

IP to ATM Class of Service

This feature module describes the IP to ATM Class of Service feature. It contains the following sections:

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Feature Overview

The IP to ATM Class of Service feature implements a solution for coarse-grained mapping of QoS characteristics between IP and ATM, using Cisco Enhanced ATM port adapters (PA-A3) on Cisco 7200 and 7500 series routers. (This category of coarse-grained QoS is often referred to as CoS). The resulting feature makes it possible to support differential services in network service provider environments.

IP to ATM CoS is designed to provide a true working solution to class-based services, without the investment of new ATM network infrastructures. Now networks can offer different service classes (sometimes termed *differential service classes*) across the entire WAN, not just the routed portion. Mission-critical applications can be given exceptional service during periods of high network usage and congestion. In addition, noncritical traffic can be restricted in its network usage, which ensures greater QoS for more important traffic and user types.

IP to ATM CoS supports configuration of the following:

- Single ATM virtual circuits (VCs)
- VC bundles

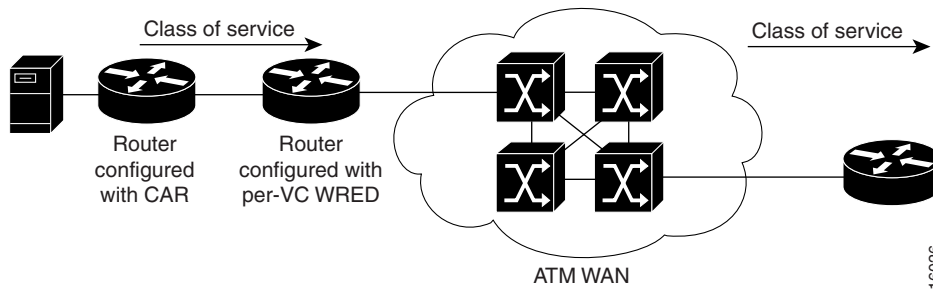
Single ATM VC Support

IP to ATM CoS support for a single ATM VC allows network managers to use existing features, such as committed access rate (CAR) or policy-based routing (PBR) to classify and mark different IP traffic by modifying the IP Precedence field in the IPv4 packet header. Subsequently, Weighted Random Early Detection (WRED) or Distributed WRED (DWRED) can be configured on a per-VC basis so that the IP traffic is subject to different drop probabilities (and therefore priorities) as IP traffic coming into a router competes for bandwidth on a particular VC.

Enhanced ATM port adapters (PA-A3) provide the ability to shape traffic on each VC according to the ATM service category and traffic parameters employed. When you use the IP to ATM CoS feature, congestion is managed entirely at the IP layer by WRED running on the routers at the edge of the ATM network.

Figure 1 illustrates the IP to ATM CoS support for a single ATM VC.

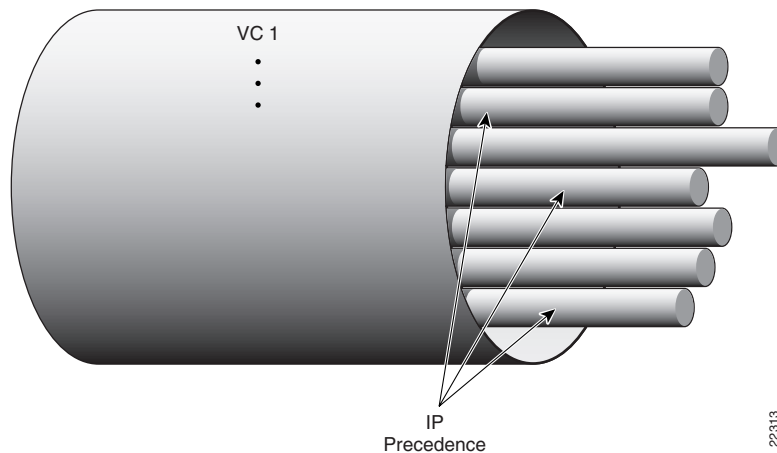
Figure 1 Single ATM Circuit Class



VC Bundle Support and Bundle Management

ATM VC bundle management allows you to configure multiple VCs that have different QoS characteristics between any pair of ATM-connected routers. As shown in Figure 2, these VCs are grouped in a bundle and are referred to as bundle members.

