



Quality of Service Configuration Guidelines for RSP3 Module

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Quality of Service

QoS refers to the ability of a network to provide improved service to selected network traffic over various underlying technologies including Ethernet and 802.1 networks, and IP-routed networks. In particular, QoS features provide improved and more predictable network service by implementing the following services:

- Supporting guaranteed bandwidth
- Improving loss characteristics
- Avoiding and managing network congestion
- Shaping network traffic
- Setting traffic priorities across the network

Quality of Service Configuration

This document provides details on the platform-dependent implementation of QoS on the router.

QoS Support Overview

Table below provides an overview of QoS feature support on the router. For more detail about the support for each feature, see *Global QoS Limitations* section.

Table 1: QoS Feature Overview

Feature	Main	Service Instance	Trunk EFP
Dynamic policy modification	3.16	3.16	3.16
EFP QoS Support	3.16	3.16	3.16
Classification			
Ingress	3.16	3.16	3.16
Egress	3.16	3.16	3.16
Match any	3.16	3.16	3.16
Marking			
Ingress	3.16	3.16	3.16
Egress	3.16	3.16	3.16
Policing			
Ingress	3.16	3.16	3.16

Feature	Main	Service Instance	Trunk EFP
Shaping			
Port Shaping	3.16	3.16	3.16
Congestion Avoidance			
WRED	3.16	3.16	3.16
Multiple Priority Queues	3.16	3.16	3.16
Congestion Management			
Strict Priority	3.16	3.16	3.16
Scheduling			
Egress	3.16	3.16	3.16
QoS ACLs			
Ingress	3.16	3.16	3.16

Cisco RSP3 Module QoS Capabilities

- RSP3 module has 4 GB external packet buffers per NPU.
- RSP3 module supports 48000 queues.
- By default, RSP3 module supports upto 1 MB queue-limit per queue.
- Queue limit percentage is considered out of 1 GB of the total buffers.
- Usage of Traffic Classes (TC) in RSP3 module:
 - TC is used to map packets into appropriate queue (Priority, default and so on).
 - TC can be used to remark packet on egress interface.
 - Upto 8 TCs are supported on RSP3 module.
 - Based on packet forwarding type, NPU picks specific PHB from a packet.
- Default mapping of traffic classes:

Table 2: Default Mapping of Packet Fields to Traffic Classes

Flow Type	From	To
Layer2 Flow	COS Bits (0-7)	TC (0-7)
Layer3 (L3/BDI) Flow	IP PREC (0-7)	TC (0-7)

Flow Type	From	To
MPLS Flow	EXP (0-7)	TC (0-7)

Table 3: Default Queue priority for respective Traffic Classes

Traffic Class	Default Priority
TC0 – TC6	Fair Queue
TC7	Strict Priority



Note Effective Cisco IOS XE Everest 16.6.1, the inner DSCP preservation is supported.

TCAM Scale Support for Ingress QoS

Ternary content-addressable memory (TCAM) resources are commonly used for PHB policies that use match DSCP or IP precedence, multi match PHB policies, or parent match EFP policies with child PHB. Starting with Cisco IOS XE Fuji 16.7.1 release, the supported TCAM scale limit per network processor (NPU) for ingress QoS policy maps is increased from 1024 entries to 2048.

Since TCAM resources are shared between multiple features, increasing the scale limit for one feature may not be supported by other features. For example, QoS, IPv4 ACL, and IPv6 multicast features share the common TCAM resources. When you increase the TCAM scale limit for QoS, then the other two features might not be able to support these increased scale limits.

The supported TCAM scale limit for IPv4 ACL is 1000 and IPv6 multicast is 2000 TCAM entries. These supported scale numbers cannot be achieved with the QoS TCAM scale of 2048.

The following **show platform hardware pp active feature qos resource-summary** command displays the increased scale support for QoS:

```
router#show platform hardware pp active feature qos resource-summary 0
RSP3 QoS Resource Summary

Type Total Used Free
-----
QoS TCAM 2048 0 2048
VOQs 49152 816 48336
QoS Policers 32768 0 32768
QoS Policers Profiles 1023 0 1023
Ingress CoS Marking Profiles 16 1 15
Egress CoS Marking Profiles 16 1 15
Ingress Exp & QoS-Group Marking Profiles 64 3 61
Ingress QoS LPM Entries 32768 0 32768

router#show platform hardware pp active feature qos resource-summary 1
RSP3 QoS Resource Summary

Type Total Used Free
```

```

-----
QoS TCAM 2048 0 2048
VOQs 49152 816 48336
QoS Policers 32768 0 32768
QoS Policer Profiles 1023 0 1023
Ingress CoS Marking Profiles 16 1 15
Egress CoS Marking Profiles 16 1 15
Ingress Exp & QoS-Group Marking Profiles 64 3 61
Ingress QoS LPM Entries 32768 0 32768

```

Table 4: Feature History

Feature Name	Release	Description
Increase QoS Service-Policy Scale	Cisco IOS XE Bengaluru 17.5.1	Starting with Cisco IOS XE Bengaluru 17.5.1 release, you can further increase the TCAM scale limit per NPU from 2048 entries to 3072 entries for ingress QoS policy maps. This feature is supported on the Cisco RSP3 module.

Starting with Cisco IOS XE Bengaluru 17.5.1 release, you can further increase the TCAM scale limit per NPU from 2048 entries to 3072 entries for ingress QoS policy maps. This increased scale limit is to support certain use cases that may require higher TCAM resources.

Use the following SDM template to set the TCAM scale limit.

- **enable_qos_scale** – Enable this template to achieve 3072 QoS TCAM entries.
- **disable_qos_scale** – Disable this template to get back to 2048 QoS TCAM entries.



Note If the system is configured with SDM template `enable_qos_scale`, then the scale limits of IPv6 multicast and IPv4 ACLs behave as follows:

- No TCAM entries are consumed for IPv6 multicast
- TCAM limit is reduced to 700 for IPv4 ACL

You can perform the following sample configuration across multiple EFPs to increase the scale value.

```

Class-map:
=====
class-map match-any cos4
match cos 4
match dscp ef
class-map match-any cos3
match cos 3
match dscp cs3
class-map match-any cos2
match cos 2
match dscp cs2
class-map match-any cos1
match cos 1
match dscp cs1

Policy-map:
=====

```

```

policy-map cos
class cos1
police cir 10000000
set qos-group 1
class cos2
police cir 20000000
set qos-group 2
class cos3
police cir 30000000
set qos-group 3
class cos4
police cir 40000000
set qos-group 4

Interface config (policy-map attachment):
=====
interface HundredGigE0/5/0
no ip address
cdp enable
service instance 1 ethernet
encapsulation dot1q 1
rewrite ingress tag pop 1 symmetric
service-policy input cos
bridge-domain 1
!
service instance 2 ethernet
encapsulation dot1q 2
rewrite ingress tag pop 1 symmetric
service-policy input cos
bridge-domain 2
!
service instance 3 ethernet
encapsulation dot1q 3
rewrite ingress tag pop 1 symmetric
service-policy input cos
bridge-domain 3
!
.
.
.
.
.
service instance 341 ethernet
encapsulation dot1q 341
rewrite ingress tag pop 1 symmetric
service-policy input cos
bridge-domain 341
!

```

Use the following **show platform hardware pp active feature qos resource-summary** command to display the increased scale values for QoS:

```

router#show platform hardware pp active feature qos resource-summary 0
RSP3 QoS Resource Summary

```

Type	Total	Used	Free
QoS TCAM	3072	3069	3
VOQs	49152	648	48504
QoS Policers	32768	0	32768
QoS Policer Profiles	1023	0	1023
Ingress CoS Marking Profiles	16	1	15
Egress CoS Marking Profiles	16	1	15

Ingress Exp & QoS-Group Marking Profiles	64	3	61
Ingress QoS LPM Entries	32768	0	32768

Cisco RSP3 Module Marking Capabilities

- The DSCP field (TAG to IP) value does not change in both the uniform mode and in pipe mode. This is applicable to both the Unicast and Multicast traffic scenario.
- Time to Live (TTL) value does not decrement on the imposition node in IP to MPLS LABEL case with L3VPN Conditional Marking.
- By default, tunnel mode in RSP3 module is in Uniform mode.
- For MPLS L3VPN:
 1. PREC/DSCP values are automatically copied to the EXP bit on imposition.
 2. EXP topmost values are automatically copied to PREC/DSCP bits on disposition.
 3. For marking MPLS EXP, **set mpls exp imposition** on imposition and **set mpls exp topmost** on swap cases.
- For MPLS L2VPN:
 1. COS values are automatically copied to the EXP bit on imposition.
 2. EXP topmost values are automatically copied to COS bits on disposition.
 3. For marking MPLS EXP, **set qos-group** on imposition and **set mpls exp topmost** on swap cases.



Note Starting from:

- Cisco IOS XE Everest 16.7.1 and later, conditional marking is supported in Pipe mode.
- Cisco IOS XE Fuji 16.8.x and later, conditional marking for L2VPN is supported on BDI.

Configuring Short-Pipe Mode on QoS

Short-pipe mode on QoS RSP3 module can be activated using an SDM template. You can identify the egress traffic on an interface or EVC and classify based on DSCP, mark qos-group, and color using the platform table-map command. You can perform WFQ/WRED based on qos-group and color on egress interface using egress policy-map.

Procedure

Step 1 **enable**

Example:

```
Device> enable
```

Enables privileged EXEC mode.

- Enter your password if prompted.

Step 2 **configure terminal**

Example:

```
Device# configure terminal
```

Enters global configuration mode.

Step 3 **sdm prefer enable_egr_l3vpn_cm**

Example:

```
Device(config)# sdm prefer enable_egr_l3vpn_cm
```

Enables the SDM template.

Step 4 **platform qos-table-map**

Example:

```
Device(config-table-map)# platform qos-table-map Customer#6
  from dscp 10 to qos-group 0 discard-class 0
  from dscp 63 to qos-group 0 discard-class 1
```

```
qos-table-map Customer#6 interface GigabitEthernet0/4/0
```

Creates platform table-map and applying it on an interface.

Step 5 **Class-map match-any qos0**

Example:

```
Device(config-table-map)# Class-map match-any qos0
  match qos-group 0
Policy-map short-pipe-qos
  class qos0
    bandwidth 30000
    random-detect discard-class-based
    random-detect discard-class 0 25000 bytes 75000 bytes 1
    random-detect discard-class 1 95000 bytes 300000 bytes 1
    queue-limit 375000 bytes
```

Creates egress class map and policy map.

Example

Configuration Example

```
sdm prefer enable_egr_l3vpn_cm
```

```
platform qos-table-map Customer#6
  from dscp 10 to qos-group 0 discard-class 0
```



```

    from dscp 63 to qos-group 0 discard-class 1

qos-table-map Customer#6 interface GigabitEthernet0/4/0

interface Gig 0/5/0
    service-policy output short-pipe-qos

Class-map match-any qos0
    match qos-group 0

Policy-map short-pipe-qos
    class qos0
        bandwidth 30000
        random-detect discard-class-based
        random-detect discard-class 0 25000 bytes 75000 bytes 1
        random-detect discard-class 1 95000 bytes 300000 bytes 1
        queue-limit 375000 bytes

```

Restrictions on Short-Pipe Mode

- The **enable_egr_l3vpn_cm** SDM template command cannot co-exist with other templates such as **sdm prefer enable_copp** and **sdm prefer enable_match_inner_dscp** commands.
- Short-pipe mode on QoS RSP3 module is applicable only for conditional marking, which is not supported for multicast L3VPN traffic flows (TAG to IP).
- Short-pipe mode on QoS RSP3 module is not applicable for IPv6 traffic.
- You can configure only up to 7 table-maps.
- Following QoS classifications does not work after you enable the **sdm template** to activate short-pipe mode QoS feature:
 - DstMac
 - InnerVlanPri
 - InnerVlan
 - SrcIp
 - DstIp
- Before deleting the corresponding BDI interface, ensure to detach or unconfigure the table-map, if the table-map is applied on the BDI interface.
- Each table-map entry (classify on DSCP, mark to Qos-Group and DC) consumes up to 3 TCAM entries.
- Egress table-map matched traffic does not hit core interface policy-map.
- Core interface policy-map stats do not count egress table-map hit packets.
- Platform table-map stats are not supported.
- All backup paths (LB/FRR case) should be mapped with same table-map profile.

