Quality of Service Overview

Quality of service (QoS) refers to the ability of a network to provide improved service to selected network traffic over various underlying technologies including Frame Relay, ATM, Ethernet and 802.1 networks, SONET, and IP-routed networks. The QoS features available on the Cisco 10000 series router provide the following services:

- Congestion management
- Congestion control
- Traffic policing
- Traffic shaping
- Ability to handle differential services and queuing requirements

This chapter provides an overview of QoS on the Cisco 10000 series router and includes the following topics:

- Benefits of Quality of Service Features, page 1-2
- Restrictions and Limitations for Quality of Service, page 1-2
- Modular QoS Command-Line Interface, page 1-2
- QoS Management Information Base Support, page 1-4
- QoS Implementation Guidelines, page 1-4
- QoS Execution on the Router, page 1-4
- QoS Configuration on an Interface, page 1-5
- QoS Models, page 1-6
- QoS Features, Commands, and Changes, page 1-11
- Related Documentation, page 1-61
Benefits of Quality of Service Features

Quality of service (QoS) features enable you to create differentiated services on your network that you can use to:

- Give preferential treatment to different classes of network traffic
- Ensure sufficient bandwidth to meet average network loads
- Determine the network response during times of congestion
- Classify traffic so that different applications or traffic classes receive treatment in accordance with defined requirements
- Ensure adequate resources are allocated so that the network delivers the performance the customer requires

Restrictions and Limitations for Quality of Service

- The ability to apply a QoS feature to an interface does not imply support for all QoS features on the interface.
- The router does not have a limit on the number of interfaces that can have a QoS policy.
- Trunk interfaces require multiple flows to achieve line-rate performance at packet sizes smaller than 250 bytes.
- A service-policy should not be attached to an interface that has an IP interface session.

Note
A flow consists of IP packets with the same source and destination addresses.

Modular QoS Command-Line Interface

To configure QoS features, use the modular quality of service command-line interface (MQC).

For Frame Relay, you can configure QoS features using the:

- MQC, applied on the physical interface
- MQC, applied on point-to-point Frame Relay subinterfaces (Release 12.0(19)SL or later)
- Frame Relay QoS command-line interface (CLI)

Note
The router does not support interface-based, legacy QoS commands such as the rate-limit and traffic-shape interface configuration commands. For information on these commands, see Appendix A, “Configuring Frame Relay QoS Using Frame Relay Legacy Commands”

The following apply when you configure QoS on Frame Relay:

- When you apply a service policy on the physical interface instead of on the individual subinterfaces, the aggregate traffic from all PVCs is subject to the service policy. This allows you to apply QoS policies independently of PVCs.
- When you apply a service policy on a Frame Relay point-to-point subinterface, only the subinterface traffic is subject to the service policy.
Using the legacy Frame Relay QoS CLI, you can enable Weighted Random Early Detection (WRED), traffic shaping, fair queuing, and low-latency queuing on a PVC basis.

Using the MQC, you can configure the following elements:

- Class map—Defines the criteria by which packets are classified.
- Policy map—Defines the actions to be taken on the traffic matching the class map criteria.
- Service policy—Attaches the service policy to an interface and specifies if the policy is to be applied to inbound or outbound traffic.

For more information about class maps, policy maps, and service policies, see the following chapters in this guide:

- Chapter 2, “Classifying Traffic”
- Chapter 3, “Configuring QoS Policy Actions and Rules”
- Chapter 4, “Attaching Service Policies”

Feature History for MQC

<table>
<thead>
<tr>
<th>Cisco IOS Release</th>
<th>Description</th>
<th>Required PRE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Release 12.0(17)SL</td>
<td>The MQC feature was introduced on the PRE1.</td>
<td>PRE1</td>
</tr>
<tr>
<td>Release 12.2(15)BX</td>
<td>This feature was introduced on the PRE2.</td>
<td>PRE2</td>
</tr>
<tr>
<td>Release 12.2(28)SB</td>
<td>This feature was integrated in Cisco IOS Release 12.2(28)SB for the PRE2.</td>
<td>PRE2</td>
</tr>
<tr>
<td>Release 12.2(31)SB2</td>
<td>This feature was introduced on the PRE3 and included the new <strong>qos match statistics</strong> command. Enhancements to the MQC allow you to classify packets on the L2TP access concentrator (LAC) based upon the IP type of service (ToS) bits in an embedded IP packet. When a policer is configured, the router uses the packet classification to police ingress traffic according to the DSCP value.</td>
<td>PRE3</td>
</tr>
<tr>
<td>Release 12.2(33)SB</td>
<td>This feature was introduced on the PRE4.</td>
<td>PRE4</td>
</tr>
</tbody>
</table>

QoS CLI Migration from PRE2 to PRE3

The Quality of Service (QoS) Command Line Interface (CLI) Migration from PRE2 to PRE3 feature provides QoS CLI backward-compatibility between the PRE2 and PRE3, thereby enabling the PRE3 to accept PRE2-style commands.

The PRE2 uses a proprietary version of the modular QoS CLI, while the PRE3 uses a non-proprietary CLI. The QoS CLI migration feature enables the PRE3 to parse PRE2-style commands and translate them to PRE3 commands.

For more information, see the **QoS CLI Migration from PRE2 to PRE3**, Release 12.2(31)SB2 feature module.
Feature History for QoS CLI Migration from PRE2 to PRE3

<table>
<thead>
<tr>
<th>Cisco IOS Release</th>
<th>Description</th>
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<tbody>
<tr>
<td>Release 12.2(31)SB2</td>
<td>This feature was introduced.</td>
<td>PRE3</td>
</tr>
<tr>
<td>Release 12.2(33)SB</td>
<td>This feature was introduced on the PRE4.</td>
<td>PRE4</td>
</tr>
</tbody>
</table>

QoS Management Information Base Support

The Cisco 10000 series router supports the Cisco Class-Based Quality of Service Management Information Base (Class-based QoS MIB). This MIB provides read access to QoS configurations and also provides QoS statistical information based on the modular QoS CLI (MQC), including information about class map and policy map parameters.

The Class-based QoS MIB is actually two MIBs: CISCO-CLASS-BASED-QOS-MIB and CISCO-CLASS-BASED-QOS-CAPABILITY-MIB.

To locate MIBs online, use the Cisco Network Management Toolkit for MIBs tool available on Cisco.com.

QoS Implementation Guidelines

Typically, the business model that you define and the applications you use determine the QoS features needed to meet your network requirements. Before deciding which QoS features to implement, consider the following guidelines:

- Provide preferential service to customers or applications that cannot tolerate dropped packets during periods of congestion.
- Provide dedicated bandwidth and low-latency queuing to privileged data that cannot tolerate delay.
- Share the bandwidth fairly among competing traffic. For example, allocate percentages of a link bandwidth to the various applications.
- Prevent congestion by using congestion control algorithms such as random early detection (RED) and weighted random early detection (WRED), instead of using the default tail drop mode of operation.
- Police and shape transmission rates to limit and control traffic that exceeds predefined transmission rate limits.
- Identify, set, or modify traffic priorities to provide end-to-end service quality.

QoS Execution on the Router

The Cisco 10000 series router executes the QoS features in the following order:

1. Fragment reassembly
2. QoS Policy Propagation through Border Gateway Protocol (QPPB)
3. Input classification
4. Input marking
5. Input metering (policing)
6. Output classification
7. Output marking
8. Output metering (policing)
9. Bandwidth distribution, priority service, traffic shaping, random early detection (RED), and tail drop
10. Fragmentation

QoS Configuration on an Interface

The QoS service policy attached to an interface tells the Cisco 10000 series router how to handle packets received on the interface. Service policies consist of:

- Classification criteria—Defined in class maps and tell the router how to classify packets received on the interface.
- Actions—Defined in policy maps and tell the router the actions and rules to apply to the packets.

To configure a QoS service policy on an interface, do the following:

**Step 1** Create a class map. (See Chapter 2, “Classifying Traffic.”)

**Step 2** Create a policy map. (See Chapter 3, “Configuring QoS Policy Actions and Rules.”)

**Step 3** Attach the service policy to an interface. (See Chapter 4, “Attaching Service Policies.”)

Figure 1-1 shows the process of QoS configuration on an interface.

**Figure 1-1   Quality of Service Process**
QoS Models

This section defines two QoS models with respect to Ether-DSL aggregation, supported on the Cisco 10000 series router. It includes the following topics:

- Overview of QoS Models, page 1-6
- Configuration Tasks, page 1-8
- Configuration Examples, page 1-9

Overview of QoS Models

The E-DSL QoS models are defined based on whether its requirement is generic to all services or specific to residential or business services.

Generic requirements are common to all subscriber lines regardless of whether they support residential or business services. Generic requirements per subscriber line include the following:

- Avoid indiscriminate loss of traffic downstream at the DSLAM
- Minimum assured rate per service or class
- Maximum enforced rate per service or class
- Ability for one service or class of a particular subscriber to re-use unused bandwidth from another service or class for the same subscriber.

Business services additionally include the following requirements:

- Single point of traffic injection
- Enforce a sub modem train rate max (shaped) aggregate rate per subscriber line
- Child queuing policy
- Analogous to current Layer 3 VPN access QOS services

Residential services additionally include the following requirements:

- Support multiple points of traffic injection into the Layer 2 access network
- Wholesale bandwidth concept –analogous to a virtual path in ATM-DSL
- Per session services
- Support VLAN aggregation

The two DSLAM model configurations that are supported on Cisco 10000 series router for business and residential services are:

- Model D.2 Definition, page 1-7
- Model F Definition, page 1-7

Note: QoS Models D.2 and F are supported on PRE3 and PRE4.
Model D.2 Definition

This model is equivalent to the ATM-DSL model where shaped virtual circuits (VCs) terminate on an interface, without shaped virtual paths (VPs). In this model all QoS control is maintained at the broadband remote access server or network processing engine (BRAS / NPE) and none at the DSLAM.

The traffic to each subscriber line is shaped to less than or equal to the DSLAM modem train rate. This shaping at the BRAS / NPE accounts for the ATM overhead on the DSLAM-to-CPE link, even though the downstream interface on the BRAS / NPE is an Ethernet interface.

The subscriber line is represented by individual or groups of IP or Point-to-Point Protocol (PPP) sessions. The policy for per class policing or marking is applied per PPP or IP session.

The key components of Model D.2 are shown in Figure 1-2.

Figure 1-2 Key Components of Model D.2

Upstream and downstream per subs/session per class:
• 1 rate 2 color policer

Downstream per subscriber line:
• shape/min bw
• per class PQ + CBQ + WRED

Treated as any other trunk network:
Could use per class PQ+CBQ, or overprovision

No QOS supported

bw = bandwidth
PQ = Priority Queue
CBQ = Class Based Queue
WRED = Weighted Random Early Detection

Model F Definition

This model is functionally equivalent to the ATM model with shaped virtual paths (VPs) and shaped virtual circuits (VCs). Similar to the Model D.2, this model has all QOS control at the broadband remote access server or network processing engine (BRAS / NPE) and none at the DSLAM.

The traffic to a group of subscriber lines is shaped to a defined rate, equivalent to a virtual path in ATM. In the case of residential services, a group of subscribers is represented by a VLAN, and for business services a group of subscribers is represented by the outer 802.1q tag.

The traffic to individual subscriber lines is shaped to less than or equal to the DSLAM modem train rate. The subscriber line for business services is identified by the inner and outer 802.1q tag. The subscriber line is represented by individual or groups of IP or PPP sessions.

QoS Model F requires 3 levels of shaping, queuing and scheduling –Subinterface / Session / Class queues.

The key components of Model F are shown in Figure 1-3.
Configuration Tasks

Model D.2 supports two types of configurations:

- Configuration on subinterfaces – consists of hierarchical policy-maps attached to QinQ subinterfaces, as shown in Example 1-1.
- Configuration on IP or PPP sessions – consists of hierarchical queuing policy-maps on IP or PPP sessions, as shown in Example 1-2.

Configuration Steps on Subinterfaces for QoS Model D.2

To configure subinterfaces for QoS Model D.2 follow the steps given below:

Step 1  Discover the GigabitEthernet (GE) interface.
Step 2  Create subinterfaces on the GE interface.
Step 3  Apply policy-map to Subint 1.
Step 4  Apply policy-map to Subint 2.

Configuration Steps on Sessions for QoS Model D.2

To configure sessions for QoS Model D.2 follow the steps given below:

Step 1  Discover the GE interface.
Step 2  Create sessions on the GE interface.
Step 3  Apply policy-map to session S1.
Step 4  Apply policy-map to session S2.
Model F supports multiple IP and/or PPP sessions per subscriber line with shaping occurring at the subscriber line level, by using the line ID information present in DHCP option 82 and the PPP tag. Shaping sessions with a common line ID effects traffic shaping for a particular subscriber line. See Example 1-3 for more configuration information.

