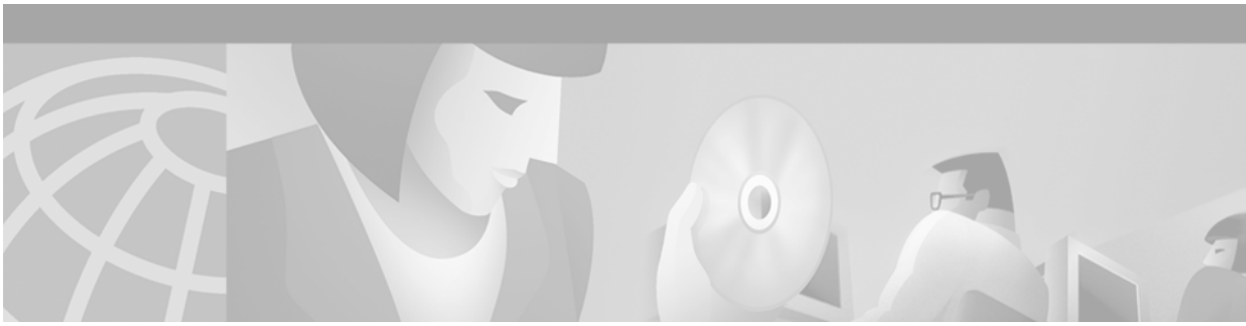


RSVP Support for ATM/PVCs

This document describes Cisco Resource Reservation Protocol (RSVP) support for the Asynchronous Transfer Mode/permanent virtual circuits (ATM/PVCs) feature. It identifies the supported platforms, provides configuration examples, and lists related IOS command line interface (CLI) commands.

This document includes the following major sections:

Feature Overview

Network administrators use queueing to manage congestion on a router interface or a permanent virtual circuit (PVC). In an ATM environment, the congestion point might not be the interface itself, but the PVC because of the traffic parameters, including the available bit rate (ABR), the constant bit rate (CBR), and the variable bit rate (VBR) associated with the PVC. For real-time traffic, such as voice flows, to be transmitted in a timely manner, the data rate must not exceed the traffic parameters, or packets might be dropped, thereby affecting voice quality. Fancy queueing such as class-based weighted fair queueing (CBWFQ), low latency queueing (LLQ), or weighted fair queueing (WFQ), can run on the PVC to provide the quality of service (QoS) guarantees for the traffic.

In previous releases, RSVP reservations were not constrained by the traffic parameters of the flow's outbound PVC. As a result, oversubscription could occur when the sum of the RSVP traffic and other traffic exceeded the PVC's capacity.

The RSVP support for ATM/PVCs feature allows RSVP to function with per-PVC queueing for voice-like flows. Specifically, RSVP can install reservations on PVCs defined at the interface and subinterface levels. There is no limit to the number of PVCs that can be configured per interface or subinterface.

RSVP Bandwidth Allocation and Modular QoS Command Line Interface (CLI)

RSVP can use an interface (or a PVC) queueing algorithm, such as WFQ, to ensure QoS for its data flows.

Admission Control

When WFQ is running, RSVP can co-exist with other QoS features on an interface (or PVC) that also reserve bandwidth and enforce QoS. When you configure multiple bandwidth-reserving features (such as RSVP, LLQ, CB-WFQ, and **ip rtp priority**), portions of the interface's (or PVC's) available bandwidth may be assigned to each of these features for use with flows that they classify.

An internal interface-based (or PVC-based) bandwidth manager prevents the amount of traffic reserved by these features from oversubscribing the interface (or PVC). You can view this pool of available bandwidth using the **show queue** command, and it is configurable (as a percentage of the interface's or PVC's capacity) via the **max-reserved-bandwidth** command.

When you configure features such as LLQ and CB-WFQ, any classes that are assigned a bandwidth reserve their bandwidth at the time of configuration, and deduct this bandwidth from the bandwidth manager. If the configured bandwidth exceeds the interface's capacity, the configuration is rejected.

When RSVP is configured, no bandwidth is reserved. (The amount of bandwidth specified in the **ip rsvp bandwidth** command acts as a strict upper limit, and does **not** guarantee admission of any flows.) Only when an RSVP reservation arrives does RSVP attempt to reserve bandwidth out of the remaining pool of available bandwidth (that is, the bandwidth that has not been dedicated to traffic handled by other features.)

Data Packet Classification

By default, RSVP performs an efficient flow-based, datapacket classification to ensure QoS for its reserved traffic. This classification runs prior to queueing consideration by **ip rtp priority** or CB-WFQ. Thus, the use of a CB-WFQ class or **ip rtp priority** command is **not** required in order for RSVP data flows to be granted QoS. Any **ip rtp priority** or CB-WFQ configuration will not match RSVP flows, but they will reserve additional bandwidth for any non-RSVP flows that may match their classifiers.

If you do **not** want RSVP to perform per-flow classification, but prefer DiffServ classification instead, then you can configure RSVP to exclude itself from data packet classification, and configure LLQ for classification. For more information, see the "RSVP Scalability Enhancements" feature regarding DiffServ integration.

Benefits

Accurate Admission Control

RSVP performs admission control based on the PVC's average cell rate, sustainable cell rate, or minimum cell rate, depending on the type of PVC that is configured, instead of the amount of bandwidth available on the interface.

Recognition of Layer 2 Overhead

RSVP automatically takes the Layer 2 overhead into account when admitting a flow. For each flow, RSVP determines the total amount of bandwidth required, including Layer 2 overhead, and uses this value for admission control with the WFQ bandwidth manager.

Improved QoS

RSVP provides QoS guarantees for high-priority traffic by reserving resources at the point of congestion (that is, the ATM PVC instead of the interface).

Flexible Configurations

RSVP provides support for point-to-point and multipoint interface configurations, thus enabling deployment of services such as voice over IP (VoIP) in ATM environments with QoS guarantees.

Prevention of Bandwidth Oversubscription

RSVP, CBWFQ, and ip rtp priority do not oversubscribe the amount of bandwidth available on the interface or the PVC even when they are running simultaneously. Prior to admitting a reservation, these features check an internal bandwidth manager to avoid oversubscription.

IP QoS Features Integration into ATM Environments

IP QoS features can now be integrated seamlessly from IP into ATM environments with RSVP providing admission control on a per PVC basis.

Restrictions

- Interface-level generic traffic shaping (GTS) is not supported.
- VC-level queueing and interface-level queueing on the same interface are not supported.
- Nonvoice RSVP flows are not supported.
- Multicast flows are not supported.
- ATM/PVCs must be preconfigured in the network.

Related Features and Technologies

The RSVP support for ATM/PVCs feature is related to QoS features such as low latency queueing and policing. (See the section on “Related Documents”.)

Related Documents

The following documents provide additional information:

- *Cisco IOS Quality of Service Solutions Guide*
- *Cisco IOS Quality of Service Solutions Command Reference*

Supported Platforms

- Cisco 3600 series (Cisco 3620, 3640, and 3660)
- Cisco 3810 multiservice access concentrator
- Cisco 7200 series

Supported Standards, MIBs, and RFCs

Standards

The RSVP support for ATM/PVCs feature supports no new or modified standards.

MIBs

RFC 2206 (RSVP Management Information Base using SMIv2)

To obtain lists of MIBs supported by platform and Cisco IOS release and to download MIB modules, go to the Cisco MIB web site on Cisco.com at http://www.cisco.com/public/sw-center/netmgmt/cmtk/mibs.shtml.