Global QoS Limitations

The following limitations apply to multiple QoS features for the router:

- Ingress policer rate does not display the configured value when member links of a port channel are configured from different ASIC boards.
- 16K QoS policers are supported per ASIC on the RSP3 module, hence 32K policers are supported per chassis (dual ASIC board).
- Both ingress MAC (L2) ACL and ingress QoS policy map are not supported on the same EFP.
- The configurable committed burst (bc) value, under the QoS policy-map must only be between 8000 and 4161500 bytes in RSP3 module.
- RSP3 module supports 2 discard-class based WRED profiles per class.
- IPv6 QoS is *not* supported on port channel and port channel member links on the RSP3 module.
- With L3VPN, Ingress QoS match on DSCP or PREC and set EXP marking, overwrites the DSCP value with EXP at imposition resulting in loss of the DSCP value.
- When EVCs under a physical interface have a QoS policy attached, the following limitations apply:
 - The port-level policy is limited to the class-default class.
 - Only the **shape** command is supported in the port-level policy.
- The router supports up to 64 unique QoS classification service instances in a given bridge domain. QoS service instances refer to ports, VLAN classes (for ingress), EFPs associated with a QoS classification policy.
- Modification of class-map definitions while applied to an interface or Ethernet Flow Point is *not* supported.
- Policy validation—Some QoS policy configurations are not validated until you apply the policy-map to an interface or Ethernet Flow Point. If a QoS configuration is invalid, the router rejects the configuration when you apply it to an interface. In some cases, a QoS configuration may be rejected due to hardware resource exhaustion or limitations. If you receive such an error message, detach the policy and adjust your QoS configuration.
- The **match-all** keyword is supported only for QinQ classification. The following matches are allowed in a match class-map.
 - Vlan and vlan-inner classification
 - Cos and cos-inner classification
- Only one **match access-group** match is supported on the same class-map.
- COS to PREC marking does not work for L2 flows.
- PREC to COS marking does not work on L3 flows.
- VLAN classification policy is not supported on EFP with cross connect configured.
- Match VLAN egress classification is not supported.

- Egress policy-map can have match QoS-group.
- Egress policing is not supported.
- Egress queuing is supported.
- CPU generated traffic is not subjected to QoS on the egress interface. So, no QoS policy is required to treat CPU generated traffic on the egress interface.
- QoS does not account for CRC values on an interface and assumes that the value is 2 bytes. CRC differences can cause accuracy issues for 2 to 3 percent of the traffic.
- QoS does not support WRED counters for all the match conditions.
- Match on DSCP classification or policing or QoS group marking is *not* supported for IPv6 traffic on the disposition node when MPLS is configured for both per-prefix and per-VRF modes.
- When the ingress interface has both the MPLS tunnel terminated packets and transit tunnel packets, and the ingress policy is applied on the interface for exp marking, then the DSCP value is not preserved for tunnel terminated packets.
- Queuing support at physical, logical, and queue levels:
 - Queuing action supported at physical level: Shaper
 - Queuing action supported at logical level: Shaper
 - Queuing action supported at queue level: Bandwidth, Shaper, WRED, Queue Limit
- Traffic drops are observed for minimum-sized MPLS pseudowire packets.
- RSP3 does not support policy-based routing.
- Match Inner DSCP feature is supported only on the L3 interface and not on the Bridge Domain Interface.
- The **hw-module subslot 0/<bay> default** command for interface module or **default interface <ethernet_interface_type> <0/bay/port>** command for interface to remove the QoS overhead accounting configuration from a particular interface module or interface at a global configuration level, does not remove the QoS overhead accounting configuration set. To disable the QoS overhead accounting configuration from a particular interface, enter the **no** form of the **qos-overhead-accounting** command manually.
- DSCP bits are not retained for Multicast traffic at the disposition node in uniform mode.
- Starting with Cisco IOS-XE Release 16.6.1, multi active port-channel templates are used to apply a QoS policy for a port-channel interface.

Following are the restrictions for QoS on Serial or MLPPP interfaces:

- For the Class-based weighted fair queueing (CBWFQ) and priority on multilink interface, the QoS policy moves to the suspend state if the configured value is greater than that of the interface bandwidth.
For the CBWFQ and priority on serial interfaces, the QoS policy is not attached to the serial interface, if the configured value is greater than that of the interface bandwidth.
- For SHAPE on multilink interface, the QoS policy move to suspend state ,iff the configured shape rate of each class is greater than that of the interface bandwidth.

- For SHAPE on serial interfaces, the policies are not attached to the interface, if the configured rate of each shape class is greater than that of the interface bandwidth.

Difference in WRED Behavior

As WRED is enforced at the VoQs, it is independently enforced on each ingress ASIC, when the ingress traffic is from interfaces belonging to different ASICs. This results in per ASIC VoQ build up and drop decision. The drops may be fair as long as the ingress traffic rate is similar across different ASICs.

This behavior is also applicable, if multiple filters exist in the egress policy-map class.

QoS Features Using MQC Limitations

Table below lists the QoS MQC scaling limitations on router per release.

Table 5: Qos on MQC Limitations

Supported on Router	Cisco IOS XE 3.16
No. of unique policy-maps	1024
No. of unique class-maps	4096
No. of classes per policy-map	512
No. of filters per class-map	16

¹ For releases which are not listed, refer to the most recent previous release limit.

Restrictions for Ingress QoS

- QoS ACL inbound policy-map is only supported.
- QoS ACLs based to classification are not supported for:
 - TCP source and destination
 - UDP source and destination
- Apply QoS ACL only to the third level class (bottom-most). This means that you cannot configure ACL classifications in a parent class.
- Deny statements within ACL are ignored for the purpose of classification.
- Classifying traffic using multiple mutually exclusive ACLs within a match-all class-map is not supported.
- MAC-based QoS ACLs are supported on destination MAC ACLs only.
- Match EFP policy is not supported on member-links.
- Match VLAN policy is not supported on member-links.
- Ingres COS marking is not supported when the service-instance is configured with encapsulation “untagged” and rewrite rule is “rewrite ingress tag push dot1g <vlan> symmetric.

The following restrictions apply to the Cisco IOS XE Everest 16.5.1 release:

- IPv6 QoS is not supported on port channel and member-link.
- In case of multi-match policy IPv6 traffic is not classified to any class, that is, QoS is not supported for IPv6 traffic.
- By default, set of eight DSCP values are mapped to one traffic class.
- Switched Layer 2 packets with IPv6 payload are not subjected to DSCP based QoS at the ingress.
- IPv6 QoS ACL is not supported.
- Match-VLAN is not supported for routed IPv6 streams.
- If set dscp policy is applied, all other DSCPs belonging to the traffic class which are being matched get classified, but set-dscp action only works for the DSCP which is being matched.

Restrictions for Egress QoS

- The maximum number of PHB classes supported on the policy map is 8, which includes one class class-default; 7 user-defined classes and class class-default is supported.
- Match EFP policy is not supported on member-links.
- High latency for priority traffic is observed during congestion for egress QoS over 1G link.

8K EFP (4 Queue Model)

In Cisco IOS XE Release 3.18SP, the 8K EFP (4 Queue Model) support allows up to 8000 EFPs at the system level. EFP scale implementation follows the static model, that is, eight queues are created per EFP by default.

Information About 8000 (8K) EFP

- In default model, 5000 EFPs can be configured on Cisco NCS 4200 RSP3 module.
- The Switch Database Management (SDM) template feature can be used to configure 8000 EFPs across ASIC(4000 EFPs per ASIC interfaces).
- In 8K EFP model, each EFP consumes four Egress queues. If 8K EFP SDM template is not enabled, each EFP consumes eight Egress queues.
- Ingress policy map can specify more than eight traffic classes based on PHB matches, which remains the same. However, Egress policy map can have three user defined class and class-default class.
- Each Egress class-maps can be mapped to a single or multiple traffic classes and each class-map mapped to a single queue.
- Maximum of two queues are set to Priority according to policy configuration.
- All the existing QoS restrictions that apply in default model are also applicable to 8K EFP model.

Prerequisites for 8000 (8K) EFP

- Activate the Metro Aggregation Services license on the device.
- To configure 8000 EFPs, enable the SDM template using CLI **sdm prefer enable_8k_efp**.
- Reset the SDM template using the CLI **sdm prefer disable_8k_efp** .

Restrictions for 8000 (8K) EFP

- With the **enable_8k_efp** SDM template, shut or noshut on Port-channel (PoCH) is blocked. To make the PoCH as UP or DOWN, all the port channel member links must be either shut or noshut.
- Traffic class to Queue mapping is done per interface and not per EVC.
- Four traffic classes including class-default can be supported in Egress policy.
- Same three traffic classes or subset of three traffic classes match is supported on EVCs of an interface.
- Traffic classes to queue mapping profiles are limited to four in global, hence excluding class-default, only three mode unique combinations can be supported across interfaces.
- TRTCM always operates with conform-action transmit, exceed-action transmit and violate-action drop.
- By default, 1R2C Policer will behave as 1R3C Policer in 4 Queue model.
- All the QOS restrictions that is applicable in default mode is also applicable in 8k EFP mode

Configuring 8K Model

Configuring 8K EFP Template

Below is the sample configuration to enable 8K EFP or 4 Queue mode template. On enabling **sdm prefer enable_8k_efp**, the router reloads and boots up with 8K EFP template.

```
RSP3-903(config)#sdm prefer enable_8k_efp
```

```
Template configuration has been modified. Save config and Reload? [yes/no]: yes
Building configuration...
```

```
Jul 22 05:58:30.774 IST: Changes to the EFP template preferences have been stored[OK]
Proceeding with system reload...
Reload scheduled for 06:00:38 IST Fri Jul 22 2016 (in 2 minutes) by console
Reload reason: EFP template change
```

Verifying 8K EFP Template

You can verify the current template as below.

```
Device#sh sdm prefer current
```

```
The current sdm template is "default" template and efp template is "enable_8k_efp" template
```

Configuring QOS in 8K EFP Model

Below is sample configuration to configure egress policy map when 4Q mode is enabled.

```
Device#enable
Device#configure terminal
Device(config)#interface GigabitEthernet0/3/0
Device(config-if)#service instance 10 e
Device(config-if-srv)#service-policy output egress
```

```
Current configuration : 193 bytes
```

```
!
policy-map egress
class qos2
  shape average 2000000
class qos3
  shape average 3000000
class qos4
  shape average 4000000
class class-default
  shape average 5000000
!
end
```

```
Device#sh run class-map qos2
Building configuration...
```

```
Current configuration : 54 bytes
```

```
!
class-map match-all qos2
match qos-group 2
!
end
```

```
Device#sh run class-map qos3
Building configuration...
```

```
Current configuration : 54 bytes
```

```
!
class-map match-all qos3
match qos-group 3
!
end
```

```
Device#sh run class-map qos4
Building configuration...
```

```
Current configuration : 54 bytes
```

```
!
class-map match-all qos4
match qos-group 4
!
end
```

Verifying QOS in 8K EFP Model

You need to verify the interface and policy-map details to check 8K model queue is working.

```
Device# show run interface g0/3/0
Building configuration...
```

```

Current configuration : 217 bytes
!
interface GigabitEthernet0/3/0
no ip address
negotiation auto
service instance 10 ethernet
  encapsulation dot1q 10
  rewrite ingress tag pop 1 symmetric
  service-policy output egress
  bridge-domain 10
!
end

Router#show running-config policy-map egress
Building configuration...

Current configuration : 193 bytes
!
policy-map egress
class qos2
shape average 2000000
class qos3
shape average 3000000
class qos4
shape average 4000000
class class-default
shape average 5000000
!
end

Device#sh policy-map int g0/3/0 serv inst 10
Port-channel10: EFP 10

Service-policy output: egress

Class-map: qos2 (match-all)
122566 packets, 125262452 bytes
30 second offered rate 0000 bps, drop rate 0000 bps
Match: qos-group 2
Queueing
queue limit 4096000 us/ 1024000 bytes
(queue depth/total drops/no-buffer drops) 1032720/119746/0
(pkts output/bytes output) 2820/2882040
shape (average) cir 2000000, bc 8000, be 8000
target shape rate 2000000

Class-map: qos3 (match-all)
122566 packets, 125262452 bytes
30 second offered rate 0000 bps, drop rate 0000 bps
Match: qos-group 3
Queueing
queue limit 2730666 us/ 1024000 bytes
(queue depth/total drops/no-buffer drops) 1032720/118806/0
(pkts output/bytes output) 3760/3842720
shape (average) cir 3000000, bc 12000, be 12000
target shape rate 3000000

Class-map: qos4 (match-all)
245131 packets, 250523882 bytes
30 second offered rate 0000 bps, drop rate 0000 bps
Match: qos-group 4
Queueing
queue limit 2048000 us/ 1024000 bytes
(queue depth/total drops/no-buffer drops) 1032720/239961/0

```



```

(pkts output/bytes output) 5170/5283740
shape (average) cir 4000000, bc 16000, be 16000
target shape rate 4000000

Class-map: class-default (match-any)
245131 packets, 250523882 bytes
30 second offered rate 0000 bps, drop rate 0000 bps
Match: any
Queueing
queue limit 1638400 us/ 1024000 bytes
(queue depth/total drops/no-buffer drops) 1032720/239961/0
(pkts output/bytes output) 5170/5283740
shape (average) cir 5000000, bc 20000, be 20000
target shape rate 5000000
Device#

```

16K EFP Support

Starting Cisco IOS Release 16.6.1, 16K EFPs are supported on the RSP3 module. The key features with this enhancement are:

- 16000 EFPs are supported on the RSP3 module (8K EFPs are supported per ASIC). Each port can have maximum of 8K EFPs configured.
- 8K bridge-domains are supported.
- Maximum of 16000 EVCs can be configured on the physical interface.
- Maximum of 8K Local-connect configurations are supported.
- Maximum of 1K bridge domain interface (BDI) can be configured upto BDI 4096.