Figure 2 ATM VC Bundle

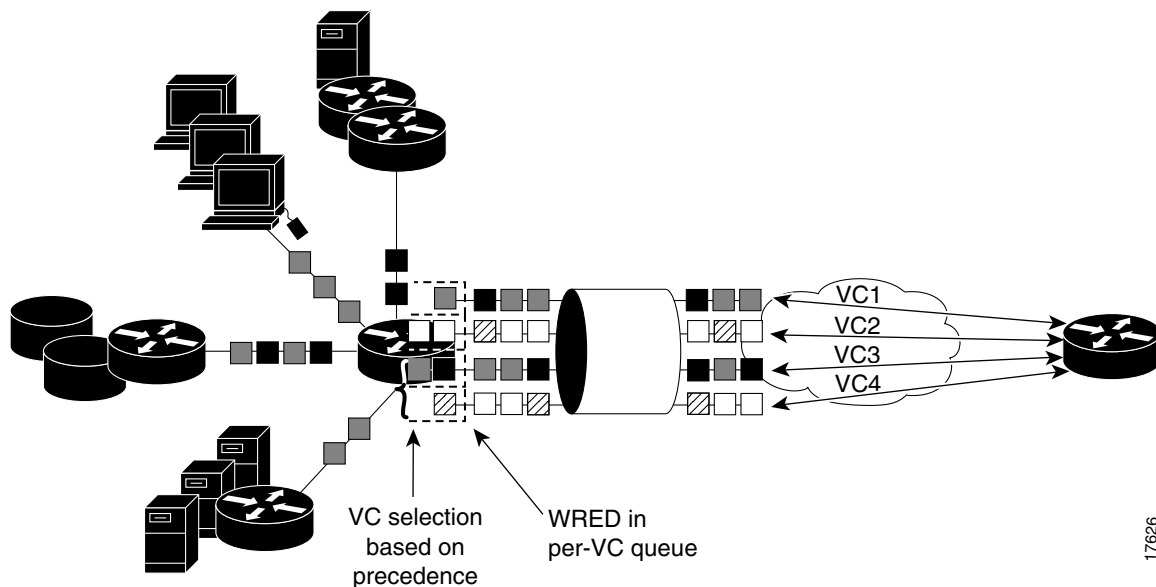


ATM VC bundle management allows you to define an ATM VC bundle and add VCs to it. Each VC of a bundle has its own ATM traffic class and ATM traffic parameters. You can apply attributes and characteristics to discrete VC bundle members or you can apply them collectively at the bundle level.

Using VC bundles, you can create differentiated service by flexibly distributing IP Precedence levels over the different VC bundle members. You can map a single precedence level or a range of levels to each discrete VC in the bundle, thereby enabling individual VCs in the bundle to carry packets marked with different precedence levels. You can use WRED (or DWRED) to further differentiate service across traffic that has different IP Precedence but that uses the same VC in a bundle.

To determine which VC in the bundle to use to forward a packet to its destination, the ATM VC bundle management software matches precedence levels between packets and VCs (see Figure 3). IP traffic is sent to the next hop address for the bundle because all VCs in a bundle share the same destination, but the VC used to carry a packet depends on the value set for that packet in the IP Precedence bits of the type of service (ToS) byte of its header. The ATM VC bundle management software matches the IP Precedence of the packet to the IP Precedence value or range of values assigned to a VC, sending the packet out on the appropriate VC. Moreover, the ATM VC bundle management feature allows you to configure how traffic will be redirected when the VC the packet was matched to goes down. Figure 3 illustrates how the ATM VC bundle management software determines which PVC bundle member to use to carry a packet and how WRED (or DWRED) is used to differentiate traffic on the same VC.

Figure 3 ATM VC Bundle PVC Selection for Packet Transfer



The support of multiple parallel ATM VCs allows you to create stronger service differentiation at the IP layer. For instance, you might want to provide IP traffic belonging to real-time CoS (such as Voice over IP traffic) on an ATM VC with strict constraints (constant bit rate (CBR) or variable bit rate (VBR-rt), for example), while transporting traffic other than real-time traffic over a more elastic ATM available bit rate (ABR) permanent virtual circuit (PVC). Using a configuration such as this would allow you to fully utilize your network capacity. You could also elect to transport best-effort IP traffic over an unspecified bit rate (UBR) PVC—UBR is effectively the ATM version of best-effort service.

Benefits

The benefits of using the IP to ATM CoS feature include the following:

- Ensures effective differential classes over IP and traditional ATM networks. For instance, the VC bundle management feature provides for differentiated QoS by allowing for the coexistence of multiple VCs with different QoS characteristics from the same source to the same destination.
- Uses existing ATM infrastructures.
- Implements solutions for coarse-grained mapping of QoS characteristics called CoS between IP and ATM.
- Employs a high-performance design benefiting from distributed processing on the Cisco 7500 series routers and virtual interface processor (VIP).
- Uses Cisco's advanced PA-A3 ATM port adapter (PA), which supports traffic shaping and has rich ATM Service Category support. This PA is supported on the Cisco 7500+VIP and 7200 series routers.
- Provides per-VC queuing on the PA, per-VC back pressure, and per-VC WRED VIP queuing, which bring stability to a network by ensuring that system packets (such as BGP and ISIS) are never dropped.
- Provides flexible management of the VC bundle on PVC failure.

List of Terms and Acronyms

available bit rate (ABR)—An ATM service category in which the network may instruct sources to reduce their rate during times of congestion.

constant bit rate (CBR)—An ATM service category that aims to emulate a dedicated circuit of a certain fixed bandwidth.