RFCs

- RFC 2205 (Resource Reservation Protocol)

Prerequisites

The network must support the following Cisco IOS features before RSVP support for ATM/PVCs is enabled:

- Resource Reservation Protocol (RSVP)
- Weighted fair queueing (WFQ)

Configuration Tasks

See the following sections for configuration tasks for the RSVP support for ATM/PVCs feature. Each task in the list indicates whether the task is optional or required.

- Creating a PVC (Required)
- Defining ATM QoS Traffic Parameters for a PVC (Required)
- Defining a Policy Map for WFQ (Required)

- Applying a Policy Map to a PVC (Required)
- Enabling RSVP on an Interface (Required)
- Configuring a Path (Optional)
- Configuring a Reservation (Optional)

Creating a PVC

To create a PVC, use the following command in interface configuration mode:

Command	Purpose
`Router(config-if)# pvc [name] vpi/vci [ilmi | qsaal | smds]`	Assigns a name and identifier to a PVC.

Defining ATM QoS Traffic Parameters for a PVC

Note In order for RSVP to reserve bandwidth, the ATM/PVC traffic parameters must be available bit rate (ABR), variable bit rate non real-time (VBR-NRT), or real-time variable bit rate (VBR). You can specify only one of these parameters per PVC connection; therefore, if you enter a new parameter, it will replace the existing one.

To configure ATM PVC traffic parameters, use *one* of the following commands beginning in interface-ATM-VC configuration mode:

Command	Purpose
`Router(config-if-atm-vc)# abr output-pcr output-mcr`	Configures the available bit rate (ABR). (ATM-CES port adapter and multiport T1/E1 ATM network module only.)
`Router(config-if-atm-vc)# vbr-nrt output-pcr output-scr output-mbs`	Configures the variable bit rate-non real time (VBR-NRT) QoS.
`Router(config-if-atm-vc)# vbr-rt peak-rate average-rate burst`	Configures the real-time variable bit rate (VBR). (Cisco MC3810 and multiport T1/E1 ATM network module only.)

The arguments used here are as follows:

- *-pcr*—peak cell rate
- *-mcr*—minimum cell rate
- *-scr*—sustainable cell rate
- *-mbs*—maximum burst size
- *output-mcr*, *output-scr*, and *average-rate*— reservable bandwidth pool on the PVC

All features running on the PVC, including RSVP, CBWFQ, and LLQ, can use up to 75 percent of the reservable bandwidth pool.

Defining a Policy Map for WFQ

To define a policy map for WFQ, use the following commands, beginning in global configuration mode:

	Command	Purpose
Step 1	`Router(config)# policy-map policy-name`	Specifies the policy map name; for example, wfq-voip.
Step 2	`Router(config-pmap)# class class-name`	Specifies the name of a previously defined class map, such as class-default.
Step 3	`Router(config-pmap-c) fair-queue number-of-queues`	Specifies the number of queues to be reserved for the default class.

Applying a Policy Map to a PVC

To apply a policy map to a PVC, use the following command, beginning in interface-ATM-VC configuration mode:

Command	Purpose
`Router(config-if-atm-vc)# service-policy output policy-name`	Applies a policy map to the output direction of the interface.

Enabling RSVP on an Interface

To enable RSVP on an interface, use the following command in interface configuration mode:

Command	Purpose
`Router(config-if)# ip rsvp bandwidth [interface-kbps] [single-flow-kbps]`	Enables RSVP on an interface.

Configuring a Path

To configure an RSVP path, use the following command in global configuration mode:

Command	Purpose
`Router(config)# ip rsvp sender session-ip-address sender-ip-address [tcp | udp | ip-protocol] session-dport sender-sport previous-hop-ip-address previous-hop-interface [bandwidth] [burst-size]`	Specifies the RSVP path parameters, including the destination and source addresses, the protocol, the destination and source ports, the previous hop address, the average bit rate, and the burst size.

Configuring a Reservation

To configure an RSVP reservation, use the following command in global configuration mode:

Command	Purpose
Router(config)# **ip rsvp reservation** *session-ip-address sender-ip-address* [**tcp** | **udp** | *ip-protocol*] *session-dport sender-sport next-hop-ip address nexthop-interface* {**ff** | **se** | **wf**} {***rate*** | **load**} [*bandwidth*] [*burst-size*]	Specifies the RSVP reservation parameters, including the destination and source addresses, the protocol, the destination and source ports, the next hop address, the next hop interface, the reservation style, the service type, the average bit rate, and the burst size.

Verifying RSVP Support for ATM/PVCs Configuration

Multipoint Configuration

To verify RSVP support for ATM/PVCs multipoint configuration, use this procedure:

Step 1 Enter the **show ip rsvp installed** command to display information about interfaces, subinterfaces, PVCs, and their admitted reservations. The output in the following example shows that the ATM 6/0.1 subinterface has four reservations:

```
Router# show ip rsvp installed

RSVP:ATM6/0.1
BPS     To              From            Protoc DPort  Sport  Weight Conversation
10K     145.30.30.213   145.40.40.214   UDP    101    101    0      40
15K     145.20.20.212   145.40.40.214   UDP    100    100    6      41
15K     145.30.30.213   145.40.40.214   UDP    100    100    6      41
10K     145.20.20.212   145.40.40.214   UDP    101    101    0      40
```

Note Weight 0 is assigned to voice-like flows, which proceed to the priority queue (PQ).

Step 2 Enter the **show ip rsvp installed detail** command to display additional information about interfaces, subinterfaces, PVCs, and their current reservations.

Note In the following output, the first flow has a weight = 0 and gets the PQ; the second flow has a weight > 0 and gets a reserved queue.

```
Router# show ip rsvp installed detail

RSVP:ATM6/0 has the following installed reservations

RSVP:ATM6/0.1 has the following installed reservations
RSVP Reservation. Destination is 145.30.30.213, Source is 145.40.40.214,
  Protocol is UDP, Destination port is 101, Source port is 101
  Reserved bandwidth:10K bits/sec, Maximum burst:1K bytes, Peak rate:10K bits/sec
  Min Policed Unit: 0 bytes, Max Pkt Size: 1514
  Resource provider for this flow:
    WFQ on ATM PVC 100/101 on AT6/0: PRIORITY queue 40.  Weight:0, BW 10 kbps
  Conversation supports 1 reservations
  Data given reserved service:0 packets (0M bytes)
  Data given best-effort service:0 packets (0 bytes)
  Reserved traffic classified for 48 seconds
  Long-term average bitrate (bits/sec):0M reserved, 0M best-effort
RSVP Reservation. Destination is 145.20.20.212, Source is 145.40.40.214,
```

```
  Protocol is UDP, Destination port is 100, Source port is 100
  Reserved bandwidth:15K bits/sec, Maximum burst:1K bytes, Peak rate:15K bits/sec
  Min Policed Unit: 0 bytes, Max Pkt Size: 1514
  Resource provider for this flow:
    WFQ on ATM PVC 100/201 on AT6/0: RESERVED queue 41.  Weight:6, BW 15 kbps
  Conversation supports 1 reservations
  Data given reserved service:0 packets (0M bytes)
  Data given best-effort service:0 packets (0 bytes)
  Reserved traffic classified for 200 seconds
  Long-term average bitrate (bits/sec):0M reserved, 0M best-effort
RSVP Reservation. Destination is 145.30.30.213, Source is 145.40.40.214,
  Protocol is UDP, Destination port is 100, Source port is 100
  Reserved bandwidth:15K bits/sec, Maximum burst:1K bytes, Peak rate:15K bits/sec
  Min Policed Unit: 0 bytes, Max Pkt Size: 1514
  Resource provider for this flow:
    WFQ on ATM PVC 100/101 on AT6/0: RESERVED queue 41.  Weight:6, BW 15 kbps
  Conversation supports 1 reservations
  Data given reserved service:0 packets (0M bytes)
  Data given best-effort service:0 packets (0 bytes)
  Reserved traffic classified for 60 seconds
  Long-term average bitrate (bits/sec):0M reserved, 0M best-effort
RSVP Reservation. Destination is 145.20.20.212, Source is 145.40.40.214,
  Protocol is UDP, Destination port is 101, Source port is 101
  Reserved bandwidth:10K bits/sec, Maximum burst:1K bytes, Peak rate:10K bits/sec
  Min Policed Unit: 0 bytes, Max Pkt Size: 1514
  Resource provider for this flow:
    WFQ on ATM PVC 100/201 on AT6/0: PRIORITY queue 40.  Weight:0, BW 10 kbps
  Conversation supports 1 reservations
  Data given reserved service:0 packets (0M bytes)
  Data given best-effort service:0 packets (0 bytes)
  Reserved traffic classified for 163 seconds
  Long-term average bitrate (bits/sec):0M reserved, 0M best-effort
```

