Power Edge router are classified based on the ingress policy-map and these actions are taken.

- Set qos-group
- Discard class or drop precedence is set implicitly or as a result of a policing action.
- Set traffic class
- Packets that violate the configured policer are dropped in the ingress processing itself.

Running Configuration:

```
class-map af11
   match cos 1
!

policy-map ingress
 class af11
  police rate percent 10 peak-rate percent 20
  !
  set qos-group 1
  set Traffic-class 3
 !
 class class-default
 !
 end-policy-map
!
```

Policy-map for conditional marking of outgoing MPLS traffic

The ingress packet undergoes MPLS encapsulation during the egress processing in the PE router which performs the label imposition. The MPLS experimental bits are marked on the basis of egress policy-map which performs the following actions:

- Match on qos-group or discard class or both
- Set the MPLS experimental bits based on the match criteria

Running Configuration:

```
class-map match-all qos-group2_0
   match qos-group 2
   match discard-class 0

policy-map egress-marking
 class qos-group2_0 # This class matches on qos-group 2 and discard-class 0
  set mpls experimental imposition 1
 !
 class class-default
 !
 end-policy-map
!
policy-map Egress-Queuing
 class Traffic-class3
  shape average 500 mbps
!
 class class-default
!
end-policy-map
!
```

CHAPTER 2

Configuring Modular QoS Congestion Avoidance

This chapter covers the following topics:

Modular QoS Congestion Avoidance

Congestion avoidance techniques monitor traffic flow to anticipate and avoid congestion at common network bottlenecks. Avoidance techniques are implemented before congestion occurs as compared with congestion management techniques that control congestion after it has occurred.

Note For traffic requiring header decapsulation, the size of the header that is being removed is still included for the egress queuing actions. To offset this header size (required to achieve line rate for small frame sizes), configure an egress user policy with user overhead accounting on the egress interface. This policy can be a dummy policy configuration as well (allowing full traffic rate), if a policy isn't already in use or required on the egress interface.

You can enable user overhead accounting using the optional configuration of **accounting user-defined <*overhead size in bytes*>** while attaching the service policy on the egress interface.

Congestion avoidance is achieved through packet dropping. The router supports these QoS congestion avoidance techniques:

Tail Drop and the FIFO Queue

Tail drop is a congestion avoidance technique that drops packets when an output queue is full until congestion is eliminated. Tail drop treats all traffic flow equally and does not differentiate between classes of service. It manages the packets that are unclassified, placed into a first-in, first-out (FIFO) queue, and forwarded at a rate determined by the available underlying link bandwidth.

Configure Tail Drop

Packets satisfying the match criteria for a class accumulate in the queue reserved for the class until they are serviced. The **queue-limit** command is used to define the maximum threshold for a class. When the maximum threshold is reached, the enqueued packets to the class queue result in tail drop (packet drop).

Restrictions

- When configuring the **queue-limit** command, you must configure one of the following commands: **priority**, **shape average**, **bandwidth** or **bandwidth remaining**, except for the default class.

Configuration Example

You have to accomplish the following to complete the tail drop configuration:

1. Creating (or modifying) a policy map that can be attached to one or more interfaces to specify a service policy
2. Associating the traffic class with the traffic policy
3. Specifying the maximum limit the queue can hold for a class policy configured in a policy map.
4. Specifying priority to a class of traffic belonging to a policy map.
5. (Optional) Specifying the bandwidth allocated for a class belonging to a policy map or specifying how to allocate leftover bandwidth to various classes.
6. Attaching a policy map to an output interface to be used as the service policy for that interface.

```
Router# configure
Router(config)# class-map qos-1
Router(config-cmap)# match traffic-class 1
Router(config-cmap)# commit
Router(config-pmap)# exit

Router(config)# policy-map test-qlimit-1
Router(config-pmap)# class qos-1
Router(config-pmap-c)# queue-limit 100 us
Router(config-pmap-c)# priority level 7
Router(config-pmap-c)# exit
Router(config-pmap)# exit

Router(config)# interface HundredGigE 0/6/0/18
Router(config-if)# service-policy output test-qlimit-1
Router(config-if)# commit
```

Running Configuration

```
class-map qos-1
 match traffic-class 1
commit

policy-map test-qlimit-1
 class qos-1
  queue-limit 100 us
  priority level 7
 !
 class class-default
 !
 end-policy-map
!
```

Verification

```
Router# show qos int hundredGigE 0/6/0/18 output

NOTE:- Configured values are displayed within parentheses
Interface HundredGigE0/6/0/18 ifh 0x3000220  -- output policy
NPU Id:                        3
Total number of classes:       2
Interface Bandwidth:           100000000 kbps
VOQ Base:                      11176
VOQ Stats Handle:              0x88550ea0
Accounting Type:               Layer1 (Include Layer 1 encapsulation and above)
------------------------------------------------------------------------------
Level1 Class (HP7)                          =   qos-1
Egressq Queue ID                            =   11177 (HP7 queue)
TailDrop Threshold                          =   1253376 bytes / 100 us (100 us)
WRED not configured for this class

Level1 Class                                =   class-default
Egressq Queue ID                            =   11176 (Default LP queue)
Queue Max. BW.                              =   101803495 kbps (default)
Queue Min. BW.                              =   0 kbps (default)
Inverse Weight / Weight                     =   1 (BWR not configured)
TailDrop Threshold                          =   1253376 bytes / 10 ms (default)
WRED not configured for this class
```

Related Topics

- Tail Drop and the FIFO Queue, on page 43

Associated Commands

- queue-limit

Random Early Detection and TCP

The Random Early Detection (RED) congestion avoidance technique takes advantage of the congestion control mechanism of TCP. By randomly dropping packets prior to periods of high congestion, RED tells the packet source to decrease its transmission rate. Assuming the packet source is using TCP, it decreases its transmission rate until all packets reach their destination, indicating that the congestion is cleared. You can use RED as a way to cause TCP to slow transmission of packets. TCP not only pauses, but it also restarts quickly and adapts its transmission rate to the rate that the network can support.

RED distributes losses in time and maintains normally low queue depth while absorbing traffic bursts. When enabled on an interface, RED begins dropping packets when congestion occurs at a rate you select during configuration.

Configure Random Early Detection

The **random-detect** command with the **default** keyword must be used to enable random early detection (RED).

Guidelines

If you configure the **random-detect default** command on any class including class-default, you must configure one of the following commands: **shape average**, **bandwidth**, and **bandwidth remaining**.

Configuration Example

You have to accomplish the following to complete the random early detection configuration:

1. Creating (or modifying) a policy map that can be attached to one or more interfaces to specify a service policy
2. Associating the traffic class with the traffic policy
3. Enabling RED with default minimum and maximum thresholds.
4. (Optional) Specifying the bandwidth allocated for a class belonging to a policy map or specifying how to allocate leftover bandwidth to various classes.
5. (Optional) Shaping traffic to the specified bit rate or a percentage of the available bandwidth.
6. Attaching a policy map to an output interface to be used as the service policy for that interface.

```
Router# configure
Router(config)# class-map qos-1
Router(config-cmap)# match traffic-class 1
Router(config-cmap)# commit
Router(config-pmap)# exit

Router# configure
Router(config)# policy-map test-wred-2
Router(config-pmap)# class qos-1
Router(config-pmap-c)# random-detect default
Router(config-pmap-c)# shape average percent 10
Router(config-pmap-c)# end-policy-map
Router(config)# commit
Router(config)# interface HundredGigE 0/6/0/18
Router(config-if)# service-policy output test-wred-2
Router(config-if)# commit
```

Running Configuration

```
class-map qos-1
 match traffic-class 1
commit

policy-map test-wred-2
 class qos-1
  random-detect default
  shape average percent 10
 !
 class class-default
 !
 end-policy-map
!

interface HundredGigE 0/6/0/18
 service-policy output test-wred-2
!
```

Verification

```
Router# show qos int hundredGigE 0/6/0/18 output

NOTE:- Configured values are displayed within parentheses
Interface HundredGigE0/6/0/18 ifh 0x3000220  -- output policy
NPU Id:                        3
Total number of classes:       2
Interface Bandwidth:           100000000 kbps
VOQ Base:                      11176
VOQ Stats Handle:              0x88550ea0
Accounting Type:               Layer1 (Include Layer 1 encapsulation and above)
------------------------------------------------------------------------------
Level1 Class                             =   qos-1
Egressq Queue ID                         =   11177 (LP queue)
Queue Max. BW.                           =   10082461 kbps (10 %)
Queue Min. BW.                           =   0 kbps (default)
Inverse Weight / Weight                  =   1 (BWR not configured)
Guaranteed service rate                  =   10000000 kbps
TailDrop Threshold                       =   12517376 bytes / 10 ms (default)

Default RED profile
WRED Min. Threshold                      =   12517376 bytes (10 ms)
WRED Max. Threshold                      =   12517376 bytes (10 ms)

Level1 Class                             =   class-default
Egressq Queue ID                         =   11176 (Default LP queue)
Queue Max. BW.                           =   101803495 kbps (default)
Queue Min. BW.                           =   0 kbps (default)
Inverse Weight / Weight                  =   1 (BWR not configured)
Guaranteed service rate                  =   50000000 kbps
TailDrop Threshold                       =   62652416 bytes / 10 ms (default)
WRED not configured for this class
```

Related Topics

- Random Early Detection and TCP, on page 45

Associated Commands

- random-detect

Weighted Random Early Detection

The Weighted Random Early Detection (WRED) drops packets selectively based on any specified criteria, like discard-class. WRED uses this matching criteria to determine how to treat different types of traffic.

You can configure WRED using the **random-detect** command and different discard-class values. The value can be range or a list of values that are valid for that field. You can also use minimum and maximum queue thresholds to determine the dropping point. Ensure that the WRED maximum threshold value is close to the queue limit. When the maximum threshold value is reached, packets start to get dropped.

When a packet arrives, the following actions occur:

- The average queue size is calculated.
- If the average queue size is less than the minimum queue threshold, the arriving packet is queued.
- If the average queue size is between the minimum queue threshold for that type of traffic and the maximum threshold for the interface, the packet is either dropped or queued, depending on the packet drop probability for that type of traffic.
- If the average queue size is greater than the maximum threshold, the packet is dropped.

Average Queue Size for WRED

The router automatically determines the parameters to use in the WRED calculations. The average queue size is based on the previous average and current size of the queue. The formula is:

average = (old_average * (1-2 -x)) + (current_queue_size * 2 -x)

where *x* is the exponential weight factor.

For high values of *x*, the previous average becomes more important. A large factor smooths out the peaks and lows in queue length. The average queue size is unlikely to change very quickly, avoiding a drastic change in size. The WRED process is slow to start dropping packets, but it may continue dropping packets for a time after the actual queue size has fallen below the minimum threshold. The slow-moving average accommodates temporary bursts in traffic.

Note

- The exponential weight factor, *x*, is fixed and is not user configurable.
- If the value of *x* gets too high, WRED does not react to congestion. Packets are sent or dropped as if WRED were not in effect.
- If the value of *x* gets too low, WRED overreacts to temporary traffic bursts and drops traffic unnecessarily.

For low values of *x*, the average queue size closely tracks the current queue size. The resulting average may fluctuate with changes in the traffic levels. In this case, the WRED process responds quickly to long queues. Once the queue falls below the minimum threshold, the process stops dropping packets.

Configure Weighted Random Early Detection

This configuration task is similar to that used for RED except that the **random-detect** command is not configured in RED.

Restrictions

- You cannot use the **random-detect** command in a class configured with the **priority** command, because WRED cannot be configured in a class that has been set for priority queueing (PQ).

- When configuring the **random-detect** command, you must configure one of the following commands: **shape average**, **bandwidth**, and **bandwidth remaining**.