IP Precedence—A 3-bit value in the ToS byte of the IPv4 packet header used by weighted random early detection (WRED) as a drop preference indicator.

permanent virtual circuit (PVC)—A virtual circuit that is permanently established. PVCs save bandwidth associated with circuit establishment and tear down processes in situations where certain virtual circuits must exist all the time. In ATM terminology, called a permanent virtual connection.

port adapter—Media-specific interface PCI daughter card for use on the virtual interface processor (VIP).

Random Early Detection (RED)—An algorithm that, when applied, specifies that a small percentage of packets are to be dropped when congestion is detected, that is, before the queue in question overflows completely.

type of service (ToS)—A byte in IPv4 packet header used, for example, by weighted random early detection (WRED) as a drop preference indicator.

uncommitted bit rate (UBR)—An ATM service category defined by the ATM Forum for best-effort traffic with no traffic-related service guarantees. No ATM traffic-related parameters are specified. A UBR circuit is by definition a best-effort circuit.

variable bit rate (VBR)—An ATM service category in which mean cell rate, peak cell rate, and burst tolerance are specified. A VBR circuit takes precedence over a UBR circuit in the event that there is contention for network resources.

virtual circuit (VC)—A logical circuit created to ensure reliable communication between two network devices. A VC is defined by a VPI/VCI pair, and can be either permanent (PVC) or switched (SVC). In ATM, a virtual circuit is called a virtual channel.

virtual channel identifier (VCI)—16-bit field in the header of an ATM cell. The VCI, together with the VPI, is used to identify the next destination of a cell as it passes through a series of ATM switches on its way to its destination.

Virtual Interface Processor (VIP)—Architecture for intelligent interface processors for the Cisco 7000 series routers. This architecture supports two port adapters, standard packet delivery, and distributed fast switching and feature offload.

virtual path identifier (VPI)—8-bit field in the header of an ATM cell. The VPI, together with the VCI, is used to identify the next destination of a cell as it passes through a series of ATM switches on its way to its destination.

Weighted Random Early Detection (WRED)—A variant of Random Early Detection (RED) in which the probability of a packet being dropped depends on its precedence, as well as other factors in the RED algorithm.

weighted fair queueing (WFQ)—A queueing algorithm that provides a fraction of link bandwidth (constituting the weight) to each of several queues.

Restrictions

Remember the following points when using this feature:

- IP to ATM CoS supports only PVCs.
 - For PVC connections, it supports multipoint and point-to-point subinterfaces.
 - For PVC encapsulations, it supports only aal5snap and aal5mux.
- IP to ATM CoS does not allow point-to-multipoint VCs in the bundle. All VCs share the same source and destination (target) addresses.
- IP to ATM CoS does not work with the ATM Interface Processor (AIP) and the ATM port adapter (PA-A1).

Supported Platforms

The IP to ATM CoS feature is supported on Cisco 2600, Cisco 3600, Cisco 7200, and Cisco 7500 series routers equipped with the following hardware:

- Cisco 7200 series:
 - NPE-200 or higher (NPE-300 recommended for per-VC CBWFQ)
 - One of the following Enhanced ATM port adapters (PA-A3): T3, E3, DS3, or OC-3
- Cisco 7500 series:
 - VIP2-50
 - One of the following Enhanced ATM port adapters (PA-A3): T3, E3, DS3, or OC-3
- Cisco 2600 and Cisco 3600 series:
 - One of the following port adapters: ATM OC-3, T1 IMA, E1 IMA

Prerequisites

The IP to ATM CoS feature requires ATM PVC management and Cisco Express Forwarding (CEF) switching functionality.

Supported MIBs and RFCs

None

Functional Description

This section gives a broad overview of the IP to ATM CoS feature. It includes the following topics:

- Why Use IP to ATM CoS?
- IP to ATM CoS Features
- Congestion Avoidance

Why Use IP to ATM CoS?

Internet service classes can be identified and sorted within the router network. But as traffic traverses the wide-area ATM fabric, the relative ATM class definitions are not equivalent, and a traffic type may be treated differently in the ATM switching fabric than in the router network; mission-critical applications or data could be dropped during times of network congestion.

The IP to ATM Cos feature uses the Cisco Enhanced ATM port adapter (PA-A3) on Cisco 7500 and Cisco 7200 series routers to provide the ability to map IP CoS and ATM QoS, extending the capability previously available only for IP networks; differentiated services are preserved through the ATM network.

IP to ATM CoS Features

IP to ATM CoS includes the following features:

- Per-VC queueing infrastructure
This feature enables queues to be maintained on a per-VC basis. Packets are queued and dequeued based on the back pressure from the PA. Use of a queue per VC prevents one or more congested VCs from affecting the traffic flow on other VCs that are not congested.
- Per-VC WRED (or DWRED)
This feature applies the WRED algorithm independently to each per-VC queue. The WRED parameters are configurable on a per-VC basis so that congestion management can be configured as appropriate for each VC.
- Per-VC WRED (or DWRED) statistics
This feature maintains per-flow and per-VC statistics based on IP Precedence.