Point-to-Point Configuration

To verify RSVP support for ATM/PVCs point-to-point configuration, use this procedure:

Step 1 Enter the **show ip rsvp installed** command to display information about interfaces, subinterfaces, PVCs, and their admitted reservations. The output in the following example shows that the ATM 6/0.1 subinterface has two reservations, and the ATM 6/0.2 subinterface has one reservation:

```
Router# show ip rsvp installed

RSVP:ATM6/0.1
BPS    To              From            Protoc DPort  Sport  Weight Conversation
15K    145.30.30.213   145.40.40.214   UDP    100    100    0      40
20K    145.30.30.213   145.40.40.214   UDP    101    101    6      41

RSVP:ATM6/0.2
BPS    To              From            Protoc DPort  Sport  Weight Conversation
150K   145.20.20.212   145.40.40.214   UDP    12     12     6      42
Router#
```

Note Weight 0 is assigned to voice-like flows, which proceed to the PQ.

Step 2 Enter the **show ip rsvp installed detail** command to display additional information about interfaces, subinterfaces, PVCs, and their current reservations.

Note In the following output, the first flow with a weight = 0 gets the PQ, and the second flow with a weight > 0 gets a reserved queue.

```
Router# show ip rsvp installed detail

RSVP:ATM6/0 has the following installed reservations

RSVP:ATM6/0.1 has the following installed reservations
RSVP Reservation. Destination is 145.30.30.213, Source is 145.40.40.214,
  Protocol is UDP, Destination port is 101, Source port is 101
  Reserved bandwidth:15K bits/sec, Maximum burst:1K bytes, Peak rate:15K bits/sec
  Min Policed Unit: 0 bytes, Max Pkt Size: 1514 bytes
  Resource provider for this flow:
    WFQ on ATM PVC 100/101 on AT6/0: PRIORITY queue 40.  Weight:0, BW 15 kbps
  Conversation supports 1 reservations
  Data given reserved service:0 packets (0M bytes)
  Data given best-effort service:0 packets (0 bytes)
  Reserved traffic classified for 48 seconds
  Long-term average bitrate (bits/sec):0M reserved, 0M best-effort
RSVP Reservation. Destination is 145.20.20.212, Source is 145.40.40.214,
  Protocol is UDP, Destination port is 100, Source port is 100
  Reserved bandwidth:15K bits/sec, Maximum burst:1K bytes, Peak rate:15K bits/sec
  Min Policed Unit: 0 bytes, Max Pkt Size: 1514 bytes
  Resource provider for this flow:
    WFQ on ATM PVC 100/201 on AT6/0: RESERVED queue 41.  Weight:6, BW 15 kbps
  Conversation supports 1 reservations
  Data given reserved service:0 packets (0M bytes)
  Data given best-effort service:0 packets (0 bytes)
  Reserved traffic classified for 200 seconds
  Long-term average bitrate (bits/sec):0M reserved, 0M best-effort
RSVP Reservation. Destination is 145.30.30.213, Source is 145.40.40.214,
  Protocol is UDP, Destination port is 100, Source port is 100
  Reserved bandwidth:20K bits/sec, Maximum burst:1K bytes, Peak rate:20K bits/sec
```

```
  Min Policed Unit: 0 bytes, Max Pkt Size: 1514 bytes
  Resource provider for this flow:
    WFQ on ATM PVC 100/101 on AT6/0: RESERVED queue 41.  Weight:6, BW 20 kbps
  Conversation supports 1 reservations
  Data given reserved service:0 packets (0M bytes)
  Data given best-effort service:0 packets (0 bytes)
  Reserved traffic classified for 60 seconds
  Long-term average bitrate (bits/sec):0M reserved, 0M best-effort

RSVP:ATM6/0.2 has the following installed reservations
RSVP Reservation. Destination is 145.20.20.212, Source is 145.40.40.214,
  Protocol is UDP, Destination port is 101, Source port is 101
  Reserved bandwidth:150K bits/sec, Maximum burst:1K bytes, Peak rate:150K bits/sec
  Min Policed Unit: 0 bytes, Max Pkt Size: 1514 bytes
  Resource provider for this flow:
    WFQ on ATM PVC 100/201 on AT6/0: PRIORITY queue 40.  Weight:0, BW 150 kbps
  Conversation supports 1 reservations
  Data given reserved service:0 packets (0M bytes)
  Data given best-effort service:0 packets (0 bytes)
  Reserved traffic classified for 163 seconds
  Long-term average bitrate (bits/sec):0M reserved, 0M best-effort
```

Monitoring and Maintaining RSVP Support for ATM/PVCs

To monitor and maintain RSVP support for ATM/PVCs, use the following commands in EXEC mode:

Command	Purpose
Router# **show ip rsvp installed**	Displays information about interfaces and their admitted reservations.
Router# **show ip rsvp installed detail**	Displays additional information about interfaces, PVCs, and their admitted reservations.
Router# **show queueing** [**custom** | **fair** | **priority** | **random-detect** [**interface** *serial-number*]]	Displays all or selected configured queueing strategies and available bandwidth for RSVP reservations.
Router# **show atm pvc** [*vpi/vci* | *name* | **interface atm** *interface-number*]	Displays all ATM PVCs and related traffic information.