Configuration Example

You have to accomplish the following to complete the random early detection configuration:

1. Creating (or modifying) a policy map that can be attached to one or more interfaces to specify a service policy
2. Associating the traffic class with the traffic policy
3. Enabling WRED by specifying the match criteria (discard-class).
4. (Optional) Specifying the bandwidth allocated for a class belonging to a policy map or specifying how to allocate leftover bandwidth to various classes.
5. (Optional) Shaping traffic to the specified bit rate or a percentage of the available bandwidth.
6. (Optional) Changing queue limit to fine-tune the amount of buffers available for each queue.
7. Attaching a policy map to an output interface to be used as the service policy for that interface.

```
Router# configure
Router(config)# class-map qos-1
Router(config-cmap)# match traffic-class 1
Router(config-cmap)# commit
Router(config-pmap)# exit

Router# configure
Router(config)# policy-map test-wred-1
Router(config-pmap)# class qos-1
Router(config-pmap-c)# random-detect default
Router(config-pmap-c)# random-detect discard-class 0 10 ms 500 ms
Router(config-pmap-c)# shape average percent 10
Router(config-pmap-c)# commit

Router(config)# interface HundredGigE 0/6/0/18
Router(config-if)# service-policy output policy1
Router(config-if)# commit
```

Running Configuration

```
class-map qos-1
 match traffic-class 1
commit

policy-map test-wred-1
 class qos-1
  random-detect default
  random-detect discard-class 0 10 ms 500 ms
  shape average percent 10
 !
 class class-default
 !
 end-policy-map
!
```

```
interface HundredGigE 0/6/0/18
 service-policy output test-wred-1
!
```

Verification

```
Router# show qos int hundredGigE 0/0/0/20 output

NOTE:- Configured values are displayed within parentheses
Interface HundredGigE0/0/0/20 ifh 0x38  -- output policy
NPU Id:                        0
Total number of classes:       2
Interface Bandwidth:           100000000 kbps
Policy Name:                   test-wred-1
VOQ Base:                      1184
Accounting Type:               Layer1 (Include Layer 1 encapsulation and above)
------------------------------------------------------------------------------
Level1 Class                             =   qos-1
Egressq Queue ID                         =   1185 (LP queue)
Queue Max. BW.                           =   10000152 kbps (10 %)
Queue Min. BW.                           =   0 kbps (default)
Inverse Weight / Weight                  =   1 / (BWR not configured)
Guaranteed service rate                  =   10000000 kbps
Peak burst                               =   36864 bytes (default)
TailDrop Threshold                       =   1250000896 bytes / 1000 ms (default)

WRED profile for Discard_Class 0
WRED Min. Threshold                      =   12499968 bytes (10 ms)
WRED Max. Threshold                      =   624999936 bytes (500 ms)

Default RED profile
WRED Min. Threshold                      =   7499776 bytes (6 ms)
WRED Max. Threshold                      =   12499968 bytes (10 ms)

WRED ECN                                 =   Disabled

Level1 Class                             =   class-default
Egressq Queue ID                         =   1184 (Default LP queue)
Queue Max. BW.                           =   no max (default)
Queue Min. BW.                           =   0 kbps (default)
Inverse Weight / Weight                  =   1 / (BWR not configured)
Guaranteed service rate                  =   50000000 kbps
Peak burst                               =   36864 bytes (default)
TailDrop Threshold                       =   62499840 bytes / 10 ms (default)
WRED not configured for this class
```

Related Topics

- Weighted Random Early Detection, on page 47
- Configure Random Early Detection, on page 46

Associated Commands

- random-detect

Explicit Congestion Notification (ECN)

Weighted Random Early Detection (WRED) is implemented at the core routers of a network. Edge routers assign IP precedences to packets, as the packets enter the network. With WRED, core routers then use these precedences to determine how to treat different types of traffic. WRED provides separate thresholds and weights for different IP precedences, enabling the network to provide different qualities of service, in regard to packet dropping, for different types of traffic. Standard traffic may be dropped more frequently than premium traffic during periods of congestion.

ECN is an extension to WRED. ECN marks packets instead of dropping them when the average queue length exceeds a specific threshold value. When configured, ECN helps routers and end hosts to understand that the network is congested and slow down sending packets. However If the number of packets in the queue is above the maximum threshold, packets are dropped based on the drop probability. This is the identical treatment that a packet receives when WRED is enabled without ECN configured on the router.

RFC 3168, *The Addition of Explicit Congestion Notification (ECN) to IP*, states that with the addition of active queue management (for example, WRED) to the Internet infrastructure, routers are no longer limited to packet loss as an indication of congestion.

Note You cannot use this feature when you have set qos-group or mpls experimental along with a traffic class in the ingress policy.

Implementing ECN

Implementing ECN requires an ECN-specific field that has 2 bits—the ECN-capable Transport (ECT) bit and the CE (Congestion Experienced) bit—in the IP header. The ECT bit and the CE bit can be used to make four ECN field combinations of 00 to 11. The first number is the ECT bit and the second number is the CE bit.

Table 3: ECN Bit Setting

ECT Bit	CE Bit	Combination Indicates
0	0	Not-ECN-capable.
0	1	Endpoints of the transport protocol are ECN-capable.
1	0	Endpoints of the transport protocol are ECN-capable.
1	1	Congestion experienced.

The ECN field combination 00 indicates that a packet is not using ECN. The ECN field combinations 01 and 10—Called ECT(1) and ECT(0), respectively—are set by the data sender to indicate that the endpoints of the transport protocol are ECN-capable. Routers treat these two field combinations identically. Data senders can use either one or both of these two combinations. The ECN field combination 11 indicates congestion to the endpoints. Packets arriving a full queue of a router will be dropped.

Packet Handling When ECN Is Enabled

When the number of packets in the queue is below the minimum threshold, packets are transmitted. This happens whether ECN is enabled or not, and this treatment is identical to the treatment a packet receives when WRED only is being used on the network.

If the number of packets in the queue is above the maximum threshold:

- For traffic flows that are not ECN-enabled in only WRED-configured queues, packets are tail-dropped after the queue size exceeds the WRED maximum threshold.
- For traffic flows that are ECN-enabled in only WRED-configured queues, packets are tail-dropped when the queue size exceeds the tail-drop threshold.
- When you configure ECN remarking on your router, incoming packets with ECT bit settings 0 or 1 are marked as CE.

Note When the number of packets reaches the queue limit, all packets are dropped. This is the identical treatment that a packet receives when you enable WRED without ECN configured on the router.

Three different scenarios arise if the number of packets in the queue is between the minimum threshold and the maximum threshold:

- If the ECN field on the packet indicates that the endpoints are ECN-capable (that is, the ECT bit is set to 1 and the CE bit is set to 0, or the ECT bit is set to 0 and the CE bit is set to 1)—and the WRED algorithm determines that the packet should have been dropped based on the drop probability—the ECT and CE bits for the packet are changed to 1, and the packet is transmitted. This happens because ECN is enabled and the packet gets marked instead of dropped.
- If the ECN field on the packet indicates that neither endpoint is ECN-capable (that is, the ECT bit is set to 0 and the CE bit is set to 0), packet is dropped once the queue limit is reached.
- If the ECN field on the packet indicates that the network is experiencing congestion (that is, both the ECT bit and the CE bit are set to 1), the packet is transmitted. No further marking is required.

Note When the incoming IP traffic with ECN bits set to 10 passes through the ingress qos-policy-map that has the class-map definition of `set DSCP/PREC <value>`, then the ECN bits in the IP header gets modified to 01.

Limitations

Configuration Example

```
Router# configure
Router(config)# policy-map policy1
Router(config-pmap)# class class1
Router(config-pmap-c)# bandwidth percent 50
Router(config-pmap-c)# random-detect 1000 packets 2000 packets
Router(config-pmap-c)# random-detect ecn
Router(config-pmap-c)# exit
Router(config-pmap)# exit
Router(config)# commit
```

Verification

Use the **show policy-map interface** to verify the configuration.

```
Router# show policy-map interface tenGigE 0/0/0/6 output
TenGigE0/0/0/6 output: pm-out-queue

Class cm-tc-1
  Classification statistics          (packets/bytes)     (rate - kbps)
    Matched             :            85528554/87581239296          4830672
    Transmitted         :            16240891/16630672384          966585
    Total Dropped       :            69287663/70950566912          3864087
  Queueing statistics
    Queue ID                             : 1113
    Taildropped(packets/bytes)           : 69287663/70950566912

    WRED profile for
    RED Transmitted (packets/bytes)            : N/A
    RED random drops(packets/bytes)            : N/A
    RED maxthreshold drops(packets/bytes)      : N/A
    RED ecn marked & transmitted(packets/bytes): N/A
Class class-default
  Classification statistics          (packets/bytes)     (rate - kbps)
    Matched             :                   0/0                   0
    Transmitted         :                   0/0                   0
    Total Dropped       :                   0/0                   0
  Queueing statistics
    Queue ID                             : 1112
    Taildropped(packets/bytes)           : 0/0
```

Note No ECN-specific statistics are displayed in the show output for this command. ECN is enabled if all rows indicate **N/A**, as highlighted in the example.

CHAPTER 3

Configuring Modular QoS Congestion Management

This chapter covers the following topics:

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 types of traffic regulation mechanisms supported are:

Class-based Weighted Fair Queueing

Class-based Weighted Fair Queueing (CBWFQ) allows definition of traffic classes based on customer match criteria. With CBWFQ you can define traffic classes and assign guaranteed amount of minimum bandwidth to them. CBWFQ also allows for a strict priority queue for delay-sensitive traffic.

Bandwidth Remaining

The algorithm derives the weight for each class from the bandwidth remaining value allocated to the class. The **bandwidth remaining** option specifies a weight for the class to the . After the priority-queue is serviced, the leftover bandwidth is distributed as per bandwidth remaining ratio (BWRR) or percentage. If you do not configure this command for any class, the default value of the BWRR is considered as 1 (one). In the case of

bandwidth remaining percent, the remaining bandwidth is equally distributed among other classes, to make it 100 percentage (100%).

Restrictions

- The **bandwidth remaining** command is supported only for egress policies.

Configuring Bandwidth Remaining

Supported Platforms: Cisco NCS 560 Series Routers.

This procedure configures the minimum bandwidth and bandwidth remaining on the router

Note The **bandwidth**, **bandwidth remaining**, **shaping**, **queue-limit** and wred commands may be configured together in the same class. But, **priority** cannot be configured along with **bandwidth**, **bandwidth remaining** and wred commands.

Configuration Example

You have to accomplish the following to complete the bandwidth remaining configuration:

1. Creating or modifying a policy-map that can be attached to one or more interfaces
2. Specifying the traffic class whose policy has to be created or changed
3. Allocating the leftover bandwidth for the class
4. Attaching the policy-map to an output interface

```
Router# configure
Router(config)#class-map qos-6
Router(config-cmap)#match traffic-class 4
Router(config-cmap)#exit
Router(config-cmap)#commit

Router(config)#class-map qos-5
Router(config-cmap)#match traffic-class 5
Router(config-cmap)#commit

Router(config)# policy-map test-bw-bw-rem
Router(config-pmap)# class qos-6
Router(config-pmap-c)# bandwidth percent 60
Router(config-pmap-c)# bandwidth remaining percent 60
Router(config-pmap)#class qos-5
Router(config-pmap-c)#bandwidth percent 20
Router(config-pmap-c)#bandwidth remaining percent 40
Router(config-pmap-c# exit
Router(config-pmap)# exit
Router(config)# interface HundredGigE 0/6/0/18
Router(config-if)# service-policy output test-bw-bw-rem
Router(config-if)# commit
```

Running Configuration

```
policy-map test-bw-bw-rem
 class qos-6
  bandwidth percent 60
  bandwidth remaining percent 60
 !
 class qos-5
  bandwidth percent 20
  bandwidth remaining percent 40
 !
 class class-default
 !
 end-policy-map
!

interface HundredGigE0/6/0/18
 service-policy output test-bw-bw-rem
!
```

Verification

```
Router# **show qos interface HundredGigE 0/6/0/18 output**

NOTE:- Configured values are displayed within parentheses
Interface HundredGigE0/6/0/18 ifh 0x3000220  -- output policy
NPU Id:                        3
Total number of classes:       3
Interface Bandwidth:           100000000 kbps
VOQ Base:                      11176
VOQ Stats Handle:              0x88550ea0
Accounting Type:               Layer1 (Include Layer 1 encapsulation and above)
------------------------------------------------------------------------------
Level1 Class                             =   qos-6
Egressq Queue ID                         =   11182 (LP queue)
Queue Max. BW.                           =   100824615 kbps (default)
Queue Min. BW.                           =   60494769 kbps (60 %)
Inverse Weight / Weight                  =   2 (60%)
Guaranteed service rate                  =   71881188 kbps
TailDrop Threshold                       =   90177536 bytes / 10 ms (default)
WRED not configured for this class

Level1 Class                             =   qos-5
Egressq Queue ID                         =   11181 (LP queue)
Queue Max. BW.                           =   100824615 kbps (default)
Queue Min. BW.                           =   20164923 kbps (20 %)
Inverse Weight / Weight                  =   3 (40%)
Guaranteed service rate                  =   27920792 kbps
TailDrop Threshold                       =   35127296 bytes / 10 ms (default)
WRED not configured for this class

Level1 Class                             =   class-default
Egressq Queue ID                         =   11176 (Default LP queue)
Queue Max. BW.                           =   101803495 kbps (default)
Queue Min. BW.                           =   0 kbps (default)
Inverse Weight / Weight                  =   120 (BWR not configured)
Guaranteed service rate                  =   198019 kbps
TailDrop Threshold                       =   247808 bytes / 10 ms (default)
WRED not configured for this class
```

Related Topics

- Bandwidth Remaining, on page 55

Associated Commands

- bandwidth remaining

Low-Latency Queuing with Strict Priority Queuing

The Low-Latency Queuing (LLQ) feature brings strict priority queuing (PQ) to the CBWFQ scheduling mechanism. Priority queuing (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.

Configuring Low Latency Queuing with Strict Priority queuing

Configuring low latency queuing (LLQ) with strict priority queuing (PQ) allows delay-sensitive data such as voice to be de-queued and sent before the packets in other queues are de-queued.