Note In scenarios where VLAN range is greater than 5, VLAN compression is enabled.

Restrictions for 16K EFP

- 16k EFP scale is *not* supported if sdm template is enabled for split horizon scale.
- Egress policy-map is *not* supported on interfaces with 8K EFP configuration.
- The EVC/BD scale is *not* supported for port-channel.
- Minute traffic outage (few milliseconds) may be observed when applying or removing a policy-map.
- MAC security configuration must be reconfigured after every policy is attached or detached.
- G8032, CFM and other Layer2 configurations are *not* supported if bridge-domains configured exceeds 4096.
- EVC MAC flush is triggered after attaching or detaching an egress policy map on the EVC.
- In a full scale setup, the EFP statistics update takes more than 1min to complete.

Configuring QoS with 16K EFP

Sample configuration on how to configure 16K EFP

```
enable
Configure terminal
interface gigabitethernet interface 0/0/1
service instance 8001 ethernet
encapsulation dot1q 20
bridge-domain 20
```

Verifying QoS Using 16k EFP

Following are verification examples to verify QoS configurations using 16K EFP.

show ethernet service instance summary

```
Router# show ethernet ser instance summary
```

System summary

	Total	Up	AdminDo	Down	ErrorDi	Unknown	Deleted	BdAdmDo
bdomain	16000	16000	0	0	0	0	0	0
xconnect	0	0	0	0	0	0	0	0
local sw	0	0	0	0	0	0	0	0
other	0	0	0	0	0	0	0	0
all	16000	16000	0	0	0	0	0	0

Associated interface: GigabitEthernet0/6/1

	Total	Up	AdminDo	Down	ErrorDi	Unknown	Deleted	BdAdmDo
bdomain	8000	8000	0	0	0	0	0	0
xconnect	0	0	0	0	0	0	0	0
local sw	0	0	0	0	0	0	0	0
other	0	0	0	0	0	0	0	0
all	8000	8000	0	0	0	0	0	0

Associated interface: TenGigabitEthernet0/7/7

	Total	Up	AdminDo	Down	ErrorDi	Unknown	Deleted	BdAdmDo
bdomain	8000	8000	0	0	0	0	0	0
xconnect	0	0	0	0	0	0	0	0
local sw	0	0	0	0	0	0	0	0
other	0	0	0	0	0	0	0	0
all	8000	8000	0	0	0	0	0	0

show ethernet service instance id interface stats

```
Router# show ethernet service instance id 12000 interface te0/7/7 stats
```

Port maximum number of service instances: 16000

Service Instance 12000, Interface TenGigabitEthernet0/7/7

Pkts In	Bytes In	Pkts Out	Bytes Out
252	359352	252	359352

show platform hardware pp active interface all

```
Router# show platform hardware pp active interface all
```

Interface manager platform keys

```
-----
Name: TenGigabitEthernet0/7/7, Asic: 0, hwidx: 62
lpn: 0, ppn: 62, gid: 62, mac: 7426.acf6.5685
InLportId: 0, ELportId: 0, dpidx: 22, l3ID: 19
port_flags: 0, port_speed: 10000 Mbps, efp_count: 8000, destIndex: 62, intType: 1
etherchnl: 0, efp: 0, bdi: 0, l2PhyIf: 1, l3PhyIf: 0, l3TDM: 0, loopBack: 0
tunnel: 0, tunneltp: 0, icmp_flags: 0, icmp6_flags: 0
bandwidth: 10000000, fcid: 0, cid: 0, mpls_tbid: 65535, protocols: 0
v4_netsmask: 0, v4_tableid: 0, v6_tableid: 65535, vrf_tbid_dstrm: , snmp_index: 0
bd_id: 0, encap: 1, ip_mtu: 1500, l2_max_tu: 1500, l2_min_tu: 0
```

```
vrfid: 0, enctype: 0, admin_state: 1, admin_state_oir: 0
```

show platform hardware pp active feature qos resource-summary

```
Router# show platform hardware pp active feature qos resource-summary 0
RSP3 QoS Resource Summary
```

```
Type Total Used Free
-----
QoS TCAM 1024 0 1024
VOQs 49152 784 48368
QoS Policers 32768 0 32768
QoS Policer Profiles 1023 0 1023
Ingress CoS Marking Profiles 16 1 15
Egress CoS Marking Profiles 16 1 15
Ingress Exp & QoS-Group Marking Profiles 64 3 61
Ingress QoS LPM Entries 32768 32000 32768
```

```
Router# show platform hardware pp active feature qos resource-summary 1
RSP3 QoS Resource Summary
```

```
Type Total Used Free
-----
QoS TCAM 1024 0 1024
VOQs 49152 784 48368
QoS Policers 32768 0 32768
QoS Policer Profiles 1023 0 1023
Ingress CoS Marking Profiles 16 1 15
Egress CoS Marking Profiles 16 1 15
Ingress Exp & QoS-Group Marking Profiles 64 3 61
Ingress QoS LPM Entries 32768 0 32768
```

show interface

```
Router# show interface gig0/1/6 | in pack
 30 second input rate 43604000 bits/sec, 43955 packets/sec
 30 second output rate 0 bits/sec, 0 packets/sec
 1521946 packets input, 188721304 bytes, 0 no buffer
 0 packets output, 0 bytes, 0 underruns
```

```
Router# show interface gig0/1/7 | in pack
 30 second input rate 0 bits/sec, 0 packets/sec
 30 second output rate 43131000 bits/sec, 43482 packets/sec
 0 packets input, 0 bytes, 0 no buffer
 1523724 packets output, 188941776 bytes, 0 underruns
```

16K EFP Support on Port Channel

Starting with Cisco IOS XE 16.8.1 release, 16K EFPs on port channel are supported on the RSP3 module.

The following are the key features supported:

- In order to enable 16K EFP over a port channel, you need to enable the following template:
enable_portchannel_qos_multiple_active
- 16000 EFPs are supported on the RSP3 module (8K EFPs are supported per ASIC). Each port can have a maximum of 8K EFPs configured.

- 8K bridge domains are supported.
- On the RSP3 module, 1024 BDI interfaces that include physical interface, port channel interface, and BDI are available, and these interfaces can be configured upto 4096 BDI interfaces.

**Note**

- If a port channel is configured on an application-specific integrated circuit (ASIC), for example ASIC 0, then ensure that physical members to be added to port channel also should be in the same ASIC.
- While adding member links to port channels with 3K to 8K EFPs, the router sends CPUHOG messages to the console output to inform that this process has consumed CPU memory. The number of messages increases with the increase in the scale of the EFPs. Such messages do not impact any functionality. They ensure that the system does not become unresponsive or locked up due to the total consumption of the CPU.

Restrictions for 16K EFP on Port Channel

- G.8032, SADT, CFM, and TEFM are not supported on the port channel.
- 16k EFP scale is not supported if SDM template is enabled for split horizon scale.
- Minimal traffic outage (for example, in milliseconds) is observed, when a policy map is applied or removed.
- In a complete scale environment, the EFP statistics update requires more than 1 minute to complete.

Configuring 16K EFP on Port Channel

To configure 16K EFP on port channel, use the following commands:

```
router>enable
router#configure terminal
router(config)#sdm prefer enable_portchannel_qos_multiple_active
router(config)#platform port-channel 10 members-asic-id 1
router(config)#platform qos-port-channel_multiple_active port-channel 10
router(config)#interface port-channel 10
router(config-if)#end
```

After the SDM template update, the device reloads automatically and you need to enter `yes` to save the configuration.

Verifying 16k EFP on Port Channel

The following are examples to verify for 16K EFP configuration on port channel.

show etherchannel summary

```
Router# show etherchannel summary
Flags: D - down          P/bndl - bundled in port-channel
       I - stand-alone  s/susp - suspended
       H - Hot-standby  (LACP only)
       R - Layer3       S - Layer2
```

```

        U - in use          f - failed to allocate aggregator
        M - not in use, minimum links not met
        u - unsuitable for bundling
        w - waiting to be aggregated
        d - default port
Number of channel-groups in use: 1
Number of aggregators:          1
Group  Port-channel  Protocol  Ports
-----+-----+-----+-----
10      Po10 (RU)          LACP      Te0/5/0 (bndl) Te0/5/1 (bndl)

RU - L3 port-channel UP State
SU - L2 port-channel UP state
P/bndl - Bundled
S/susp  - Suspended

```

show ethernet service instance id interface stats

```

Router# show ethernet service instance id 12000 interface port-channel 10 stats
Port maximum number of service instances: 16000
Service Instance 12000, Interface port-channel 10
  Pkts In   Bytes In   Pkts Out   Bytes Out
    252     359352     252       359352

```

show ethernet service instance summary

```

Router# show ethernet service instance summary
System summary
      Total      Up  AdminDo    Down  ErrorDi  Unknown  Deleted  BdAdmDo
bdomain  16000    16000      0        0        0        0        0
xconnect    0         0        0        0        0        0        0
local sw    0         0        0        0        0        0        0
other       0         0        0        0        0        0        0
all        16000    16000      0        0        0        0        0
Associated interface: port-channel 10
      Total      Up  AdminDo    Down  ErrorDi  Unknown  Deleted  BdAdmDo
bdomain   8000     8000      0        0        0        0        0
xconnect    0         0        0        0        0        0        0
local sw    0         0        0        0        0        0        0
other       0         0        0        0        0        0        0
all        8000     8000      0        0        0        0        0
Associated interface: port-channel 11
      Total      Up  AdminDo    Down  ErrorDi  Unknown  Deleted  BdAdmDo
bdomain   8000     8000      0        0        0        0        0
xconnect    0         0        0        0        0        0        0
local sw    0         0        0        0        0        0        0
other       0         0        0        0        0        0        0
all        8000     8000      0        0        0        0        0

```

QoS on Ether Channels

Restrictions of Legacy Ether Channel QoS

This section lists the various restrictions/limitations of the QoS-specific port-channel.

- Egress QoS policy-map is supported only on a member-link interface and not on a port-channel, port-channel EVC and port-channel TEFP.

- Effective Cisco IOS XE Everest 16.5.1 release, the egress policy-map can be configured on port-channel interface, which is in active/standby mode.
- Egress Match efp policy is not supported on PC member-links.
- Egress Match vlan policy is not supported on PC member-links.
- A maximum of 8 member-links will be bundled into a port-channel.
- All the other restrictions that are applicable to a regular port interface on the Cisco RSP3 Module are applicable to a port-channel interface and port-channel EVC.
- Egress policy-map with marking action is not supported on port-channel member links.

Example for Configuring QoS on an Ether Channel

Ingress Policy Map

The below example shows how to configure an ingress QoS policy-map.

```
do sh policy-map cos
  Policy Map cos
  Class cos1
  police cir 1000000 bc 31250
  conform-action transmit
  exceed-action drop
```

Member Link Policy-Map

The below example shows how to apply an ingress QoS policy-map onto a member-link.

```
interface GigabitEthernet0/2/1
  no ip address
  negotiation auto
  service-policy input cos
  channel-group 1
```

Port-Channel Interface Level

The below example shows how to apply an ingress QoS policy-map onto a port-channel interface.

```
interface Port-channell
  no ip address
  negotiation auto
  service-policy input cos
  service instance 1 ethernet
  encapsulation dot1q 10
  rewrite ingress tag pop 1 symmetric
  bridge-domain 10
!
```

Port-Channel EVC Level

The below example shows how to apply an ingress QoS policy-map onto a port-channel EVC.

```
interface Port-channell
  no ip address
  negotiation auto
  service instance 1 ethernet
  encapsulation dot1q 10
  rewrite ingress tag pop 1 symmetric
  service-policy input cos
  bridge-domain 10
```

Egress Policy-Map

The below example shows how to configure an egress QoS policy-map

```
sh policy-map qos
  Policy Map qos
  Class qos-1
  Average Rate Traffic Shaping
  cir 1000000 (bps)
```

Member-Link Policy Map

The below example shows how to apply an egress QoS policy-map on a member-link.

```
interface GigabitEthernet0/2/1
  no ip address
  negotiation auto
  service-policy output qos
  channel-group 1
```

Hierarchical Policy Design

Policing at two levels for the policy map is supported.