Configuration Examples

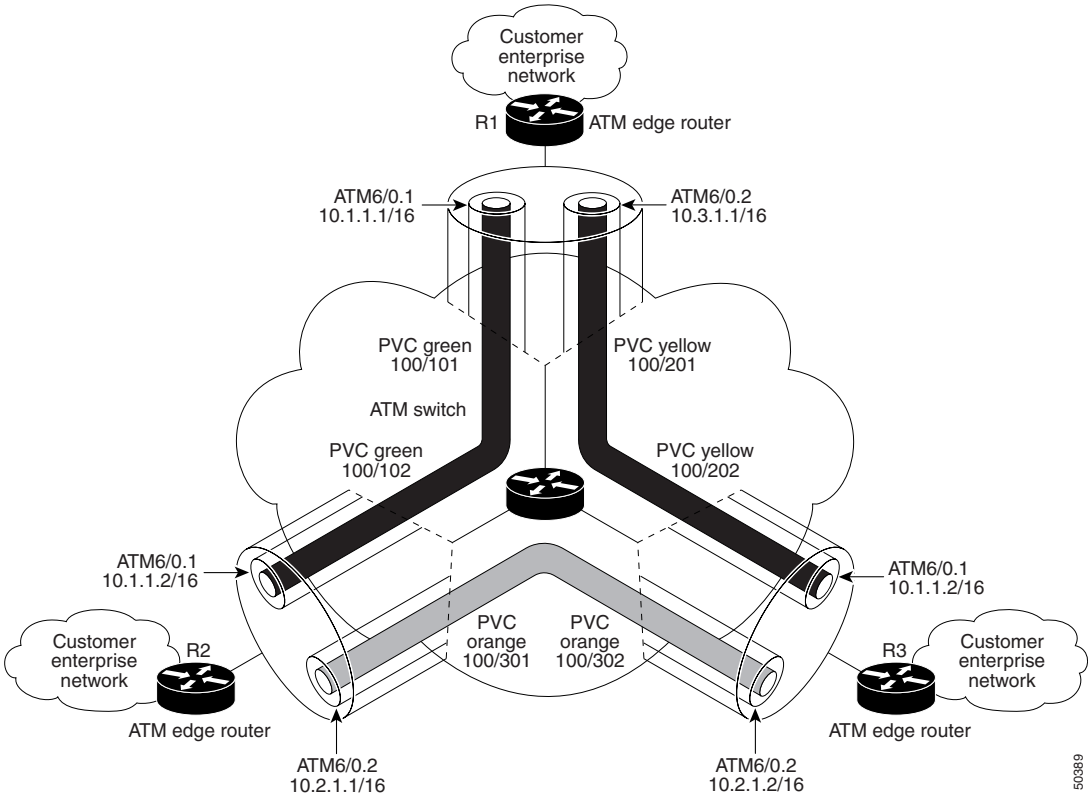
This section provides point-to-point and multipoint configuration examples for the RSVP support for ATM/PVCs feature.

Point-to-Point Configuration

Figure 1 shows a sample point-to-point interface configuration commonly used in ATM environments in which one PVC per subinterface is configured at router R1.

Three small clouds represent office branches that are connected through PVCs over an ATM network.

Figure 1 Point-to-Point Interface Configuration



Here is sample output for a point-to-point configuration:

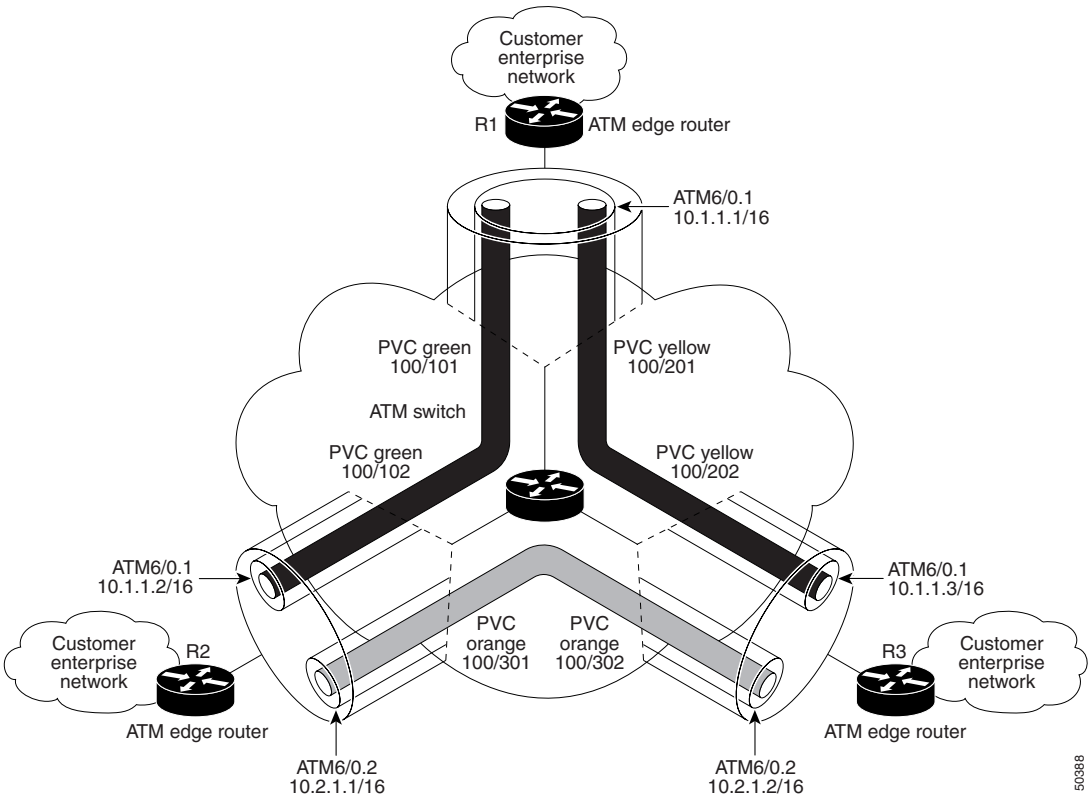
```
Router#
policy-map wfq-voip
  class class-default
   fair-queue

interface ATM6/0
 no ip address
 ip rsvp bandwidth 112320 112320

interface ATM6/0.1 point-to-point
 ip address 10.1.1.1 255.0.0.0
 pvc green 100/101
  vbr-rt 400 300 200
  inarp 1
  broadcast
  service-policy output wfq-voip
 ip rsvp bandwidth 1250 1250
 ip rsvp resource-provider wfq pvc

interface ATM6/0.2 point-to-point
 ip address 10.3.1.1 255.0.0.0
 pvc yellow 100/201
  vbr-nrt 500 400 1000
  inarp 1
  broadcast
  service-policy output wfq-voip
 ip rsvp bandwidth 1250 1250
 ip rsvp resource-provider wfq pvc
```

Multipoint Configuration

Figure 2 shows a multipoint interface configuration commonly used in ATM environments in which multiple PVCs are configured on the same subinterface at router R1.

The customer enterprise network that includes R1 is the headquarters of a company with PVC connections to each remote office.

Figure 2 Multipoint Interface Configuration



Here is sample output for a multipoint configuration:

```
Router#
policy-map wfq-voip
  class class-default
   fair-queue

interface ATM6/0
 no ip address
 ip rsvp bandwidth 112320 112320

interface ATM6/0.1 multipoint
 ip address 10.1.1.1 255.0.0.0
 pvc green 100/101
  vbr-rt 400 300 200
  inarp 1
  broadcast
  service-policy output wfq-voip

 pvc yellow 100/201
```

```
 vbr-nrt 500 400 1000
 inarp 1
 broadcast
 service-policy output wfq-voip

ip rsvp bandwidth 1250 1250
ip rsvp resource-provider wfq pvc
```

Command Reference

This section describes five CLI commands that you can use with the RSVP support for ATM/PVCs feature:

- **ip rsvp layer2 overhead**
- **ip rsvp resource-provider**
- **show ip rsvp installed**
- **show ip rsvp interface**
- **show queueing**

All other commands used with this feature are documented in the Cisco IOS Release10.0, 11.0, and 12.0 command reference publications.

ip rsvp layer2 overhead

To control the overhead accounting performed by RSVP/WFQ when a flow is admitted onto an ATM PVC, use the **ip rsvp layer2 overhead** interface configuration command. To disable the **ip rsvp layer2 overhead** interface configuration command, use the **no** form of this command.

ip rsvp layer2 overhead [*h c n*]

no ip rsvp layer2 overhead

Syntax Description

h	(Optional) Specifies the Layer 2 encapsulation header plus trailer size applied to each Layer 3 packet in bytes.
c	(Optional) Specifies the Layer 2 cell header size applied to each Layer 2 cell in bytes.
n	(Optional) Specifies the Layer 2 payload size in bytes.