Congestion Avoidance

For each VC that is created on the Enhanced ATM port adapter (PA-A3), the PA allocates some of the buffers from its buffer pool to that VC in order to create a queue for that VC.

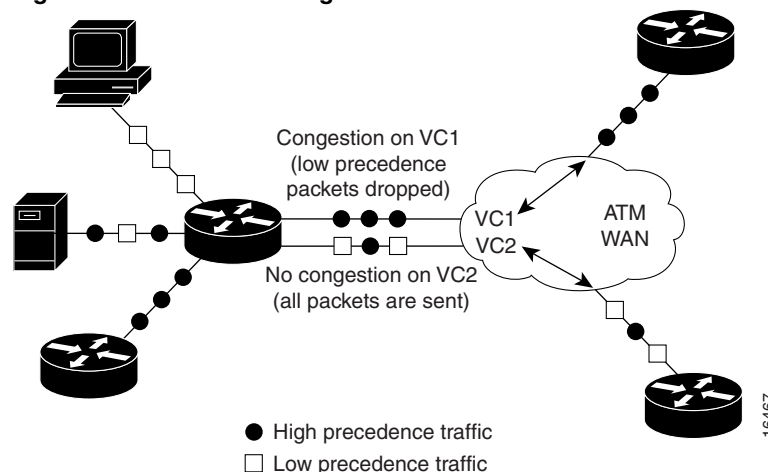
The use of per-VC queues ensures that a direct relationship exists between the outgoing ATM VC and the IP packets to be forwarded on that queue. This mechanism establishes a packet queue for each outgoing ATM VC. In this manner, should an ATM VC become congested, only the packet queue associated with that VC will begin to fill. If the queue overfills, then all other queues remain unaffected. Such a mechanism ensures that an individual VC cannot consume all of the resources of the router should only one of its outgoing VCs be congested or underprovisioned.

Queues for buffering more packets for a particular VC are created in the Layer 3 processor system and are mapped one-to-one to the per-VC queues on the PA. When the PA per-VC queues become congested, they signal back pressure to the Layer 3 processor; the Layer 3 processor can then continue to buffer packets for that VC in the corresponding Layer 3 queue. Furthermore, because the Layer 3 queues are accessible by the Layer 3 processor, a user can run flexible software scheduling algorithms on those queues.

When you transport data over ATM fabrics, it is essential that decisions to discard data (because of insufficient network resources or congestion) be made at the packet level. To do otherwise would be to send incomplete data packets into the ATM fabric, causing the packets to be discarded by either the ATM switched fabric (if it is equipped with early packet discard) or at the remote end where the packet will be reassembled and found to be incomplete.

To initiate effective congestion management techniques, IP to ATM CoS uses per-VC WRED (or DWRED). Per-VC WRED (or DWRED) selectively places TCP sessions in slow start to ensure higher aggregate throughput under congestion. Figure 4 shows low priority packets being dropped on VC1 because VC1 is congested. In this example, VC2 is not congested and all packets, regardless of priority, are transmitted.

Figure 4 Traffic Congestion with IP to ATM CoS and Per-VC WRED



Running the WRED algorithm independently on each per-VC queue provides differentiated QoS to traffic of different IP Precedence values.

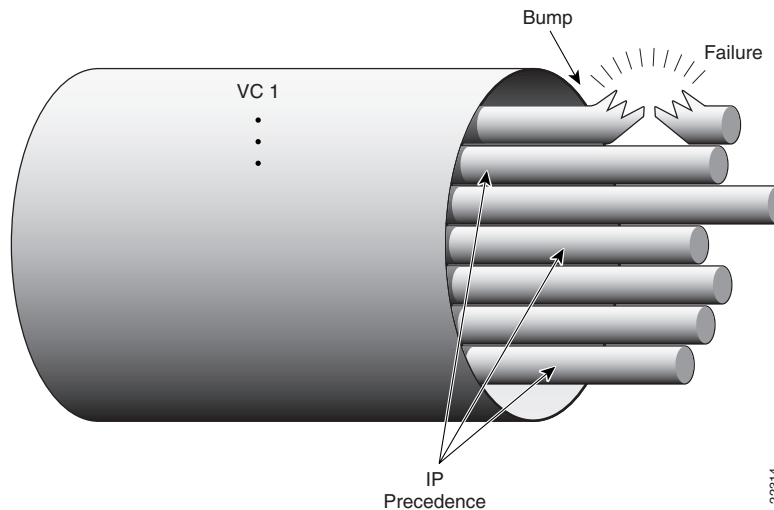
Bumping and ATM VC Bundles

The ATM VC bundle is designed to behave as a single routing link to the destination router while managing the integrity of its group of circuits. The integrity of each circuit is maintained through individual monitoring. Should a circuit fail, appropriate action is taken, in the form of circuit bumping or bundle disabling.