Ingress Hierarchical Policy Support

Three-Level Policy: You can only apply a three-level policy to a physical port on the router. A three-level policy consists of:

- Topmost policy: class-default
- Middle policy: match vlan/match efp
- Lowest policy: match prec/match cos/match dscp/match mpls exp topmost/match acl

The following sample policy uses a flat class-default policy on the port and VLAN policies on EFP interfaces to unique QoS behavior to each EFP.

Sample Policy

```
Policy-map port-policer
Class class-default
police cir 7m
Service-policy Vlan_set
Policy-map Vlan_set
Class vlan100
police cir 3m

Policy-map child1
Class prec2
police cir 3m

Service-policy port-policer-1
Class vlan200_300
police cir 4m
Service-policy child1
```

- Two-Level Policy
 - Topmost policy: match vlan/match efp
 - Lowest policy: match prec/match cos/match dscp
- Two-Level Policy
 - Topmost policy: class-default
 - Lowest policy: match vlan
- Two-Level Policy
 - Topmost policy: class-default
 - Lowest policy: match mpls experimental topmost
- Flat policy: match ip dscp
- Flat policy: class-default

Egress Hierarchical Policy Support

The following are examples of supported policy-map configurations:

- Three-Level Policy—You can only apply a three-level policy to a physical port on the router. A three-level policy consists of:
 - Topmost policy: class-default
 - Middle policy: match efp
 - Lowest policy: match qos-group

The following sample policy uses a flat class-default policy on the port and class-default or PHB policy on the EFP interfaces to unique QoS behavior to each EFP.

Sample Policy

```

Policy-map port-shaper
Class class-default
Shape average percent 70
Service-policy child2
Service-policy Efp_set

Service-policy child1
Policy-map Efp_set
Class efp100
Shape average 200m
Class efp200_300
Shape average 200m

Policy-map child1
Class qos2
Shape average percent 40

```



```

Policy-map child2
Class qos4
Shape average percent 50

```

- Two-Level Policy
 - Topmost policy: match efp
 - Lowest policy: match qos-group
- Two-Level Policy
 - Topmost policy: class-default
 - Lowest policy: match efp
- Two-Level Policy
 - Topmost policy: class-default
 - Lowest policy: match qos-group
- Flat policy: match qos-group
- Flat policy: class-default
- Flat policy: match efp

MPLS VPN QoS Mapping

Tables below summarize the default MPLS propagation and MPLS QoS mapping for the router.

Table 6: Default Propagation

Feature	IP to TAG	TAG to TAG	TAG to IP	Comments
L3VPN Uniform mode	Copy IP Prec/DiffServ into MPLS EXP by default	When the outer label is displayed, copy the exp of the . tag to the inner tag	MPLS EXP copied to IP Prec/DiffServ	
		When outer tag is swapped out, copy the exp to newly added tag		

Feature	IP to TAG	TAG to TAG	TAG to IP	Comments
L2VPN Uniform mode	Copy the outer COS to MPLS Exp by default	When the outer tag is popped out, copy the exp of the . tag to the inner tag	MPLS EXP is copied to COS by default.	
		When outer tag is swapped out, copy the exp to newly added tag		

Table 7: MPLS QoS Mapping

Feature	IP to TAG	TAG to TAG	TAG to IP	Comments
L3VPN Uniform mode	Match on PREC/DSCP and mark to MPLS EXP imposition	Match on MPLS EXP topmost and mark to MPLS EXP topmost	EXP to PREC marking is supported at ingress.	With L3VPN, Ingress QoS match on DSCP or PREC and set EXP marking, overwrites the DSCP value with EXP at imposition resulting in loss of the DSCP value.
L2VPN Uniform mode	With the policy-map with match on COS and set QoS_Group (which marks internally to EXP)	Match on MPLS EXP topmost and mark to MPLS EXP topmost	Use policy-map with match on EXP and mark to qos-group, which maps to COS. Egress COS can be marked by match on qos-group and set cos at access interface on PE2.	Sample configuration <pre>policy-map P class expl set qos-group 1 policy-map P1 class qos2 set cos 2</pre>



Note You can modify the default mapping behaviors using explicit marking policies.

QoS Policer and Shaper Calculation

Table below summarizes the packet accounting information used to make policer and shaper calculations on the router.

Table 8: QoS Accounting Calculation

Feature	Direction	Traffic Type	Values Counted
Policing	Ingress	IPv4/L3VPN	L2 overhead, VLAN tag, CRC
Shaping	Egress	IPv4/L3VPN	L2 Ethernet overhead, VLAN tag, CRC, preamble, IPG
Policing	Ingress	L2VPN	Layer 2 Ethernet overhead, VLAN tag, CRC
Shaping	Egress	L2VPN	Layer 2 Ethernet overhead, VLAN tag, CRC, preamble, IPG

The following considerations also apply when understanding QoS policer and shaper calculations:

- Egress shaping is applied at layer 1.
- Ingress packet length accounting is performed at egress.
- Egress shaping is supported and accounts for newly pushed VLAN tags and MPLS labels.

Simultaneous Policy support on Port/EFP

This feature provides the flexibility to apply EFP based classification on port and PHB based classification on EFP simultaneously.

At egress, it supports 4 level egress scheduling hierarchy and at ingress it supports simultaneous port and EFP policies.

Information about Simultaneous Policy Support on Port/EFP

In the Cisco RSP3 Module, this feature enables you to group EFP's and share policy (shaper/policer) for the range of EFP's simultaneously. This is designed to achieve the aggregate policer /shaper in ingress/egress respectively.

In RSP1/RSP2, this feature is implemented by the name "Service Group".

Benefits of simultaneous policy support on Port/EFP

This section provides the benefit/s of implementing simultaneous policy support on Port/EFP.

- Enables nested shaper up to fourth level.
- Enables EFP based classification on port and PHB based classification on EFP simultaneously.

Restrictions for simultaneous policy support on Port/EFP

- This feature is not supported on port channel, member-link and T-EFP.
- Policy-map should be applied on Port before applying on EFP, but in case of detaching, policy-map on EFP should be removed before removing from the port.
- BW/ BRR /BRP / WRED is supported only at PHB at egress.
- 2 level policy-map on port and marking policy on EVC, simultaneously is not supported.

- Only Match cos policy on EVC and match-efp policy on port is supported.
- Limited support is provided for statistics counters.

How to configure simultaneous policy support on Port/EFP

This feature is configured through qos policy on port (matching EFP range with policing/shaping action) and policy on EFP(matching PHB) simultaneously.

The configuration includes the following steps:

1. Create a class-map with efp range based classification.
2. Create a policy based on the class-map defined in step1.
3. Apply the efp classification based policy on the main interface.
4. Create a PHB policy to be applied on service instance.
5. Apply PHB based policy on service instance.

Configuring simultaneous policy support on Port/EFP

You can configure this feature in order to limit the traffic across all the instances where it is applied.

Before you begin

Ensure you add policy on interface first and then on the service instance.

Procedure

Ingress Configuration

1. Create a class-map with efp range based classification:


```
enable
configure terminal
class-map match-any efp_range
match service instance ethernet 1-100
```
2. Create a policy based on the class-map defined in step1:


```
policy-map ing_efp_range
class efp_range
police cir 40m
```
3. Apply the efp classification based policy on the main interface:


```
interface GigabitEthernet 0/14/0
service-policy input ing_efp_range
```
4. Create a PHB policy to be applied on service instance:


```
policy-map cos1
class cos1
police cir 10m
```
5. Apply PHB based policy on service instance:


```
interface GigabitEthernet 0/14/0
service instance 1 ethernet
service-policy input cos1
```

Egress configuration

```

1. Create a class-map with efp range based classification:
enable
configure terminal
class-map match-any efp_range
match service instance ethernet 1-100

2. Create a policy based on the class-map defined in step1:
policy-map egress_efp_range
class efp_range
shape average 500m

3. Apply the efp classification based policy on the main interface:
interface GigabitEthernet 0/14/0
service-policy output egress_efp_range

4. Create a PHB policy:
policy-map qos1
class qos1
shape average 300000000

5. Create a policy based on class-default:
policy-map egress_efp
class class-default
  shape average 500000000
  service-policy qos1

6. Apply class-default policy-map on Service Instance:
Interface gigabitEthernet 0/14/0
  service instance 1 ethernet
    service-policy output egress_efp

```

Result

You will be able to apply policy-maps on interface & EFP simultaneously.

Verification of the simultaneous policy support on Port/EFP configuration

To verify the configuration, use the **show policy-map** command in privileged EXEC mode to display summary configuration information.

```

Router#show policy-map interface brief
Service-policy input: ing_efp_range
GigabitEthernet0/14/0
Service-policy input: cos1
GigabitEthernet0/14/0: EFP 1

Router#show policy-map interface gig 0/14/0
GigabitEthernet0/14/0

Service-policy input: ing_efp_range

Class-map: efp_range (match-any)
  0 packets, 0 bytes
  30 second offered rate 0000 bps, drop rate 0000 bps
Match: service instance ethernet 1-100
police:
  cir 40000000 bps, bc 1250000 bytes
  conformed 0 packets, 0 bytes; actions:
  transmit
  exceeded 0 packets, 0 bytes; actions:

```

```

drop
conformed 0000 bps, exceeded 0000 bps

Class-map: class-default (match-any)
0 packets, 0 bytes
30 second offered rate 0000 bps, drop rate 0000 bps
Match: any

Router#show policy-map interface gig 0/14/0 service instance 1
GigabitEthernet0/0/5: EFP 1

Service-policy input: cos1

Class-map: cos1 (match-any)
48828201 packets, 49023513804 bytes
30 second offered rate 490218000 bps, drop rate 480258000 bps
Match: cos 1
QoS Set
qos-group 1
Marker statistics: Disabled
police:
cir 10000000 bps, bc 312500 bytes
conformed 992125 packets, 996093500 bytes; actions:
transmit
exceeded 47836076 packets, 48027420304 bytes; actions:
drop
conformed 9961000 bps, exceeded 480258000 bps

```

Configuring simultaneous policy support on Port/EFP: Example

The following example shows how to configure simultaneous policy support on Port/EFP:

```

interface GigabitEthernet0/14/0
no ip address
negotiation auto
service-policy input p1
service-policy output q1
service instance 1 ethernet
encapsulation dot1q 1
rewrite ingress tag pop 1 symmetric
service-policy input cos1
service-policy output qos1
bridge-domain 1
!

```

MPLS Diffserv Tunneling Modes Implementation

The MPLS specification defines Diffserv operation mode.

Uniform Mode—There is only one DiffServ marking that is relevant for a packet when traversing the MPLS network.

The following section describe how to implement uniform mode on the router using QoS policies.

Implementing Uniform Mode

Table 9: Default Propagation

Feature	IP to TAG	TAG to TAG	TAG to IP	Comments
L3VPN Uniform mode	Copy IP Prec/DiffServ into MPLS EXP by default	When the outer label is displayed, copy the exp of the . tag to the inner tag	MPLS EXP copied to IP Prec/DiffServ	
		When outer tag is swapped out, copy the exp to newly added tag		
L2VPN Uniform mode	COS is not copied to EXP by default, explicit policy-map is required to set qos-group which marks the EXP automatically.	When the outer tag is popped out, copy the exp of the . tag to the inner tag	MPLS EXP copied to COS by default	
		When outer tag is swapped out, copy the exp to newly added tag		

Use the following guidelines to implement uniform mode on the router:

MPLS EXP Imposition/Topmost Marking:

For L3 VPN

- Classify based on Prec bit or DSCP bit at ingress
- Set the mpls exp imposition

Tag-to-tag Transfer

- Classify based on mpls exp topmost
- Set the mpls exp topmost

For L2 VPN

- Classify based on COS bit at ingress
- Set the qos-group (which marks the mpls exp imposition)

Tag-to-tag Transfer

- Classify based on mpls exp topmost
- Set the mpls exp topmost

Classification

Classifying network traffic allows you to organize packets into traffic classes or categories on the basis of whether the traffic matches specific criteria. Classifying network traffic (used in conjunction with marking network traffic) is the foundation for enabling many quality of service (QoS) features on your network.