Defaults

This command is enabled by default on ATM interfaces that are running RSVP and WFQ. You can also use this command on non-ATM interfaces.

The default version of the command, which you specify by entering the default prefix, **default ip rsvp layer2 overhead**, or by omitting the parameters (h, c, and n) and entering **ip rsvp layer2 overhead** causes RSVP to determine the overhead values automatically, based on the interface/PVC encapsulation. (Currently, RSVP recognizes ATM Adaptation Layer 5 (AAL5) subnetwork access protocol (SNAP) and MUX encapsulations.)

On non-ATM/PVC interfaces, the configured h, c, and n parameters determine the values that RSVP uses for its overhead.

Command Modes

Interface configuration

Command History

Release	Modification
12.2(2)T	This command was introduced.

Usage Guidelines

When an IP flow traverses a link, the overhead of Layer 2 encapsulation can increase the amount of bandwidth that the flow requires to exceed the advertised (Layer 3) rate.

In many cases, the additional bandwidth a flow requires due to Layer 2 overhead is negligible and can be transmitted as part of the 25 percent of the link, which is unreservable and kept for routing updates and Layer 2 overhead. This is typically true when the IP flow uses large packet sizes or when the Layer 2 encapsulation allows for frames of variable size (such as in Ethernet and Frame Relay encapsulations).

However, when a flow's packet sizes are small and the underlying Layer 2 encapsulation uses fixed-size frames, the Layer 2 encapsulation overhead can be significant. This is usually the case when VoIP flows traverse ATM links.

To avoid oversubscribing ATM PVCs, which use AAL5 SNAP or AAL5 MUX encapsulations, RSVP automatically accounts for the Layer 2 overhead when admitting a flow. For each flow, RSVP determines the total amount of bandwidth required, including Layer 2 overhead, and uses this value for admission control with the WFQ bandwidth manager.

Note The **ip rsvp layer2 overhead** command does not affect bandwidth requirements of RSVP flows on ATM switched virtual circuits (SVCs).

Examples

In the following example, the total amount of bandwidth reserved with WFQ appears:

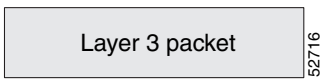
```
Router# show ip rsvp installed detail

RSVP:ATM6/0 has the following installed reservations
RSVP Reservation. Destination is 11.1.1.1, Source is 10.1.1.1,
  Protocol is UDP, Destination port is 1000, Source port is 1000
  Reserved bandwidth:50K bits/sec, Maximum burst:1K bytes, Peak rate:50K bits/sec
  Min Policed Unit:60 bytes, Max Pkt Size:60 bytes
  Resource provider for this flow:
    WFQ on ATM PVC 100/101 on AT6/0: PRIORITY queue 40.  Weight:0, BW 89 kbps
  Conversation supports 1 reservations
  Data given reserved service:0 packets (0M bytes)
  Data given best-effort service:0 packets (0 bytes)
  Reserved traffic classified for 9 seconds
  Long-term average bitrate (bits/sec):0M reserved, 0M best-effort
Router#
```

In the preceding example, the flow's advertised Layer 3 rate is 50 kbps. This value is used for admission control with the **ip rsvp bandwidth** value. The actual bandwidth required, inclusive of Layer 2 overhead, is 89 kbps. WFQ uses this value for admission control.

Typically, you should not need to configure or disable the Layer 2 overhead accounting. RSVP uses the advertised Layer 3 flow rate, minimum packet size, and maximum unit size in conjunction with the Layer 2 encapsulation characteristics of the ATM PVC to compute the required bandwidth for admission control. However, you can disable or customize the Layer 2 overhead accounting (for any link type) with the **ip rsvp layer2 overhead** command. The parameters of this command are based on the following steps that show how a Layer 3 packet is fragmented and encapsulated for Layer 2 transmission:

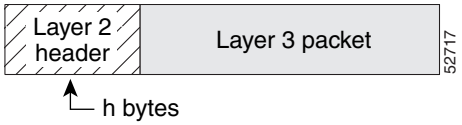
Step 1 Start with a Layer 3 packet, as shown in Figure 3, which includes an IP header and a payload.

Figure 3 Layer 3 Packet



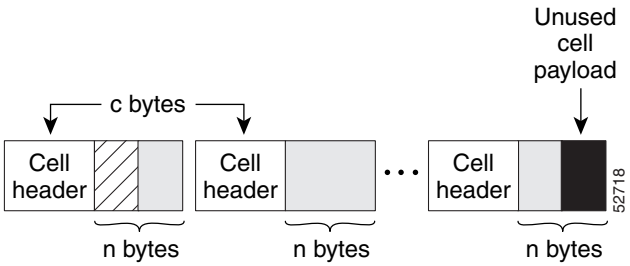
Step 2 Add an encapsulation header/trailer, as shown in Figure 4, of size h:

Figure 4 Layer 3 Packet with Layer 2 Header



Step 3 Segment the resulting packet into fixed-sized cells, as shown in Figure 5, with a cell header of c bytes and a cell payload of n bytes:

Figure 5 Segmented Packet



Step 4 Transmit the resulting Layer 2 cells.

More Configuration Examples

In the following example, Layer 2 overhead accounting is disabled for all reservations on the interface and its PVCs:

```
Router(config-if)# no ip rsvp layer2 overhead
```

In the following example, Layer 2 overhead accounting is configured with ATM AAL5 SNAP encapsulation:

```
Router(config-if)# no ip rsvp layer2 overhead 8 5 48
```

In the following example, Layer 2 overhead accounting is configured with ATM AAL5 MUX encapsulation:

```
Router(config-if)# ip rsvp layer2 overhead 0 5 48
```

In the following example, Layer 2 overhead accounting is configured with Ethernet V2.0 encapsulation (including 8-byte preamble, 6-byte source-active (SA) messages, 6-byte destination-active (DA) messages, 2-byte type, and 4-byte frame check sequence (FCS) trailer):

```
Router(config-if)# ip rsvp layer2 overhead 26 0 1500
```

Related Commands

Command	Description
show ip rsvp installed	Displays information about interfaces and their admitted reservations.

ip rsvp resource-provider

To configure a resource provider for an aggregate flow, use the **ip rsvp resource-provider** interface configuration command. To disable the **ip rsvp resource-provider** interface configuration command, use the **no** form of the command.

ip rsvp resource-provider {*none* | *wfq interface* | *wfq pvc*}

no ip rsvp resource-provider

Syntax Description

none	(Optional) Specifies no resource provider, regardless of whether there is one on the interface. Not used in ATM/PVC environments.
wfq interface	(Optional) Specifies WFQ as the resource provider on the interface. Not used in ATM/PVC environments.
wfq pvc	(Optional) Specifies WFQ as the resource provider on the PVC.