Guidelines

- Priority level 1 to 7 is supported for non-H-QoS profiles, with 1 being the highest priority and 7 being the lowest. For H-QoS profiles, priority level 1 to 4 is supported. For all profiles, however, the class default is CoSQ 0 and has the lowest priority among all.
- Egress policing is not supported. Hence, in the case of strict priority queuing, there are chances that the other queues do not get serviced.
- You can configure **shape average** and **queue-limit** commands along with **priority**.
- You can configure **shape average**, **random-detect**, and **queue-limit** commands along with **priority**.

Configuration Example

You have to accomplish the following to complete the LLQ with strict priority queuing:

1. Creating or modifying a policy-map that can be attached to one or more interfaces
2. Specifying the traffic class whose policy has to be created or changed.
3. Specifying priority to the traffic class
4. Attaching the policy-map to an output interface

```
Router# configure
Router(config)#class-map qos-1
Router(config-cmap)#match traffic-class 1
Router(config-cmap)#commit

Router(config)#class-map qos-2
Router(config-cmap)#match traffic-class 2
Router(config-cmap)#commit

Router(config)# policy-map test-priority-1
Router(config-pmap)# class qos1
Router(config-pmap-c)# priority level 7
Router(config-pmap-c)# shape average percent 2
Router(config-pmap-c)# class qos-2
Router(config-pmap-c)# priority level 6
Router(config-pmap-c)# shape average percent 1
Router(config-pmap-c)# commit
Router(config-pmap-c# exit
Router(config-pmap)# exit

Router(config)# interface HundredGigE 0/0/0/20
Router(config-if)# service-policy output test-priority-1
Router(config-if)# commit
```

Running Configuration

```
policy-map test-priority-1
 class qos-1
  priority level 7
  shape average percent 2
 !
 class qos-2
  priority level 6
  shape average percent 1
 !
 class class-default
 !
 end-policy-map
!

interface HundredGigE0/0/0/20
 service-policy output test-priority-1
!
```

Verification

```
Router#  show qos int hundredGigE 0/0/0/20 output

NOTE:- Configured values are displayed within parentheses
Interface HundredGigE0/0/0/20 ifh 0x38  -- output policy
NPU Id:                         0
Total number of classes:        3
Interface Bandwidth:            100000000 kbps
Policy Name:                    test-priority-1
VOQ Base:                       1184
Accounting Type:                Layer1 (Include Layer 1 encapsulation and above)
------------------------------------------------------------------------------
Level1 Class (HP7)                       =   qos-1
Egressq Queue ID                         =   1185 (HP7 queue)
Queue Max. BW.                           =   2000000 kbps (2 %)
Guaranteed service rate                  =   2000000 kbps
Peak burst                               =   36864 bytes (default)
TailDrop Threshold                       =   2499840 bytes / 10 ms (default)
WRED not configured for this class

Level1 Class (HP6)                       =   qos-2
```

```
Egressq Queue ID                        =   1186 (HP6 queue)
Queue Max. BW.                          =   1000000 kbps (1 %)
Guaranteed service rate                 =   1000000 kbps
Peak burst                              =   36864 bytes (default)
TailDrop Threshold                      =   1249792 bytes / 10 ms (default)
WRED not configured for this class

Level1 Class                            =   class-default
Egressq Queue ID                        =   1184 (Default LP queue)
Queue Max. BW.                          =   no max (default)
Queue Min. BW.                          =   0 kbps (default)
Inverse Weight / Weight                 =   1 / (BWR not configured)
Guaranteed service rate                 =   97000000 kbps
Peak burst                              =   36864 bytes (default)
TailDrop Threshold                      =   121249792 bytes / 10 ms (default)
WRED not configured for this class
```

Associated Commands

- priority

Overhead Accounting

Traffic shapers and policers use packet traffic descriptors to ensure adherence to the service level agreement in QoS. However, when traffic flows from one hop to another in a network, headers added or removed at interim hops affect the packet bytes being accounted for by QoS at each hop. When your end-user network measures the packet bytes to ensure they receive the payload as agreed, these additional header bytes cause a discrepancy.

QoS overhead accounting provides the flexibility to operators to decide which header bytes can be excluded by the traffic shaper and policer and which can be included, depending on the end user's requirements and device capabilities, to meet the committed payload in units of bytes.

For example, if the QoS commitment includes the additional header bytes, the overhead accounting feature allows your router to account for this overhead and reduces the traffic policing and shaping rates accordingly. This is also called a **positive accounting overhead**.

If however, the committed rate doesn't include the additional bytes, overhead accounting allows your router to adjust the core stream traffic such that the traffic policing and shaping rates are increased. This is also called a **negative accounting overhead**.

To summarize, QoS overhead accounting enables the router to account for packet overhead when shaping and policing traffic to a specific rate. This accounting ensures that the router runs QoS features on the actual bandwidth that the subscriber traffic consumes.

Any interface that supports QoS policies supports overhead accounting.

Note You can enable user overhead accounting using the optional configuration of **accounting user-defined <*overhead size in bytes*>** while attaching the service policy on the egress interface.

Guidelines and Restrictions

- Overhead accounting for ingress shaping is not supported.

- You can't program more than one compensation value per NPU or router, even if they're on different egress ports.
- You can configure the same egress compensation for different egress ports.

Configuring for Overhead Accounting

To configure overhead accounting, you must:

1. Create a policy map and configure QoS actions for that map.
2. Configure overhead accounting and attach the map to an interface.

```
/* create QoS policy */
Router#configure terminal
Router(config)#policy-map policer
Router(config-pmap)#class class-default
Router(config-pmap-c)#police rate percent 10
Router(config-pmap-c-police)#commit
```

```
/* configure account overhead value while attaching the QoS policy to interface */
Router(config)#int hundredGigE 0/0/0/2
Router(config-if)#service-policy input policer account user-defined 12
Router(config-if)#commit
Router(config-if)#root
Router(config)#end
```

Running Configuration

```
Router#sh run int hundredGigE 0/0/0/2
interface HundredGigE0/0/0/2
service-policy input policer account user-defined 12
!
```

The following example shows how to **configure a negative overhead accounting value**:

```
Router#conf
Router(config)#int hundredGigE 0/0/0/2
Router(config-if)#service-policy input policer account user-defined -12
Router(config-if)#commit
```

To **modify an overhead accounting value,** you must:

1. Remove the existing QoS policy and re-add it.
2. Configure the new overhead accounting value.

```
Router#conf
Router(config)#int hundredGigE 0/0/0/2
Router(config-if)#no service-policy input policer
Router(config-if)#service-policy input policer account user-defined -20
Router(config-if)#commit
Router#sh run int hundredGigE 0/0/0/2
interface HundredGigE0/0/0/2
service-policy input policer account user-defined -20
!
```

Positive Accounting Use Case

If QoS commitment includes Preamble, Frame Delimiter & Interframe Gap and has the following configuration:

```
service-policy input <foo> account user-defined +20
```

For QoS purposes, your router treats this packet as a packet of size = Actual Packet size + 20. Hence, the effective policing and shaping is *reduced* to match the downstream interface.

Negative Accounting Use Case

If QoS commitment to your router does not include VLAN header information, and has the following configuration:

```
service-policy input <foo> account user-defined -4
```

For QoS purposes, your router treats this packet as a packet of size = Actual Packet size – 4. Hence, the effective policing and shaping is *increased* to match the downstream interface.

Associated Commands

service-policy (overhead accounting)

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, hence eliminating bottlenecks in topologies with data-rate mismatches.

Note If you apply a policy map that has configured traffic policing and traffic shaping on the basis of a percentage of bandwidth available on the interface and you change the speed of the interface, you must delete that policy map and reattach it to the interface. Else, QoS programming for the earlier speed remains in effect and does not change with change in the port speed.

Note Traffic shaping is supported only in egress direction.

Configure Traffic Shaping

The traffic shaping performed on outgoing interfaces is done at the Layer 1 level and includes the Layer 1 header in the rate calculation.

Guidelines

- Only egress traffic shaping is supported.
- It is mandatory to configure all the eight traffic-class classes (including class-default) for the egress policies.
- You can configure **shape average** command along with **priority** command.

Configuration Example

You have to accomplish the following to complete the traffic shaping configuration:

1. Creating or modifying a policy-map that can be attached to one or more interfaces
2. Specifying the traffic class whose policy has to be created or changed
3. Shaping the traffic to a specific bit rate and set peak burst size
4. Attaching the policy-map to an output interface

```
Router# configure
Router(config)#class-map c5
Router(config-cmap)#match traffic-class 5
Router(config-cmap)#commit

Router(config)# policy-map egress_policy1
Router(config-pmap)# class c5
Router(config-pmap-c)# shape average 40 percentpercent 50 1000
Router(config-pmap-c# exit
Router(config-pmap)# exit
Router(config)# interface HundredGigE 0/1/0/0
Router(config-if)# service-policy output egress_policy1
Router(config-if)# commit
```

Running Configuration

```
class-map c5
 match traffic-class 5
commit

policy-map egress_policy1
 class c5
  shape average percent 40
 !
 class class-default
 !
 end-policy-map
!

interface HundredGigE0/6/0/18
 service-policy output egress_policy1
!
```

```
class-map c5
 match traffic-class 5
commit

policy-map egress_policy1
 class c5
  shape average percent 50 1000
 !
 class class-default
 !
 end-policy-map
!

interface HundredGigE0/6/0/18
 service-policy output egress_policy1
!
```

Verification

```
Router#  show qos interface hundredGigE 0/6/0/18 output

NOTE:- Configured values are displayed within parentheses
Interface HundredGigE0/6/0/18 ifh 0x3000220  -- output policy
NPU Id:                        3
Total number of classes:       2
Interface Bandwidth:           100000000 kbps
VOQ Base:                      11176
VOQ Stats Handle:              0x88550ea0
Accounting Type:               Layer1 (Include Layer 1 encapsulation and above)
------------------------------------------------------------------------------
Level1 Class                             =   c5
Egressq Queue ID                         =   11177 (LP queue)
Queue Max. BW.                           =   40329846 kbps (40 %)
Queue Min. BW.                           =   0 kbps (default)
Inverse Weight / Weight                  =   1 (BWR not configured)
Guaranteed service rate                  =   40000000 kbps
TailDrop Threshold                       =   50069504 bytes / 10 ms (default)
WRED not configured for this class

Level1 Class                             =   class-default
Egressq Queue ID                         =   11176 (Default LP queue)
Queue Max. BW.                           =   101803495 kbps (default)
Queue Min. BW.                           =   0 kbps (default)
Inverse Weight / Weight                  =   1 (BWR not configured)
Guaranteed service rate                  =   50000000 kbps
TailDrop Threshold                       =   62652416 bytes / 10 ms (default)
WRED not configured for this class



Router#  ios#show qos interface tenGigE 0/0/0/0 output

Wed Jul 10 14:18:37.783 UTC
NOTE:- Configured values are displayed within parentheses
Interface TenGigE0/0/0/0 ifh 0x120  -- output policy
NPU Id:                        0
Total number of classes:       1
Interface Bandwidth:           10000000 kbps
Policy Name:                   test
VOQ Base:                      1024
Accounting Type:               Layer1 (Include Layer 1 encapsulation and above)
------------------------------------------------------------------------------
Level1 Class                             =   class-default
Egressq Queue ID                         =   1024 (Default LP queue)
Queue Max. BW.                           =   5031499 kbps (50 %)
Queue Min. BW.                           =   0 kbps (default)
Inverse Weight / Weight                  =   1 / (BWR not configured)
Guaranteed service rate                  =   5000000 kbps
Peak burst                               =   2240 bytes (1000 bytes)
TailDrop Threshold                       =   6258688 bytes / 10 ms (default)
```

Important Notes

Related Topics

- Congestion Management Overview, on page 55

Associated Commands

- shape average

Traffic Policing

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. By default, the configured bandwidth value takes into account the Layer 2 encapsulation that is applied to traffic leaving the interface.

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). See, Committed Bursts , on page 66.

The router supports the following traffic policing mode(s):

- Single-Rate Two-Color (SR2C) in color-blind mode. See Single-Rate Policer, on page 66.
- Single-Rate Three-Color (SR3C) in color-blind mode.
- Two-Rate Three-Color (2R3C) in color-blind mode. See Two-Rate Policer, on page 70 .

Note In Cisco NCS 560, QoS enhanced stats is enabled by default.

Restrictions

- Traffic policing is supported only in ingress direction, and only color-blind mode is supported.
- The policing rate accuracy may vary up to +/-2% from the configured policer value.
- Ensure that you don’t configure a policer and match criteria for **discard-class** in the same class. Even though the configuration is allowed, the policer doesn’t work and allows all traffic without dropping packets.
- Policer marking is not supported.
- Policers are configured in the interface at the core level and “show qos int <>” value is displayed at the NPU level.

  For policers configured in a bundle interface where bundle members are from the same NPU but different cores (NPU cores), each member sends the traffic up to the core level policer configuration, but “show qos int <>” displays the NPU level policer output.