Model F configuration requires three levels of shaping/queuing hierarchy on the BRAS or NPE—at the Subinterface, Session and Class levels.

Configuration Steps for QoS Model F

To configure QoS Model F follow the steps given below:

1. Discover the GE interface.
2. Create subinterface1 on the GE interface.
3. Apply isp_A shape policy to subinterface1.
4. Create sessions on subinterface 1.
5. Apply session-parent policy-map to session S1 belonging to subinterface1

Configuration Examples

An example of Model D.2 subinterface configuration is described in Example 1-1.

Example 1-1 Configuring Model D.2 Subinterface Configuration

Policy business-A-child
   class voip
       priority level 1
       police <rate> <nb>
       set cos <cos>
   class video
       priority level 2
       police <rate> <nb>
       set cos <cos>
   class gaming
       bandwidth remaining ratio <i> [account qinq aalx xxx]
       set cos <cos>
   class class-default
       bandwidth remaining ratio <j> [account qinq aalx xxx]
       set cos <cos>

Policy company-A-parent
   class class-default
   bandwidth remaining ratio <number> [account qinq aalx xxx]
   shape average <cir> <nb> [account qinq aalx xxx]
   service policy business-A-child
   ...

   interface GigabitEthernet1/0/0.n
       description Company A
       encapsulation dot1q i second-dot1q n
       service-policy output company-A-parent

   interface GigabitEthernet1/0/0.m
       description Company B
       encapsulation dot1q i second-dot1q m
       service-policy output company-B-parent
An example of Model D.2 session configuration is described in Example 1-2.

**Example 1-2  Model D.2 Session Configuration**

```
Policy session-A-child
  class voip
    priority level 1
    police <rate> <nb>
    set cos <cos>
  class video
    priority level 2
    police <rate> <nb>
    set cos <cos>
  class gaming
    bandwidth remaining ratio <i> [account xxx aalx xxx]
    set cos <cos>
  class class-default
    bandwidth remaining ratio <j> [account xxx aalx xxx]
    set cos <cos>

Policy session-A-parent
  bandwidth remaining ratio <number> [account xxx aalx xxx]
  shape average <cir> <nb> [account xxx aalx xxx]
  service-policy session-A-child
```

Session-N-parent policy-maps attached to PPP/IP sessions via Radius or via a Virtual-Template

An example of Model F configuration is described in Example 1-3.

**Example 1-3  QoS Model F Configuration**

```
Policy session-N-child
  class voip
    priority level 1
    police <rate> <nb>
    set cos <cos>
  class video
    priority level 2
    police <rate> <nb>
    set cos <cos>
  class gaming
    bandwidth remaining ratio <i> [account xxx aalx xxx]
    set cos <cos>
  class class-default
    bandwidth remaining ratio <j> [account xxx aalx xxx]
    set cos <cos>

Policy session-N-parent
  class class-default
  bandwidth remaining ratio <number> [account xxx aalx xxx]
  shape average <cir> <nb> [account xxx aalx xxx]
  service-policy session-N-child
```

Policy isp_A
  class class-default
  shape average _

interface GigabitEthernet1/0/0.1
  encapsulation dot1q 1
  service-policy output isp_A
QoS Features, Commands, and Changes

This section describes the QoS features and commands supported on the Cisco 10000 series router, and lists feature and command changes. It includes the following topics:

- Applying QoS Parameters Dynamically to Sessions, page 1-12
- Applying Traffic Shaping Parameters Using RADIUS Profiles, page 1-12
- Attaching QoS Service Policies, page 1-13
- Classifying Traffic, page 1-15
- Configuring QoS for MPLS Traffic, page 1-18
- Control Plane Policing, page 1-19
- Controlling Packet Queue Congestion, page 1-21
- Distributing Bandwidth Between Queues, page 1-25
- Dynamically Changing VC Weight and Watermark Values, page 1-26
- Hierarchical Queuing Framework, page 1-27
- Hierarchical Policies, page 1-27
- IP Quality of Service for Subscribers, page 1-29
- Layer 2 Access Concentrator, page 1-30
- Link Fragmentation and Interleaving, page 1-31
- Marking Traffic, page 1-36
- Modular QoS Command Line Interface, page 1-39
- Overhead Accounting, page 1-39
- Oversubscribing Physical and Virtual Links, page 1-41
- Policing Traffic, page 1-44
- Prioritizing Traffic, page 1-48
- PVC Bundles, page 1-50
- QoS Policy Maps, page 1-53
- Qos Policy Propagation through the Border Gateway Protocol, page 1-55
- Shaping PPPoE Over VLAN Sessions Using RADIUS, page 1-55
- Shaping Traffic, page 1-55
- Sharing Bandwidth Fairly During Congestion, page 1-59
- Simultaneous Policy Maps, page 1-60
Applying QoS Parameters Dynamically to Sessions

**Documentation Reference:** Chapter 18, “Regulating and Shaping Subscriber Traffic”

**Cisco IOS Release:** Release 12.3(7)XI2

**Description:** The Define Interface Policy-Map AV Pairs AAA feature was introduced on the PRE2 to provide two RADIUS vendor-specific attributes (VSAs): cisco-avpair = “atm:vc-qos-policy-in=<in policy name>” and cisco-avpair = “atm:vc-qos-policy-out=<out policy name>”. These VSAs allow you to apply (pull) a policy map on an ATM virtual circuit (VC) during Point-to-Point Protocol over ATM (PPPoA) or PPP over Ethernet over ATM (PPPoEoA) session establishment.

**Cisco IOS Release:** Release 12.2(28)SB

**Description:** This feature was integrated in Cisco IOS Release 12.2(28)SB and enhanced to provide “push” functionality.

Applying Traffic Shaping Parameters Using RADIUS Profiles

**Documentation Reference:** Chapter 17, “Configuring Dynamic Subscriber Services”

- db enable Command, page 1-12
- default db enable Command, page 1-12
- Dynamic Bandwidth Selection Feature, page 1-13

**db enable Command**

**Cisco IOS Release:** Release 12.2(16)BX

**Description:** The `db enable` command was introduced on the PRE2 to enable dynamic bandwidth selection.

**Cisco IOS Release:** Release 12.2(28)SB

**Description:** This command was integrated in Cisco IOS Release 12.2(28)SB.

**default db enable Command**

**Cisco IOS Release:** Release 12.2(16)BX

**Description:** The `default db enable` command was introduced on the PRE2 to remove the `db enable` or `no db enable` command from an existing configuration.

**Cisco IOS Release:** Release 12.2(28)SB

**Description:** This command was integrated in Cisco IOS Release 12.2(28)SB.
Dynamic Bandwidth Selection Feature

Cisco IOS Release: Release 12.2(16)BX

Description: The Dynamic Bandwidth Selection (DBS) feature was introduced on the PRE2 to dynamically change ATM traffic shaping parameters based on a subscriber’s RADIUS profile. This feature is also known as Per User QoS Using AAA Policy Name.

Cisco IOS Release: Release 12.2(28)SB

Description: This feature was integrated in Cisco IOS Release 12.2(28)SB.

Attaching QoS Service Policies

Documentation Reference: Chapter 4, “Attaching Service Policies”

- service-policy Command, page 1-13
- Attaching ATM QoS Service Policies, page 1-14
- Attaching Frame Relay QoS Service Policies, page 1-14
- Attaching LAC QoS Service Policies, page 1-15
- Attaching Virtual LAN QoS Service Policies, page 1-15
- Attaching Virtual Access Interface QoS Service Policies, page 1-15

service-policy Command

Cisco IOS Release: Release 12.0(17)SL

Description: The service-policy command was introduced on the PRE1 to attach a policy map that the router can use to apply QoS services to inbound and outbound packets.

Cisco IOS Release: Release 12.2(15)BX

Description: This command was introduced on the PRE2.

Cisco IOS Release: Release 12.3(7)XI2

Description: This command was enhanced on the PRE2 to allow you to attach a policy map to a range of PVCs, and to a specific PVC within the PVC range.

Cisco IOS Release: Release 12.2(28)SB

Description: This command was integrated in Cisco IOS Release 12.2(28)SB.

Cisco IOS Release: Release 12.2(31)SB2

Description: This command was introduced on the PRE3.
Attaching ATM QoS Service Policies

**Cisco IOS Release:** Release 12.0(17)SL

**Description:** The ATM QoS service policies feature was introduced on the PRE1 to enable you to attach QoS policies to ATM interfaces, subinterfaces, and permanent virtual circuits (PVCs).

**Cisco IOS Release:** Release 12.0(22)S

**Description:** This feature was ported to the S train.

**Cisco IOS Release:** Release 12.2(15)BX

**Description:** This feature was introduced on the PRE2.

**Cisco IOS Release:** Release 12.3(7)XI2

**Description:** This feature was enhanced on the PRE2 to enable you to attach QoS policies to a range of PVCs and to a specific PVC within the PVC range.

**Cisco IOS Release:** Release 12.2(28)SB

**Description:** This feature was integrated in Cisco IOS Release 12.2(28)SB.

**Cisco IOS Release:** Release 12.2(31)SB2

**Description:** This feature was introduced on the PRE3.

Attaching Frame Relay QoS Service Policies

**Cisco IOS Release:** Release 12.0(23)SX

**Description:** The Frame Relay QoS service policies feature was introduced on the PRE1 to enable you to attach QoS policies to Frame Relay interfaces, subinterfaces, and data-link connection identifiers (DLCIs).

**Cisco IOS Release:** Release 12.0(25)S

**Description:** This feature was ported to the S train.

**Cisco IOS Release:** Release 12.2(16)BX

**Description:** This feature was introduced on the PRE2.

**Cisco IOS Release:** Release 12.2(28)SB

**Description:** This feature was integrated in Cisco IOS Release 12.2(28)SB.

**Cisco IOS Release:** Release 12.2(31)SB2

**Description:** This feature was introduced on the PRE3.
Attaching LAC QoS Service Policies

Cisco IOS Release: Release 12.3(7)XI3
Description: The LAC QoS feature was introduced on the PRE2 to enable you to attach QoS service policies to ATM virtual circuits (VCs) on the Layer 2 Access Concentrator (LAC).

Attaching Virtual LAN QoS Service Policies

Cisco IOS Release: Release 12.2(15)BX
Description: The virtual LAN (VLAN) QoS service policies feature was introduced on the PRE2 to enable you to attach QoS policies to a physical Ethernet interface, an individual VLAN subinterface, or to both the physical interface and one or more VLAN subinterfaces.

Cisco IOS Release: Release 12.2(28)SB
Description: This feature was integrated in Cisco IOS Release 12.2(28)SB.

Attaching Virtual Access Interface QoS Service Policies

Cisco IOS Release: Release 12.2(15)BX
Description: The virtual access interface (VAI) QoS service policies feature was introduced on the PRE2 to enable you to apply virtual template interfaces with QoS policies to VCs. When the router creates the VAI for a session, the router applies the QoS policies to the VAI.

Cisco IOS Release: Release 12.2(28)SB
Description: This feature was integrated in Cisco IOS Release 12.2(28)SB.

Classifying Traffic

Documentation Reference: Chapter 2, “Classifying Traffic”
- class-map Command, page 1-15
- match Commands, page 1-16
- Class Map Feature, page 1-18

class-map Command

Cisco IOS Release: Release 12.0(17)SL
Description: The class-map command was introduced on the PRE1 to enable you to configure a classification policy for traffic classes.

Cisco IOS Release: Release 12.2(15)BX
Description: This command was introduced on the PRE2.

Cisco IOS Release: Release 12.2(28)SB
Description: This command was integrated in Cisco IOS Release 12.2(28)SB.
Cisco IOS Release: Release 12.2(31)SB2
Description: This command was introduced on the PRE3.
Enhancements to the modular quality of service CLI (MQC) allow you to classify packets on the L2TP access concentrator (LAC) based upon the IP type of service (ToS) bits in an embedded IP packet. The classification is used to police ingress traffic according to the DSCP value.

Cisco IOS Release: Release 12.2(33)SB
Description: This command was introduced on the PRE4.

**match Commands**

Cisco IOS Release: Release 12.0(17)SL
Description: The match command was introduced on the PRE1 to enable you to define the following match criteria for a class map:
- **match-all** Command—Indicates that a packet must match all of the match criteria specified.
- **match-any** Command—Indicates that a packet must match only one of the match criteria specified.
- **match access-group** Command—Indicates that a packet must match one of the predefined access control list (ACL) statements.
- **match input-interface** Command—Indicates that the input interface on which the packet arrives must match the value you set using the **set input-interface** command.
- **match ip dscp** Command—Indicates that the IP DSCP value of the packet must match the value you set using the **set ip dscp** command.
- **match ip precedence** Command—Indicates that the IP precedence value of the packet must match the value you set using the **set ip precedence** command.
- **match ip rtp** Command—Indicates that the IP Real-Time Transport Protocol (RTP) value of the packet must match the value you set using the **set ip rtp** command.
- **match qos-group** Command—Indicates that the QoS group value of the packet must match the value you set using the **set qos-group** command.
- **match not** Command—Indicates that the packet must not match the criteria you set. You can use the **match not** command with any match criteria.