Defaults

This command has no default behavior or values.

Command Modes

Interface configuration

Command History

Release	Modification
12.2(2)T	This command was introduced.

Usage Guidelines

Use the **ip rsvp resource-provider** command with the *wfq pvc* argument in ATM/PVC environments. To ensure that a flow receives QoS, WFQ has to be running on the PVC or reservations fail.

Examples

Here is an example of the **ip rsvp resource-provider** command:

```
Router# configure terminal
Router(config)# int atm6/0
Router(config-if)# ip rsvp resource-provider wfq pvc
Router(config-if)#
```

Related Commands

Command	Description
show ip rsvp installed	Displays information about interfaces and their admitted reservations.

show ip rsvp installed

To display information about interfaces and their admitted reservations, use the **show ip rsvp installed** EXEC command.

show ip rsvp installed [**detail**]

Syntax Description

detail	(Optional) Specifies additional information about interfaces and their reservations, including the Layer 2 bandwidth field.

Defaults

No default behavior or values.

Command Modes

EXEC

Command History

Release	Modification
11.2	This command was introduced.

Usage Guidelines

The **show ip rsvp installed** command displays information about interfaces and their reservations. Enter the optional keyword, **detail**, for additional information, including the reservation's traffic parameters, downstream hop, and resources that RSVP uses to ensure QoS for this reservation.

Examples

Here is sample output from the **show ip rsvp installed** command on an ATM interface:

```
Router# show ip rsvp installed

RSVP:ATM6/0
BPS     To              From            Protoc DPort  Sport  Weight Conversation
15K     145.20.20.212   145.10.10.211   UDP    14     14     6      74
20K     145.20.20.212   145.10.10.211   UDP    10     10     6      72
Router#
```

Table 1 describes the fields in the preceding output.

Table 1 Field Descriptions for show ip rsvp installed Command Output

Field	Description
BPS	Bits per second; reserved rate of reservation
To	The session's (receiver's) IP address
From	The sender's IP address
Protoc	The protocol used by the sender
DPort	Destination port; session
Sport	Source port; sender

Table 1 Field Descriptions for show ip rsvp installed Command Output

Field	Description
Weight	Weight assigned to the reservation; 0 = PQ
Conversation	Traffic stream number

Here is sample output from the **show ip rsvp installed detail** command on an ATM interface:

```
Router# show ip rsvp installed detail
RSVP: ATM6/0 has the following installed reservations
RSVP Reservation. Destination is 145.20.20.212, Source is 145.10.10.211,
  Protocol is UDP, Destination port is 14, Source port is 14
  Reserved bandwidth: 50K bits/sec, Maximum burst: 1K bytes, Peak rate: 50K bits/sec
  Min Policed Unit: 0 bytes, Max Pkt Size: 1514 bytes
  Resource provider for this flow:
    WFQ on ATM PVC 200/100 on AT6/0:  RESERVED queue 74.  Weight: 6, BW 50 kbps
  Conversation supports 1 reservations
  Data given reserved service: 227 packets (110776 bytes)
  Data given best-effort service: 1 packets (488 bytes)
  Reserved traffic classified for 17 seconds
  Long-term average bitrate (bits/sec): 50571 reserved, 222 best-effort
RSVP Reservation. Destination is 145.20.20.212, Source is 145.10.10.211,
  Protocol is UDP, Destination port is 10, Source port is 10
  Reserved bandwidth: 20K bits/sec, Maximum burst: 1K bytes, Peak rate: 20K bits/sec
  Min Policed Unit: 0 bytes, Max Pkt Size: 1514 bytes
  Resource provider for this flow:
    WFQ on ATM PVC 200/100 on AT6/0:  PRIORITY queue 72.  Weight: 0, BW 20 kbps
  Conversation supports 1 reservations
  Data given reserved service: 202 packets (98576 bytes)
  Data given best-effort service: 0 packets (0 bytes)
  Reserved traffic classified for 40 seconds
  Long-term average bitrate (bits/sec): 19523 reserved, 0M best-effort
```

show ip rsvp interface

To display RSVP-related interface information, use the **show ip rsvp interface** EXEC command.

show ip rsvp interface [*interface-type interface-number*] [**detail**]

Syntax Description

interface-type	(Optional) The type of the interface.
interface-number	(Optional) The number of the interface.
detail	(Optional) Specifies additional information about interfaces.

Defaults

No default behavior or values.

Command Modes

EXEC

Command History

Release	Modification
11.2	This command was introduced.
12.2(2)T	This command was modified to include the keyword, **detail**.

Usage Guidelines

Use the **show ip rsvp interface** command to display the current bandwidth allocation budget and maximum available bandwidth. Enter the optional keyword, **detail**, for additional information, including a resource provider, if you configured one.

Examples

In the following output from the **show ip rsvp interface** command, a flow of 15 kbps is admitted on subinterface AT6/0.1:

```
Router# show ip rsvp interface
interface    allocated  i/f max  flow max pct UDP  IP   UDP_IP   UDP M/C
AT6/0        15K        116250K  116250K  0   0    0    0        0
AT6/0.1      15K        1250K    1250K    2   0    1    0        0
AT6/0.2      0M         1250K    1250K    0   0    1    0        0
```

Table 2 describes the fields in the preceding output.

Table 2 Field Descriptions for show ip rsvp interface Command Output

Field	Description
interface	Interface name
allocated	Current allocation budget
i/f max	Maximum allocated bandwidth
flow max	Maximum flow possible on this interface
pct	Percent of bandwidth used

Table 2 Field Descriptions for show ip rsvp interface Command Output

Field	Description
UDP	Number of neighbors sending UDP-encapsulated RSVP
IP	Number of neighbors sending IP-encapsulated RSVP
UDP_IP	Number of neighbors sending both
UDP M/C	Router configured for UDP on this interface

Here is sample output from the **show ip rsvp interface detail** command showing that no resource provider has been configured:

```
Router# show ip rsvp interface detail
 AT6/0:
   Bandwidth:
     Curr allocated: 190K bits/sec
     Max. allowed (total): 112320K bits/sec
     Max. allowed (per flow): 112320K bits/sec
   Neighbors:
     Using IP encap: 1.  Using UDP encaps: 0
   DSCP value used in Path/Resv msgs: 0x30
```

show queueing

To display the current state of the queues, use the **show queueing** EXEC command.

show queueing [**custom | fair | priority | random-detect** [**interface** *serial-number*]]

Syntax Description

custom	(Optional) Shows status of custom queueing list configuration.
fair	(Optional) Shows status of the fair queueing configuration. This is the default.
priority	(Optional) Shows status of priority queueing list configuration.
random-detect	(Optional) Shows status of the weighted random early detection (WRED) and distributed WRED (DWRED) configuration, including configuration of flow-based WRED.
interface *serial-number*	(Optional) Displays the WRED parameters of every virtual circuit (VC) with WRED enabled on the specified serial interface.

Defaults

Fair queueing configuration

Command Modes

EXEC

Command History

Release	Modification
10.3	This command was introduced.

Usage Guidelines

Use the **show queueing** command to verify that RSVP, CBWFQ, and ip rtp priority contact the bandwidth manager. Initiate RSVP flows by using the **ip rsvp sender** and the **ip rsvp reservation** commands and verify that the value in the last line of the following output (available bandwidth) decreases as RSVP flows are admitted.