Committed Bursts

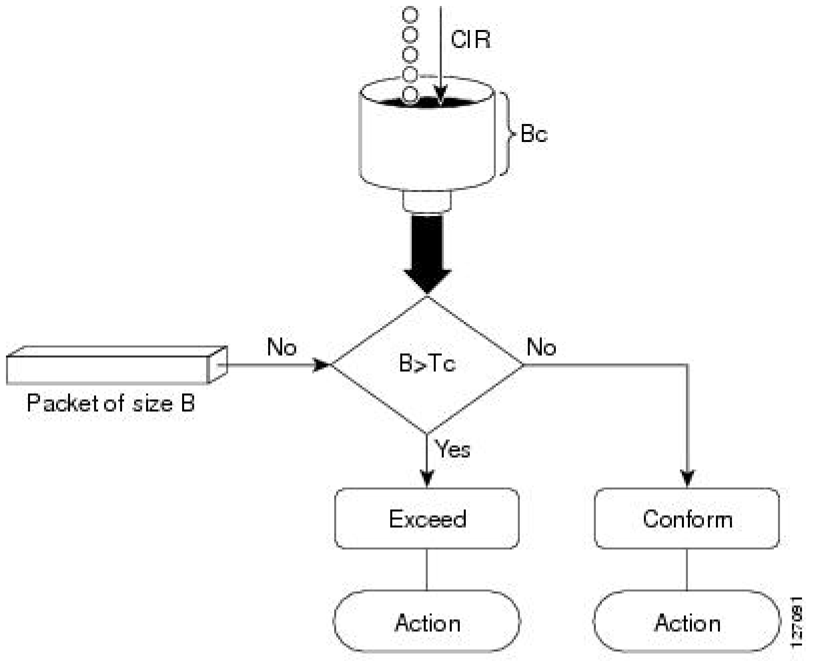
Unlike a traffic shaper, a traffic policer does not buffer excess packets and transmit them later. Instead, the policer executes a “send or do not send” policy without buffering. Policing uses normal or committed burst (bc) values to ensure that the router reaches the configured committed information rate (CIR). Policing decides if a packet conforms or exceeds the CIR based on the burst values you configure. Burst parameters are based on a generic buffering rule for routers, which recommends that you configure buffering to be equal to the round-trip time bit-rate to accommodate the outstanding TCP windows of all connections in times of congestion. During periods of congestion, proper configuration of the burst parameter enables the policer to drop packets less aggressively.

Single-Rate Policer

Single-Rate Two-Color Policer

A single-rate two-color (SR2C) policer provides one token bucket with two actions for each packet: a conform action and an exceed action.

Figure 3: Workflow of Single-Rate Two-Color Policer



Based on the committed information rate (CIR) value, the token bucket is updated at every refresh time interval. 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 action is performed. If a packet of size B is less than the Tc token bucket, then the packet conforms and a different action is performed.

Configure Traffic Policing (Single-Rate Two-Color)

Traffic policing is often configured on interfaces at the edge of a network to limit the rate of traffic entering or leaving the network. The default conform action for single-rate two color policer is to transmit the packet and the default exceed action is to drop the packet. Users cannot modify these default actions.

Configuration Example

You have to accomplish the following to complete the traffic policing configuration:

1. Creating or modifying a policy-map that can be attached to one or more interfaces
2. Specifying the traffic class whose policy has to be created or changed
3. (Optional) Specifying the marking action
4. Specifying the policy rate for the traffic
5. Attaching the policy-map to an input interface

```
Router# configure
Router(config)# policy-map test-police-1
Router(config-pmap)# class  ipv6-6
Router(config-pmap-c)# set dscp cs2 (optional)
Router(config-pmap-c)# set qos-group 7 (optional)
Router(config-pmap-c)# police rate percent 20 burst 10000 bytes
Router(config-pmap-c-police)# exit
Router(config-pmap-c)# exit
Router(config-pmap)# exit
Router(config)# interface HundredGigE 0/6/0/18
Router(config-if)# service-policy input test-police-1
Router(config-if)# commit
```

Running Configuration

```
class-map match-any ipv6-6
 match precedence 3
 end-class-map
!

policy-map test-police-1
 class ipv6-6
  set dscp cs2
  set qos-group 7
  police rate percent 20 burst 10000 bytes
  !
 !
 class class-default
 !
 end-policy-map
!

interface HundredGigE0/6/0/18
 service-policy input test-police-1
 service-policy output test-priority-1
!
```

Verification

```
Router# show qos interface hundredGigE 0/6/0/18 input

NOTE:- Configured values are displayed within parentheses
Interface HundredGigE0/6/0/18 ifh 0x3000220  -- input policy
NPU Id:                        3
Total number of classes:       2
Interface Bandwidth:           100000000 kbps
Accounting Type:               Layer1 (Include Layer 1 encapsulation and above)
------------------------------------------------------------------------------
Level1 Class                             =   ipv6-6
New dscp                                 =   16
New qos group                            =   7

Policer Bucket ID                        =   0x102a0
Policer Stats Handle                     =   0x8a8090c0
Policer committed rate                   =   19980000 kbps (20 %)
Policer conform burst                    =   9856 bytes (10000 bytes)

Level1 Class                             =   class-default

Default Policer Bucket ID                =   0x102a1
Default Policer Stats Handle             =   0x8a808e78
Policer not configured for this class
```

Related Topics

- Traffic Policing, on page 65

Associated Commands

- police rate

Configure Traffic Policing (Single-Rate Three-Color)

The default conform action and exceed actions for single-rate three-color policer are to transmit the packet and the default violate action is to drop the packet. User cannot modify these default actions.

Configuration Example

You have to accomplish the following to complete the traffic policing configuration:

1. Creating or modifying a policy-map that can be attached to one or more interfaces
2. Specifying the traffic class whose policy has to be created or changed
3. (Optional) Specifying the marking action
4. Configuring the policy rate for the traffic along with the peak-burst values
5. Attaching the policy-map to an input interface

```
Router# configure
Router(config)# policy-map test-police-1R3C
Router(config-pmap)# class ipv4-5
Router(config-pmap-c)# set qos-group 2 (optional)
Router(config-pmap-c)# police rate percent 20 burst 100000 bytes peak-burst 190000 bytes
Router(config-pmap-c-police)# exit
Router(config-pmap-c)# exit
Router(config-pmap)# exit
Router(config)# interface HundredGigE 0/6/0/18
Router(config-if)# service-policy input test-police-1R3C
Router(config-if)# commit
```

Running Configuration

```
class-map match-any ipv4-5
 match precedence 3
 end-class-map
!

policy-map test-police-1R3C
 class ipv4-5
  set qos-group 7
  police rate percent 20 burst 100000 bytes peak-burst 190000 bytes
  !
 !
 class class-default
 !
 end-policy-map
!

interface HundredGigE0/6/0/18
 service-policy input test-police-1R3C
 service-policy output test-priority-1
!
```

Verification

```
Router# show qos interface hundredGigE 0/6/0/18 input

NOTE:- Configured values are displayed within parentheses
Interface HundredGigE0/6/0/18 ifh 0x3000220  -- input policy
NPU Id:                        3
Total number of classes:       2
Interface Bandwidth:           100000000 kbps
Accounting Type:               Layer1 (Include Layer 1 encapsulation and above)
------------------------------------------------------------------------------
Level1 Class                             =   ipv4-5
New qos group                            =   2

Policer Bucket ID                        =   0x102a1
Policer Stats Handle                     =   0x8a8090c0
Policer committed rate                   =   19980000 kbps (20 %)
Policer conform burst                    =   99584 bytes (100000 bytes)
Policer exceed burst                     =   188672 bytes (190000 bytes)

Level1 Class                             =   class-default

Default Policer Bucket ID                =   0x102a1
Default Policer Stats Handle             =   0x8a808e78
Policer not configured for this class
```

Related Topics

- Traffic Policing, on page 65

Associated Commands

- police rate

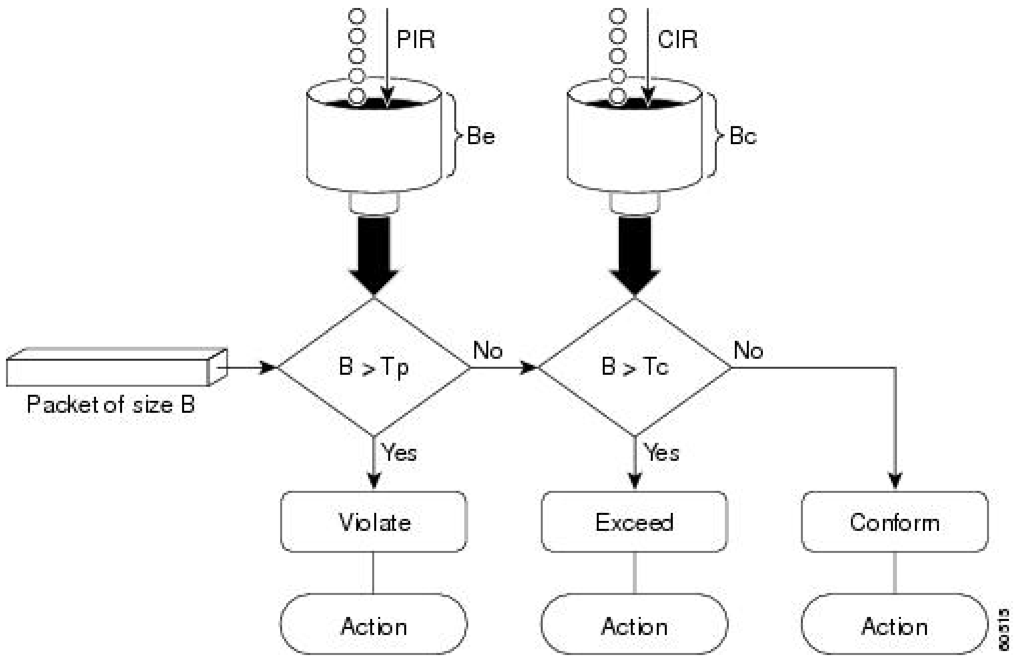
Two-Rate Policer

The two-rate policer manages the maximum rate of traffic by using two token buckets: the committed token bucket and the peak token bucket. The dual-token bucket algorithm uses user-configured values to determine the maximum rate of traffic allowed on a queue at a given moment. In this way, the two-rate policer can meter traffic at two independent rates: the committed information rate (CIR) and the peak information rate (PIR).

The dual-token bucket algorithm provides users with three actions for each packet—a conform action, an exceed action, and an optional violate action. Traffic entering a queue with the two-rate policer configured is placed into one of these categories.

This figure shows how the two-rate policer marks a packet and assigns a corresponding action to the packet.

Figure 4: Marking Packets and Assigning Actions—Two-Rate Policer



Also, see Two-Rate Policer Details, on page 77.

The router supports Two-Rate Three-Color (2R3C) policer.

Configure Traffic Policing (Two-Rate Three-Color)

The default conform and exceed actions for two-rate three-color (2R3C) policer are to transmit the packet and the default violate action is to drop the packet. Users cannot modify these default actions.

Configuration Example

You have to accomplish the following to complete the two-rate three-color traffic policing configuration:

1. Creating or modifying a policy-map that can be attached to one or more interfaces
2. Specifying the traffic class whose policy has to be created or changed
3. Specifying the packet marking
4. Configuring two rate traffic policing
5. Attaching the policy-map to an input interface

```
Router# configure
Router(config)# policy-map policy1
Router(config-pmap)# class ipv4-7
Router(config-pmap-c)# set qos-group 4
Router(config-pmap-c)# police rate percent 20 burst 100000 bytes peak-rate percent 50
peak-burst 200000 bytes
Router(config-pmap-c-police)# exit
Router(config-pmap-c)# exit
Router(config-pmap)# exit
Router(config)# interface HundredGigE 0/6/0/18
Router(config-if)# service-policy input policy1
Router(config-if)# commit
```

Running Configuration

```
policy-map policy1
 class ipv4-7
  set qos-group 4
  police rate percent 20 burst 100000 bytes peak-rate percent 50 peak-burst 200000 bytes
  !
 !

interface HundredGigE 0/6/0/18
 service-policy input policy1
!
```

Verification

```
Router# show policy-map interface HundredGigE 0/6/0/18

NOTE:- Configured values are displayed within parentheses
Interface HundredGigE0/6/0/18 ifh 0x3000220  -- input policy
NPU Id:                        3
Total number of classes:       8
Interface Bandwidth:           100000000 kbps
Accounting Type:               Layer1 (Include Layer 1 encapsulation and above)
------------------------------------------------------------------------------
Level1 Class                             =   ipv4-4
- - -
- - -
Level1 Class                             =   ipv4-7
New qos group                            =   4

Policer Bucket ID                        =   0x102a3
Policer Stats Handle                    =   0x8a8089e8
Policer committed rate                  =   19980000 kbps (20 %)
Policer peak rate                       =   49860000 kbps (50 %)
Policer conform burst                   =   99584 bytes (100000 bytes)
Policer exceed burst                    =   199168 bytes (200000 bytes)

Level1 Class                            =   class-default

Policer Bucket ID                       =   0x102a7
Policer Stats Handle                    =   0x8a7c8510
Policer committed rate                  =   29880000 kbps (30 %)
Policer conform burst                   =   4194304 bytes (default)
```

Important Notes

- A policer is programmed per NPU core on a bundle interface. So, all members on a bundle interface from the same core share the policer.