Table below summarizes the QoS Classification limitations for the router. In the table, I represents Ingress and E represents Egress.

Table 10: QoS Classification Limitations

Match	Main Interface		EFP Interface		Trunk EFP	
	I	E	I	E	I	E
Features	I	E	I	E	I	E
Multiple match statements	3.16	3.16	3.16	3.16	3.16	3.16
access-group	3.16	X	3.16	X	3.16	X
all	3.16	3.16	3.16	3.16	3.16	3.16
any	3.16	3.16	3.16	3.16	3.16	3.16
cos	3.16	X	3.16	X	3.16	X
cos inner	3.16	X	3.16	X	3.16	X
dscp (IPv4)	3.16	X	3.16	X	3.16	X
dscp (IPv6)	16.5.1	X	16.5.1	X	16.5.1	X
ip dscp	3.16	X	3.16	X	3.16	X
ip precedence (IPv4)	3.16	X	3.16	X	3.16	X
ip precedence (IPv6)	16.5.1	X	16.5.1	X	16.5.1	X
mpls experimental topmost	3.16	X	3.16	X	3.16	X
precedence (IPv4)	3.16	X	3.16	X	3.16	X
qos-group	X	3.16	X	3.16	X	3.16
service instance ethernet	3.16	3.16	3.16	3.16	3.16	3.16
vlan	3.16	X	3.16	X	3.16	X
vlan inner	3.16	X	3.16	X	3.16	X

Ingress Classification Limitations

The following limitations apply to QoS classification on the router:

- QoS ACLs are supported only for ingress traffic.
- QoS ACLs are not supported for L4 traffic match criteria.

Egress Classification Limitations

- Egress classification can have only match qos-group.

Classifying Traffic using an Access Control List

You can classify inbound packet based on an IP standard or IP extended access control list (ACL). By default, TCAM optimization or expansion method is used. Both Security ACL and QoS ACL can be configured on the same interface. Follow these steps to classify traffic based on an ACL:

1. Create an access list using the **access-list** or **ip access-list** commands
2. Reference the ACL within a QoS class map using the **match access-group** configuration command
3. Attach the class map to a policy map

Limitations and Usage Guidelines

The following limitations and usage guidelines apply when classifying traffic using an ACL:

- QoS ACLs are supported only for IPv4 traffic.
- QoS ACLs are supported only for ingress traffic.
- You can use QoS ACLs to classify traffic based on the following criteria:
 - Source and destination host
 - Source and destination subnet
- Named and numbered ACLs are supported.
- You can apply QoS ACLs only to the third level class (bottom-most).
- The following range of numbered access lists are supported:
 - 1-99—IP standard access list
 - 100-199—IP extended access list
 - 1300-1999—IP standard access list (expanded range)
 - 2000-2699—IP extended access list (expanded range)
- You must create an ACL before referencing it within a QoS policy.
- Deny statements within an ACL are ignored for the purposes of classification.
- Classifying traffic based on TCP flags using an ACL is not supported.
- Classifying traffic using multiple mutually exclusive ACLs within a **match-all** class-map is not supported.
- Classifying traffic on a logical/physical level using an ACL is not supported.

- Applying QoS ACLs to MAC addresses is supported for L2 flows only destination MAC.

For more information about configuring access control lists, see the *Security Configuration Guide: Access Control Lists for NCS 4200 Series*.

Configuring Multiple Match Statements

The router supports a single **match** or **match-any** command in a given QoS class-map, as shown in the following example:

Example for IOS XE 3.16 Class Map

```
class-map match-any my-restrict-class_00
  match ip precedence 0

class-map match-any my-restrict-class_01
  match qos-group 2

class-map match-any my-restrict-class_03
  match cos 3
```

Support for multiple **match** or **match-any** commands in a given QoS class-map, as shown in the following example:

Example for IOS XE 3.16 Class Map

```
class-map match-any my-class
  match ip prec 1
  match ip prec 2
  match ip prec 3
```

The router treats the statements as a logical OR operation and classifies traffic that matches any **match** statement in the class map.

Traffic Classification Using Match EFP Service Instance Feature

Service Provider configurations have various service instances on the PE. QoS policy-maps are applied on these service instances or group of service instances. The benefits of the Match EFP Service Instance feature are:

- Identify the various types of service-instances like EFP, Trunk EFPs.
- Apply policies on these service instances at the port.
- Apply policies on a group of transport service instances such as applying similar policies to a group of EFPs.

Restrictions for Configuring Match Service Instances

- Ethernet service instances configured under the interface can be classified in a class of a policy-map. The class can match on a group or set of match service instance statements.

```
class-map match-any policeServiceInstance
  match service instance ethernet 100
  match service instance ethernet 200
```

- Match service instance supported at both Ingress and Egress level.

- match service instance and match PHB per flows classification are defined at respective levels in the policy hierarchy under the port.
- The number of EFPs supported per group is 256. Only 256 match statements are supported per class.
- Match EFP policy-map can be configured only on the port and *not* under the service instance.

Example for Configuring Match Service Instances

```

interface GigabitEthernet0/3/4
 no ip address
 negotiation auto
 service-policy output BTS_Total
 service instance 10 ethernet
  encapsulation dot1q 100
  rewrite ingress tag pop 1 symmetric
  bridge-domain 100
 !
 service instance trunk 20 ethernet
  encapsulation dot1q 20-29
  rewrite ingress tag pop 1 symmetric
  bridge-domain from-encapsulation
 !
 service instance 30 ethernet
  encapsulation dot1q 30
  xconnect 192.44.32.21 101 encapsulation mpls

class-map match-any service-instance-group-with-BMG
match service instance ethernet 10
match service instance ethernet 20

class-map service-instance-30
match service instance ethernet 30

class-map service-instance-20
match service instance ethernet 20

class-map VOICE
match qos-group 0

class-map SIGNALING
match qos-group 1

class-map match-any DATA
match qos-group 2
match qos-group 4

policy-map child-X
class VOICE
priority level 1 30000
class SIGNALING
priority level 2 30000
class DATA
shape average 90m

policy-map BTS_OUT_Bi
class service-instance-group-with-BMG
shape average 100m
service-policy child-X
class service-instance-30

```

```

shape average 200m
service-policy child-X

policy-map BTS_Total
class class-default
shape average 250m
service-policy BTS_OUT_Bi

```

QoS Marking

QoS marking allows you to set a desired value on network traffic to make it easy for core devices to classify the packet.

Table below summarizes the QoS Marking limitations for the router. In the table, I represents Ingress and E represents Egress.

Table 11: Marking QoS Limitations

Features	Main Interface		EFP Interface		Trunk EFP	
	I	E	I	E	I	E
set	I	E	I	E	I	E
cos	3.16	3.16	3.16	3.16	3.16	3.16
cos inner	X	X	X	X	X	X
discard-class	3.16	X	3.16	X	3.16	X
dscp (IPv4)	3.16	X	3.16	X	3.16	X
dscp (IPv6)	16.5.1	X	16.5.1	X	16.5.1	X
ip dscp	3.16	X	3.16	X	3.16	X
ip precedence (IPv4)	3.16	X	3.16	X	3.16	X
ip precedence (IPv6)	16.5.1	X	16.5.1	X	16.5.1	X

Features	Main Interface		EFP Interface		Trunk EFP
mpls experimental imposition	3.16	X	3.16	X	3.16
mpls experimental topmost	3.16	X	3.16	X	3.16
precedence	3.16	X	3.16	X	3.16
qos-group	3.16	X	3.16	X	3.16

Overview of Marking

The router supports the following parameters with the **set** command:

- **set cos**
- **set discard-class**
- **set dscp**
- **set precedence**
- **set ip dscp**
- **set ip precedence**
- **set mpls experimental imposition**
- **set mpls experimental topmost**
- **set qos-group**

Ingress Marking Limitations

The following limitations apply to QoS marking on the router:

- The router does *not* support hierarchical marking.
- COS to PREC/DSCP marking does not work for L2 flows.
- PREC/DSCP to COS marking does not work on L3 flows.
- **set mpls experimental imposition** command is not supported for L2VPN. Mark to qos-group, which internally marks to EXP value as qos-group marked.
- **set cos inner** command is not supported on the router.
- Ingress COS marking is supported only with no rewrite type EFPs and rewrite PUSH cases.
- Ingress COS marking is not supported for all remaining POP rewrite types.
- Ingress marking to qos-group, mark the egress COS based on qos-group marked value.
- With L3VPN, Ingress marking to mpls experimental imposition, mark the egress PREC based on mpls exp imposition value.
- With L3VPN, BDI based configuration; classification based on COS is supported only for marking.
- **set cos** command has no effect unless there is a egress push action to add an additional header at egress. The COS value set by this action will be used in the newly added header as a result of the push rewrite. If there are no push rewrite on the packet, the new COS value will have no effect.

Egress Marking Limitations

The following limitations apply when configuring marking on egress interfaces:

- Egress COS marking is supported. Match on qos-group and **set cos** command is supported.
- For Egress L3 BDI, match on qos-group and mark to COS is supported.
- Egress MPLS EXP and PREC/DSCP marking are not supported.

Egress Marking based on Color of Traffic

Egress marking is based on color of traffic. The RSP3 supports TRTCM and SRTCM policing algorithms. This results in different colors such as green, yellow, and red. The policer drops the red packets at ingress. With this feature, the packets are marked such that the policer passes or drops the packets accordingly. However the RSP3 policer has the following limitations:

- Direct marking or update to the MPLS EXP or DSCP packets based on policer result is not supported; only drop precedence packets are updated. To achieve marking, the drop precedence values from policer are used to mark the packet. The drops precedence packet values are 0 and 1 for green and yellow packets respectively.
- WRED has only 2 curves for drop precedence values 0 and 1.
- Marking is applicable to all traffic going out at the egress interface.



Note Egress marking policy-map is supported only at the interface level, and only on the imposition nodes (core interfaces). Egress marking *cannot* be done on Provider (P) routers in the network.

As the RSP3 module *does not* support the direct marking of the PHB, to achieve egress marking based on color, another child policy level must be added to the existing queue class level policy as in the below example.

```
class-map match-all dp0
match discard-class 0
class-map match-all dp1
match discard-class 1
class-map match-all qos5
match qos-group 5
class-map match-all qos4
match qos-group 4
class-map match-all qos1
match qos-group 1

policy-map egress_evcl86_norm_parent
class class-default
  shape average 31250000
  service-policy egress_evcl86_norm_child

policy-map egress_evcl86_norm_child
class qos1
  bandwidth 4000
class qos4
  bandwidth 9000
  service-policy sub-child
class qos5
  bandwidth 18000
class class-default
policy-map sub-child
class dp0
  set mpls experimental topmost 4
class dp1
  set mpls experimental topmost 4
!
```

Restrictions for Egress MPLS EXP Marking based on Color of Traffic

- Green and yellow packets are only marked.



Note The packet marking actions are as:

- Confirm color is green
- Exceed color is yellow
- Violate color is red

Red packets are dropped by default.

- Egress MPLS EXP marking based on color of traffic is supported only for L2VPN and VPLS EFPs (xconnect and EFPs) services.
- Marking occurs only at egress interface. Hence, all traffic (from multiple policers and non-policed policers) going out through this interface is marked.
- Mapping from color to PHB value occurs only at the egress interface. Ingress policer marks the incoming packet to green and yellow. Use the **set discard-class** command to mark the color of the packets explicitly.

- Marking statistics is *not* supported.
- WRED based on DSCP is *not* supported. WRED based on discard class is supported.

Example: Configuring Egress MPLS EXP Marking

```

class-map match-all dp0
match discard-class 0

class-map match-all dp1
match discard-class 1

class-map match-all qos4
match qos-group 4
class-map match-all qos5
match qos-group 5
class-map match-all qos4
match qos-group 4
class-map match-all qos1
match qos-group 1
!

policy-map cond-marking
class dp0
set mpls experimental topmost 4
class dp1
set mpls experimental topmost 4

policy-map egress_child
class qos1
bandwidth 4000
class qos4
bandwidth 9000
queue-limit 300000 bytes
random-detect discard-class-based
random-detect discard-class 0 160000 bytes 256000 bytes 1
random-detect discard-class 1 16000 bytes 256000 bytes 1
service-policy cond-marking
class qos5
bandwidth 18000
class class-default
shape average 1000000

policy-map egress_parent
class class-default
shape average 31250000
service-policy egress_child

interface tenGigabitEthernet 0/8/6
service-policy output egress_parent

```

Example: Configuring Color based Marking At Ingress

```

class-map match-any cos012
match cos 0 1 2

policy-map police_policy
class cos012
police cir 256000 bc 9216 pir 512000 be 9216
set qos-group 4

```


CoS Marking

Table 12: CoS Marking with Policy Map

Incoming Tag	Ingress Rewrite	Egress Rewrite			
		NO-RW	Pop-1(push 1 tag)	POP-2(push 2 tag)	PUSH-1(pop 1 tag)
One	NO-RW	Ingress COS marking supported	Outer COS copied to inner COS	N/A	N/A
	POP-1	N/A	Ingress COS marking not supported	Ingress COS marking not supported	N/A
	POP-2	N/A	N/A	N/A	N/A
	PUSH-1	Outer COS only marked and inner COS retained	N/A	N/A	Results in inner COS marking
Two	NO-RW	Cos marked as configured	N/A	N/A	Results in inner COS marking
	POP-1	Ingress COS marking not supported	Ingress COS marking not supported	N/A	N/A
	POP-2	N/A	Ingress COS marking not supported	Ingress COS marking not supported	N/A
	PUSH-1	N/A	N/A	N/A	N/A

CoS Marking Limitations

The following limitations apply when configuring CoS marking:

- The **set cos inner** command is not supported.