VC integrity is maintained through ATM Operation, Administration, and Maintenance (OAM) polling mechanisms. These mechanisms will determine whether a VC is unavailable or severely congested. Should an individual circuit become unavailable, then the device consults a preset series of rules to determine what course of action to take next. These rules are defined by the Internet service provider (ISP) through configuration parameters.

Figure 5 conceptualizes a failed VC bundle member whose failure calls into effect the configured bumping rules.

Figure 5 VC Bundle Member Circuit Failure Enacting Bumping Rules



In the event of failure, the router responds with one of two methods. The first method dynamically assigns the traffic bound on the failed VC to an alternative VC. This is termed *circuit bumping*. Bumped traffic is then shared on an existing in-service VC. Traffic typically would be bumped from a higher class to a lower one, although it does not have to be. For example, should the premium, or first class, data circuit become unavailable, then all premium users would share the second class or general circuit. Preference would then be given to the premium traffic within this shared circuit.

The second method is to declare all circuits of the bundle to be down. In effect, the device is declaring the routed bundle inactive and asking the routing layer to search for an alternate.

The determination of whether to bump or whether to declare the bundle inactive is predefined by the network provider when administering the network configuration.

Configuration Tasks

You can configure IP to ATM CoS on either a single ATM VC, or on an ATM bundle. To configure IP to ATM CoS on a single ATM VC, perform the tasks in the following sections.

To configure IP to IP to ATM CoS on an ATM bundle, perform the tasks in the “Configuring IP to ATM CoS on an ATM Bundle” section later in this document.

Configuring IP to ATM CoS on a Single ATM VC

To configure IP to ATM CoS for a single ATM VC, perform the tasks in the following sections. The first two sections are required; the remaining sections are optional.

- Defining the WRED Parameter Group (Required)
- Configuring the WRED Parameter Group (Required)
- Displaying the WRED Parameters (Optional)
- Displaying the Queuing Statistics (Optional)

Defining the WRED Parameter Group

To define the Weighted Random Early Detection (WRED) parameter group, use the following command in global configuration mode:

Command	Purpose
random-detect-group <i>group-name</i>	Defines the WRED or VIP-Distributed WRED (DWRED) parameter group.

Configuring the WRED Parameter Group

To configure the exponential weight factor for the average queue size calculation for a WRED parameter group or to configure a WRED parameter group for a particular IP precedence, use the following commands beginning in global configuration mode:

Step	Command	Purpose
1	random-detect-group <i>group-name</i>	Specifies the WRED or DWRED parameter group.
2	exponential-weighting-constant <i>exponent</i> or precedence <i>precedence min-threshold max-threshold mark-probability-denominator</i>	Configures the exponential weight factor for the average queue size calculation for the specified WRED or DWRED parameter group. or Configures the specified WRED or DWRED parameter group for a particular IP Precedence.

Displaying the WRED Parameters

To display the configured WRED parameters, use the following command in privileged EXEC mode:

Command	Purpose
show queuing random-detect [<i>interface atm_subinterface</i> [<i>vc</i> [[<i>vpi</i>] <i>vci</i>]]]	Displays the parameters of every virtual circuit (VC) with WRED or DWRED enabled on the specified ATM subinterface.

Displaying the Queueing Statistics

To display the queuing statistics of an interface, use the following command in privileged EXEC mode:

Command	Purpose
show queuing interface <i>interface-number</i> [<i>vc</i> [[<i>vpi</i>] <i>vci</i>]]	Displays the queuing statistics of a specific VC on an interface.

Configuring IP to ATM CoS on an ATM Bundle

To configure IP to ATM CoS an ATM PVC bundle, perform the tasks in the following sections. The first four sections are required; the remaining sections are optional.

- Creating a VC Bundle (Required)
- Applying Bundle-Level Parameters (Required)
 - Configuring the Bundle-Level Parameters
 - Configuring VC Class Parameters to Apply to a Bundle
 - Attaching a Class to a Bundle
- Committing a VC to a Bundle (Required)
- Applying Parameters to Individual VCs (Required)
 - Configuring a VC Bundle Member Directly
 - Configuring VC Class Parameters to Apply to a VC Bundle Member
 - Applying a VC Class to a Discrete VC Bundle Member
- Configuring a VC Not to Accept Bumped Traffic (Optional)
- Monitoring and Maintaining VC Bundles and Their VC Members (Optional)

The IP to ATM CoS feature requires ATM PVC management and CEF switching functionality.

Creating a VC Bundle

To create a bundle and enter bundle configuration mode in which you can assign attributes and parameters to the bundle and all of its member VCs, use the following command in subinterface configuration mode:

Command	Purpose
bundle <i>bundle-name</i>	Creates the specified bundle and enters bundle configuration mode.

Applying Bundle-Level Parameters

Bundle-level parameters can be applied either by assigning VC classes or by directly applying them to the bundle.