For example, to classify packets that do not have a specific class of service value, enter the **match not cos** command in the appropriate class map as a match criterion. The router classifies a packet when the CoS value of the packet does not match the value you set using the **set cos** command.

Cisco IOS Release: Release 12.0(22)S
Description: This command was enhanced to enable you to match the MPLS experimental (EXP) bit value of the class. If you specify the **match mpls experimental** command, the router classifies a packet when the MPLS EXP value of the packet matches the value you set using the **set mpls experimental** command. The **match mpls experimental** command is available only on the PRE1.
Cisco IOS Release: Release 12.2(15)BX

Description: This command was enhanced to enable you to match on the class of service of a packet. When you specify the **match cos** command, packets that match the value you set using the **set cos** command are assigned to the associated traffic class. The **match cos** command is available only on the PRE2.

Cisco IOS Release: Release 12.2(16)BX

Description: This command was enhanced on the PRE2 to enable you to match the experimental (EXP) value in the topmost label of the packet. The **match mpls experimental topmost** command is available only on the PRE2.

**Note**
The router does not support the **set mpls experimental topmost** command.

Cisco IOS Release: Release 12.3(7)XI

Description: This command was enhanced on the PRE2 to enable you to match the MPLS experimental (EXP) bit value on the imposed label entry of the packet. When you specify the **match mpls experimental imposition** command, the router classifies a packet when the MPLS EXP value on the imposed label entry of the packet matches the value you set using the **set mpls experimental imposition** command. This command is available only on the PRE2.

The **match** command was also enhanced to enable you to match the discard value of the class. The discard value indicates the drop eligibility of a packet. When you specify the **match discard-class** command, the router classifies a packet when the discard value of the packet matches the value you set using the **set discard-class** command. The **match discard-class** command is available only on the PRE2.

Cisco IOS Release: Release 12.2(28)SB

Description: The **match** commands were integrated in Cisco IOS Release 12.2(28)SB.

Cisco IOS Release: Release 12.2(31)SB2

Description: This command was introduced on the PRE3 to enable you to match on the class of service of a packet. When you specify the **match cos** command, packets that match the value you set using the **set cos** command are assigned to the associated traffic class. The **match cos** command is available on the PRE2 and PRE3.

Enhancements to the modular quality of service CLI (MQC) allow you to classify packets on the L2TP access concentrator (LAC) based upon the IP type of service (ToS) bits in an embedded IP packet. The classification is used to police ingress traffic according to the DSCP value.
Cisco IOS Release: Release 12.2(33)SB
Description: This command was enhanced to enable you to match the Frame Relay discard eligibility (DE) bit value, and was implemented on the PRE2, PRE3, and PRE4.

Class Map Feature

Cisco IOS Release: Release 12.0(17)SL
Description: The class map feature was introduced on the PRE1 to enable you to create and modify a classification policy for traffic classes.

Cisco IOS Release: Release 12.2(15)BX
Description: This feature was introduced on the PRE2.

Cisco IOS Release: Release 12.2(28)SB
Description: This feature was integrated in Cisco IOS Release 12.2(28)SB.

Cisco IOS Release: Release 12.2(31)SB2
Description: This feature was introduced on the PRE3.
Enhancements to the modular quality of service CLI (MQC) allow you to classify packets on the L2TP access concentrator (LAC) based upon the IP type of service (ToS) bits in an embedded IP packet. The classification is used to police ingress traffic according to the DSCP value.

Cisco IOS Release: Release 12.2(33)SB
Description: This feature was introduced on the PRE4.

Configuring QoS for MPLS Traffic

Documentation Reference: Chapter 20, “Configuring Quality of Service for MPLS Traffic”
- MPLS CoS Multi-VC Mode, page 1-18
- MPLS QoS Feature, page 1-19
- MPLS Traffic Engineering—DiffServ Aware Feature, page 1-19

MPLS CoS Multi-VC Mode

Cisco IOS Release: Release 12.0(17)S
Description: The MPLS CoS Multi-VC Mode feature was introduced on the PRE1 to enable you to map the experimental (EXP) field values of an MPLS label to an ATM VC, creating sets of labeled virtual circuits (LVCs) to provide varying levels of QoS services for different types of traffic in an MPLS network.

Cisco IOS Release: Release 12.2(16)BX
Description: This feature was introduced on the PRE2.
Cisco IOS Release: Release 12.2(28)SB
Description: This feature was integrated in Cisco IOS Release 12.2(28)SB.

**MPLS QoS Feature**

Cisco IOS Release: Release 12.0(19)SL
Description: The MPLS QoS feature was introduced on the PRE1 to provide varying levels of QoS for different types of traffic in an MPLS network.

Cisco IOS Release: Release 12.0(22)S
Description: This feature was enhanced to allow classification and marking based on the MPLS experimental (EXP) field.

Cisco IOS Release: Release 12.2(16)BX
Description: This feature was introduced on the PRE2.

Cisco IOS Release: Release 12.2(28)SB
Description: This feature was integrated in Cisco IOS Release 12.2(28)SB.

**MPLS Traffic Engineering—DiffServ Aware Feature**

Cisco IOS Release: Release 12.3(7)XI
Description: The MPLS Traffic Engineering—DiffServ Aware (DS-TE) feature was introduced on the PRE2 to provide stricter quality of service (QoS) guarantees.

Cisco IOS Release: Release 12.2(28)SB
Description: This feature was integrated in Cisco IOS Release 12.2(28)SB.

Cisco IOS Release: Release 12.2(31)SB2
Description: This feature was introduced on the PRE3.

**Control Plane Policing**

- Divert Cause Policer, page 1-19
- Control Plane Policing—Platform Enhancement, page 1-20

**Divert Cause Policer**

Cisco IOS Release: Release 12.2(31)SB
Description: The Divert Cause Policer was introduced on the PRE3.
Cisco IOS Release: Release 12.2(33)SB

**Description:** This feature was enhanced on the PRE3 and introduced on the PRE4 to enable you to configure the rate and burst size of the divert cause policer. See the Control Plane Policing—Platform Enhancement feature.

### Control Plane Policing—Platform Enhancement

Cisco IOS Release: Release 12.2(33)SB

**Description:** The Control Plane Policing—Platform Enhancement feature was introduced on the PRE3 and PRE4 and included:

- User-Level Punt Monitoring, page 1-20
- Configurable Rate and Burst Size for the Divert Cause Policer, page 1-20
- Drop Alarms for Packet Drops by the To-RP Queues and Divert Cause Policer, page 1-20

### User-Level Punt Monitoring

Cisco IOS Release: Release 12.2(33)SB

**Description:** The User-Level Punt Monitoring feature was introduced on the PRE3 and PRE4 to prevent a denial of service (DoS) attack. Using this feature, you can monitor individual users and display statistical information about traffic that the PXF engine sends (punts) to the route processor (RP).

### Configurable Rate and Burst Size for the Divert Cause Policer

Cisco IOS Release: Release 12.2(33)SB

**Description:** The Configurable Rate and Burst Size for the Divert Cause Policer feature was introduced on the PRE3 and PRE4 to configure the rate and burst size of the divert cause policer.

### Drop Alarms for Packet Drops by the To-RP Queues and Divert Cause Policer

Cisco IOS Release: Release 12.2(33)SB

**Description:** The Drop Alarms for Packet Drops by the To-RP Queues and Divert Cause Policer feature was introduced on the PRE3 and PRE4 to monitor possible DoS attacks by sending warning messages (alarms) to the console and the syslog log file to alert you when a change in drop activities occurs, such as packet drops due to congestion in the To-RP queues or due to aggregated traffic that violates the divert cause policer.
Controlling Packet Queue Congestion

Documentation Reference: Chapter 11, “Managing Packet Queue Congestion”

- queue-limit Command, page 1-21
- random-detect Command, page 1-22
- random-detect basis Command, page 1-23
- show pxf cpu queue interface summary, page 1-23
- Tail Drop Feature, page 1-23
- Random Early Detection Feature, page 1-24
- Weighted Random Early Detection Feature, page 1-24

queue-limit Command

Cisco IOS Release: Release 12.0(17)SL

Description: The queue-limit command was introduced on the PRE1 to allow you to specify or modify the maximum number of packets that a particular class queue can hold.

Cisco IOS Release: Release 12.0(25)SX

Description: This command was enhanced on the PRE1 to allow you to simultaneously configure both the queue-limit and random-detect commands in the same class of a policy map.

Cisco IOS Release: Release 12.2(16)BX

Description: This command was introduced on the PRE2 without the ability to simultaneously configure the random-detect command and the queue-limit command for the same class queue.

Cisco IOS Release: Release 12.3(7)XI

Description: This command was enhanced on the PRE2 to allow you to simultaneously configure both the queue-limit and random-detect commands in the same class of a policy map.

Cisco IOS Release: Release 12.2(28)SB

Description: This command was integrated in Cisco IOS Release 12.2(28)SB.

Cisco IOS Release: Release 12.2(31)SB2

Description: This command was introduced on the PRE3.
random-detect Command

Cisco IOS Release: Release 12.0(17)SL
Description: The `random-detect` command was introduced on the PRE1 to configure a random early detection drop policy for a traffic class that includes a bandwidth guarantee. The command allows you to configure a drop policy based on IP precedence. An exponential-weight-constant option allows you to change the default method random-detect uses to calculate the average queue size.

Cisco IOS Release: Release 12.0(21)ST
Description: This command was enhanced to support the MPLS experimental (EXP) field.

Cisco IOS Release: Release 12.0(22)S
Description: This command was enhanced to allow you to configure a drop policy based on a differentiated services code point (DSCP).

Cisco IOS Release: Release 12.0(25)SX
Description: This command was enhanced to allow you to simultaneously configure the `random-detect` command and the `queue-limit` command for the same class queue.

Cisco IOS Release: Release 12.2(16)BX
Description: This command was introduced on the PRE2.

Cisco IOS Release: Release 12.3(7)XI
Description: This command was enhanced on the PRE2 to:
- Enable the configuration of eight unique drop precedence levels for one queue instead of four levels
- Allow the simultaneous configuration of both the `random-detect` and `queue-limit` commands for a class queue
- Support discard-class-based WRED
- Maintain separate WRED drop statistics for each IP precedence, discard-class, and DSCP value

Cisco IOS Release: Release 12.2(28)SB
Description: This command was integrated in Cisco IOS Release 12.2(28)SB.

Cisco IOS Release: Release 12.2(31)SB2
Description: This command was introduced on the PRE3.

Cisco IOS Release: Release 12.2(33)SB
Description: This command was enhanced to support the `atm-clp clp-value` option and implemented on the PRE2, PRE3, and PRE4. This option allows you to specify a number that indicates the drop eligibility of a packet based on the ATM CLP bit. Valid values are 0 or 1.
random-detect basis Command

Cisco IOS Release: Release 12.0(17)SL
Description: The random-detect basis command was introduced on the PRE1 with the dscp-based and prec-based options to enable a weighted random early detection (WRED) drop policy based on a DSCP value or IP precedence level.

Cisco IOS Release: Release 12.2(16)BX
Description: This command was introduced on the PRE2.

Cisco IOS Release: Release 12.3(7)XI
Description: This command was enhanced to enable a drop policy based on a discard-class value. The discard-class-based option is available only on the PRE2 for Cisco IOS Release 12.3XI images.

Cisco IOS Release: Release 12.2(28)SB
Description: This command was integrated in Cisco IOS Release 12.2(28)SB with the dscp-based, prec-based, and discard-class-based options.

Cisco IOS Release: Release 12.2(31)SB2
Description: This command was introduced on the PRE3 with the dscp-based, prec-based, and discard-class-based options.

Cisco IOS Release: Release 12.2(33)SB
Description: This command was enhanced to include the atm-clp-based option and implemented on the PRE2, PRE3, and PRE4.

show pxf cpu queue interface summary

Cisco IOS Release: Release 12.2(33)SB
Description: The show pxf cpu queue interface summary command was modified to display only the physical interface and the number of logical links, and implemented on the PRE3 and PRE4. The output of the command no longer displays the number of priority queues, class queues and so on.

Tail Drop Feature

Cisco IOS Release: Release 12.0(17)SL
Description: The tail drop feature was introduced on the PRE1 to allow you to manage congestion of a queue. When a queue reaches its configured queue limit, tail drop activates and drops packets. Tail drop continues to drop packets until the queue is no longer full. Tail drop is the default mechanism used to control congestion.

Cisco IOS Release: Release 12.2(16)BX
Description: This feature was introduced on the PRE2.