CoS Conditional Marking

Table 13: Feature History

Feature Name	Release	Description
CoS Conditional Marking	Cisco IOS XE Amsterdam 17.3.1	This feature lets you implement the CoS marking on the basis of the Traffic class and the Drop precedence. This feature is supported on the Cisco RSP3 module.

The CoS Conditional Marking implements the CoS marking on the basis of the Traffic class and the Drop precedence.

Restrictions for CoS Conditional Marking

- The Four-level policy is not supported.
- The modification of policy with unsupported or a combination of COS and EXP is not supported.
- The COS conditional marking is not supported when the EFP is configured with encapsulation **default**.
- The COS conditional marking is not supported when the rewrite ingress tag push rule is configured on the EFPs.
- The policies attached to the EFPs stop COS conditional marking. This happens because of the two-level conditional marking policy attached to the individual EFPs and a class-default shaper on the port. When attaching a two-level child policy to the class-default on port-shaper, results in unexpected conditional COS marking change and corrupt policy-map counters. However, detaching the port-shaper, results in COS conditional marking failure.
- The conditional marking policy displays the Profile Exhaustion error. This error occurs due to a limitation of the profile creation or modification logic in the system and the marker profile 15 is changed or detached from the parent policy.
- The CoS marking is supported on EFP interface when the SR PFP Template is configured.
- The conditional marking does not work when an egress policy with class-default is attached, as a profile is not created. However, when a non default class is attached to the egress policy, the Conditional Marking on class-default works as a profile gets created.

How to Configure CoS Conditional Marking

Configuring Ingress Policy Map

You can set CIR and PIR values for police action and apply transmit actions to ingress traffic. You can set QoS group to the policy map applied.

To configure ingress traffic using policy map, enter the following commands:

```

class-map match-any cos012
  match cos 0 1 2

policy-map ingress
  class cos012
  set qos-group 1
  police cir 256000 pir 556000

```

Configuring Egress Policy Map

To configure egress policy map, enter the following commands:

```

class-map match-all dp0
  match discard-class 0
class-map match-all dp1
  match discard-class 1

class-map qos1
  match qos-group 1

policy-map egress_parent
  class class-default
  shape average 31250000
  service-policy egress_child

policy-map egress_child
  class qos1
  bandwidth 4000
  service-policy sub-child
  class class-default

policy-map sub-child
  class dp0
  set cos 4
  class dp1
  set cos 5

```

Configuring Short-Pipe Mode on QoS

Short-pipe mode on QoS RSP3 module can be activated using an SDM template. You can identify the egress traffic on an interface or EVC and classify based on DSCP, mark qos-group, and color using the platform table-map command. You can perform WFQ/WRED based on qos-group and color on egress interface using egress policy-map.

Procedure

Step 1 enable

Example:

```
Device> enable
```

Enables privileged EXEC mode.

- Enter your password if prompted.

Step 2 **configure terminal****Example:**

```
Device# configure terminal
Enters global configuration mode.
```

Step 3 **sdm prefer enable_egr_l3vpn_cm****Example:**

```
Device(config)# sdm prefer enable_egr_l3vpn_cm
Enables the SDM template.
```

Step 4 **platform qos-table-map****Example:**

```
Device(config-table-map)# platform qos-table-map Customer#6
    from dscp 10 to qos-group 0 discard-class 0
    from dscp 63 to qos-group 0 discard-class 1

    qos-table-map Customer#6 interface GigabitEthernet0/4/0
```

Creates platform table-map and applying it on an interface.

Step 5 **Class-map match-any qos0****Example:**

```
Device(config-table-map)# Class-map match-any qos0
    match qos-group 0
Policy-map short-pipe-qos
    class qos0
        bandwidth 30000
        random-detect discard-class-based
        random-detect discard-class 0 25000 bytes 75000 bytes 1
        random-detect discard-class 1 95000 bytes 300000 bytes 1
        queue-limit 375000 bytes
```

Creates egress class map and policy map.

Example

Configuration Example

```
sdm prefer enable_egr_l3vpn_cm

platform qos-table-map Customer#6
    from dscp 10 to qos-group 0 discard-class 0
    from dscp 63 to qos-group 0 discard-class 1

qos-table-map Customer#6 interface GigabitEthernet0/4/0

interface Gig 0/5/0
    service-policy output short-pipe-qos
```

```

Class-map match-any qos0
  match qos-group 0

Policy-map short-pipe-qos
  class qos0
    bandwidth 30000
    random-detect discard-class-based
    random-detect discard-class 0 25000 bytes 75000 bytes 1
    random-detect discard-class 1 95000 bytes 300000 bytes 1
    queue-limit 375000 bytes

```

Restrictions on Short-Pipe Mode

- The **enable_egr_l3vpn_cm** SDM template command cannot co-exist with other templates such as **sdm prefer enable_copp** and **sdm prefer enable_match_inner_dscp** commands.
- Short-pipe mode on QoS RSP3 module is applicable only for conditional marking, which is not supported for multicast L3VPN traffic flows (TAG to IP).
- Short-pipe mode on QoS RSP3 module is not applicable for IPv6 traffic.
- You can configure only up to 7 table-maps.
- Following QoS classifications does not work after you enable the **sdm template** to activate short-pipe mode QoS feature:
 - DstMac
 - InnerVlanPri
 - InnerVlan
 - SrcIp
 - DstIp
- Before deleting the corresponding BDI interface, ensure to detach or unconfigure the table-map, if the table-map is applied on the BDI interface.
- Each table-map entry (classify on DSCP, mark to Qos-Group and DC) consumes up to 3 TCAM entries.
- Egress table-map matched traffic does not hit core interface policy-map.
- Core interface policy-map stats do not count egress table-map hit packets.
- Platform table-map stats are not supported.
- All backup paths (LB/FRR case) should be mapped with same table-map profile.

CoS Marking for Pseudowires

The packet when enters the pseudowire, COS is mapped to EXP by default. The policy-map on interface level is applicable for all xconnects. The policy-map attached at xconnect efp is specific to the xconnect.

- Egress set cos using egress policy overwrites the S-COS.
- If the topmost EXP is changed through ingress marking, the modified EXP is propagated to the egress outer S-COS. Egress set cos can overwrite S-COS.

- If the topmost EXP is changed through egress marking, the modified EXP is propagated to the egress outer S-COS. Egress set cos can overwrite S-COS.

Example

In the following configuration example, the MPLS is configured between PE1 and P routers. MPLS in physical interfaces is configured between P and PE 2 routers. The EFP X-connect is configured on the Access side.

Topology

ixia---(g0/0/1)PE1(teng0/0/2)---(teng0/2)P(g0/7)---(g0/7)PE2(g0/1)---ixia

PE1 Router

```
interface Loopback0
ip address 10.0.0.1 255.255.255.255

interface BDI2
no shut
ip address 20.0.0.1 255.255.255.0
mpls ip
mpls label protocol ldp

router ospf 10
network 10.0.0.1 0.0.0.0 area 0
network 20.0.0.1 0.0.0.0 area 0

policy-map ingress
class class-default
set qos-group 4
interface GigabitEthernet 0/0/1
load-interval 30
service-policy input ingress
service instance 2 ethernet
encapsulation dot1q 2
xconnect 10.0.0.2 10 encapsulation mpls
```



Note The default mapping of EXP from COS is *not* supported on the Cisco RSP3 Module. But the mapping is done via COS to QoS group and QoS group to EXP. An explicit policy-map with match on COS and set qos-group is also used to mark the EXP.

Verifying PE 1 Router

```
show policy-map interface GigabitEthernet 0/9/7
GigabitEthernet0/9/7

Service-policy input: ingress

Class-map: class-default (match-any)
13602943 packets, 13602943000 bytes
30 second offered rate 98040000 bps, drop rate 0000 bps
Match: any
QoS Set
qos-group 4
Marker statistics: Disabled
```

P router

```

class-map match-all exp4
match mpls exp topmost 4

policy-map ingress
class exp4

interface TenGigabitEthernet 0/2
load-interval 30
service-policy input ingress

interface BDI2
ip address 20.0.0.2 255.255.255.0
mpls ip
mpls label protocol ldp

router ospf 10
network 20.0.0.2 0.0.0.0 area 0
network 30.0.0.2 0.0.0.0 area 0

```

Verifying P Router

```

Router# show policy-map interface TenGigabitEthernet 0/2
TenGigabitEthernet0/2

Service-policy input: ingress

Class-map: exp4 (match-all)
560284 packets, 574851384 bytes
30 second offered rate 78284000 bps
Match: mpls experimental topmost 4

Class-map: class-default (match-any)
94 packets, 8224 bytes
30 second offered rate 0000 bps, drop rate 0000 bps
Match: any

```

PE 2 Router

```

class-map match-all exp4
match mpls experimental topmost 4

policy-map ingress
class exp4

interface Loopback0
ip address 10.0.0.2 255.255.255.255

interface GigabitEthernet 0/7
no switchport
ip address 30.0.0.1 255.255.255.0
media-type rj45
mpls ip
mpls label protocol ldp
service-policy input ingress 10:39 AM

router ospf 10
network 10.0.0.2 0.0.0.0 area 0
network 30.0.0.1 0.0.0.0 area 0 10:40 AM

interface GigabitEthernet 0/1
load-interval 30
service instance 2 ethernet
encapsulation dot1q 2

```

```
xconnect 10.0.0.1 10 encapsulation mpls
```

Verifying PE2 Route

```
show policy-map interface GigabitEthernet 0/7
GigabitEthernet0/7
```

```
Service-policy input: ingress
```

```
Class-map: exp4 (match-all)
133436 packets, 136905336 bytes
30 second offered rate 2956000 bps
Match: mpls experimental topmost 4
```

```
Class-map: class-default (match-any)
7 packets, 562 bytes
30 second offered rate 0000 bps, drop rate 0000 bps
Match: any
```

Global Table Map

A table-map helps you to define a mapping from an integer to an integer. In the RSP3 platform, by default global table-map configuration is used to map DSCP to EXP for L3 VPN services. Usage of ingress policy-map for marking the EXP is not recommended as it also modifies the DSCP. Hence, the global table-map allow you to configure a global level mapping of fields in the packet, without configuring a policy and keeps the DSCP value transparent.

The table-map is applicable to all L3 VPN MPLS packets, which sets the EXP field that is based on the incoming packet DSCP field. This mapping is also applicable to all L3 VPN IPv4/IPV6 traffic on the router.

The global table-map supports L2 VPN and L3 VPN traffic. L2 VPN conditional marking policy-map is supported and conditional marking policy is applicable to L2 VPN traffic.

The following sample table-map configuration enables a mapping at the router-level and it supports modification and deletion of table-map.

```
Router(config)# table-map DSCPTOEXP
Router(config-tablemap)# map from 10 to 1
Router(config-tablemap)# map from 22 to 2
Router(config-tablemap)# default copy
```

```
Router# show table-map
table-map DSCPTOEXP
  map from 10 to 1
  map from 22 to 2
  default copy
```

Restrictions

Following limitations are applicable to global table-map:

- Only one table-map configuration is supported globally.
- Table-map configuration is limited to DSCP to EXP mapping of L3 VPN traffic.
- Ingress policy-map to mark EXP on ingress interface is not recommended when you have global table-map configured for L3 VPN traffic.

MPLS Layer 3 VPN Conditional Marking QoS for RSP3 Module

The MPLS Layer 3 conditional marking feature enables you to mark the traffic with appropriate QoS group and sets policer to mark the color (discard class) based on Committed Information Rate (CIR) and Peak Information Rate (PIR) values. You can use the QoS group to create ingress policy map. It is mandatory to set the QoS group as a part of ingress policy-map to support Layer 3 VPN conditional marking.