Parameters applied through a VC class assigned to the bundle are superseded by those applied at the bundle level. Bundle-level parameters are superseded by parameters applied to an individual VC.

Configuring the Bundle-Level Parameters

Configuring the bundle-level parameters is optional if a class is attached to the bundle to configure it.

To configure parameters that apply to the bundle and all of its members, use the following commands in bundle configuration mode:

Command	Purpose
protocol <i>protocol</i> { <i>protocol-address</i> inarp } [[no] broadcast]	Configures a static map or enables Inverse Address Resolution Protocol (Inverse ARP) or Inverse ARP broadcasts for the bundle.
encapsulation <i>aal-encap</i>	Configures the ATM adaptation layer (AAL) and encapsulation type for the bundle.
inarp <i>minutes</i>	Configures the Inverse ARP time period for all VC bundle members.
broadcast	Enables broadcast forwarding for all VC bundle members.
oam retry <i>up-count down-count retry frequency</i>	Configures the VC bundle parameters related to OAM management.
oam-bundle [manage] [<i>frequency</i>]	Enables end-to-end F5 OAM loopback cell generation and OAM management for all VCs in the bundle.

Configuring VC Class Parameters to Apply to a Bundle

Use of a VC class allows you to configure a bundle applying multiple attributes to it at once because you apply the class itself to the bundle. Use of a class allows you to generalize a parameter across all VCs, after which (for some parameters) you can modify that parameter for individual VCs. (See the section “Applying Parameters to Individual VCs” for more information.)

To configure a VC class to contain commands that configure all VC members of a bundle when the class is applied to that bundle, use the following command in *vc-class* configuration mode. To enter *vc-class* configuration mode, use the **vc-class atm** command.

Command	Purpose
oam-bundle [manage] [<i>frequency</i>]	Enables end-to-end F5 OAM loopback cell generation and OAM management for all VCs in the bundle.

In addition to these commands, you can add the following commands to a VC class to be used to configure a bundle: **broadcast**, **encapsulation**, **inarp**, **oam**, and **protocol** commands. For information on these commands, including configuration tasks and command syntax, refer to the *Cisco IOS Wide-Area Networking Configuration Guide* and the *Cisco IOS Wide-Area Networking Command Reference*.

Attaching a Class to a Bundle

To attach a preconfigured VC class containing bundle-level configuration commands to a bundle, use the following command in bundle configuration mode:

Command	Purpose
class <i>vc-class-name</i>	Configures a bundle with the bundle-level commands contained in the specified VC class.

Parameters set through bundle-level commands contained in the VC class are applied to the bundle and all of its VC members. Bundle-level parameters applied through commands configured directly on the bundle supersede those applied through a VC class.

Note that some bundle-level parameters applied through a VC class or directly to the bundle can be superseded by commands that you directly apply to individual VCs in bundle-vc configuration mode.

Committing a VC to a Bundle

To add a VC to an existing bundle and enter bundle-vc configuration mode, use the following command in bundle configuration mode:

Command	Purpose
pvc-bundle <i>pvc-name</i> [vpi] [vci]	Adds the specified VC to the bundle and enters bundle-vc configuration mode in order to configure the specified VC bundle member.

For information on how to first create the bundle and configure it, see the sections “Creating a VC Bundle” and “Configuring VC Class Parameters to Apply to a Bundle” earlier in this feature module.

Applying Parameters to Individual VCs

Parameters can be applied to individual VCs either by using VC classes or by directly applying them to the bundle members.

Parameters applied to an individual VC supersede bundle-level parameters. Parameters applied directly to a VC take precedence over the same parameters applied within a class to the VC at the bundle-vc configuration level.

Configuring a VC Bundle Member Directly

Configuring VC bundle members directly is optional if a VC class is attached to the bundle member.

To configure an individual VC bundle member directly, use the following command in bundle-vc configuration mode:

Command	Purpose
ubr <i>output-pcr</i> [<i>input-pcr</i>]	Configures the VC for UBR QoS and specify the output peak cell rate for it.
ubr+ <i>output-pcr output-mcr</i> [<i>input-pcr</i>] [<i>input-mcr</i>]	Configures the VC for UBR QoS and specifies the output PCR and output minimum guaranteed cell rate for it.

Command	Purpose
vbr-nrt <i>output-pcr output-scr output-mbs</i> <i>[input-pcr] [input-scr] [input-mbs]</i>	Configures the VC for variable bit rate nonreal time (VBR-NRT) QoS and specify the output PCR, output sustainable cell rate, and output maximum burst cell size for it.
precedence [other <i>range</i>]	Configures the precedence levels for the VC.
bump { implicit explicit <i>precedence-level</i> traffic }	Configures the bumping rules for the VC.
protect { group vc }	Configures the VC to belong to the bundle's protected group or to be an individually protected VC bundle member.

Parameters set directly for a VC at the bundle-vc configuration level take precedence over values for these parameters set for the VC at any other level, including application of a VC class at the bundle-vc configuration level.