Related Topics

- Two-Rate Policer, on page 70

Associated Commands

- police rate

Shared Policer

The classification of the incoming packet occurs only once. However, based on the different classification criteria, the shared policer feature allows sharing of the policer bucket amongst two or more classes in a QoS policy map . That is, the same token bucket is used for a traffic flow matching against any of the classes sharing the policer.

For example, let us say a policer of 10 Mbps is shared among two classes C1 and C2. This feature ensures that both C1 and C2 get traffic flow assigned on First Come First Serve (FCFS) basis. Also that, if C2 does not have any traffic, C1 uses all of the 10 Mbps for transmission.

This feature includes two components:

- Policer Bucket Shared
- Policer Bucket Referred

Policer Bucket Shared

The policer bucket shared feature defines and shares a policer bucket instance among multiple classes.

Here is a sample configuration that defines and shares policer bucket instance sp1 :

```
policy-map parent
        class long-distance
          police bucket shared sp1 rate 1 mbps
```

In this configuration, a policy-map for class long-distance traffic type is created to police at 1Mbps rate and the policer bucket is shared.

Policer Bucket Referred

The policer bucket referred feature refers a defined policer bucket instance. Shared policer is not supported across policy levels. This means for example, that parent and child policy cannot share a common bucket.

Here is a sample configuration that refers shared policer bucket instance sp1 :

```
policy-map voip-child
        class long-distance-voip
         police bucket referred sp1
```

In this configuration, a policy-map for class long-distance-voip traffic type is created and the shared policer bucket sp1 is referred.

Shared Policer Statistics

Currently, individual class statistics are not available as a default option for shared policer. You can access statistics in the following modes.

Aggregate Mode

In this mode the policer bucket is shared among two or more classes. However, statistics are not available for every individual class. You can view the aggregate statistics that combine the numbers for all the classes sharing the policer bucket.

Per-Class Mode

In this mode the policer bucket is shared among two or more classes, and you can also view individual class statistics. However, when this mode is active, the Policy-Based Tunnel Selection (PBTS) mechanism is disabled. To enable the per-class mode, you must configure the **hw-module profile qos shared-policer-per-class-stats** command.

Restrictions and Guidelines

The following restrictions and guidelines apply while configuring the shared policer feature.

- When shared policer is enabled in per-class mode, Policy-Based Tunnel Selection (PBTS) mechanism is disabled. In other words, shared policer-per-class-mode and PBTS are mutually exclusive features.
- Shared policer is not supported across policy levels. This means, for example, that parent and child policies cannot share a common policer bucket.
- Shared policer is not supported in ingress peering mode.
- Shared policer is supported within classes of the same policy. However, cross-policy bucket sharing is not supported.
- There are no limitations on the number of classes that can share policer.
- There are no changes in policer scale numbers in the aggregate and per-class modes.
- All the existing policer types (1R2C, 1R3C and 2R3C) are supported.

- You must reload the affected line card to enable the per-class-stats mode.

Configuring Shared Policer

To configure shared policer, you must:

1. Create a class map to be used for matching packets to the specified class.
2. Create a policy map to be used for matching packets to the specified class.
3. Specify a class name.
4. Define and share a policer bucket.
5. Specify a class name.
6. Refer a shared policer bucket.

```
RP/0/RSP0/CPU0:ios(config)#class-map match-any c1
RP/0/RSP0/CPU0:ios(config-cmap)#match precedence 1
RP/0/RSP0/CPU0:ios(config-cmap)#end-class-map
RP/0/RSP0/CPU0:ios(config)#class-map match-any c2
RP/0/RSP0/CPU0:ios(config-cmap)#match precedence 2
RP/0/RSP0/CPU0:ios(config-cmap)#end-class-map
RP/0/RSP0/CPU0:ios(config)#policy-map s-pol
RP/0/RSP0/CPU0:ios(config-pmap)#class c1
RP/0/RSP0/CPU0:ios(config-pmap-c)#police bucket shared 1 rate 10 mbps
RP/0/RSP0/CPU0:ios(config-pmap-c-police)#exit
RP/0/RSP0/CPU0:ios(config-pmap-c)#exit
RP/0/RSP0/CPU0:ios(config-pmap)#class c2
RP/0/RSP0/CPU0:ios(config-pmap-c)#police bucket referred 1
RP/0/RSP0/CPU0:ios(config-pmap-c-police)#class class-default
RP/0/RSP0/CPU0:ios(config-pmap-c)#exit
RP/0/RSP0/CPU0:ios(config-pmap)#exit
RP/0/RSP0/CPU0:ios(config)#interface HundredGigE 0/6/0/18
RP/0/RSP0/CPU0:ios(config-if)#service-policy input s-pol
RP/0/RSP0/CPU0:ios(config-if)#commit
```

Running Configuration

```
class-map match-any c1
 match precedence 1
 end-class-map

class-map match-any c2
 match precedence 2
 end-class-map

policy-map s-pol
 class c1
  police bucket shared 1 rate 10 mbps
  !
 !
 class c2
  police bucket referred 1
  !
 !
 class class-default
 !
 end-policy-map
!
```

```
interface HundredGigE0/6/0/18
 service-policy input s-pol
!
```

Verification

In Aggregate Mode

```
RP/0/RP0/CPU0:ios#sh policy-map interface tenGigE 0/0/0/0 input
Fri Nov 15 12:55:56.817 UTC

TenGigE0/0/0/0 input: s-pol

Class c1
  Classification statistics          (packets/bytes)     (rate - kbps)
    Matched             :          1784530245/228419871360         8640780
    Transmitted         :             2067504/264640512            10011
    Total Dropped       :          1782462741/228155230848         8630769
  Policing statistics                (packets/bytes)     (rate - kbps)
    Policed(conform)    :             2067504/264640512            10011
    Policed(exceed)     :          1782462741/228155230848         8630769
    Policed(violate)    :                   0/0                    0
    Policed and dropped :          1782462741/228155230848
Class c2
  Classification statistics          (packets/bytes)     (rate - kbps)
    Matched             :                   0/0                    0
    Transmitted         :                   0/0                    0
    Total Dropped       :                   0/0                    0
  Policing statistics                (packets/bytes)     (rate - kbps)

Policed(conform)    :                   0/0                    0
    Policed(exceed)     :                   0/0                    0
    Policed(violate)    :                   0/0                    0
    Policed and dropped :                   0/0
Class class-default
  Classification statistics          (packets/bytes)     (rate - kbps)
    Matched             :                   0/0                    0
    Transmitted         :                   0/0                    0
    Total Dropped       :                   0/0                    0
Policy Bag Stats time: 1573822531986  [Local Time: 11/15/19 12:55:31.986]
```

In Per-Class Mode

```
RP/0/RP0/CPU0:ios#sh policy-map interface tenGigE 0/0/0/0 input
Fri Nov 15 15:18:18.319 UTC

TenGigE0/0/0/0 input: s-pol

Class c1
  Classification statistics          (packets/bytes)     (rate - kbps)
    Matched             :          1005369276/128687267328         4320337
    Transmitted         :             1163300/148902400            5013
    Total Dropped       :          1004205976/128538364928         4315324
  Policing statistics                (packets/bytes)     (rate - kbps)
    Policed(conform)    :             1163300/148902400            5013
    Policed(exceed)     :          1004205976/128538364928         4315324
    Policed(violate)    :                   0/0                    0
    Policed and dropped :          1004205976/128538364928
Class c2
  Classification statistics          (packets/bytes)     (rate - kbps)
    Matched             :          1005341342/128683691776         4320335
    Transmitted         :             1166269/149282432            4997
    Total Dropped       :          1004175073/128534409344         4315338
  Policing statistics                (packets/bytes)     (rate - kbps)
    Policed(conform)    :            1166269/149282432            4997
    Policed(exceed)     :          1004175073/128534409344         4315338
    Policed(violate)    :                  0/0                    0
    Policed and dropped :          1004175073/128534409344
Class class-default
  Classification statistics          (packets/bytes)     (rate - kbps)
    Matched             :              49159/6292352              0
    Transmitted         :              49159/6292352              0
    Total Dropped       :                  0/0                    0
Policy Bag Stats time: 1573831087338  [Local Time: 11/15/19 15:18:07.338]
```

Related Commands hw-module profile qos shared-policer-per-class-stats

References for Modular QoS Congestion Management

Committed Bursts

The committed burst (bc) parameter of the police command implements the first, conforming (green) token bucket that the router uses to meter traffic. The bc parameter sets the size of this token bucket. Initially, the token bucket is full and the token count is equal to the committed burst size (CBS). Thereafter, the meter updates the token counts the number of times per second indicated by the committed information rate (CIR).

The following describes how the meter uses the conforming token bucket to send packets:

- If sufficient tokens are in the conforming token bucket when a packet arrives, the meter marks the packet green and decrements the conforming token count by the number of bytes of the packet.
- If there are insufficient tokens available in the conforming token bucket, the meter allows the traffic flow to borrow the tokens needed to send the packet. The meter checks the exceeding token bucket for the number of bytes of the packet. If the exceeding token bucket has a sufficient number of tokens available, the meter marks the packet.

  Green and decrements the conforming token count down to the minimum value of 0.

  Yellow, borrows the remaining tokens needed from the exceeding token bucket, and decrements the exceeding token count by the number of tokens borrowed down to the minimum value of 0.
- If an insufficient number of tokens is available, the meter marks the packet red and does not decrement either of the conforming or exceeding token counts.

Note When the meter marks a packet with a specific color, there must be a sufficient number of tokens of that color to accommodate the entire packet. Therefore, the volume of green packets is never smaller than the committed information rate (CIR) and committed burst size (CBS). Tokens of a given color are always used on packets of that color.

Excess Bursts

The excess burst (be) parameter of the police command implements the second, exceeding (yellow) token bucket that the router uses to meter traffic. The exceeding token bucket is initially full and the token count is equal to the excess burst size (EBS). Thereafter, the meter updates the token counts the number of times per second indicated by the committed information rate (CIR).

The following describes how the meter uses the exceeding token bucket to send packets:

- When the first token bucket (the conforming bucket) meets the committed burst size (CBS), the meter allows the traffic flow to borrow the tokens needed from the exceeding token bucket. The meter marks the packet yellow and then decrements the exceeding token bucket by the number of bytes of the packet.
- If the exceeding token bucket does not have the required tokens to borrow, the meter marks the packet red and does not decrement the conforming or the exceeding token bucket. Instead, the meter performs the exceed-action configured in the police command (for example, the policer drops the packets).

Two-Rate Policer Details

The committed token bucket can hold bytes up to the size of the committed burst (bc) before overflowing. This token bucket holds the tokens that determine whether a packet conforms to or exceeds the CIR as the following describes:

- A traffic stream is conforming when the average number of bytes over time does not cause the committed token bucket to overflow. When this occurs, the token bucket algorithm marks the traffic stream green.
- A traffic stream is exceeding when it causes the committed token bucket to overflow into the peak token bucket. When this occurs, the token bucket algorithm marks the traffic stream yellow. The peak token bucket is filled as long as the traffic exceeds the police rate.

The peak token bucket can hold bytes up to the size of the peak burst (be) before overflowing. This token bucket holds the tokens that determine whether a packet violates the PIR. A traffic stream is violating when it causes the peak token bucket to overflow. When this occurs, the token bucket algorithm marks the traffic stream red.

For example, if a data stream with a rate of 250 kbps arrives at the two-rate policer, and the CIR is 100 kbps and the PIR is 200 kbps, the policer marks the packet in the following way:

- 100 kbps conforms to the rate
- 100 kbps exceeds the rate
- 50 kbps violates the rate

The router updates the tokens for both the committed and peak token buckets in the following way:

- The router updates the committed token bucket at the CIR value each time a packet arrives at the interface. The committed token bucket can contain up to the committed burst (bc) value.
- The router updates the peak token bucket at the PIR value each time a packet arrives at the interface. The peak token bucket can contain up to the peak burst (be) value.
- When an arriving packet conforms to the CIR, the router takes the conform action on the packet and decrements both the committed and peak token buckets by the number of bytes of the packet.

- When an arriving packet exceeds the CIR, the router takes the exceed action on the packet, decrements the committed token bucket by the number of bytes of the packet, and decrements the peak token bucket by the number of overflow bytes of the packet.
- When an arriving packet exceeds the PIR, the router takes the violate action on the packet, but does not decrement the peak token bucket.

See Two-Rate Policer, on page 70.

CHAPTER 4

Configuring Modular QoS on Link Bundles

This chapter covers the following topics:

QoS on Link Bundles

A bundle is a group of one or more ports that are aggregated together and treated as a single link. The router supports Ethernet interfaces and VLAN interfaces (bundle sub-interfaces) bundles. All QoS features currently supported on physical interfaces, are also supported on all link bundle interfaces. Applying QoS on bundle members is not supported.