Cisco IOS Release: Release 12.2(28)SB
Description: This feature was integrated in Cisco IOS Release 12.2(28)SB.
Cisco IOS Release: Release 12.2(31)SB2  
**Description:** This feature was introduced on the PRE3.

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**Random Early Detection Feature**

**Cisco IOS Release:** 12.0(17)SL  
**Description:** The random early detection (RED) feature was introduced on the PRE1 to enable the configuration of a packet drop policy. RED is a mechanism that is used to control congestion by randomly discarding packets before a queue reaches its queue limit.

**Cisco IOS Release:** Release 12.0(22)S  
**Description:** This feature was enhanced to include RED based on a differentiated services code point (DSCP). For the PRE1, DSCP-based RED supports one default drop profile per class, three assured forwarding (AF) drop profiles per class, and four non-AF drop profiles per policy map.

**Cisco IOS Release:** Release 12.0(25)SX  
**Description:** This feature was enhanced to allow you to simultaneously configure a packet drop policy for a class queue (using the `random-detect` command) and the size of the class queue (using the `queue-limit` command).

**Cisco IOS Release:** Release 12.2(16)BX  
**Description:** This feature was introduced on the PRE2.

**Cisco IOS Release:** Release 12.2(28)SB  
**Description:** This feature was integrated in Cisco IOS Release 12.2(28)SB.

**Cisco IOS Release:** Release 12.2(31)SB2  
**Description:** This feature was introduced on the PRE3.

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**Weighted Random Early Detection Feature**

**Cisco IOS Release:** Release 12.0(17)SL  
**Description:** The weighted random early detection (WRED) feature was introduced on the PRE1 to provide preferential handling of higher priority packets. WRED allows drop policies based on a differentiated services code point (DSCP) and IP precedence levels.

**Cisco IOS Release:** Release 12.0(22)S  
**Description:** This feature was enhanced to include WRED based on a differentiated services code point (DSCP).

**Cisco IOS Release:** Release 12.0(25)SX  
**Description:** This feature was enhanced to allow you to simultaneously configure a packet drop policy for a class queue (using the `random-detect` command) and the size of the class queue (using the `queue-limit` command).
Cisco IOS Release: Release 12.2(16)BX  
**Description:** This feature was introduced on the PRE2.

Cisco IOS Release: Release 12.3(7)XI  
**Description:** This feature was enhanced on the PRE2 to:
- Enable the configuration of eight unique drop precedence levels for one queue instead of four levels
- Allow the simultaneous configuration of both the `random-detect` and `queue-limit` commands for a class queue
- Support discard-class-based WRED
- Maintain separate WRED drop statistics for each IP precedence, discard-class, and DSCP value

Cisco IOS Release: Release 12.2(28)SB  
**Description:** This feature was integrated in Cisco IOS Release 12.2(28)SB on the PRE2.

Cisco IOS Release: Release 12.2(31)SB2  
**Description:** This feature was introduced on the PRE3. It provides DiffServ-compliant WRED and uses per-packet RED.

Cisco IOS Release: Release 12.2(33)SB  
**Description:** ATM cell loss priority-based WRED was introduced on the PRE3 and PRE4 to configure a drop policy for WRED based on the CLP value.

**Distributing Bandwidth Between Queues**

**Documentation Reference:** Chapter 5, “Distributing Bandwidth Between Queues”
- `bandwidth` Command, page 1-25
- `bandwidth remaining ratio` Command, page 1-26
- Distribution of Remaining Bandwidth Using Ratio, page 1-26

**bandwidth Command**

Cisco IOS Release: Release 12.0(17)SL  
**Description:** The `bandwidth` command was introduced on the PRE1 to enable bandwidth fair queuing and to create multiple class queues based on bandwidth.

Cisco IOS Release: Release 12.0(22)S  
**Description:** This command was enhanced to include the `percent` option.

Cisco IOS Release: Release 12.0(23)SX  
**Description:** This command was enhanced to include the remaining `percent` option.
Cisco IOS Release: Release 12.2(15)BX
Description: This command was introduced on the PRE2 and included the kilobits per second (kbps), percent, and remaining percent options.

Cisco IOS Release: Release 12.2(28)SB
Description: This command was integrated in Cisco IOS Release 12.2(28)SB.

Cisco IOS Release: Release 12.2(31)SB2
Description: This feature was introduced on the PRE3.

Cisco IOS Release: Release 12.2(31)SB6
Description: This command supports per-session shaping and queuing on a L2TP Network Server (LNS) on the PRE3.
Cisco IOS Release: Release 12.2(31)SB2
Description: This command was enhanced to support overhead accounting.
Cisco IOS Release: Release 12.2(33)SB
Description: This command was enhanced to support a user-defined offset, which the router uses when calculating overhead.

bandwidth remaining ratio Command
Cisco IOS Release: Release 12.2(31)SB2
Description: The bandwidth remaining ratio command was introduced on the PRE3.

Distribution of Remaining Bandwidth Using Ratio
Cisco IOS Release: Release 12.2(31)SB2
Description: The distribution of remaining bandwidth using ratio feature was introduced on the PRE3 to allow you to prioritize subscriber traffic during periods of congestion. A bandwidth-remaining ratio is used to influence how the router allocates excess bandwidth (unused by priority traffic) to a class of non-priority traffic.

Dynamically Changing VC Weight and Watermark Values
Documentation Reference: Chapter 17, “Configuring Dynamic Subscriber Services”
Cisco IOS Release: Release 12.3(7)XI7
Description: The DBS Extensions—VC Weight and Watermarks feature was introduced on the PRE2 to enable you to modify existing VC weight and watermark values without tearing down and recreating the VC.
Cisco IOS Release: Release 12.2(28)SB
Description: This feature was integrated in Cisco IOS Release 12.2(28)SB.
Hierarchical Queuing Framework

Documentation Reference: Chapter 22, “Hierarchical Scheduling and Queuing”
- Hierarchical Queuing Framework Feature, page 1-27
- MQC Hierarchical Queuing with 3 Level Scheduler, page 1-27

Hierarchical Queuing Framework Feature

Cisco IOS Release: Release 12.2(31)SB2

Description: The Hierarchical Queuing Framework (HQF) feature was introduced on the PRE3 to define a QoS architecture for implementing hierarchical packet scheduling and queuing. The HQF enables service providers to manage their QoS at three layers of hierarchy: physical, logical, and class.

MQC Hierarchical Queuing with 3 Level Scheduler

Cisco IOS Release: Release 12.2(31)SB2

Description: The MQC Hierarchical Queuing with 3 Level Scheduler feature provides a flexible packet scheduling and queuing system in which you can specify how excess bandwidth is to be allocated among the subscriber queues and logical interfaces. Rather than allocating an implicit minimum bandwidth guarantee to each queue, the three-level scheduler uses the bandwidth-remaining ratio parameter to allocate unused bandwidth to each logical queue.

Hierarchical Policies

Documentation Reference: Chapter 13, “Defining QoS for Multiple Policy Levels”
- Nested Hierarchical Policies, page 1-27
- Three-Level Hierarchical Policies, page 1-28
- Hierarchical Input Policing, page 1-28

Nested Hierarchical Policies

Cisco IOS Release: Release 12.0(22)S

Description: The nested hierarchical policies feature was introduced on the PRE1. This feature defines a minimum bandwidth for the multiple classes and a combined maximum bandwidth for the classes. This feature supports two-level hierarchical policies.

Cisco IOS Release: Release 12.2(16)BX

Description: This feature was introduced on the PRE2.

Cisco IOS Release: Release 12.2(28)SB

Description: This feature was integrated in Cisco IOS Release 12.2(28)SB.
Three-Level Hierarchical Policies

Cisco IOS Release: Release 12.0(25)SX
Description: The nested hierarchical policies feature was enhanced on the PRE1 to support three-level hierarchical policies.

Cisco IOS Release: Release 12.3(7)XI
Description: The nested hierarchical policies feature was enhanced on the PRE2 to support three-level hierarchical policies.

Cisco IOS Release: Release 12.2(28)SB
Description: This feature was integrated in Cisco IOS Release 12.2(28)SB.

Hierarchical Input Policing

Cisco IOS Release: Release 12.2(28)SB
Description: The hierarchical input policing feature was introduced on the PRE2 to define up to two levels of hierarchy for inbound traffic only.

Cisco IOS Release: Release 12.2(31)SB2
Description: This feature was introduced on the PRE3.
IP Quality of Service for Subscribers

Documentation Reference: Chapter 18, “Regulating and Shaping Subscriber Traffic”

- MQC Support for IP Sessions, page 1-29
- Per-Session Shaping for ATM Interfaces, page 1-29
- Per Session Rate Limiting, page 1-29
- Per User Multiservice Rate Limiting, page 1-29
- Per Session Service Policy Using RADIUS, page 1-30
- Per Session Shaping and Queuing on LNS, page 1-30
- PPP Session Queuing on ATM VCs, page 1-30

MQC Support for IP Sessions

Cisco IOS Release: Release 12.2(33)SB

Description: The Modular QoS CLI (MQC) Support for IP Sessions feature was introduced on the PRE2, PRE3, and PRE4 to support per-user QoS on IP sessions. Using this feature, you can configure queuing and non-queuing features on IP sessions, either locally on the router or remotely using an authentication, authorization, and accounting (AAA) server such as RADIUS.

Per-Session Shaping for ATM Interfaces

Cisco IOS Release: Release 12.2(33)SB

Description: The Per-Session Shaping for ATM Interfaces feature enables the router to shape session traffic on L2TP network server (LNS) outbound ATM interfaces. Using this feature, you can apply a hierarchical QoS policy to an ATM interface and manage the traffic belonging to a session.

Per Session Rate Limiting

Cisco IOS Release: Release 12.2(16)BX

Description: The per session rate limiting feature was introduced on the PRE2 to control the maximum rate of traffic sent or received on an interface for a session.

Cisco IOS Release: Release 12.2(28)SB

Description: This feature was integrated in Cisco IOS Release 12.2(28)SB.

Per User Multiservice Rate Limiting

Cisco IOS Release: Release 12.2(16)BX

Description: The per user multiservice rate limiting feature was introduced on the PRE2 to control the maximum rate of traffic for each user behind a multiservice subscriber.

Cisco IOS Release: Release 12.2(28)SB

Description: This feature was integrated in Cisco IOS Release 12.2(28)SB.
Per Session Service Policy Using RADIUS

Cisco IOS Release: Release 12.2(16)BX
Description: The per session service policy using RADIUS feature was introduced on the PRE2 to enable a subscriber management server (SMS), typically a RADIUS server, to dynamically change the traffic policing parameters for a user session.

Cisco IOS Release: Release 12.2(28)SB
Description: This feature was integrated in Cisco IOS Release 12.2(28)SB.

Per Session Shaping and Queuing on LNS

Cisco IOS Release: Release 12.2(31)SB6
Description: The Per Session Shaping and Queuing on LNS feature was introduced on the PRE3 to shape or queue traffic from an ISP to a subscriber as it traverses over an LNS.

PPP Session Queuing on ATM VCs

Cisco IOS Release: Release 12.2(31)SB6
Description: The PPP Session Queuing on ATM VCs feature was introduced on the PRE3 to enable you to shape and queue PPP over ATM (PPPoA) and PPP over Ethernet over ATM (PPPoEoA) sessions to a user specified rate.

Layer 2 Access Concentrator

- Classification, Policing, and Marking on the LAC, page 1-30
- LAC QoS, page 1-30

Classification, Policing, and Marking on the LAC

Cisco IOS Release: Release 12.2(31)SB2
Description: The classification, policing, and marking on the LAC feature was introduced on the PRE2 and PRE3 to allow you to configure class maps and policy maps with policers on the LAC.

LAC QoS

Cisco IOS Release: Release 12.2(31)SB3
Description: The show pxf cpu queue atm command displays dropped and dequeued packets for classes associated with sessions that inherit queues from VCs.

Cisco IOS Release: Release 12.3(7)XI3
Description: The LAC QoS feature was introduced on the PRE2 to allow you to attach QoS service policies to ATM VCs on the on the Layer 2 Access Concentrator (LAC).
Link Fragmentation and Interleaving

Documentation Reference: Chapter 16, “Fragmenting and Interleaving Real-Time and Nonreal-Time Packets”
- interface multilink Command, page 1-31
- multilink group Command, page 1-31
- ppp multilink Command, page 1-32
- ppp multilink fragment-delay Command, page 1-32
- ppp multilink fragmentation Command, page 1-33
- ppp multilink fragment disable Command, page 1-33
- ppp multilink group Command, page 1-33
- ppp multilink interleave Command, page 1-34
- MLP Over ATM-Based LFI Feature, page 1-34
- Multi-VC MLP Over ATM-Based LFI Feature, page 1-34
- MLP Over Frame Relay-Based LFI Feature, page 1-35
- Multi-VC MLP Over ATM-Based LFI Feature, page 1-34
- FRF.12 Fragmentation Feature, page 1-35

interface multilink Command

Cisco IOS Release: Release 12.0
Description: The interface multilink command was introduced on the PRE1 to create and configure a MLP bundle.