Configuring VC Class Parameters to Apply to a VC Bundle Member

To configure a VC class to contain commands that configure a specific VC member of a bundle when the class is applied to it, use the following commands in VC-class configuration mode. To enter vc-class configuration mode, use the **vc-class atm** command in global configuration mode.

Command	Purpose
bump { implicit explicit <i>precedence-level</i> traffic }	Configures the bumping rules for the VC.
precedence <i>precedence min-threshold</i> <i>max-threshold</i> <i>mark-probability-denominator</i>	Defines precedence levels for the VC member of the bundle to which the class is applied.
protect { group vc }	Configures the VC as a member of the bundle's protected group or as an individually protected VC.

You can also add the following commands to a VC class to be used to configure a VC bundle member: **ubr+** and **vbr-nrt**.

Use of a VC class allows you to configure a VC bundle member with multiple attributes at once because you can apply the class to the VC.

Note When a VC is a member of a VC bundle, the following commands cannot be used in vc-class mode to configure the VC: **encapsulation**, **protocol**, **inarp**, and **broadcast**. These commands are useful only at the bundle level, not the bundle member level.

Applying a VC Class to a Discrete VC Bundle Member

To attach a preconfigured VC class containing bundle-level configuration commands to a bundle, use the following command in bundle configuration mode:

Command	Purpose
class <i>vc-class-name</i>	Assign a VC class to a VC bundle member.

Parameters that configure a VC that are contained in a VC class assigned to that VC are superseded by parameters that are directly configured for the VC through discrete commands entered in bundle-vc configuration mode.

Configuring a VC Not to Accept Bumped Traffic

To configure an individual VC bundle member not to accept traffic that otherwise might be directed to it if the original VC carrying the traffic goes down, use the following command in bundle-vc configuration mode:

Command	Purpose
no bump traffic	Configures the VC not to accept any bumped traffic that would otherwise be redirected to it.

Monitoring and Maintaining VC Bundles and Their VC Members

To gather information on bundles so as to monitor them or to troubleshoot problems that pertain to their configuration or use, use one or more of the following commands in privileged EXEC mode or debug mode:

Command	Purpose
show atm bundle <i>bundle-name</i>	Displays the bundle attributes assigned to each bundle VC member and the current working status of the VC members.
show atm bundle <i>bundle-name</i> statistics [detail]	Displays statistics or detailed statistics on the specified bundle.
show atm map	Displays a list of all configured ATM static maps to remote hosts on an ATM network and on ATM bundle maps.
debug atm bundle errors	Prints information on bundle errors.
debug atm bundle events	Prints a record of bundle events.

Configuration Examples

This section provides the following configuration examples:

- Single ATM VC with WRED Group and IP Precedence Example
- VC Bundle Configuration Using a VC Class Example

Single ATM VC with WRED Group and IP Precedence Example

The following example creates a PVC on an ATM interface and applies the WRED parameter group sanjose to that PVC. Next, the IP Precedence values are configured for the WRED parameter group sanjose.

```

interface ATM1/1/0.46 multipoint
 ip address 200.126.186.2 255.255.255.0
 no ip mroute-cache
 shutdown
 pvc cisco 46
 encapsulation aal5nlpid
 random-detect attach sanjose
 !
 random-detect-group sanjose
 precedence 0 200 1000 10
 precedence 1 300 1000 10
 precedence 2 400 1000 10
 precedence 3 500 1000 10
 precedence 4 600 1000 10
 precedence 5 700 1000 10
 precedence 6 800 1000 10
 precedence 7 900 1000 10
 !

```

VC Bundle Configuration Using a VC Class Example

This example configures VC bundle management on a router that uses Intermediate System-to-Intermediate System (IS-IS) as its IP routing protocol.

Bundle-Class Class

At the outset, this configuration defines a VC class called bundle-class that includes commands that set VC parameters. When the class bundle-class is applied at the bundle level, these parameters are applied to all VCs that belong to the bundle. Note that any commands applied directly to an individual VC of a bundle in bundle-vc mode take precedence over commands applied globally at the bundle level. Taking into account hierarchy precedence rules, VCs belonging to any bundle to which the class bundle-class is applied will be characterized by these parameters: aal5snap encapsulation, broadcast on, use of Inverse ARP to resolve IP addresses, and OAM enabled.

```

router isis
 net 49.0000.0000.0000.1111.00

vc-class atm bundle-class
 encapsulation aal5snap
 broadcast
 protocol ip inarp
 oam-bundle manage 3
 oam 4 3 10

```

Control-Class Class

The following sections of the configuration define VC classes that contain commands specifying parameters that can be applied to individual VCs in a bundle by assigning the class to that VC.