Load Balancing

Load balancing function is a forwarding mechanism to distribute traffic over multiple links based on Layer 3 routing information in the router. Per-destination load balancing isonly supported on the router, where the router is allowed to distribute packets over one of the links in the bundle. When the per-destination load balancing is enabled, all packets for a certain source-destination pair goes through the same link, though there are multiple links available. In other words, per-destination load balancing can ensure that packets for a certain source-destination pair could arrive in order.

Layer 3 Load Balancing on Link Bundles

Layer 3 load balancing for link bundles is done on Ethernet Flow Points (EFPs) and is based on the IPv4 source and destination addresses in the packet. When Layer 3 service-specific load balancing is configured, all egress bundles are load balanced based on the IPv4 source and destination addresses. When packets do not have IPv4 addresses, default load-balancing (based on the MAC SA/DA fields in the packet header) is used.

Configure QoS on Link Bundles

QoS is configured on link bundles in the same way that it is configured on individual interfaces.

Guidelines

• When a QoS policy is applied on a bundle in the egress direction, it's also applied at each member interface.

- When a QoS policy is applied on a bundle (ingress direction), it's replicated at each NPU core.
- If a QoS policy is not applied to a bundle interface, both the ingress and egress traffic use the default queue of the per link member port.
- The shape rate that is specified in the bundle policy-map is not an aggregate for all bundle members. The shape rate applied to the bundle depends on the load balancing of the links. For example, if a policy map with a shape rate of 10 Mbps is applied to a bundle with two member links, and if the traffic is always load-balanced to the same member link, then an overall rate of 10 Mbps applies to the bundle. However, if the traffic is load-balanced evenly between the two links, the overall shape rate for the bundle becomes 20 Mbps.
- If a member is deleted from a bundle, the total bundle statistics changes because the statistics that belongs to the detached link is lost.
- The QoS policy that is applied on bundle is inherited to all its member links and the reference bandwidth that is used to calculate shaper/bandwidth is applied as per the physical member interface bandwidth, and not the bundle as a whole.

Configuration Example

You have to accomplish the following to complete the QoS configuration on link bundles:

Note The policy works only if it is applied on the ingress direction. The egress is supported on COS, DEI and MPLS exp marking. So the below policy may not work when it is applied on egress.

1. Creating a class-map
2. Creating a policy-map and specifying the respective class-map
3. Specifying the action type for the traffic

   Refer Attach a Traffic Policy to an Interface, on page 8 for details on step 1, 2 and 3.
4. Creating a link bundle
5. Applying traffic policy to the link bundle

```
/* Configure Ether-Bundle and apply traffic policy */
Router(config)# interface Bundle-Ether 12000
Router(config-if)# mtu 9100
Router(config-if)# service-policy input ingress
Router(config-if)# service-policy output egress
Router(config-if)# ipv4 address 100.12.0.0 255.255.255.254
Router(config-if)# bundle maximum-active links 64
Router(config-if)# commit
```

Running Configuration

This example shows how a traffic policy is applied on an Ethernet link bundle. The policy is applied to all interfaces that are members of the Ethernet link bundle.

```
/* Policy-map */
```

```
policy-map ingress
 class inet4-classifier-af1
  set qos-group 1
 !
 class inet4-classifier-af2
  set qos-group 2
 !
 class inet4-classifier-af3
  set qos-group 3
 !
 class inet4-classifier-af4
  set qos-group 4
 !
 class inet4-classifier-be1
  set qos-group 5
 !
 class inet4-classifier-nc1
  set qos-group 6
 !
 class class-default
 !
 end-policy-map
!

/* Ether Bundle */
interface Bundle-Ether12000
 mtu 9100
 service-policy input ingress
 service-policy output egress
 ipv4 address 100.12.0.0 255.255.255.254
 load-interval 30
 flow ipv4 monitor FMM-V4 sampler SM ingress
 flow ipv6 monitor FMM-V6 sampler SM ingress
 flow mpls monitor FMM-MPLS sampler SM ingress
 ipv4 access-group IPV4ACL_101 ingress
 ipv6 access-group IPV6ACL_101 ingress
!
```

Verification

- Verify that the bundle status is UP.

```
router# show bundle bundle-ether 1200
Wed Dec 16 19:55:49.974 PST

Bundle-Ether12000
  Status:                                    Up
  Local links <active/standby/configured>:   35 / 0 / 35
  Local bandwidth <effective/available>:     3500000000 (3500000000) kbps
  MAC address (source):                      ea3b.745f.c4b0 (Chassis pool)
  Inter-chassis link:                        No
  Minimum active links / bandwidth:          1 / 1 kbps
  Maximum active links:                      64
  Wait while timer:                          2000 ms
  Load balancing:                            Default
  LACP:                                      Operational
    Flap suppression timer:                  Off
    Cisco extensions:                        Disabled
    Non-revertive:                           Disabled
  mLACP:                                     Not configured
  IPv4 BFD:                                  Not configured
  Port                  Device           State        Port ID         B/W, kbps
  --------------------  ---------------  -----------  --------------  ----------
  Hu0/4/0/0             Local            Active       0x8000, 0x0009   100000000
      Link is Active
  Hu0/4/0/1             Local            Active       0x8000, 0x000a   100000000
      Link is Active
- - -
- - -
  Hu0/4/0/35            Local            Active       0x8000, 0x002b   100000000
      Link is Active
```

- Verify the bundle statistics:

```
router# show policy-map interface bundle-ether 12000

Bundle-Ether12000 input: ingress

Class inet4-classifier-af1
  Classification statistics          (packets/bytes)     (rate - kbps)
    Matched             :         4647401962/21236124455654       26403040
    Transmitted         :         4647401962/21236124455654       26403040
    Total Dropped       :                  0/0                    0
Class inet4-classifier-af2
  Classification statistics          (packets/bytes)     (rate - kbps)
    Matched             :         4502980177/20576584333939       25571493
    Transmitted         :         4502980177/20576584333939       25571493
    Total Dropped       :                  0/0                    0
Class inet4-classifier-af3
  Classification statistics          (packets/bytes)     (rate - kbps)
    Matched             :         4647404125/21236213667880       26389086
    Transmitted         :         4647404125/21236213667880       26389086
    Total Dropped       :                  0/0                    0
Class inet4-classifier-af4
  Classification statistics          (packets/bytes)     (rate - kbps)
    Matched             :         9291188840/42456120548683       52771168
    Transmitted         :         9291188840/42456120548683       52771168
    Total Dropped       :                  0/0                    0
Class inet4-classifier-be1
  Classification statistics          (packets/bytes)     (rate - kbps)
    Matched             :         4647413429/21235847852686       26393414
    Transmitted         :         4647413429/21235847852686       26393414
    Total Dropped       :                  0/0                    0
Class inet4-classifier-nc1
  Classification statistics          (packets/bytes)     (rate - kbps)
    Matched             :         9294887621/42473100149807       52778258
    Transmitted         :         9294887621/42473100149807       52778258
    Total Dropped       :                  0/0                    0

Class class-default
  Classification statistics          (packets/bytes)     (rate - kbps)
    Matched             :                  0/0                    0
    Transmitted         :                  0/0                    0
    Total Dropped       :                  0/0                    0

Bundle-Ether12000 output: egress

Class c1
  Classification statistics          (packets/bytes)     (rate - kbps)
    Matched             :        16665494532/75878118942463       8760591
    Transmitted         :        16655834643/75834136022017       8760591
    Total Dropped       :            9659889/43982920446          0
  Queueing statistics
    Queue ID                             : None (Bundle)
    Taildropped(packets/bytes)           : 9659889/43982920446
Class c2
  Classification statistics          (packets/bytes)     (rate - kbps)
    Matched             :        16665421959/75877849543188       8718687
    Transmitted         :        16665421959/75877849543188       8718687
    Total Dropped       :                  0/0                    0
  Queueing statistics
    Queue ID                             : None (Bundle)
    Taildropped(packets/bytes)           : 0/0
Class c3
  Classification statistics          (packets/bytes)     (rate - kbps)
    Matched             :        16665247833/75877509455458       8703470
    Transmitted         :        16665187414/75877234624197       8703470
    Total Dropped       :              60419/274831261            0
  Queueing statistics
    Queue ID                             : None (Bundle)
    Taildropped(packets/bytes)           : 60419/274831261
Class c4
  Classification statistics          (packets/bytes)     (rate - kbps)
    Matched             :        33330896131/151755393012945      17470745
    Transmitted         :        33330745421/151754709368565      17470745
    Total Dropped       :             150710/683644380            0
  Queueing statistics
    Queue ID                             : None (Bundle)
    Taildropped(packets/bytes)           : 150710/683644380
Class c5
  Classification statistics          (packets/bytes)     (rate - kbps)
    Matched             :        16878910340/76849791869834       8833394
    Transmitted         :        16878849464/76849514633309       8833394
    Total Dropped       :              60876/277236525            0
  Queueing statistics
    Queue ID                             : None (Bundle)
    Taildropped(packets/bytes)           : 60876/277236525
Class c6
  Classification statistics          (packets/bytes)     (rate - kbps)
    Matched             :        33330898844/151756094112925      17456785
    Transmitted         :        33330752668/151755427708382      17456785
    Total Dropped       :             146176/666404543            0
  Queueing statistics
    Queue ID                             : None (Bundle)
    Taildropped(packets/bytes)           : 146176/666404543
Class c7
  Classification statistics          (packets/bytes)     (rate - kbps)
    Matched             :             244106/79922040             74
    Transmitted         :             244106/79922040             74
    Total Dropped       :                  0/0                    0
  Queueing statistics
    Queue ID                             : None (Bundle)
    Taildropped(packets/bytes)           : 0/0
Class class-default
  Classification statistics          (packets/bytes)     (rate - kbps)
    Matched             :       267075066180/1215993441123215     139917482
    Transmitted         :       267075066180/1215993441123215     139917482
    Total Dropped       :                  0/0                    0
  Queueing statistics
    Queue ID                             : None (Bundle)
    Taildropped(packets/bytes)           : 0/0
```

Related Topics

- QoS on Link Bundles, on page 79

Associated Commands

- bundle maximu-active links
- interface Bundle-Ether

CHAPTER 5

Configuring Hierarchical Modular QoS

Hierarchical QoS (H-QoS) is a QoS model that enables you to specify QoS behavior at multiple levels of hierarchy. This chapter provides information about this feature and the different steps involved in configuring it.

This chapter covers the following topics:

Overview of Hierarchical Modular QoS

Hierarchical QoS (H-QoS) allows you to specify QoS behavior at multiple policy levels, which provides a high degree of granularity in traffic management.

H-QoS is applied on the router interface using nested traffic policies. The first level of traffic policy, the parent traffic policy, is used for controlling the traffic at the main interface or sub-interface level. The second level of traffic policy, the child traffic policy, is used for more control over a specific traffic stream or class. The child traffic policy, is a previously defined traffic policy, that is referenced within the parent traffic policy using the **service-policy** command.

Two-level H-QoS is supported on both ingress and egress directions on all line cards and on physical or bundle main interfaces and sub-interfaces.

Three-level Hierarchical QoS (H-QoS) enables enforcement of class/service, group/ Ethernet Flow Point (EFP), and port level SLAs. You can apply regular two-level egress H-QoS policies on the sub-interfaces to achieve class and EFP SLAs at child and parent levels. In addition, you can apply a port shaper policy on the main interface to achieve an aggregated port level SLA in a 1+2 H-QoS or three-level H-QoS model.

An important point to note is that before Release 6.6.25 (where the three-level H-QoS capability was introduced), when you applied class-default shaper on a main interface, it was enforced *only* on the traffic going through the main interface. With three-level HQoS, a class default shaper that is applied on the main interface is considered as a port shaper and enforced on *all* traffic going out of that physical port. The advantage of three-level H-QoS is that the parent shaper on the sub-interfaces is allowed to oversubscribe, thus enabling best effort sharing of the aggregate port shaper at the third level.

Restrictions for Configuring H-QoS

The following restrictions are applicable while configuring H-QoS:

1. The parent traffic policy only supports the traffic class of type class-default.
2. The parent traffic policy only supports the class-action **shape** and no other queuing action can be configured in it.
3. While configuring on the router, it is mandatory that the priority class must have traffic shaper in the child traffic policy.
4. The sum of the bandwidth of the child policies must be less than the parent policy's traffic shaper.
5. For congestion avoidance and management, the traffic shaper in the parent traffic policy calculates the queue limit and drop priority.
6. PBTS feature does not work when the H-QoS profile is enabled. This is due to TCAM limitations.
7. A maximum of 896 bundle sub-interfaces are only supported in the system, even if there are no QoS policies applied. This is due to an internal LAG_ID resource consumption in HQoS profile mode for bundle sub-interfaces with or without QoS policies being applied.
8. A maximum of 4 priority levels are only supported in HQoS profile mode unlike the default mode where 7-priority levels are supported. The restriction also applies to physical and bundle main interface policies where 7-level priorities were previously used in non-H-QoS profile mode.
9. Bandwidth and Bandwidth remaining configurations are not supported simultaneously within the same policy-map. If a class has bandwidth (CIR), other classes must also have only bandwidth configuration. If a class-map has bandwidth remaining percent/ratio (EIR), other classes should also have only the bandwidth remaining configuration. Shaping is applied on any class.
10. In HQOS Mode, if multiple queues are configured with BRR and there is high congestion on the LP (Low Priority) queues then one queue with BRR gets more credits than rest of the LP queues. The deviation is proportional to the congestion in LP queues.
11. Priority classes must have rate limit configuration by using a Shaping configuration. The effective shaper value is taken as priority bandwidth reservation. Sum of priority bandwidth reservations across all sub-interfaces and main interfaces must not exceed the network interface (NIF) port speed. This is to avoid over-subscription of priority traffic across the network interface port.