Cisco IOS Release: Release 12.2(16)BX
Description: This command was introduced on the PRE2 and provides a multilink interface range of 1 to 9999.

Cisco IOS Release: Release 12.2(28)SB
Description: This command was integrated in Cisco IOS Release 12.2(28)SB.

Cisco IOS Release: Release 12.2(31)SB2
Description: This command was introduced on the PRE3 and the valid interface values for MLP over serial and multi-VC MLP over ATM changed from 1 to 9999 (Release 12.2(28)SB) to from 1 to 9999 and 65,536 to 2,147,483,647.

multilink group Command

Cisco IOS Release: Release 12.0(23)SX
Description: The multilink group command was introduced on the PRE1 to assign a physical link to a multilink group.
Cisco IOS Release: Release 12.2

Description: This command was changed to **ppp multilink group** on the PRE2 to restrict a physical link to joining only a designated multilink group interface. The multilink-group command is accepted by the command line interpreter through Cisco IOS Release 12.2.

Cisco IOS Release: Release 12.2(28)SB

Description: This command was integrated in Cisco IOS Release 12.2(28)SB.

Cisco IOS Release: Release 12.2(31)SB2

Description: This command was introduced on the PRE3.

### ppp multilink Command

Cisco IOS Release: Release 12.0(23)SX

Description: The **ppp multilink** command was introduced on the PRE1 to enable Multilink PPP (MLP) on an interface.

Cisco IOS Release: Release 12.2(16)BX

Description: This command was introduced on the PRE2.

Cisco IOS Release: Release 12.2(28)SB

Description: This command was integrated in Cisco IOS Release 12.2(28)SB.

Cisco IOS Release: Release 12.2(31)SB2

Description: This command was introduced on the PRE3.

### ppp multilink fragment-delay Command

Cisco IOS Release: Release 12.0(23)SX

Description: The **ppp multilink fragment-delay** command was introduced on the PRE1 to specify the maximum amount of time, in milliseconds, that is required to transmit a fragment.

Cisco IOS Release: Release 12.2(16)BX

Description: This command was introduced on the PRE2.

Cisco IOS Release: Release 12.2(28)SB

Description: This command was integrated in Cisco IOS Release 12.2(28)SB.

Cisco IOS Release: Release 12.2(31)SB2

Description: This command was introduced on the PRE3.
ppp multilink fragmentation Command

**Cisco IOS Release:** Release 12.0(23)SX

**Description:** The `ppp multilink fragmentation` command was introduced on the PRE1 to enable fragmentation.

**Cisco IOS Release:** Release 12.2(16)BX

**Description:** This command was introduced on the PRE2.

**Cisco IOS Release:** Release 12.2

**Description:** The `no ppp multilink fragmentation` command was changed to `ppp multilink fragment disable`. The `no ppp multilink fragmentation` command was recognized and accepted through Cisco IOS Release 12.2.

**Cisco IOS Release:** Release 12.2(28)SB

**Description:** This command was integrated in Cisco IOS Release 12.2(28)SB.

**Cisco IOS Release:** Release 12.2(31)SB2

**Description:** This command was introduced on the PRE3.

ppp multilink fragment disable Command

**Cisco IOS Release:** Release 11.3

**Description:** The `ppp multilink fragment disable` command was introduced on the PRE1 as `ppp multilink fragmentation`.

**Cisco IOS Release:** Release 12.2

**Description:** The `no ppp multilink fragmentation` command was changed to `ppp multilink fragment disable` to disable fragmentation. The `no ppp multilink fragmentation` command was recognized and accepted through Cisco IOS Release 12.2.

**Cisco IOS Release:** Release 12.2(28)SB

**Description:** This command was integrated in Cisco IOS Release 12.2(28)SB.

**Cisco IOS Release:** Release 12.2(31)SB2

**Description:** This command was introduced on the PRE3.

ppp multilink group Command

**Cisco IOS Release:** Release 12.0

**Description:** The `ppp multilink group` command was introduced on the PRE1 as `multilink-group`. 
Cisco IOS Release: Release 12.2
Description: The `multilink-group` command was changed to `ppp multilink group` to restrict a physical link to joining only a designated multilink group interface. The `multilink-group` command was accepted by the command line interpreter through Cisco IOS Release 12.2.

Cisco IOS Release: Release 12.2(28)SB
Description: This command was integrated in Cisco IOS Release 12.2(28)SB.

Cisco IOS Release: Release 12.2(31)SB2
Description: This command was introduced on the PRE3.

### ppp multilink interleave Command

Cisco IOS Release: Release 12.0(23)SX
Description: The `ppp multilink interleave` command was introduced on the PRE1 to enable interleaving of real-time packets among the fragments of larger nonreal-time packets.

Cisco IOS Release: Release 12.2(16)BX
Description: This command was introduced on the PRE2.

Cisco IOS Release: Release 12.2(28)SB
Description: This command was integrated in Cisco IOS Release 12.2(28)SB.

Cisco IOS Release: Release 12.2(31)SB2
Description: This command was introduced on the PRE3.

### MLP Over ATM-Based LFI Feature

Cisco IOS Release: Release 12.2(28)SB
Description: The Multilink PPP (MLP) over ATM feature was introduced on the PRE2 to allow you to fragment and interleave real-time and nonreal-time packets on ATM VCs.

Cisco IOS Release: Release 12.2(31)SB2
Description: This feature was introduced on the PRE3.

### Multi-VC MLP Over ATM-Based LFI Feature

Cisco IOS Release: Release 12.2(28)SB
Description: The Multi-VC MLP over ATM-based LFI feature was introduced on the PRE2 to allow you to fragment and interleave real-time and nonreal-time packets on multiple ATM VCs.

Cisco IOS Release: Release 12.2(31)SB2
Description: This feature was introduced on the PRE3 and the valid interface values changed from 1 to 9999 (Release 12.2(28)SB and later) to from 1 to 9999 and 65,536 to 2,147,483,647 (Release 12.2(31)SB2 and later).
MLP Over Frame Relay-Based LFI Feature

Cisco IOS Release: Release 12.2(28)SB

Description: The MLP over Frame Relay-based LFI feature was introduced on the PRE2 to allow you to fragment and interleave real-time and nonreal-time packets on Frame Relay interfaces and DLCIs.

Cisco IOS Release: Release 12.2(31)SB2

Description: This feature was introduced on the PRE3.

MLP Over Serial-Based LFI Feature

Cisco IOS Release: Release 12.0(23)SX

Description: The MLP over serial-based LFI feature was introduced on the PRE1 to allow you to fragment and interleave real-time and nonreal-time packets on serial links.

Cisco IOS Release: Release 12.2

Description: This feature was introduced on the PRE2.

Cisco IOS Release: Release 12.2(28)SB

Description: This feature was integrated in Cisco IOS Release 12.2(28)SB.

Cisco IOS Release: Release 12.2(31)SB2

Description: This feature was introduced on the PRE3 and the valid interface values changed from 1 to 9999 (Release 12.2(28)SB and later) to from 1 to 9999 and 65,536 to 2,147,483,647 (Release 12.2(31)SB2 and later).

FRF.12 Fragmentation Feature

Cisco IOS Release: Release 12.0(23)SX

Description: The PVC-based FRF.12 Fragmentation feature was introduced on the PRE1.

Cisco IOS Release: Release 12.0(27)S

Description: This feature was enhanced to allow interface-based FRF.12 fragmentation.

Cisco IOS Release: Release 12.2

Description: This feature was introduced on the PRE2 to allow PVC-based and interface-based FRF.12 fragmentation.

Cisco IOS Release: Release 12.2(28)SB

Description: This feature was integrated in Cisco IOS Release 12.2(28)SB.

Cisco IOS Release: Release 12.2(31)SB2

Description: This feature was introduced on the PRE3.
Marking Traffic

Documentation Reference: Chapter 7, “Marking Traffic”

- set atm-clp Command, page 1-36
- set cos Command, page 1-36
- set discard-class Command, page 1-36
- set fr-de Command, page 1-37
- set ip dscp Command, page 1-37
- set ip precedence Command, page 1-37
- set mpls experimental Command, page 1-37
- set mpls experimental imposition Command, page 1-38
- set qos-group Command, page 1-38
- Marking Feature, page 1-38

set atm-clp Command

Cisco IOS Release: Release 12.0(17)SL
Description: The `set atm-clp` command was introduced on the PRE2 to set the cell loss priority (CLP) bit to 1.

Cisco IOS Release: Release 12.2(28)SB
Description: This command was integrated in Cisco IOS Release 12.2(28)SB for the PRE2.

Cisco IOS Release: Release 12.2(33)SB
Description: This command was introduced on the PRE3 and PRE4.

set cos Command

Cisco IOS Release: Release 12.2(16)BX
Description: The `set cos` command was introduced on the PRE2 to set the Layer 2 class of service (CoS) value of an outgoing packet. This command is available only on the PRE2.

Cisco IOS Release: Release 12.2(28)SB
Description: This command was integrated in Cisco IOS Release 12.2(28)SB.

set discard-class Command

Cisco IOS Release: Release 12.3(7)XI
Description: The `set discard-class` command was introduced on the PRE2 to mark a packet with a discard-class value or to drop a specific traffic type during congestion. This command is available only on the PRE2.
Cisco IOS Release: Release 12.2(28)SB
Description: This command was integrated in Cisco IOS Release 12.2(28)SB.

set fr-de Command

Cisco IOS Release: Release 12.2(31)SB2
Description: The set fr-de command was introduced on the PRE2 and PRE3 to mark a Frame Relay packet’s discard eligibility (DE) bit.

Cisco IOS Release: Release 12.2(33)SB
Description: This command was introduced on the PRE4.

set ip dscp Command

Cisco IOS Release: Release 12.0(17)SL
Description: The set ip dscp command was introduced on the PRE1 to mark a packet by setting the differentiated services code point (DSCP) value in the type of service (ToS) byte.

Cisco IOS Release: Release 12.2(28)SB
Description: This command was integrated in Cisco IOS Release 12.2(28)SB.

Cisco IOS Release: Release 12.2(31)SB2
Description: This command was introduced on the PRE3 to allow you to mark the IP DSCP bits of traffic on the L2TP access concentrator (LAC).

set ip precedence Command

Cisco IOS Release: Release 12.0(17)SL
Description: The set ip precedence command was introduced on the PRE1 to set the precedence value in a packet header.

Cisco IOS Release: Release 12.2(28)SB
Description: This command was integrated in Cisco IOS Release 12.2(28)SB.

set mpls experimental Command

Cisco IOS Release: Release 12.0(22)S
Description: The set mpls experimental command was introduced on the PRE1 to set the value of the Multiprotocol Label Switching (MPLS) experimental (EXP) field. This command is available only on the PRE1.

Cisco IOS Release: Release 12.2(28)SB
Description: This command was integrated in Cisco IOS Release 12.2(28)SB.
set mpls experimental imposition Command

Cisco IOS Release: Release 12.3(7)XI
Description: The set mpls experimental imposition command was introduced on the PRE2 to set the value of the Multiprotocol Label Switching (MPLS) experimental (EXP) field on all imposed label entries. This command is available only on the PRE2.

Cisco IOS Release: Release 12.2(28)SB
Description: This command was integrated in Cisco IOS Release 12.2(28)SB.

set qos-group Command

Cisco IOS Release: Release 12.0(17)SL
Description: The set qos-group command was introduced on the PRE1 to set a quality of service (QoS) group identifier (ID) that can be used later to classify packets.

Cisco IOS Release: Release 12.2(28)SB
Description: This command was integrated in Cisco IOS Release 12.2(28)SB.

Marking Feature

Cisco IOS Release: Release 12.0(17)SL
Description: The marking feature was introduced on the PRE1 to enable you to differentiate packets based on designated markings. Other devices can examine the marked bits and classify traffic based on the marked values.

Cisco IOS Release: Release 12.0(22)S
Description: This feature was enhanced to support MPLS experimental (EXP) marking.

Cisco IOS Release: Release 12.2(16)BX
Description: This feature was introduced on the PRE2 and was enhanced to support 802.1Q class of service (CoS) marking. This enhancement is available only on the PRE2.

Cisco IOS Release: Release 12.3(7)XI
Description: This feature was enhanced on the PRE2 to support MPLS experimental (EXP) and discard-class marking. The discard-class enhancement is available only on the PRE2.

Cisco IOS Release: Release 12.2(28)SB
Description: This feature was integrated in Cisco IOS Release 12.2(28)SB for the PRE2.

Cisco IOS Release: Release 12.2(31)SB2
Description: This feature was introduced on the PRE3 to allow you to mark the IP DSCP bits of traffic on the L2TP access concentrator (LAC). Frame Relay DE bit marking and tunnel header marking were also introduced on the PRE3.
Cisco IOS Release: Release 12.2(33)SB
Description: This feature was introduced on the PRE4 and enhanced to allow Frame Relay DE bit marking.