Note You can observe the changes in interface bandwidth when interface-level WFQ is enabled.

Examples

In the following output, the available bandwidth on the ATM6/0 VC 100/101 interface is 225 kbps:

```
Router# show queueing interface atm6/0
Interface ATM6/0 VC 0/5
  Queueing strategy: fifo
  Output queue 0/40, 0 drops per VC
  Interface ATM6/0 VC 0/16
  Queueing strategy: fifo
  Output queue 0/40, 0 drops per VC
  Interface ATM6/0 VC 100/101
  Queueing strategy: weighted fair
  Total output drops per VC: 0
  Output queue: 0/512/64/0 (size/max total/threshold/drops)
```

```
   Conversations  0/1/32 (active/max active/max total)
   Reserved Conversations 0/0 (allocated/max allocated)
   Available Bandwidth 225 kilobits/sec
Interface ATM6/0 VC 100/201
Queueing strategy: weighted fair
Total output drops per VC: 0
Output queue: 0/512/64/0 (size/max total/threshold/drops)
   Conversations  0/1/32 (active/max active/max total)
   Reserved Conversations 0/1 (allocated/max allocated)
   Available Bandwidth 300 kilobits/sec
```

Admit a flow of 15 kbps on the AT6/0.1 subinterface:

```
Router# show ip rsvp interface
interface    allocated  i/f max  flow max pct UDP  IP   UDP_IP   UDP M/C
AT6/0        15K        116250K  116250K  0   0    0    0        0
AT6/0.1      15K        1250K    1250K    2   0    1    0        0
AT6/0.2      0M         1250K    1250K    0   0    1    0        0
```

Notice that the available bandwidth on the ATM6/0 VC 100/101 interface decreases from 225 kbps to 210 kbps:

```
Router# show queueing interface atm6/0
Interface ATM6/0 VC 0/5
  Queueing strategy: fifo
  Output queue 0/40, 0 drops per VC
  Interface ATM6/0 VC 0/16
  Queueing strategy: fifo
  Output queue 0/40, 0 drops per VC
  Interface ATM6/0 VC 100/101
  Queueing strategy: weighted fair
  Total output drops per VC: 0
  Output queue: 0/512/64/0 (size/max total/threshold/drops)
     Conversations  0/1/32 (active/max active/max total)
     Reserved Conversations 0/0 (allocated/max allocated)
     Available Bandwidth 210 kilobits/sec
  Interface ATM6/0 VC 100/201
  Queueing strategy: weighted fair
  Total output drops per VC: 0
  Output queue: 0/512/64/0 (size/max total/threshold/drops)
     Conversations  0/1/32 (active/max active/max total)
     Reserved Conversations 0/1 (allocated/max allocated)
     Available Bandwidth 300 kilobits/sec
```

Debug Commands

This section describes the **debug** commands that are related to the RSVP support for ATM/PVC feature:

- **debug ip rsvp traffic-control**
- **debug ip rsvp wfq**

Note You can use **debug ip rsvp traffic-control** and **debug ip rsvp wfq** simultaneously. Use the **show debug** command to see which debugging commands are enabled.

debug ip rsvp traffic-control

To display debug messages for traffic control, use the **debug ip rsvp traffic-control** EXEC command. To disable the **debug ip rsvp traffic-control** command, use the **no** form of this command.

[**no**] **debug ip rsvp traffic-control**

Syntax Description

This command has no arguments or keywords.

Defaults

No default behavior or values.

Command History

Release	Modification
12.0	This command was introduced.

Examples

Here is an example of output from the **debug ip rsvp traffic-control** command:

```
Router# debug ip rsvp traffic-control
RSVP debugging is on
Router# show debugging
IP RSVP debugging is on
IP RSVP debugging (Traffic Control events) is on
Router#
```

The following output is from a successful allocation:

```
1w4d:RSVP-TC:Attempting to install QoS for rsb 62E2497C
1w4d:RSVP-TC:Adding new tcsb 0001A801 for rsb 62E2497C
1w4d:RSVP-TC:Assigning WFQ QoS (on ATM VC 100/101) to tcsb 0001A801
1w4d:RSVP-TC:Consulting policy for tcsb 0001A801
1w4d:RSVP-TC:Policy granted QoS for tcsb 0001A801
1w4d:RSVP-TC:Requesting QoS for tcsb 0001A801
1w4d:RSVP-TC:   ( r = 1875       bytes/s   M = 1514       bytes
1w4d:RSVP-TC:     b = 1000       bytes     m = 0          bytes )
1w4d:RSVP-TC:     p = 1875       bytes/s   Service Level = priority
1w4d:RSVP-TC:Allocation succeeded for tcsb 0001A801
```

The following output is from an unsuccessful allocation:

```
1w4d:RSVP-TC:Attempting to install QoS for rsb 62E66A84
1w4d:RSVP-TC:Adding new tcsb 0001EB01 for rsb 62E66A84
1w4d:RSVP-TC:Assigning WFQ QoS (on ATM VC 100/101) to tcsb 0001EB01
1w4d:RSVP-TC:Consulting policy for tcsb 0001EB01
1w4d:RSVP-TC:Policy granted QoS for tcsb 0001EB01
1w4d:RSVP-TC:Requesting QoS for tcsb 0001EB01
1w4d:RSVP-TC:   ( r = 31250      bytes/s   M = 1514       bytes
1w4d:RSVP-TC:     b = 1000       bytes     m = 0          bytes )
1w4d:RSVP-TC:     p = 31250      bytes/s   Service Level = non-priority
1w4d:RSVP-TC:Allocation failed for tcsb 0001EB01
```

Related Commands

Command	Description
show debug	Displays active debug output.

debug ip rsvp wfq

To display debug messages for weighted fair queueing (WFQ), use the **debug ip rsvp wfq** EXEC command. To disable the **debug ip rsvp wfq** command, use the **no** form of this command.

[**no**] **debug ip rsvp wfq**

Syntax Description

This command has no arguments or keywords.

Defaults

No default behavior or values.

Command History

Release	Modification
12.1(3)T	This command was introduced.

Examples

Here is an example of output from the **debug ip rsvp wfq** command:

```
Router# show debugging

Router# debug ip rsvp wfq
RSVP debugging is on
Router# show debugging
IP RSVP debugging is on
IP RSVP debugging (Traffic Control events) is on
IP RSVP debugging (WFQ events) is on
Router#
```

The following output is from a successful allocation with Layer 2 overhead accounting disabled:

```
1w4d:RSVP-TC:Attempting to install QoS for rsb 62E60CD8
1w4d:RSVP-TC:Adding new tcsb 00021C01 for rsb 62E60CD8
1w4d:RSVP-TC:Assigning WFQ QoS (on ATM VC 100/101) to tcsb 00021C01
1w4d:RSVP-TC:Consulting policy for tcsb 00021C01
1w4d:RSVP-TC:Policy granted QoS for tcsb 00021C01
1w4d:RSVP-TC:Requesting QoS for tcsb 00021C01
1w4d:RSVP-TC:    ( r = 1875       bytes/s   M = 1514       bytes
1w4d:RSVP-TC:      b = 1000       bytes     m = 0          bytes )
1w4d:RSVP-TC:      p = 1875       bytes/s   Service Level = priority
1w4d:RSVP-WFQ:Update for tcsb 00021C01 on ATM PVC 100/101 on AT6/0
1w4d:RSVP-WFQ:Admitted 15 kbps of bandwidth
1w4d:RSVP-WFQ:Allocated PRIORITY queue 40
1w4d:RSVP-TC:Allocation succeeded for tcsb 00021C01
```