    Rates of non-priority classes and parent shaping can be over-subscribed.
12. The granularity of bandwidth or bandwidth remaining ration (BRR) is 1:64 as compared to 1:4096 in non-hqos mode. So, there could be accuracy differences in bandwidth performance based on the values used.
13. Filtering for egress IPv4 and IPv6 multicast traffic is not supported if H-QoS is configured on the router.

The following restrictions are applicable while configuring three-level H-QoS:

- There is no support for bandwidth action at the EFP parent level. All EFP/sub-interface policies get a fair share of the port shaper.
- Three-level H-QoS does not apply to ingress policies or to egress marking policies.

- Executing **clear qos counters** on the main interface clears only the main interface policy statistics. Use the “all” option to clear all sub-interface statistics or alternately, clear the sub-interface policy statistics individually.
- Main interface policy statistics do not reflect the sub-interface packet / byte counters, although the port shaper is enforced on all logical ports for a given physical interface. The sub-interface policy-map statistics reflect the transmitted and dropped packet/byte count post-port shaper enforcement.

Configuring Hierarchical Queuing

Before you configure H-QoS, you must enable the H-QoS profile on the router. After enabling H-QoS profile, reload the router, as shown in the following configuration.

```
admin
hw-module location all reload
Router# configure
Router(config)# hw-module profile qos hqos-enable
Router(config)# commit
Router# admin
sysadmin-vm:0_RP0# hw-module location all reload
```

The steps that are involved in configuring hierarchical queuing are as follows:

1. Configure a class-map.
2. Configure a child traffic policy using the class-map that was configured in the previous step.
3. Configure a parent traffic policy and add the child traffic policy in it.

The parent traffic policy is the H-QoS traffic policy and it can be applied on physical or bundle main interfaces and sub-interfaces.

Configuration Example

Configuration of a class-map is as follows:

```
Router# configure
Router(config)# class-map match-any tc2
Router(config-cmap)# match traffic-class 1
Router(config-cmap)# end-class-map
Router(config)# commit
```

Configuration of a child traffic policy is as follows:

```
Router# configure
Router(config)# policy-map child
Router(config-pmap)# class tc2
Router(config-pmap-c)# shape average percent 20
Router(config-pmap-c)# exit
Router(config-pmap)# class class-default
Router(config-pmap-c)# shape average percent 1
Router(config-pmap)# end-policy-map
Router(config)# commit
```

Configuration of a parent traffic policy is as follows:

```
Router# configure
Router(config)# policy-map parent
Router(config-pmap)# class class-default
Router(config-pmap-c)# service-policy child
Router(config-pmap-c)# shape average percent 50
Router(config-pmap)# end-policy-map
Router(config)# commit
```

Running Configuration

```
/* Configuration of a Class-map */
class-map match-any tc2
 match traffic-class 1
 end-class-map
!
/* Configuration of a Child Traffic Policy */
policy-map child
 class tc2
  shape average percent 20
 !
 class class-default
  shape average percent 1
 !
 end-policy-map
!
/* Configuration of a Parent Traffic Policy */
policy-map parent
 class class-default
  service-policy child
  shape average percent 50
 !
 end-policy-map
!
```

Applying the Parent Traffic Policy on a Main Interface

```
Router# configure
Router(config)# Interface TenGigE 0/0/0/10
Router(config-int)# service-policy output parent
Router(config-int)# commit
```

Applying the Parent Traffic Policy on a Sub-interface

```
Router# configure
Router(config)# Interface TenGigE 0/0/0/10.1
Router(config-int)# service-policy output parent
Router(config-int)# commit
```

Verification

Verify if the H-QoS traffic policy is applied correctly on the interface using the commands **show qos interface** *interface-name* **output**. In the following example, the **Level1 Class** gives information about the class-map that is associated with the parent traffic policy and the **Level2 Class** gives information about the class-maps that are associated with the child traffic policy.

```
RP/0/RP0/CPU0:ios#show qos interface ten0/0/0/10 output
```

```
NOTE:- Configured values are displayed within parentheses
Interface TenGigE0/0/0/10 ifh 0x1e0  -- output policy
NPU Id:                        0
Total number of classes:       3
Interface Bandwidth:           10000000 kbps
VOQ Base:                      1136
Accounting Type:               Layer1 (Include Layer 1 encapsulation and above)
------------------------------------------------------------------------------
Level1 Class                             =   class-default
Queue Max. BW.                           =   no max (50 %)
Queue Min. BW.                           =   0 kbps (default)
Inverse Weight / Weight                  =   0 / (BWR not configured)
   Level2 Class                             =   tc2
   Egressq Queue ID                         =   1138 (LP queue)
   Queue Max. BW.                           =   1020015 kbps (20 %)
   Queue Min. BW.                           =   0 kbps (default)
   Inverse Weight / Weight                  =   1 / (BWR not configured)
   Guaranteed service rate                  =   1000000 kbps
   TailDrop Threshold                       =   1253376 bytes / 10 ms (default)
   WRED not configured for this class
   Level2 Class                             =   class-default
   Egressq Queue ID                         =   1136 (Default LP queue)
   Queue Max. BW.                           =   50625 kbps (1 %)
   Queue Min. BW.                           =   0 kbps (default)
   Inverse Weight / Weight                  =   1 / (BWR not configured)
   Guaranteed service rate                  =   50000 kbps
   TailDrop Threshold                       =   62720 bytes / 10 ms (default)
   WRED not configured for this class
```

The statistics for the packets that have matched the different traffic classes of the parent and child traffic policies can be viewed using the command **show policy-map interface** *interface-name* **output**. Also, this command also shows the number of packets that are transmitted or dropped when the specified action is applied on the packets that have matched the respective traffic class.

```
Router# show policy-map interface ten0/0/0/10 output

TenGigE0/0/0/10 output: parent
Class class-default
  Classification statistics          (packets/bytes)     (rate - kbps)
    Matched             :         2313578823/296138089344         8494665
    Transmitted         :          232805738/29799134464          854465
    Total Dropped       :         2080773085/266338954880         7640200
  Policy child Class tc2
    Classification statistics          (packets/bytes)     (rate - kbps)
      Matched             :         2313578823/296138089344         8494665
      Transmitted         :          232805738/29799134464          854465
      Total Dropped       :         2080773085/266338954880         7640200
    Queueing statistics
      Queue ID                           : 1138

      Taildropped(packets/bytes)         : 2080773085/266338954880
  Policy child Class class-default
    Classification statistics          (packets/bytes)     (rate - kbps)
      Matched             :                   0/0                    0
      Transmitted         :                   0/0                    0
      Total Dropped       :                   0/0                    0
    Queueing statistics
      Queue ID                           : 1136

      Taildropped(packets/bytes)         : 0/0
```

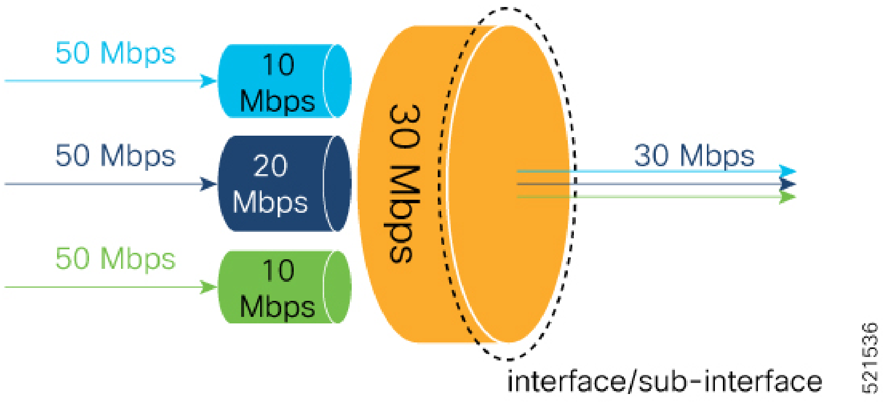
When using hierarchical policers, there is no independent set of hardware counters to store the parent policer statistics. Instead, parent policer statistics are manipulated in the software to be the sum of all child policers under the same policy-map.

This is shown in the following example where two streams of traffic, with CoS value of 1 and 2 are sent at a speed of 3.5 Gbps each.

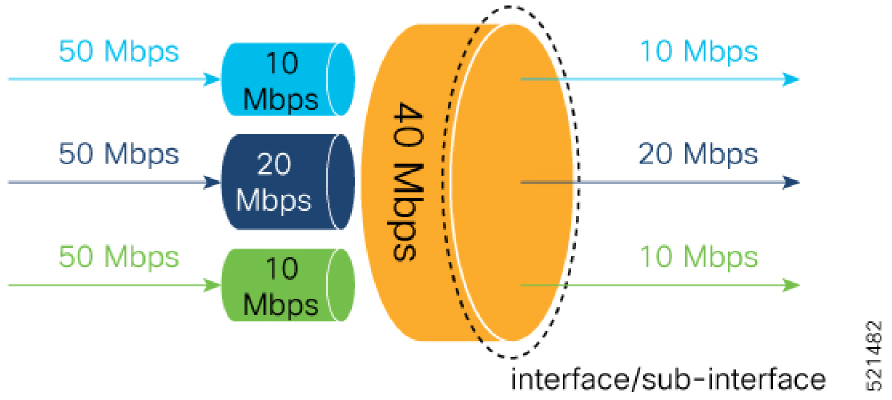
```
/*Hierarchical Policy Map Configuration*/
===================================================
Router# show running-config policy-map Hingress
policy-map Hingress
 class class-default
  service-policy ingress
  police rate 5 gbps peak-rate 9 gbps
   !
 !
 end-policy-map
!
 /*Ingress Policy Map Configuration*/
=====================================
Router#show running-config policy-map ingress
policy-map ingress
 class cos1
  set traffic-class 1
  police rate 5 gbps
   !
 !
 class cos2
  set traffic-class 2
  police rate 5 gbps
   !
 !
 class class-default
 !
 end-policy-map
!
 /*Policy Map applied at TenGigE0/0/0/6.100 Interface*/
======================================================
Router#show policy-map interface tenGigE 0/0/0/6.100 input

TenGigE0/0/0/6.100 input: Hingress

Class class-default
  Classification statistics          (packets/bytes)     (rate - kbps)
    Matched             :          856717937/109659895936         6683676
    Transmitted         :          856717937/109659895936         6683676
    Total Dropped       :                  0/0                    0
  Policing statistics                (packets/bytes)     (rate - kbps)
    Policed(conform)    :          856717937/109659895936         6683674
    Policed(exceed)     :                  0/0                    0
    Policed(violate)    :                  0/0                    0
    Policed and dropped :                  0/0

  Policy ingress Class cos1
    Classification statistics          (packets/bytes)     (rate - kbps)
      Matched             :          437826303/56041766784          3341838
      Transmitted         :          437826303/56041766784          3341838
      Total Dropped       :                  0/0                    0
    Policing statistics                (packets/bytes)     (rate - kbps)
      Policed(conform)    :          437826303/56041766784          3341838
      Policed(exceed)     :                  0/0                    0
      Policed(violate)    :                  0/0                    0
      Policed and dropped :                  0/0
      Policed and dropped(parent policer)  : 0/0
  Policy ingress Class cos2
    Classification statistics          (packets/bytes)     (rate - kbps)
      Matched             :          418891634/53618129152          3341838
      Transmitted         :          418891634/53618129152          3341838
      Total Dropped       :                  0/0                    0
    Policing statistics                (packets/bytes)     (rate - kbps)
      Policed(conform)    :          418891634/53618129152          3341838
      Policed(exceed)     :                  0/0                    0
      Policed(violate)    :                  0/0                    0
      Policed and dropped :                  0/0
      Policed and dropped(parent policer)  : 0/0

  Policy ingress Class class-default
    Classification statistics          (packets/bytes)     (rate - kbps)
      Matched             :                  0/0                    0
      Transmitted         :                  0/0                    0
      Total Dropped       :                  0/0                    0
Policy Bag Stats time: 0
Policy Bag Stats time: 0
```

Conform Aware Hierarchical Policy Overview

Hierarchical QoS (H-QoS), while allowing for granular and multi-level management of traffic, does not allow for conform traffic from a child-level policy to a parent-level policy to get priority. This means that in case of excess traffic, the parent policer drops conform traffic packets from the child level as well.