Modular QoS Command Line Interface

Documentation Reference: Chapter 1, “Quality of Service Overview”
- MQC Feature, page 1-39
- QoS CLI Migration from PRE2 to PRE3, page 1-39

MQC Feature

Cisco IOS Release: Release 12.0(17)SL
Description: The MQC feature was introduced on the PRE1 to enable you to configure QoS services on the Cisco 10000 series router.

Cisco IOS Release: Release 12.2(15)BX
Description: This feature was introduced on the PRE2.

Cisco IOS Release: Release 12.2(28)SB
Description: This feature was integrated in Cisco IOS Release 12.2(28)SB for the PRE2.

Cisco IOS Release: Release 12.2(31)SB2
Description: This feature was introduced on the PRE3. Enhancements to the MQC allow you to classify packets on the L2TP access concentrator (LAC) based upon the IP type of service (ToS) bits in an embedded IP packet. When a policer is configured, the router uses packet classification to police ingress traffic according to the DSCP value.

QoS CLI Migration from PRE2 to PRE3

Cisco IOS Release: Release 12.2(31)SB2
Description: The QoS CLI Migration from PRE2 to PRE3 feature was introduced on the PRE3 to provide a migration path from PRE2 CLI commands to PRE3 CLI commands.

Overhead Accounting

Documentation Reference: Chapter 10, “Overhead Accounting”
- bandwidth Command, page 1-25
- shape Command, page 1-56
- ATM Overhead Accounting, page 1-40
- Ethernet Overhead Accounting, page 1-40
- Traffic Shaping Overhead Accounting for ATM, page 1-40
ATM Overhead Accounting

Cisco IOS Release: Release 12.2(28)SB
Description: The ATM Overhead Accounting feature was introduced on the PRE2 to enable the router to account for various encapsulation types when applying QoS to packets. The router uses the encapsulation type you configure to calculate the ATM overhead per packet.

Cisco IOS Release: Release 12.2(33)SB
Description: This feature was enhanced on the PRE3 to allow a user-defined number of overhead bytes.

Ethernet Overhead Accounting

Cisco IOS Release: Release 12.2(33)SB
Description: The Ethernet Overhead Accounting feature was introduced on the PRE2, PRE3, and PRE4 to enable the router to account for downstream Ethernet frame headers when applying shaping to packets. A user-defined offset specifies the number of overhead bytes the router is to use when calculating the overhead per packet.

Traffic Shaping Overhead Accounting for ATM

Cisco IOS Release: Release 12.2(28)SB
Description: The Traffic Shaping Overhead Accounting for ATM feature was introduced on the PRE2 to enable the broadband access system (BRAS) to account for ATM encapsulation on the subscriber line and the overhead added by cell segmentation. This enables the service provider to prevent overruns at the subscriber line and ensures that the router executes QoS features on the actual bandwidth used by ATM subscriber traffic.

Cisco IOS Release: Release 12.2(31)SB2
Description: This feature was introduced on the PRE3.

Cisco IOS Release: Release 12.2(33)SB
Description: This feature was introduced on the PRE4.
Oversubscribing Physical and Virtual Links

Documentation Reference: Chapter 15, “Oversubscribing Physical and Virtual Links”
- atm over-subscription-factor Command, page 1-41
- Interface Oversubscription Feature, page 1-41
- ATM Virtual Circuit Oversubscription Feature, page 1-42
- map-class frame-relay Command, page 1-42
- Frame Relay PVC Oversubscription Feature, page 1-42
- Virtual LAN Oversubscription Feature, page 1-43
- queue-depth Command, page 1-43
- weight Command, page 1-43
- Weighting Feature, page 1-44

atm over-subscription-factor Command

Cisco IOS Release: Release 12.2(16)BX
Description: The atm over-subscription-factor command was introduced on the PRE2 to enable you to oversubscribe ATM virtual circuits (VCs). The allowable oversubscription amount is 1 to 50 times the physical transmission capacity.

Cisco IOS Release: Release 12.3(7)XI3
Description: The amount of oversubscription you can configure was increased to 500. For example, you can oversubscribe the physical transmission capacity from 1 to 500 times.

Cisco IOS Release: Release 12.2(28)SB
Description: This command was integrated in Cisco IOS Release 12.2(28)SB.

Cisco IOS Release: Release 12.2(31)SB2
Description: This command was introduced on the PRE3 to allow the aggregate VLAN rates to exceed the available bandwidth. The oversubscription factor is from 1 to 500.

Interface Oversubscription Feature

Cisco IOS Release: Release 12.0(25)SX
Description: The interface oversubscription feature was introduced on the PRE1 to enable you to assign a total committed information rate (CIR) to a given port that is greater than the speed of the port.

Cisco IOS Release: Release 12.3(7)XI
Description: This feature was introduced on the PRE2 to enable you to assign a total committed information rate (CIR) to a given port that is greater than the speed of the port.

Cisco IOS Release: Release 12.2(28)SB
Description: This feature was integrated in Cisco IOS Release 12.2(28)SB.
Cisco IOS Release: Release 12.2(31)SB2
Description: This command was introduced on the PRE3 with an oversubscription factor from 1 to 500.

ATM Virtual Circuit Oversubscription Feature

Cisco IOS Release: Release 12.2(16)BX
Description: The ATM virtual circuit (VC) oversubscription feature was introduced on the PRE2 to enable you to assign a rate to a variable bit rate-nonreal time (VBR-nrt) VC, a constant bit rate (CBR) VC, or a virtual path (VP) tunnel that is greater than the speed of the interface. The amount of allowable oversubscription is 1 to 50 times the physical transmission capacity.

Cisco IOS Release: Release 12.3(7)XI3
Description: The amount of allowable ATM VC oversubscription was increased to 500 on the PRE2. For example, you can oversubscribe the physical transmission capacity from 1 to 500 times.

Cisco IOS Release: Release 12.2(28)SB
Description: This feature was integrated in Cisco IOS Release 12.2(28)SB.

Cisco IOS Release: Release 12.2(31)SB2
Description: This command was introduced on the PRE3 with an oversubscription factor from 1 to 500.

map-class frame-relay Command


Cisco IOS Release: Release 12.0(23)SX
Description: The map-class frame-relay command was introduced on the PRE1.

Cisco IOS Release: Release 12.0(25)S
Description: This command was ported to the S train.

Cisco IOS Release: Release 12.2(15)BX
Description: This command was introduced on the PRE2.

Cisco IOS Release: Release 12.2(28)SB
Description: This command was integrated in Cisco IOS Release 12.2(28)SB.

Frame Relay PVC Oversubscription Feature

Cisco IOS Release: Release 12.3(7)XI1
Description: The Frame Relay PVC oversubscription feature was introduced on the PRE2 to enable you to assign a total committed information rate (CIR) to a given PVC that is greater than the speed of the interface.
Virtual LAN Oversubscription Feature

Cisco IOS Release: Release 12.3(7)XI1
Description: The virtual LAN (VLAN) oversubscription feature was introduced on the PRE2 to enable you to assign a total committed information rate (CIR) to a given VLAN that is greater than the speed of the interface.

Cisco IOS Release: Release 12.2(28)SB
Description: This feature was integrated in Cisco IOS Release 12.2(28)SB.

Cisco IOS Release: Release 12.2(31)SB2
Description: This command was introduced on the PRE3 to allow the aggregate VLAN rates to exceed the available bandwidth. The oversubscription factor is a value from 1 to 500.

queue-depth Command

Cisco IOS Release: Release 12.3(7)XI1
Description: The queue-depth command was introduced on the PRE2 to allow you to configure the segmentation and reassembly (SAR) line card queue depth for each VC interface queue.

Cisco IOS Release: Release 12.2(28)SB
Description: This command was integrated in Cisco IOS Release 12.2(28)SB.

Cisco IOS Release: Release 12.2(31)SB2
Description: This command was introduced on the PRE3.

weight Command

Cisco IOS Release: Release 12.3(7)XI1
Description: The weight command was introduced on the PRE2 to allow you to control virtual circuit (VC) bandwidth when the virtual path (VP) is congested.

Cisco IOS Release: Release 12.2(28)SB
Description: This command was integrated in Cisco IOS Release 12.2(28)SB.

Cisco IOS Release: Release 12.2(31)SB2
Description: This command was introduced on the PRE3.
Weighting Feature

Cisco IOS Release: Release 12.3(7)XI1
Description: The VC weighting feature was introduced on the PRE2 to control the number of cells for each VC that is sent into the virtual path (VP).

Cisco IOS Release: Release 12.2(28)SB
Description: This feature was integrated in Cisco IOS Release 12.2(28)SB.

Cisco IOS Release: Release 12.2(31)SB2
Description: This feature was introduced on the PRE3.

Policing Traffic

Documentation Reference: Chapter 6, “Policing Traffic”
- police Command (Single-Rate), page 1-44
- police percent Command, page 1-45
- police Command (Two-Rate), page 1-45
- show atm vp Command, page 1-46
- Percent-Based Policing Feature, page 1-46
- Policing Feature, page 1-46
- Single-Rate Color Marker Feature, page 1-47
- Two-Rate Three-Color Marker Feature, page 1-47
- ATM VP Average Traffic Rate, page 1-48

police Command (Single-Rate)

Cisco IOS Release: Release 12.0(17)SL
Description: The police command was introduced on the PRE1 to allow you to control the maximum rate of traffic sent or received on an interface. This command included a single-rate two-color policer, which allows you to classify traffic into two groups: traffic that conforms to the specified committed information rate (CIR) and burst sizes, and traffic that exceeds either the CIR or the burst sizes.

Cisco IOS Release: Release 12.0(22)S
Description: This command was enhanced to include the set-mpls-exp-transmit policing action. This action is available only on the PRE1.

Cisco IOS Release: Release 12.0(25)S
Description: This command was enhanced to include a three-color marker. A new violate-action parameter allows you to specify the action to take for traffic that consistently violates the committed rate.

Cisco IOS Release: Release 12.2(16)BX
Description: This command was introduced on the PRE2 and included a single-rate two-color marker.
Cisco IOS Release: Release 12.3(7)XI
Description: This command was enhanced on the PRE2 to include a three-color marker and the `set-mpls-exp-imposition-transmit` policing action. This action is available only on the PRE2.

Cisco IOS Release: Release 12.2(28)SB
Description: This command was integrated in Cisco IOS Release 12.2(28)SB.

Cisco IOS Release: Release 12.2(31)SB2
Description: This command was introduced on the PRE3 to allow you to police traffic on the L2TP access concentrator (LAC) based on the value of a packet’s IP DSCP bits.

Cisco IOS Release: Release 12.2(33)SB
Description: This command was enhanced to include the following police actions:
- `set-cos-transmit` to set the class of service (CoS) bit value
- `set-atm-clp-transmit` to set the ATM cell loss priority (CLP) bit value.
- `set-frde-transmit` to set the Frame Relay discard eligibility (DE) bit value.

**police percent Command**

Cisco IOS Release: Release 12.0(25)SX
Description: The `police percent` command was introduced on the PRE1 to allow you to configure traffic policing as a percentage of the interface bandwidth on which policing is applied. Configuring traffic policing based on bandwidth percentage enables you to use the same policy map for multiple interfaces with differing amounts of bandwidth.

Cisco IOS Release: Release 12.3(7)XI
Description: This command was introduced on the PRE2.

Cisco IOS Release: Release 12.2(28)SB
Description: This command was enhanced on the PRE2 to allow you to configure two traffic policing rates as a percentage: the committed information rate (CIR) and the peak information rate (PIR).

Cisco IOS Release: Release 12.2(31)SB2
Description: This command was introduced on the PRE3 to allow you to police traffic on the L2TP access concentrator (LAC) based on the value of a packet’s IP DSCP bits.

**police Command (Two-Rate)**

Cisco IOS Release: Release 12.2(28)SB
Description: The single-rate `police` command was enhanced on the PRE2 to allow you to configure two traffic policing rates: the committed information rate (CIR) and the peak information rate (PIR).
Cisco IOS Release: Release 12.2(31)SB2
description: This command was introduced on the PRE3 to allow you to police traffic on the L2TP access concentrator (LAC) based on the value of a packet’s IP DSCP bits.

**show atm vp Command**

Cisco IOS Release: Release 12.2(33)SB
description: The `show atm vp` command was enhanced on the PRE2, PRE3, and PRE4 to provide rate information. Minute counters on the ATM VPs support the `show atm vp` command.

**Percent-Based Policing Feature**

Cisco IOS Release: Release 12.0(25)SX
description: The percent-based policing feature was introduced on the PRE1 to allow you to configure traffic policing as a percentage of the interface bandwidth on which policing is applied. Configuring traffic policing based on bandwidth percentage enables you to use the same policy map for multiple interfaces with differing amounts of bandwidth.