At the egress side, you can classify the packets based on qos-group and discard class and set the EXP bits. Before configuring the ingress and egress policy maps, you need to activate an SDM template **enable_egr_l3vpn_cm** on the router.

After configuring the ingress and egress policy maps, you need to attach service policy to the ingress interface and QoS policy to the egress interface.

You can verify the configuration using the **show policy-map interface** command.

Restrictions for MPLS Layer 3 VPN Conditional Marking

- The MPLS layer 3 conditional marking for QoS can be enabled only using an SDM template: **enable_egr_l3vpn_cm**.
- LB and Fast Reroute (FRR) cases should have marking policies applied on data paths.
- The MPLS layer 3 conditional marking for QoS is not supported for the IPv6 and multicast traffic.
- Discard-class statistics is not supported.
- Control Plane Policing (COPP) and match-inner-dscp templates are not supported.
- It is mandatory that you need to set QoS-group as a part of ingress policy-map.
- The number of egress conditional marking policy-maps is limited to 2.
- The following QoS qualifiers are not supported for the **enable_egr_l3vpn_cm** SDM template:
 - Match inner VLAN
 - Match inner QoS
 - Source (SRC) IP
 - Destination (DST) IP
- TCAM utilization for Layer 3 VPN conditional marking template:
 - Service policy under an interface for COS based classification takes 1 entry
 - Service policy under an EFP for COS based classification takes 2 entries on LPM
 - Service policy under an EFP for COS/DSCP based classification occurs on LPM

Restrictions for CoS Conditional Marking

- The Four-level policy is not supported.

- The modification of policy with unsupported or a combination of COS and EXP is not supported.
- The COS conditional marking is not supported when the EFP is configured with encapsulation **default**.
- The COS conditional marking is not supported when the rewrite ingress tag push rule is configured on the EFPs.
- The policies attached to the EFPs stop COS conditional marking. This happens because of the two-level conditional marking policy attached to the individual EFPs and a class-default shaper on the port. When attaching a two-level child policy to the class-default on port-shaper, results in unexpected conditional COS marking change and corrupt policy-map counters. However, detaching the port-shaper, results in COS conditional marking failure.
- The conditional marking policy displays the Profile Exhaustion error. This error occurs due to a limitation of the profile creation or modification logic in the system and the marker profile 15 is changed or detached from the parent policy.
- The CoS marking is supported on EFP interface when the SR PFP Template is configured.
- The conditional marking does not work when an egress policy with class-default is attached, as a profile is not created. However, when a non default class is attached to the egress policy, the Conditional Marking on class-default works as a profile gets created.

Configuring Ingress Policy Map

You can set CIR and PIR values for police action and apply transmit actions to ingress traffic. You can set QoS group to the policy map applied.

To configure ingress traffic using policy map, enter the following commands:

```
class-map match-any cos012
  match cos 0 1 2

policy-map ingress
  class cos012
  set qos-group 1
  police cir 256000 pir 556000
```

Configuring Egress Policy Map

To configure egress policy map, enter the following commands:

```
class-map match-all dp0
  match discard-class 0
class-map match-all dp1
  match discard-class 1

class-map qos1
  match qos-group 1

policy-map egress_parent
  class class-default
  shape average 31250000
  service-policy egress_child

policy-map egress_child
```

```

class qos1
bandwidth 4000
service-policy sub-child
class class-default

policy-map sub-child
class dp0
set cos 4
class dp1
set cos 5

```

How to Configure MPLS Layer 3 Conditional Marking

Enabling SDM Template

Before configuring ingress and egress policy map, you need to enable the SDM template on router.

```
router(config)#sdm prefer enable_egr_l3vpn_cm
```

Configuring Ingress Policy Map

After enabling the SDM template, you can match the class map and DSCP for ingress traffic, and apply class map to the policy map. You can set CIR and PIR values for police action and apply transmit actions to ingress traffic. You can set QoS group to the policy map applied.

To configure ingress traffic using policy map, enter the following commands:

```

class-map match-all AF41
match dscp af41
policy-map INGRESS
class AF41
police cir 200000000 pir 300000000 conform-action
transmit exceed-action transmit violate-action drop
set qos-group 2

```

Configuring Egress Policy Map

To configure egress policy map, enter the following commands:

```

class-map match-any qos-group2
match qos-group 2
policy-map Conditional_Marking_Leaf
class DC0
set mpls experimental topmost 2
class DC1
set mpls experimental topmost 1
policy-map Conditional_Marking_Child
class qos-group2
bandwidth percent 20
service-policy Conditional_Marking_Leaf
policy-map EGRESS_PARENT
class class-default
shape average 150000000
service-policy Conditional_Marking_Child

```

Attaching Service Policy to Ingress

To attach service policy to the ingress direction, enter the following commands:

```
service-policy input INGRESS
```

Attaching QoS Policy Map on Egress Interface

To attach QoS policy map on egress direction, enter the following commands:

```
service-policy output EGRESS_PARENT
```

Verifying MPLS Layer 3 Conditional Marking

To verify the MPLS Layer 3 conditional marking configuration, use the **show policy-map interface *interface-name*** command.

```
router#show policy-map interface gi 0/15/2
GigabitEthernet0/15/2

Service-policy output: EGRESS_PARENT

Class-map: class-default (match-any)
 2749290 packets, 23705425676 bytes
 5 minute offered rate 362014000 bps, drop rate 250204000 bps
Match: any
Queueing
queue limit 54613 us/ 1024000 bytes
(queue depth/total drops/no-buffer drops) 0/1844419/0
(pkts output/bytes output) 904871/7105654676
shape (average) cir 150000000, bc 600000, be 600000
target shape rate 150000000

Service-policy : Conditional_Marking_Child

queue stats for all priority classes:
Queueing
priority level 2
queue limit 109226 us/ 1024000 bytes
(queue depth/total drops/no-buffer drops) 1037760/131743/0
(pkts output/bytes output) 394863/3553767000

queue stats for all priority classes:
Queueing
priority level 1
queue limit 2730666 us/ 1024000 bytes
(queue depth/total drops/no-buffer drops) 0/0/0
(pkts output/bytes output) 0/0

Class-map: qos-group0 (match-any)
 0 packets, 0 bytes
 5 minute offered rate 0000 bps, drop rate 0000 bps
Match: qos-group 0
Queueing
queue limit 54613 us/ 1024000 bytes
(queue depth/total drops/no-buffer drops) 0/0/0
(pkts output/bytes output) 0/0
bandwidth remaining 10%

Class-map: qos-group1 (match-any)
```

```
526606 packets, 4739454000 bytes
5 minute offered rate 72387000 bps, drop rate 54345000 bps
Match: qos-group 1
Queueing
queue limit 54613 us/ 1024000 bytes
(queue depth/total drops/no-buffer drops) 1037760/395342/0
(pkts output/bytes output) 131264/1181376000
bandwidth remaining 20%

Class-map: qos-group2 (match-any)
526606 packets, 4739454000 bytes
5 minute offered rate 72387000 bps, drop rate 63373000 bps
Match: qos-group 2
Queueing
queue limit 54613 us/ 1024000 bytes
(queue depth/total drops/no-buffer drops) 1037760/461018/0
(pkts output/bytes output) 65588/590292000
bandwidth remaining 10%

Class-map: qos-group3 (match-any)
526606 packets, 4739454000 bytes
5 minute offered rate 72387000 bps, drop rate 63365000 bps
Match: qos-group 3
Queueing
queue limit 54613 us/ 1024000 bytes
(queue depth/total drops/no-buffer drops) 1037760/460973/0
(pkts output/bytes output) 65633/590697000
bandwidth remaining 10%

Class-map: qos-group5 (match-any)
526607 packets, 4739463000 bytes
5 minute offered rate 72387000 bps, drop rate 54346000 bps
Match: qos-group 5
Queueing
queue limit 54613 us/ 1024000 bytes
(queue depth/total drops/no-buffer drops) 1037760/395343/0
(pkts output/bytes output) 131264/1181376000
bandwidth remaining 20%

Class-map: qos-group4 (match-any)
526606 packets, 4739454000 bytes
5 minute offered rate 72387000 bps, drop rate 18118000 bps
Match: qos-group 4
Priority: 50% (75000 kbps), burst bytes 1875000, b/w exceed drops: 131743

Priority Level: 2
Service-policy : Conditional_Marking_Leaf

Class-map: DC0 (match-any)
0 packets, 0 bytes
5 minute offered rate 0000 bps, drop rate 0000 bps
Match: discard-class 0
QoS Set
mpls experimental topmost 2
Marker statistics: Disabled

Class-map: DC1 (match-any)
0 packets, 0 bytes
5 minute offered rate 0000 bps, drop rate 0000 bps
Match: discard-class 1
QoS Set
mpls experimental topmost 1
Marker statistics: Disabled
```

```

Class-map: class-default (match-any)
  0 packets, 0 bytes
  5 minute offered rate 0000 bps, drop rate 0000 bps
  Match: any

Class-map: qos-group6 (match-any)
  0 packets, 0 bytes
  5 minute offered rate 0000 bps, drop rate 0000 bps
  Match: qos-group 6
  Priority: 2% (3000 kbps), burst bytes 75000, b/w exceed drops: 0

Priority Level: 1

Class-map: class-default (match-any)
  116259 packets, 8146676 bytes
  5 minute offered rate 134000 bps, drop rate 0000 bps
  Match: any

queue limit 54613 us/ 1024000 bytes
(queue depth/total drops/no-buffer drops) 0/0/0
(pkts output/bytes output) 116259/8146676

```

Traffic Policing

Traffic policing allows you to control the maximum rate of traffic sent and received on an interface. Traffic policing also allows partition of a network into multiple priority levels or class of service (CoS). This section describes the policing limitations and configuration guidelines for the router.

The router supports the following policing types:

- Single-rate policer with two color marker (1R2C) (default is color-aware mode)
- Two-rate policer with three color marker (2R3C) (default is color-aware mode)

Table 14: Feature History

Feature Name	Release	Description
Inter-cos bursting support	Cisco IOS XE Bengaluru 17.6.2, Cisco IOS XE Cupertino 17.7.1	This feature introduces color-blind mode of policer operation support on routers with single-rate policer (1R2C) and two-rate policer (2R3C) policing types. With this feature, all policers support color-blind mode with the new template.

Starting with 17.6.2 and 17.7.1 releases, policer modes support the RSP3 module with the following approach:

- Color-aware mode (default mode) – All policers support color-aware mode with the existing template.
- Color-blind mode – All policers support color-blind mode with the new template.

When you configure a child with a two-rate policer with three color marker (2R3C) policy, then the packets with green, yellow, and red is marked accordingly. Even if the parent policy single-rate policer with two color marker (1R2C) is configured with higher policer rate (CIR or PIR), the yellow and red packets marked by the child policer is not allowed.

With the color-blind mode of policer operation, parent policer configured with higher policer rate allows the packets marked with yellow and red.

The conditional CoS or EXP marking of packets perform based on the color result of the child policer.

Use the following SDM template to set the color-blind mode:

- **enable_color_blind_policer** – Enable this template to set policers to work in color-blind mode.
- **disable_color_blind_policer** – Disable this template to set policers to work in color-aware mode (default mode).



Note Ensure to remove the color-blind mode configured template before you downgrade the image.

The following table summarizes the QoS policing limitations for the router. In the table, I represent Ingress and E represents Egress.