The conform-aware hierarchical policy feature enables the parent-level policy to prioritize conform traffic from child-level policy over exceed and violate traffic.



Here is how it works: the child-level policer initially marks its packets as red, yellow, or green. Packets are marked based on the committed information rate (CIR) value and the two associated burst sizes - committed burst size (CBS) and excess burst size (EBS). If a packet does not exceed the CBS, it is marked as conformed packet (green). The packet is marked as exceeded if it exceeds CBS, but not the EBS (yellow). If it exceeds the EBS as well, it is marked as violate packet (red).

When the packets arrive at the parent level policer (which is color aware), the policer prioritizes the packets marked green over the packets marked yellow. After all the conform traffic (green) is transmitted and there are tokens available still, the yellow packets are transmitted next, instead of being marked as violate traffic (red).

To enable the conform-aware hierarchical policy feature run the command.

```
hw-module profile qos conform-aware-policer
```

Table 4: Feature History Table

Feature Name	Release Information	Feature Description
4K Pseudowire on bundle with QoS enhancement with min shaper value of 144 mbps	Release 7.2.2	To enable hierarchical egress policies on the physical or on the virtual main interfaces with lower shaper values (lesser than 400 MB), use the **hw-module profile qos physical-hqos-enable** command.

To enable hierarchical egress policies on the physical or on the virtual main interfaces with lower shaper values (lesser than 400 MB), use the **hw-module profile qos physical-hqos-enable** command.

Note To activate the new QoS profile, you must manually reload all line cards.

Configuring Conform Aware Hierarchy Policy

To enable and configure shared policer:

1. Run the **hw-module profile qos conform-aware-policer** command.
2. Reload the affected line card.

3. Configure class maps to be used for matching packets to the class specified.
4. Create a child policy map.
5. Configure traffic policing for the classes in the child policy map.
6. Attach the child policy-map to the parent's class-default class.
7. Configure traffic policing for the parent policy map.

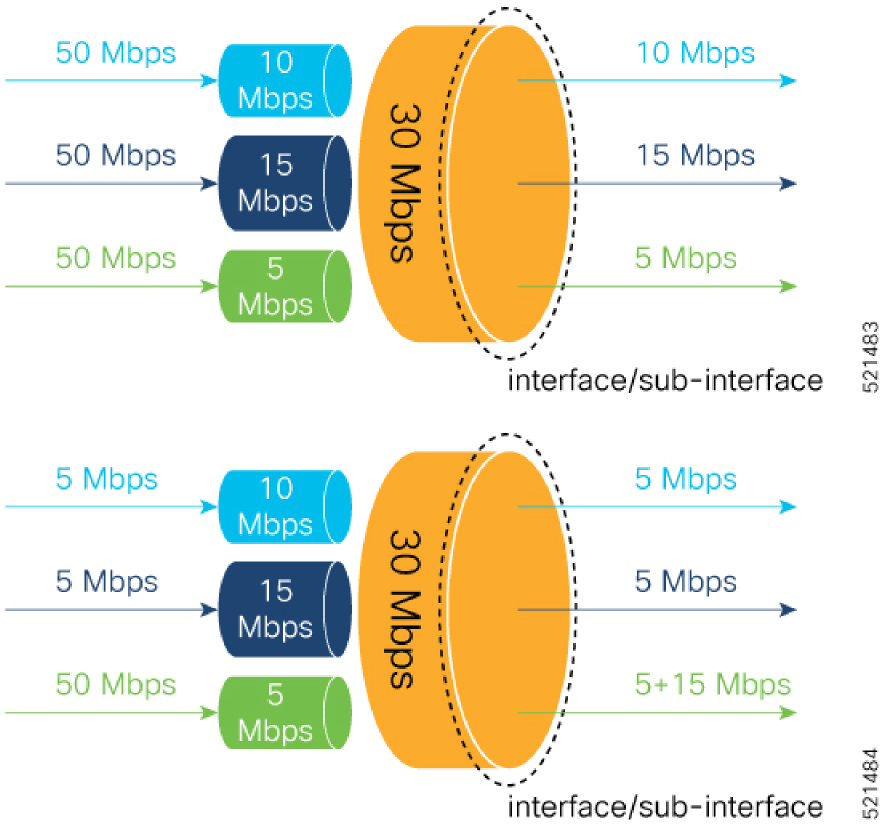
```
RP/0/RP0/CPU0:ios(config)#hw-module profile qos conform-aware-policer
/* To activate this profile, you must manually reload the chassis or all line cards */
RP/0/RP0/CPU0:ios(config)#exit
Uncommitted changes found, commit them before exiting(yes/no/cancel)? [cancel]:yes
RP/0/RP0/CPU0:router# reload location 0/0/CPU0
RP/0/RSP0/CPU0:ios(config)# policy-map CHILD-INGRESS
RP/0/RSP0/CPU0:ios(config-pmap)# class REAL-TIME
RP/0/RSP0/CPU0:ios(config-pmap-c)# set traffic-class 5
RP/0/RSP0/CPU0:ios(config-pmap-c-police)#police rate 20 mbps
RP/0/RSP0/CPU0:ios(config-pmap)# class NET-CONTROL
RP/0/RSP0/CPU0:ios(config-pmap-c)# set traffic-class 4
RP/0/RSP0/CPU0:ios(config-pmap-c-police)#police rate 5 mbps
RP/0/RSP0/CPU0:ios(config-pmap)# class DATA1
RP/0/RSP0/CPU0:ios(config-pmap-c)# set traffic-class 3
RP/0/RSP0/CPU0:ios(config-pmap-c-police)#police rate 5 mbps
RP/0/RSP0/CPU0:ios(config-cmap)# set qos-group 3
RP/0/RSP0/CPU0:ios(config-cmap)# class DATA2
RP/0/RSP0/CPU0:ios(config-pmap-c)# set traffic-class 2
RP/0/RSP0/CPU0:ios(config-pmap-c-police)#police rate 5 mbps
RP/0/RSP0/CPU0:ios(config-cmap)# set qos-group 3
RP/0/RSP0/CPU0:ios(config-pmap-c)#class class-default
RP/0/RSP0/CPU0:ios(config-pmap-c-police)#police rate 10 mbps
RP/0/RSP0/CPU0:ios(config-pmap)#end-policy-map
RP/0/RSP0/CPU0:ios(config)# policy-map PARENT-INGRESS
RP/0/RSP0/CPU0:ios(config-pmap)#class class-default
RP/0/RSP0/CPU0:ios(config-cmap-c)# service-policy CHILD-INGRESS
RP/0/RSP0/CPU0:ios(config-pmap-c-police)#police rate 100 mbps
RP/0/RSP0/CPU0:ios(config-pmap)#end-policy-map
RP/0/RSP0/CPU0:ios(config-pmap)#
RP/0/RSP0/CPU0:ios(config-pmap)# interface GigabitEthernet0/0/0/22.13
RP/0/RSP0/CPU0:ios(config-pmap)# service-policy in parent-policer
RP/0/RSP0/CPU0:ios (config-subif)#end
Uncommitted changes found, commit them before exiting(yes/no/cancel)? [cancel]:yes
```

Running Configuration

```
RP/0/RP0/CPU0:ios#show run interface GigabitEthernet0/0/0/22.13
Tue Feb 23 20:45:08.889 GMT
interface GigabitEthernet0/0/0/22.13
 description Testing interface
 service-policy input parent-policer
 vrf customer1
 ipv4 address 172.16.1.1 255.255.255.252

policy-map PARENT-INGRESS
  class class-default
    service-policy CHILD-INGRESS
    police rate 100 mbps
  !
end-policy-map
!
policy-map CHILD-INGRESS
  class REAL-TIME
```

```
    set traffic-class 5
    police rate 20 mbps
  !
  class NET-CONTROL
    set traffic-class 4
    police rate 5 mbps
  !
  class DATA1
    set traffic-class 3
    police rate 5 mbps
    set qos-group 3
  !
  class DATA2
    set traffic-class 2
    police rate 5 mbps
    set qos-group 3
 !
  class class-default
    police rate 10 mbps
!
end-policy-map
```

Figure 5: Parent Conform Aware-Ingress Policing



```
RP/0/RSP0/CPU0:ios(config)#policy-map parent-policer
RP/0/RSP0/CPU0:ios(config-pmap)#class class-default
RP/0/RSP0/CPU0:ios(config-pmap-c)#service-policy child-policer
RP/0/RSP0/CPU0:ios(config-pmap-c)#police rate 30 mbps peak-rate 30 mbps
RP/0/RSP0/CPU0:ios(config-pmap-c-police)#end-policy-map
RP/0/RSP0/CPU0:ios(config)# policy-map child-policer
RP/0/RSP0/CPU0:ios(config-pmap)# class cos3
```

```
RP/0/RSP0/CPU0:ios(config-pmap-c-police)#police rate 10 mbps peak-rate 30 mbps
RP/0/RSP0/CPU0:ios(config-pmap)# class cos4
RP/0/RSP0/CPU0:ios(config-pmap-c-police)#police rate 15 mbps peak-rate 30 mbps
RP/0/RSP0/CPU0:ios(config-pmap-c)#class class-default
RP/0/RSP0/CPU0:ios(config-pmap-c-police)#police rate 5 mbps peak-rate 30 mbps
RP/0/RSP0/CPU0:ios(config-pmap)#end-policy-map
```

Running Configuration

```
RP/0/RP0/CPU0:ios#show run policy-map parent-policer
Tue Feb 23 19:37:57.500 GMT
policy-map parent-policer
 class class-default
  service-policy child-policer
  police rate 30 mbps peak-rate 30 mbps
  !
 end-policy-map

RP/0/RP0/CPU0:ios#show run policy-map child-policer
Tue Feb 23 19:38:35.472 GMT
policy-map child-policer
 class cos3
  police rate 10 mbps peak-rate 30 mbps
  !
 class cos4
  police rate 15 mbps peak-rate 30 mbps
  !
 class class-default
  police rate 5 mbps peak-rate 30 mbps
  !
 end-policy-map
```

Verification

Run the **show policy-map interface** command in XR EXEC mode to confirm that the committed information rate (CIR) is prioritized over the peak information rate (PIR).

In the example below, **Policed (conform)** or CIR from each class is prioritized over **Policed (exceed)** or PIR.

```
RP/0/RP0/CPU0:ios# show policy-map interface GigabitEthernet0/0/0/22.13 input

GigabitEthernet0/0/0/22.13 input: parent-policer

Class class-default
  Classification statistics          (packets/bytes)     (rate - kbps)
    Matched             :          217797200/111512166400         2344847
    Transmitted         :            8314388/4256966656           88089
    Total Dropped       :          209482812/107255199744         2256758

  Policing statistics                (packets/bytes)     (rate - kbps)
    Policed(conform)    :            6602174/3380313088           69926
    Policed(exceed)     :            1712214/876653568            18165
    Policed(violate)    :          209482812/107255199744         2256782
    Policed and dropped :          209482812/107255199744

  Policy child-policer Class cos3
    Classification statistics          (packets/bytes)     (rate - kbps)
      Matched             :          54449300/27878041600          586215
      Transmitted         :           3246813/1662368256           34399
      Total Dropped       :          51202487/26215673344          551816
    Policing statistics                (packets/bytes)     (rate - kbps)
      Policed(conform)    :           2818471/1443057152           29851
      Policed(exceed)     :             428342/219311104            4547
      Policed(violate)    :            51202487/26215673344          551816
      Policed and dropped :            51202487/26215673344
      Policed and dropped(parent policer)  : 0/0

  Policy child-policer Class cos4
    Classification statistics          (packets/bytes)     (rate - kbps)
      Matched             :            54449300/27878041600          586213
      Transmitted         :             2319731/1187702272           24577
     Total Dropped       :            52129569/26690339328          561636
    Policing statistics                (packets/bytes)     (rate - kbps)
      Policed(conform)    :             1891851/968627712            20037
      Policed(exceed)     :              427880/219074560            4540
      Policed(violate)    :            52129569/26690339328          561636
      Policed and dropped :            52129569/26690339328
      Policed and dropped(parent policer)  : 0/0

  Policy child-policer Class class-default
    Classification statistics          (packets/bytes)     (rate - kbps)
      Matched             :           108898600/55756083200          1172419
      Transmitted         :             2747844/1406896128           29113
      Total Dropped       :           106150756/54349187072          1143306
    Policing statistics                (packets/bytes)     (rate - kbps)
      Policed(conform)    :             1891852/968628224            20036
      Policed(exceed)     :              855992/438267904            9076
      Policed(violate)    :           106150756/54349187072          1143306
      Policed and dropped :           106150756/54349187072
      Policed and dropped(parent policer)  : 0/0
```

Related Commands hw-module profile qos conform-aware-policer

Conform Aware Hierarchical Policy Restrictions

The parent-policy traffic police rate must be greater than or equal to the sum of child conform rates.

- The Confirm-Aware hierarchical policer function allows the child level policy to color the traffic as either green, yellow, or red for handling at the parent-level policer.
- All classes in the child-level of the QoS policy need to have a policer configured for their packets to be handled correctly by the parent policer.