Cisco IOS Release: Release 12.3(7)XI
description: This feature was introduced on the PRE2.

Cisco IOS Release: Release 12.2(28)SB
description: This feature was enhanced on the PRE2 to allow you to configure two traffic policing rates as a percentage: the committed information rate (CIR) and the peak information rate (PIR).

Cisco IOS Release: Release 12.2(31)SB2
description: This command was introduced on the PRE3 to allow you to police traffic on the L2TP access concentrator (LAC) based on the value of a packet’s IP DSCP bits.

**Policing Feature**

Cisco IOS Release: Release 12.0(17)SL
description: The policing feature was introduced on the PRE1 to allow you to control the maximum rate of traffic sent or received on an interface. This feature included a single-rate two-color policer.

Cisco IOS Release: Release 12.0(25)S
description: This feature was enhanced on the PRE1 to include a three-color marker.

Cisco IOS Release: Release 12.2(16)BX
description: This feature was introduced on the PRE2 and included a single-rate two-color policer.

Cisco IOS Release: Release 12.3(7)XI
description: This feature was enhanced on the PRE2 to include a three-color marker.
Cisco IOS Release: Release 12.2(28)SB
Description: This feature was enhanced on the PRE2 to include a two-rate policer.

Cisco IOS Release: Release 12.2(31)SB2
Description: This feature was introduced on the PRE3 to allow you to police traffic on the L2TP access concentrator (LAC) based on the value of a packet’s IP DSCP bits. Control plane policing, policing of GRE tunnels, and tunnel header marking using a police action were also introduced on the PRE3.

### Single-Rate Color Marker Feature

Cisco IOS Release: Release 12.0(17)SL
Description: The single-rate color marker feature was introduced on the PRE1 with two-color marking to allow you to police traffic streams into groups of conforming and non-conforming traffic.

Cisco IOS Release: Release 12.0(25)S
Description: This feature was enhanced on the PRE1 to include a single-rate three-color marker to allow you to police traffic streams into groups of conforming, non-conforming, and violating traffic.

Cisco IOS Release: Release 12.2(16)BX
Description: This feature was introduced on the PRE2 and included a single-rate two-color marker.

Cisco IOS Release: Release 12.3(7)XI
Description: This feature was enhanced on the PRE2 to include a three-color marker.

Cisco IOS Release: Release 12.2(28)SB
Description: This feature was integrated in Cisco IOS Release 12.2(28)SB.

Cisco IOS Release: Release 12.2(31)SB2
Description: This feature was introduced on the PRE3 to allow you to police traffic on the L2TP access concentrator (LAC) based on the value of a packet’s IP DSCP bits.

### Two-Rate Three-Color Marker Feature

Cisco IOS Release: Release 12.2(28)SB
Description: The two-rate three-color marker feature was introduced on the PRE2 to allow you to manage bandwidth by setting the committed information rate (CIR) and the peak information rate. Using this feature you can police traffic streams into groups of conforming, non-conforming, and violating traffic.

Cisco IOS Release: Release 12.2(31)SB2
Description: This feature was introduced on the PRE3 to allow you to police traffic on the L2TP access concentrator (LAC) based on the value of a packet’s IP DSCP bits.
ATM VP Average Traffic Rate

Cisco IOS Release: Release 12.2(33)SB

Description: This feature was introduced on the PRE2, PRE3, and PRE4 to enable you to display the 5-minute traffic rates on virtual path (VP) counters. This feature is a subscriber and VP traffic reporting feature that extends the `show atm vp` command to provide rate information. Minute counters on the ATM VPs support the `show atm vp` command.

Prioritizing Traffic

Documentation Reference: Chapter 8, “Prioritizing Services”

- priority Command, page 1-48
- priority level Command, page 1-49
- Child Service Policy Allowed Under Priority Class, page 1-49
- Multi-Level Priority Queues, page 1-49
- Priority Queuing Feature, page 1-49

priority Command

Cisco IOS Release: Release 12.0(17)SL

Description: The `priority` command was introduced on the PRE1 to give priority to a traffic class in a policy map and to set the bandwidth rate for the queue in kilobits per second.

Cisco IOS Release: Release 12.0(20)ST

Description: This command was enhanced on the PRE1 to include a percent-based bandwidth rate.

Cisco IOS Release: Release 12.0(25)S

Description: This command was modified on the PRE1 to provide strict priority queuing. Strict priority queuing guarantees low-latency for any packet that enters a priority queue, regardless of the current congestion level on the link. To specify a bandwidth rate for a strict priority queue, you must specify the `police` command.

Cisco IOS Release: Release 12.2(16)BX

Description: This command was introduced on the PRE2 to allow you to set the bandwidth rate for a queue in kilobits per second or as a percentage.

Cisco IOS Release: Release 12.3(7)XI

Description: This command was modified to provide strict priority queuing on the PRE2. To specify a bandwidth rate for a strict priority queue, you must specify the `police` command.

Cisco IOS Release: Release 12.2(28)SB

Description: This command was integrated in Cisco IOS Release 12.2(28)SB.
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Cisco IOS Release: Release 12.2(31)SB2
Description: This command was introduced on the PRE3.

priority level Command

Cisco IOS Release: Release 12.2(31)SB2
Description: The priority level command was introduced on the PRE3 to allow you to configure multiple priority queues for multiple traffic classes.

Child Service Policy Allowed Under Priority Class

Cisco IOS Release: Release 12.2(31)SB2
Description: The child service policy allowed under priority class feature was introduced on the PRE3 to allow you to attach a child policy with non-queuing features to a priority class.

Multi-Level Priority Queues

Cisco IOS Release: Release 12.2(31)SB2
Description: The multi-level priority queues (MPQ) feature was introduced on the PRE3 to allows you to configure multiple priority queues for multiple traffic classes by specifying a different priority level for each of the traffic classes in a single service policy map.

Priority Queuing Feature

Cisco IOS Release: Release 12.0(17)SL
Description: The priority queuing feature was introduced on the PRE1 to allow the router to dequeue and transmit delay-sensitive data such as voice before it dequeues and sends packets in other queues. Using priority queuing, delay-sensitive data receives preferential treatment over other traffic. This feature allows you to set a bandwidth rate for a queue in kilobits per second.

Cisco IOS Release: Release 12.0(20)ST
Description: This feature was enhanced on the PRE1 to allow you to set a bandwidth rate for a queue as a percentage.

Cisco IOS Release: Release 12.0(25)S
Description: This feature was modified on the PRE1 to provide strict priority queuing. Strict priority queuing guarantees low-latency for any packet that enters a priority queue, regardless of the current congestion level on the link. To specify a bandwidth rate for a strict priority queue, you must specify the police command.

Cisco IOS Release: Release 12.2(16)BX
Description: This feature was introduced on the PRE2 to allow you to set a bandwidth rate for a queue in kilobits per second or as a percentage.
Cisco IOS Release: Release 12.3(7)XI1
Description: This feature was modified on the PRE2 to provide strict priority queuing. To specify a bandwidth rate for a strict priority queue, you must specify the police command.

Cisco IOS Release: Release 12.2(28)SB
Description: This feature was integrated in Cisco IOS Release 12.2(28)SB.

Cisco IOS Release: Release 12.2(31)SB2
Description: This command was introduced on the PRE3.

PVC Bundles

Documentation Reference: Chapter 19, “Configuring Quality of Service for PVC Bundles”

- bump Command, page 1-50
- bump Command (Frame Relay VC-bundle-member), page 1-51
- bundle Command, page 1-51
- class-bundle Command, page 1-51
- class-vc Command, page 1-51
- dscp Command (Frame Relay VC-bundle-member), page 1-51
- exp Command, page 1-51
- frame-relay vc-bundle Command, page 1-51
- mpls experimental Command, page 1-52
- oam-bundle Command, page 1-52
- precedence Command, page 1-52
- precedence Command (Frame Relay VC-bundle-member), page 1-52
- protect Command, page 1-52
- protect Command (Frame Relay VC-bundle-member), page 1-52
- pvc-bundle Command, page 1-53
- pvc Command (Frame Relay VC-bundle), page 1-53
- PVC Bundles Over ATM and Frame Relay Feature, page 1-53
- ATM PVC Bundle Enhancement—MPLS EXP-Based PVC Selection Feature, page 1-53
- Frame Relay PVC Bundles with QoS Support for IP and MPLS Feature, page 1-53

bump Command

Cisco IOS Release: Release 12.0(26)S
Description: The bump command was introduced on the PRE1 to configure the bumping rules for an ATM PVC bundle or a specific ATM PVC bundle member.
bump Command (Frame Relay VC-bundle-member)

Cisco IOS Release: Release 12.0(26)S
Description: The bump command was introduced on the PRE1 to configure the bumping rules for a Frame Relay permanent virtual circuit (PVC) bundle member.

bundle Command

Cisco IOS Release: Release 12.0(26)S
Description: The bundle command was introduced on the PRE1 to create an ATM bundle or modify an existing ATM bundle.

class-bundle Command

Cisco IOS Release: Release 12.0(26)S
Description: The class-bundle command was introduced on the PRE1 to configure an ATM virtual circuit (VC) bundle with the bundle-level commands contained in the specified VC class.

class-vc Command

Cisco IOS Release: Release 12.0(26)S
Description: The class-vc command was introduced on the PRE1 to assign a virtual circuit (VC) class to an ATM permanent virtual circuit (PVC) or PVC bundle member.

dscp Command (Frame Relay VC-bundle-member)

Cisco IOS Release: Release 12.0(26)S
Description: The dscp command was introduced on the PRE1 to configure the differentiated services code point (DSCP) levels for a Frame Relay permanent virtual circuit (PVC) bundle member.

exp Command

Cisco IOS Release: Release 12.0(26)S
Description: The exp command was introduced on the PRE1 to configure Multiprotocol Label Switching (MPLS) experimental (EXP) levels for a Frame Relay permanent virtual circuit (PVC) bundle member.

frame-relay vc-bundle Command

Cisco IOS Release: Release 12.0(26)S
Description: The frame-relay vc-bundle command was introduced on the PRE1 to create a Frame Relay permanent virtual circuit (PVC) bundle if it does not already exist, and to enter Frame Relay VC-bundle configuration mode.
mpls experimental Command

Cisco IOS Release: Release 12.0(26)S

Description: The mpls experimental command was introduced on the PRE1 to configure MPLS experimental (EXP) levels for a VC class or for a PVC member of a bundle. The VC class is applied to the PVC bundle and thus applied to all PVC members of the bundle.

oam-bundle Command

Cisco IOS Release: Release 12.0(26)S

Description: The oam-bundle command was introduced on the PRE1 to enable end-to-end F5 Operation, Administration, and Maintenance (OAM) loopback cell generation and OAM management for all permanent virtual circuit (PVC) members of a bundle or a VC class that can be applied to a PVC bundle.

precedence Command

Cisco IOS Release: Release 12.0(26)S

Description: The precedence command was introduced on the PRE1 to configure precedence levels for a virtual circuit (VC) class, VC, or permanent virtual circuit (PVC) member of a bundle. The VC class is assigned to a PVC bundle and thus applied to all PVC members of that bundle.

precedence Command (Frame Relay VC-bundle-member)

Cisco IOS Release: Release 12.0(26)S

Description: The precedence command was introduced on the PRE1 to configure the precedence levels for a Frame Relay permanent virtual circuit (PVC) bundle member.

protect Command

Cisco IOS Release: Release 12.0(26)S

Description: The protect command was introduced on the PRE1 to configure a virtual circuit (VC) class with protected group or protected VC status for application to a PVC bundle member and to configure a specific VC or permanent virtual circuit (PVC) as part of a protected group of the bundle or to configure it as an individually protected VC or PVC bundle member.

protect Command (Frame Relay VC-bundle-member)

Cisco IOS Release: Release 12.0(26)S

Description: The protect command was introduced on the PRE1 to configure a Frame Relay protected permanent virtual circuit (PVC) bundle member with protected group or protected PVC status.
pvc-bundle Command

Cisco IOS Release: Release 12.0(26)S

Description: The pvc-bundle command was introduced on the PRE1 to add a permanent virtual circuit (PVC) to a bundle as a member of the bundle and enter bundle-vc configuration mode in order to configure that PVC bundle member.

pvc Command (Frame Relay VC-bundle)

Cisco IOS Release: Release 12.0(26)S

Description: The pvc command was introduced on the PRE1 to create a permanent virtual circuit (PVC) that is a Frame Relay PVC bundle member, and to enter Frame Relay VC-bundle-member configuration mode.

PVC Bundles Over ATM and Frame Relay Feature

Cisco IOS Release: Release 12.0(26)S

Description: The PVC bundles over ATM and Frame Relay feature was introduced on the PRE1 to combine PVCs into one logical interface. This feature provides IP precedence and DSCP-based PVC selection.