The following output is from an unsuccessful allocation with Layer 2 overhead accounting disabled:

```
1w4d:RSVP-TC:Attempting to install QoS for rsb 62E66A84
1w4d:RSVP-TC:Adding new tcsb 00024101 for rsb 62E66A84
1w4d:RSVP-TC:Assigning WFQ QoS (on ATM VC 100/101) to tcsb 00024101
1w4d:RSVP-TC:Consulting policy for tcsb 00024101
1w4d:RSVP-TC:Policy granted QoS for tcsb 00024101
1w4d:RSVP-TC:Requesting QoS for tcsb 00024101
1w4d:RSVP-TC:    ( r = 43750      bytes/s   M = 1514       bytes
1w4d:RSVP-TC:      b = 1000       bytes     m = 0          bytes )
1w4d:RSVP-TC:      p = 43750      bytes/s   Service Level = non-priority
```

```
1w4d:RSVP-WFQ:Update for tcsb 00024101 on ATM PVC 100/101 on AT6/0
1w4d:RSVP-WFQ:FAILURE -- 350 kbps of bandwidth unavailable
1w4d:RSVP-TC:Allocation failed for tcsb 00024101
1w4d:RSVP-TC:Deleting tcsb 00024101
```

The following output is from a successful allocation with Layer 2 overhead accounting enabled:

```
2d05h:RSVP-TC:Attempting to install QoS for rsb 63546A94
2d05h:RSVP-TC:Adding new tcsb 0007800A for rsb 63546A94
2d05h:RSVP-TC:Assigning WFQ resource provider (on ifc) to tcsb 0007800A
2d05h:RSVP-TC:Consulting policy for tcsb 0007800A
2d05h:RSVP-TC:Policy granted QoS for tcsb 0007800A
2d05h:RSVP-TC:Requesting QoS for tcsb 0007800A
2d05h:RSVP-TC:    ( r = 2860       bytes/s   M = 52         bytes
2d05h:RSVP-TC:      b = 208        bytes     m = 52         bytes )
2d05h:RSVP-TC:      p = 3146       bytes/s   Service Level = priority
2d05h:RSVP-WFQ:Update for tcsb 0007800A on hw idb Et3/3
2d05h:RSVP-WFQ:Admitted 47 kbps of bandwidth
```

Note The output from the debug commands is similar, regardless of the type of subinterface.

Related Commands

Command	Description
show debug	Displays active debug output.

Glossary

AAL—ATM adaptation layer. AAL defines the conversion of user information into cells. AAL1 and AAL2 handle isochronous traffic, such as voice and video; AAL3/4 and AAL5 pertain to data communications through the segmentation and reassembly of packets.

ABR—Available bit rate. A QoS class defined by the ATM Forum for ATM networks. ABR is used for connections that do not require timing relationships between source and destination. ABR provides no guarantees in terms of cell loss or delay, providing only best-effort service. Traffic sources adjust their transmission rate in response to information they receive describing the status of the network and its capability to successfully deliver data.

admission control—The process in which an RSVP reservation is accepted or rejected based on end-to-end available network resources.

Asynchronous Transfer Mode—See ATM.

ATM—Asynchronous Transfer Mode. A cell-based data transfer technique in which channel demand determines packet allocation. This is an international standard for cell relay in which multiple service types (such as voice, video, or data) are conveyed in fixed-length (53-byte) cells. Fixed-length cells allow cell processing to occur in hardware, thereby reducing transit delays. ATM is designed to take advantage of high-speed transmission media such as E3, SONET, and T3.

available bit rate—See ABR.

bandwidth—The difference between the highest and lowest frequencies available for network signals. This term also describes the rated throughput capacity of a given network medium or protocol.

CBR—Constant bit rate. A QoS class defined by the ATM Forum for ATM networks. CBR is used for connections that depend on precise clocking to ensure undistorted delivery.

CBWFQ—Class-based weighted fair queueing. A queueing mechanism that extends the standard WFQ functionality to provide support for user-defined traffic classes.

Class-based weighted fair queueing—See CBWFQ.

constant bit rate—See CBR.

flow—A stream of data traveling between two endpoints across a network (for example, from one LAN station to another). Multiple flows can be transmitted on a single circuit.

ILMI—Interim Local Management Interface. Described in the ATM Forum's UNI specification, ILMI allows end users to retrieve basic information, such as status and configuration about virtual connections and addresses, for a particular UNI.

Interim Local Management Interface—See ILMI.

latency—The delay between the time a device receives a packet and the time that the packet is forwarded out the destination port.

MUX—A multiplexing device that combines multiple signals for transmission over a single line. The signals are demultiplexed, or separated, at the receiving end.

payload—The portion of a cell, frame, or packet that contains upper-layer information (data).

permanent virtual circuit—See PVC.

point-to-multipoint connection—One of two fundamental connection types. It is a unidirectional connection in which a single source end system (known as a root node) connects to multiple destination end systems (known as leaves).

point-to-point connection—One of two fundamental connection types. It is a unidirectional or bidirectional connection between two end systems.

PQ—Priority queue. A routing feature in which frames in an output queue are assigned priority based on various characteristics such as packet size and interface type.

priority queue—See PQ.

PVC—Permanent virtual circuit or connection. A virtual circuit that is permanently established. PVCs save bandwidth associated with circuit establishment and teardown in situations where certain virtual circuits must exist all the time.

QoS—Quality of service. A measure of performance for a transmission system that reflects its transmission quality and service availability.

quality of service—See QoS.

reservable bandwidth pool—The amount of bandwidth on a link that features can set aside in order to provide QoS guarantees.

Resource Reservation Protocol—See RSVP.

RSVP—Resource Reservation Protocol. A protocol for reserving network resources to provide quality of service guarantees to application flows.

SNAP—Subnetwork Access Protocol. An Internet protocol that operates between a network entity in the subnetwork and a network entity in the end system. SNAP specifies a standard method of encapsulating IP datagrams and ARP messages on IEEE networks. The SNAP entity in the end system makes use of the services of the subnetwork and performs three key functions: data transfer, connection management, and QoS selection.

subnetwork access protocol—See SNAP.

SVC—Switched virtual circuit or connection. A virtual circuit that is dynamically established on demand and is torn down when transmission is complete. SVCs are used in situations where data transmission is sporadic.

switched virtual circuit—See SVC.

variable bit rate—See VBR.

VBR—Variable bit rate. A QoS class defined by the ATM Forum for ATM networks. VBR is subdivided into a real time (RT) class and a non-real time (NRT) class. VBR (RT) is used for connections in which there is a fixed timing relationship between samples. VBR (NRT) is used for connections where there is no fixed timing relationship between samples, but where a guaranteed QoS is still needed.

VC—Virtual circuit. A logical circuit created to ensure reliable communication between two network devices. A virtual circuit can be either permanent (PVC) or switched (SVC).

virtual circuit—See VC.

Voice over IP—See VoIP.

VoIP—Voice over IP. The ability to carry normal telephony-style voice over an IP-based internet maintaining telephone-like functionality, reliability, and voice quality.

weighted fair queueing—See WFQ.

WFQ—Weighted fair queueing. A queue management algorithm that provides a certain fraction of link bandwidth to each of several queues, based on relative bandwidth applied to each of the queues.