Table 15: Policing Feature Support

Features	Main Interface		EFP Interface		Trunk EFP	
	I	E	I	E	I	E
One rate	3.16	X	3.16	X	3.16	X
One rate and two marking	3.16	X	3.16	X	3.16	X
Two rates and three actions	3.16	X	3.16	X	3.16	X
Drop	3.16	X	3.16	X	3.16	X
Transmit	3.16	X	3.16	X	3.16	X

Table 16: Traffic Queuing Support

Features	Main Interface		EFP Interface		Trunk EFP	
	I	E	I	E	I	E
Bandwidth	X	3.16	X	3.16	X	3.16
Bandwidth remaining ratio	X	3.16	X	3.16	X	3.16
Bandwidth percent	X	3.16	X	3.16	X	3.16
Priority	X	3.16	X	3.16	X	3.16
Priority level 1/2	X	3.16	X	3.16	X	3.16

Supported Commands

The router supports the following policing commands on ingress interfaces:

- **police** (percent)—**police cir percent percentage** [*burst-in-msec*] [**bc conform-burst-in-msec ms**] [**be peak-burst-in-msec ms**] [**pir percent percentage**] [**conform-action action**] [**exceed-action action**] [**violate-action action**]]]
- **police** (policy map)—**police cir bps** [[**bc**] *normal-burst-bytes* [*maximum-burst-bytes*] | [**be**] [*burst-bytes*]]] [**pir bps** [**be burst-bytes**]] [**conform-action action**] [**exceed-action action**] [**violate-action action**]]]
- **police** (two rates)—**police cir cir** [**bc conform-burst**] [**pir pir**] [**be peak-burst**] [**conform-action action**] [**exceed-action action**] [**violate-action action**]]]

The router supports the following queuing commands:

- **bandwidth** (policy-map class)—**bandwidth** {*bandwidth-kbps* | **remaining percent percentage** | **percent percentage**} [**account** {**qinq** | **dot1q**} **aal5 subscriber-encapsulation**]
- **bandwidth remaining ratio**—**bandwidth remaining ratio ratio** [**account** {**qinq** | **dot1q**} [**aal5**] {*subscriber-encapsulation* | **user-defined offset**}]
- **police** (policy map)—**police cir bps** [[**bc**] *normal-burst-bytes* [*maximum-burst-bytes*] | [**be**] [*burst-bytes*]]] [**pir bps** [**be burst-bytes**]] [**conform-action action**] [**exceed-action action**] [**violate-action action**]]]
- **priority**—**priority** {**percent percentage**} [*burst*]
- **priority** [**level level**<1/2>] {**percent percentage**}

Several restrictions apply when using egress policing; see the *Egress policing Limitations* section for more information.



Note The **police** (policy map) command is supported only on the ingress interface and not supported on an egress interface in the Cisco RSP3 module.

Percentage Policing Configuration

The router calculates percentage policing rates based on the maximum port PIR rate. The PIR rate is determined as follows:

- Default—Port line rate
- Speed command applied—Operational rate
- Port shaping applied to port—Shaped rate

Ingress Policing Limitations

The following limitations apply to QoS policing on the router:

- If you configure a policer rate or burst-size that the router cannot achieve within 1% accuracy, the configuration is rejected. The command output presents recommendations for the closest possible lower and higher configuration value.
- You can configure marking and policing for any number of classes on any one of the three levels of the policy-map hierarchy. If you configure marking on one level, you can configure policing without marking (transmit, drop) on another level.
- If you configure a policer using a **set** command, you cannot use the **set** command at other levels of the hierarchical policy-map.
- If you configure a SRTCM policer at parent level, you cannot use the TRTCM on any other level (child level) in case of hierarchical policy-map. Similarly, if TRTCM is configured at parent level, SRTCM cannot be configured at child level. To resolve this problem, configure parent TRTCM with exceed and violate-action as drop and TRTCM at child level policy-map hierarchy.

Example for HQOS Ingress Interface

```

Policy-map parent
Class class-default
Police cir 100m conform-action transmit exceed-action drop violate-action drop
Service-policy child

Policy-map child
Class prec2
Police cir 100000 pir 200000 conform-action transmit exceed-action transmit violate-action
drop

```

Policing at ingress also colors the traffic. You can use ingress policer to set discard-class 0 and 1, which can be used at egress for WRED. Green (confirm-action) is discard-class 0. Yellow/Red (exceed/violate action) is discard-class 1.

Traffic Shaping

Traffic shaping allows you to control the speed of traffic that is leaving an interface in order to match the flow of traffic to the speed of the receiving interface. Percentage-based shaping allows you to configure traffic shaping based on a percentage of the available bandwidth of an interface. Configuring traffic shaping in this manner enables you to use the same policy map for multiple interfaces with differing amounts of bandwidth.

This section describes the configuration guidelines for the router.

Additional Shaping Limitations

The following are the shaping usage guidelines:

- Shaping is supported at all levels in the policy-map hierarchy.
- 3-level hierarchical shaping is supported.
- Port-level shaping is supported.

Configuring Egress Shaping on EFP Interfaces

Configuring an EFP port shaper allows you to shape all EFPs on a port using a port policy with a class-default shaper configuration, as in the following partial sample configuration:

```
policy-map port-policy
  class class-default
    shape average percent 50
policy-map efp-policy
  class EFP100
    shape average percent 25
    service-policy child-policy
policy-map child-policy
  class qos-group1
    shape average percent 20
```

The following configuration guidelines apply when configuring an EFP port shaping policy:

- You can combine a port shaper policy (a flat shaper policy with no user-defined classes) with an egress EFP QoS shaping policy.
- Configure the port shaper policy before configuring other egress QoS policies on EFP interfaces; when removing EFP QoS configurations, remove other egress EFP QoS policies before removing the port shaper policy.
- When the configuration specifies a shaper rate using a percentage, the router calculates the value based on the operational speed of a port. The operational speed of a port can be the line rate of the port or the speed specified by the **speed** command.
- The rates for **bandwidth percent** and **shape percent** commands configured under a port-shaper are based on the absolute rate of the port-shaper policy.

Congestion Management

Congestion management features allow you to control congestion by determining the order in which packets are sent out an interface based on priorities assigned to those packets. Congestion management entails the creation of queues, assignment of packets to those queues based on the classification of the packet, and scheduling of the packets in a queue for transmission.

This section describes the classification limitations and configuration guidelines for the router.

Table below summarizes the QoS congestion management and queuing limitations for the router. In the table, I represents Ingress and E represents Egress.

Table 17: Congestion Management QoS Limitations

Features	Main Interface		EFP Interface		Trunk EFP	
	I	E	I	E	I	E
CBWFQ	X	3.16	X	3.16	X	3.16
LLQ	X	3.16	X	3.16	X	3.16

Features	Main Interface		EFP Interface		Trunk EFP	
bandwidth (kbps)	X	3.16	X	3.16	X	3.16
bandwidth percent	X	3.16	X	3.16	X	3.16
bandwidth remaining percent	X	3.16	X	3.16	X	3.16
bandwidth remaining ratio	X	3.16	X	3.16	X	3.16
fair-queue	X	X	X	X	X	X
priority	X	3.16	X	3.16	X	3.16
priority (kbps)	X	3.16	X	3.16	X	3.16
priority percent	X	3.16	X	3.16	X	3.16
queue-limit (bytes)	X	3.16	X	3.16	X	3.16
queue-limit (packets)	X	X	X	X	X	X
queue-limit (msec)	X	3.16	X	3.16	X	3.16

Ingress Queuing Limitations

The router does not support queuing on ingress interfaces.

Egress Queuing Limitations

The router supports tail drop queuing on egress interfaces using the **queue-limit** command. The following limitations apply to egress queuing:

- Queue allocation is per EFP/TEFP per TC(qos-group) for L2 interfaces with egress policy map applied.
- Queue allocation is per Port per TC(qos-group) for L3 interfaces.
- If class is matching multiple TC(qos-group) then multiple queues are generated for this class. For L2 interface, queues belonging to all EFP with the same TC comes under same class.
- Configuring shaping using committed burst (bc) is supported and excess burst (be) is not supported on the router.
- Granularity at lower rates is 384Kbps and at higher rates is 1.5 percent.
- **Priority Level** command and **Priority** command are not supported in the same policy.
- Strict **Priority** and **bandwidth** command cannot be configured in the same policy-map.
- Mixed bandwidth types are not supported in the same policy. For example, if you use **bandwidth remaining percent** command in one class, you cannot use **bandwidth percent** or **bandwidth remaining ratio** command in the same policy.

- The **bandwidth** and **bandwidth-remaining** commands are *not* supported on class containing the **Priority** command.
- Priority propagation is not supported.

Support for Low Latency Queuing on Multiple EFPs

The router supports the QoS policies that allow for low-latency queuing (LLQ) across multiple EFPs. For more information about this feature, see *QoS Policing and Shaping Configuration Guide for NCS 4200 Series*.

Additional Queuing Limitations

The additional queuing usage guidelines are the following:

- The router supports QoS policies that allow for low-latency queuing (LLQ) across multiple EFPs. For more information about this feature, see *QoS: Policing and Shaping Configuration for Cisco NCS 4200 Series*.
- Maximum queue-limit that can be configured in bytes is 4 MB.

Congestion Avoidance

Congestion avoidance techniques monitor network traffic loads in an effort to anticipate and avoid congestion at common network bottlenecks. Congestion avoidance is achieved through packet dropping. Among the more commonly used congestion avoidance mechanisms is Random Early Detection (RED), which is optimum for high-speed transit networks. Cisco IOS QoS includes an implementation of RED that, when configured, controls when the router drops packets. If you do not configure Weighted Random Early Detection (WRED), the router uses the cruder default packet drop mechanism called tail drop.

Table below summarizes the QoS congestion avoidance limitations for the router. In the table, I represents Ingress and E represents Egress.

Table 18: Congestion Avoidance QoS Limitations

Features	Main Layer 3 Interface		EFP Interface		Trunk EFP	
	I	E	I	E	I	E
random- detect discard- class-based	X	3.16	X	3.16	X	3.16

Congestion Avoidance Configuration

The following sections describe the supported congestion avoidance features on the router:

Supported Commands

The router supports the following commands for WRED:

- **random-detect discard-class-based**

Supported Interfaces

WRED is supported at the PHB level but not on logical or physical interfaces. You can apply WRED policies on the following interface types:

- Main interface
- Service instances
- Trunk EFPs

Verifying the Configuration

You can use the **show policy-map interface** command to display the number of WRED drops and tail drops.

For more information about configuring congestion avoidance, see the following documents:

- *QoS: Congestion Avoidance Configuration Guide for Cisco NCS 4200 Series*

Ingress Congestion Avoidance Limitations

WRED is not supported on ingress interfaces.

Egress Congestion Avoidance Limitations

The following limitations apply when configuring congestion avoidance on the router:

- WRED is only supported on egress interfaces.
- WRED based on discard-class only supported.
- Class-map match condition must be qos-group and WRED based on discard-class.
- Queuing feature to support WRED in a class such as shape or bandwidth are supported.
- You must apply WRED within a policy-map.
- WRED is *not* supported in priority queues.
- You can configure a maximum of 2 WRED curves per class.
- You can configure WRED with either the **shape** or the **fair-queue** (CBWFQ) commands.
- WRED is supported in the class-default class if there are no other user-defined classes in the policy-map.
- The default value for **exponential-weighting-constant** is 9.
- The default value for **mark-probability** is 10.

- You can specify the minimum-threshold and maximum-threshold in terms of bytes or microseconds. Setting threshold values in terms of packets is not supported.
- Aggregate-WRED is not supported.

Additional Congestion Avoidance Limitations

- You can specify the minimum-threshold and maximum-threshold in terms of bytes or microseconds. Setting threshold values in terms of packets is not supported.

Verifying the Configuration

You can use the **show policy-map interface** command to display the number of WRED drops and tail drops. For more information about configuring congestion avoidance, see *QoS: Congestion Avoidance Configuration Guide*.

Scheduling

This section describes the scheduling limitations and configuration guidelines for the router.

Ingress Scheduling Limitations

The router does not support scheduling on ingress interfaces.

Egress Scheduling Limitations

- If you configure a CIR, PIR, or EIR rate that the router cannot achieve within 1% accuracy, the configuration is rejected. The command output presents recommendations for the closest possible lower and higher configuration value.
- You can only configure one **priority** value on each parent class applied to a QoS class or logical interface.
- You can only configure priority on one class in a QoS policy.

The following limitations apply when configuring a 3-level scheduling policy on an egress interface configured as an EFP:

- Only two of the three levels can contain scheduling actions such as **bandwidth**, **shape**, or **priority**.
- Class-based excess bandwidth scheduling is supported on 2nd and 3rd level QoS classes.
- One of the levels containing scheduling actions must be the class (bottom) level.

Additional References

Related Documents

Related Topic	Document Title
Cisco IOS commands	Cisco IOS Master Commands List, All Releases
Other QoS Guides	<i>QoS: Classification Configuration Guide</i> <i>QoS: Congestion Avoidance Configuration Guide</i> <i>QoS: Congestion Management Configuration Guide</i> <i>QoS: Modular QoS Command-Line Interface Configuration Guide</i> <i>QoS: Policing and Shaping Configuration Guide</i>

Standards

Standard	Title
The supported standards applicable to the MPLS applications appear in the respective feature module for the application.	--

MIBs

MIB	MIBs Link
The supported MIBs applicable to the MPLS applications appear in the respective feature module for the application.	To locate and download MIBs for selected platforms, Cisco software releases, and feature sets, use Cisco MIB Locator found at the following URL: http://www.cisco.com/go/mibs

RFCs

RFC	Title
The supported RFCs applicable to the MPLS applications appear in the respective feature module for the application.	--

Technical Assistance

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