ATM PVC Bundle Enhancement—MPLS EXP-Based PVC Selection Feature

Cisco IOS Release: Release 12.0(26)S

Description: The ATM PVC Bundle Enhancement—MPLS EXP-Based PVC Selection feature was introduced on the PRE1 to provide ATM PVC selection based on the MPLS EXP level of a packet.

Frame Relay PVC Bundles with QoS Support for IP and MPLS Feature

Cisco IOS Release: Release 12.0(26)S

Description: The Frame Relay PVC Bundles with QoS Support for IP and MPLS feature was introduced on the PRE1 to provide Frame Relay PVC selection based on the precedence, DSCP, or MPLS EXP level of a packet.

QoS Policy Maps


- policy-map Command, page 1-54
- qos match statistics Command, page 1-54
- Policy Maps Feature, page 1-54
- Policy Map Scaling Phase 2, page 1-54
policy-map Command

Cisco IOS Release: Release 12.0(17)SL
Description: This command was introduced on the PRE1 to configure a QoS policy map.

Cisco IOS Release: Release 12.2(16)BX
Description: This command was introduced on the PRE2.

Cisco IOS Release: Release 12.2(28)SB
Description: This command was integrated in Cisco IOS Release 12.2(28)SB for the PRE2.

Cisco IOS Release: Release 12.2(31)SB2
Description: This command was introduced on the PRE3.

Cisco IOS Release: Release 12.2(33)SB
Description: This command was introduced on the PRE4.

qos match statistics Command

Cisco IOS Release: Release 12.2(31)SB2
Description: This command was introduced on the PRE3 to configure the router to count QoS matches for each class or for each match statement and class. Per-class counts provide for greater QoS scalability.

Policy Maps Feature

Cisco IOS Release: Release 12.0(17)SL
Description: The QoS policy map feature was introduced on the PRE1 to configure a QoS service policy.

Cisco IOS Release: Release 12.2(16)BX
Description: This feature was introduced on the PRE2.

Cisco IOS Release: Release 12.2(28)SB
Description: This feature was integrated in Cisco IOS Release 12.2(28)SB for the PRE2.

Cisco IOS Release: Release 12.2(31)SB2
Description: This feature was introduced on the PRE3.

Policy Map Scaling Phase 2

Cisco IOS Release: Release 12.2(33)SB
Description: This feature was introduced on the PRE2, PRE3, and PRE4 to allow up to 8192 policy maps per system.
Qos Policy Propagation through the Border Gateway Protocol

**Documentation Reference:** Appendix B, “QoS Policy Propagation Through the Border Gateway Protocol”

**Cisco IOS Release:** Release 12.0(9)SL

**Description:** The QoS policy propagation through the Border Gateway Protocol (QPPB) feature was introduced on the PRE1 to enable packet classification based on a Border Gateway Protocol (BGP) prefix, BGP community list, and BGP autonomous system (AS) paths.

**Cisco IOS Release:** Release 12.2(16)BX

**Description:** This feature was introduced on the PRE2.

**Cisco IOS Release:** Release 12.2(28)SB

**Description:** This feature was integrated in Cisco IOS Release 12.2(28)SB.

Shaping PPPoE Over VLAN Sessions Using RADIUS

**Documentation Reference:** Chapter 17, “Configuring Dynamic Subscriber Services”

- Per Session Queuing and Shaping for PPPoE Over VLAN Support Using RADIUS Feature, page 1-55

Per Session Queuing and Shaping for PPPoE Over VLAN Support Using RADIUS Feature

**Cisco IOS Release:** Release 12.3(7)XI7

**Description:** The Per Session Queuing and Shaping for PPPoE over VLAN Support Using RADIUS feature was introduced on the PRE2 to enable dynamic queuing and shaping policies on PPPoEoVLAN sessions.

**Cisco IOS Release:** Release 12.2(31)SB5

**Description:** This feature was integrated in Cisco IOS Release 12.2(31)SB5 for the PRE2.

Shaping Traffic

**Documentation Reference:** Chapter 9, “Shaping Traffic”

- atm pvp Command, page 1-56
- pvc Command, page 1-56
- shape Command, page 1-56
- shape percent Command, page 1-57
- vbr-nrt Command, page 1-57
- ATM VC/VP Shaping Feature, page 1-57
- Class-Based Traffic Shaping Feature, page 1-58
- Frame Relay Traffic Shaping Feature, page 1-58
• Percentage-Based Traffic Shaping Feature, page 1-58
• Traffic Shaping Overhead Accounting for ATM Feature, page 1-59

atm pvp Command

Cisco IOS Release: Release 12.0(17)SL
Description: This command was introduced on the PRE1.

Cisco IOS Release: Release 12.2(16)BX
Description: This command was introduced on the PRE2.

Cisco IOS Release: Release 12.2(28)SB
Description: This command was integrated in Cisco IOS Release 12.2(28)SB.

Cisco IOS Release: Release 12.2(31)SB2
Description: This command was introduced on the PRE3.

pvc Command

Cisco IOS Release: Release 12.0(17)SL
Description: This command was introduced on the PRE1.

Cisco IOS Release: Release 12.2(16)BX
Description: This command was introduced on the PRE2.

Cisco IOS Release: Release 12.2(28)SB
Description: This command was integrated in Cisco IOS Release 12.2(28)SB.

Cisco IOS Release: Release 12.2(31)SB2
Description: This command was introduced on the PRE3.

shape Command

Cisco IOS Release: Release 12.0(17)SL
Description: This command was introduced on the PRE1.

Cisco IOS Release: Release 12.2(16)BX
Description: This command was introduced on the PRE2.

Cisco IOS Release: Release 12.2(28)SB
Description: This command was integrated in Cisco IOS Release 12.2(28)SB.
Chapter 1  Quality of Service Overview

Cisco IOS Release: Release 12.2(31)SB2
Description: This command was introduced on the PRE3.

Cisco IOS Release: Release 12.2(31)SB6
Description: This command supports per-session shaping and queuing on a L2TP Network Server (LNS) on the PRE3.

Cisco IOS Release: Release 12.2(31)SB2
Description: This command was enhanced to support overhead accounting.

Cisco IOS Release: Release 12.2(33)SB
Description: This command was enhanced to support a user-defined offset, which the router uses when calculating overhead.

**shape percent Command**

Cisco IOS Release: Release 12.2(31)SB2
Description: This command was introduced on the PRE3.

**vbr-nrt Command**

Cisco IOS Release: Release 12.0(25)SX
Description: This command was introduced on the PRE1.

Cisco IOS Release: Release 12.2(16)BX
Description: This command was introduced on the PRE2.

Cisco IOS Release: Release 12.2(28)SB
Description: This command was integrated in Cisco IOS Release 12.2(28)SB.

Cisco IOS Release: Release 12.2(31)SB2
Description: This command was introduced on the PRE3.

**ATM VC/VP Shaping Feature**

Cisco IOS Release: Release 12.3(7)XI
Description: The ATM VC/VP Shaping feature was introduced on the PRE2 to enable you to shape traffic at both the VC-level and VP-level.

Cisco IOS Release: Release 12.2(28)SB
Description: This feature was integrated in Cisco IOS Release 12.2(28)SB.

Cisco IOS Release: Release 12.2(31)SB2
Description: This feature was introduced on the PRE3.
Class-Based Traffic Shaping Feature

Cisco IOS Release: Release 12.0(17)SL
Description: The Class-Based Traffic Shaping feature was introduced on the PRE1 to allow you to control a class of traffic going out an interface in order to match its transmission to the speed of the remote target interface and to ensure that the traffic conforms to policies contracted for it.

Cisco IOS Release: Release 12.2(16)BX
Description: This feature was introduced on the PRE2.

Cisco IOS Release: Release 12.2(28)SB
Description: This feature was integrated in Cisco IOS Release 12.2(28)SB.

Cisco IOS Release: Release 12.2(31)SB2
Description: This command was introduced on the PRE3.

Frame Relay Traffic Shaping Feature

Cisco IOS Release: Release 12.0(17)SL
Description: The Frame Relay Traffic Shaping (FRTS) feature was introduced on the PRE1 to eliminate bottlenecks in Frame Relay networks by allowing you to configure rate enforcement to either the committed information rate (CIR) or some other defined value, such as the excess information rate, on a per-VC basis.

Hierarchical Shaping Feature

Cisco IOS Release: Release 12.3(7)XI
Description: The Hierarchical Shaping feature was introduced on the PRE2 to enable you to shape traffic at both the VC-level and VP-level.

Cisco IOS Release: Release 12.2(28)SB
Description: This feature was integrated in Cisco IOS Release 12.2(28)SB for the PRE2.

Cisco IOS Release: Release 12.2(231)SB2
Description: This feature was introduced on the PRE3.

Percentage-Based Traffic Shaping Feature

Cisco IOS Release: Release 12.2(31)SB2
Description: This feature was introduced on the PRE3 to enable you to shape traffic based on a percentage of the available bandwidth.
Traffic Shaping Overhead Accounting for ATM Feature

**Cisco IOS Release:** Release 12.2(31)SB2

**Description:** The Traffic Shaping Overhead Accounting for ATM feature was introduced on the PRE3 to enable the broadband aggregation system (BRAS) to account for various encapsulation types when applying QoS to packets. **Cisco IOS Release:** Release 12.2(31)SB5

**Description:** The Traffic Shaping Overhead Accounting for ATM feature was enhanced to include a user-defined offset value on the PRE3.

Sharing Bandwidth Fairly During Congestion

**Documentation Reference:** Chapter 12, “Sharing Bandwidth Fairly During Congestion”

- Bandwidth Fair Queuing Feature, page 1-59
- Class-Based Weighted Fair Queuing Feature, page 1-59
- Class-Based Weighted Fair Queuing for Virtual Access Interfaces Feature, page 1-60

Bandwidth Fair Queuing Feature

**Cisco IOS Release:** Release 12.0(17)SL

**Description:** The bandwidth fair queuing feature was introduced on the PRE1 to share bandwidth fairly among competing traffic.

**Cisco IOS Release:** Release 12.2(15)BX

**Description:** This feature was introduced on the PRE2.

**Cisco IOS Release:** Release 12.2(28)SB

**Description:** This feature was integrated in Cisco IOS Release 12.2(28)SB.

**Cisco IOS Release:** Release 12.2(31)SB2

**Description:** This command was introduced on the PRE3.

Class-Based Weighted Fair Queuing Feature

**Cisco IOS Release:** Release 12.0(19)SL

**Description:** The class-based weighted fair queuing (CBWFQ) feature was introduced on the PRE1 to provide support for user-defined traffic classes based on match criteria including protocols, access control lists (ACLs), and input interfaces.

**Cisco IOS Release:** Release 12.2(16)BX

**Description:** This feature was introduced on the PRE2.

**Cisco IOS Release:** Release 12.2(28)SB

**Description:** This feature was integrated in Cisco IOS Release 12.2(28)SB.
Cisco IOS Release: Release 12.2(31)SB2
Description: This command was introduced on the PRE3.

Class-Based Weighted Fair Queuing for Virtual Access Interfaces Feature

Cisco IOS Release: Release 12.0(25)SX
Description: The Class-Based Weighted Fair Queuing (CBWFQ) for virtual access interfaces (VAIs) feature was introduced on the PRE1 to allow a VAI to inherit the service policy of the VC that the VAI uses.

Cisco IOS Release: Release 12.2(16)BX
Description: This feature was introduced on the PRE2.

Cisco IOS Release: Release 12.2(28)SB
Description: This feature was integrated in Cisco IOS Release 12.2(28)SB.

Simultaneous Policy Maps

Documentation Reference: Chapter 14, “Simultaneous Policy Maps”
- Simultaneous QoS Policy Map on Interface and PPP Session—A-DSLAM Case, page 1-60

Simultaneous QoS Policy Map on Interface and PPP Session—A-DSLAM Case

Cisco IOS Release: Release 12.2(33)SB
Description: The Simultaneous QoS Policy Map on Interface and PPP Session—A-DSLAM Case feature was introduced on the PRE2, PRE3, and PRE4 to allow the broadband aggregation system (BRAS) to provide multiple levels of QoS hierarchy that shape traffic at different points of congestion in the Layer 2 network. This enables the BRAS to avoid congestion in downstream links within the network.

VLAN Tag-Based Quality of Service

Documentation Reference: Chapter 21, “VLAN Tag-Based Quality of Service”
Cisco IOS Release: Release 12.2(31)SB2
Description: The QoS—VLAN Tag-Based feature was introduced on the PRE2 and PRE3 to enable you to apply a single QoS policy, referred to as a VLAN-group policy, to a group of IEEE 802.1Q VLAN subinterfaces.
## Related Documentation

This section provides hyperlinks to additional Cisco documentation for the features discussed in this chapter. To display the documentation, click the document title or a section of the document highlighted in blue. When appropriate, paths to applicable sections are listed below the documentation title.

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