When the class control-class is applied to a VC, the VC carries traffic whose IP Precedence level is 7. When the VC to which this class is assigned goes down, it takes the bundle down with it because this class makes the VC a protected one. The QoS type of a VC using this class is vbr-nrt.

```
vc-class atm control-class
  precedence 7
  protect vc
  vbr-nrt 1000 5000 32
```

Premium-Class Class

When the class premium-class is applied to a VC, the VC carries traffic whose IP Precedence level is 6 and 5. The VC does not allow other traffic to be bumped onto it. When the VC to which this class is applied goes down, its bumped traffic will be redirected to a VC whose IP Precedence level is 7. This class makes a VC a member of the protected group of the bundle. When all members of a protected group go down, the bundle goes down. The QoS type of a VC using this class is vbr-nrt.

```
vc-class atm premium-class
  precedence 6-5
  no bump traffic
  protect group
  bump explicitly 7
  vbr-nrt 20000 10000 32
```

Priority-Class Class

When the class priority-class is applied to a VC, the VC is configured to carry traffic with IP Precedence in the 4-2 range. The VC uses the implicit bumping rule, it allows traffic to be bumped, and it belongs to the bundle's protected group. The QoS type of a VC using this class isubr+.

```
vc-class atm priority-class
  precedence 4-2
  protect group
  ubr+ 10000 3000
```

Basic-Class Class

When the class basic-class is applied to a VC, the VC is configured through the **precedence other** command to carry traffic with IP Precedence levels not specified in the profile. The VC using this class belongs to the bundle's protected group. The QoS type of a VC using this class isubr.

```
vc-class atm basic-class
  precedence other
  protect group
  ubr 10000
```

The following sets of commands configure three bundles that the router subinterface uses to connect to three of its neighbors. These bundles are called new-york, san-francisco, and los-angeles. Bundle new-york has four VC members, bundle san-francisco has four VC members, and bundle los-angeles has three VC members.

New-York Bundle

The first part of this example specifies the IP address of the subinterface, the router protocol—the router uses IS-IS as an IP routing protocol, and it creates the first bundle called new-york and enters bundle configuration mode.

```
int a1/0.1 multipoint
  ip address 10.0.0.1 255.255.255.0
  ip router isis
  bundle new-york
```

From within bundle configuration mode, the next portion of the configuration uses two protocol commands to enable IP and Open Systems Interconnect (OSI) traffic flows in the bundle. The OSI routing packets will use the highest precedence VC in the bundle. The OSI data packets, if any, will use the lowest precedence VC in the bundle. If configured, other protocols, such as IPX or AppleTalk, will always use the lowest precedence VC in the bundle.

As the indentation levels of the preceding and following commands suggest, subordinate to bundle new-york is a command that configures its protocol and a command that applies the class bundle-class to it.

```
protocol ip 1.1.1.2 broadcast
protocol clns 49.0000.0000.2222.00 broadcast
class bundle-class
```

The class called bundle-class, which is applied to the bundle new-york, includes a **protocol ip inarp** command. According to inheritance rules, **protocol ip**, configured at the bundle level, takes precedence over **protocol ip inarp** specified in the class bundle-class.

The next set of commands beginning with `pvc-bundle ny-control 207`, which are further subordinate, add four VCs (named ny-control, ny-premium, ny-priority, and ny-basic) to the bundle new-york. A particular class—that is, one of the classes predefined in this configuration example—is applied to each VC to configure it with parameters specified by commands included in the class.

As is the case for this configuration, to configure individual VCs belonging to a bundle, the router must be in bundle mode for the mother bundle. For each VC belonging to the bundle, the subordinate mode is pvc-mode for the specific VC.

The following commands configure the individual VCs for the bundle new-york.

```
pvc-bundle ny-control 207
  class control-class
pvc-bundle ny-premium 206
  class premium-class
pvc-bundle ny-priority 204
  class priority-class
pvc-bundle ny-basic 201
  class basic-class
```

San-Francisco Bundle

The following set of commands create and configure a bundle called san-francisco. At the bundle configuration level, the configuration commands included in the class bundle-class are ascribed to the bundle san-francisco and to the individual VCs that belong to the bundle. Then, the **pvc-bundle** command is executed for each individual VC to add it to the bundle. After a VC is added and bundle-vc configuration mode is entered, a particular, preconfigured class is assigned to the VC. The configuration commands comprising that class are used to configure the VC. Rules of hierarchy

apply at this point. Command parameters contained in the applied class are superseded by same parameters applied at the bundle configuration level, which are superseded by same parameters applied directly to a VC.

```
bundle san-francisco
  protocol clns 49.0000.0000.0000.333.00 broadcast
  inarp 1
  class bundle-class
  pvc-bundle sf-control 307
    class control-class
  pvc-bundle sf-premium 306
    class premium-class
  pvc-bundle sf-priority 304
    class priority-class
  pvc-bundle sf-basic 301
    class basic-class
```

Los-Angeles Bundle

The following set of commands create and configure a bundle called los-angeles. At the bundle configuration level, the configuration commands included in the class bundle-class are ascribed to the bundle los-angeles and to the individual VCs that belong to the bundle. Then, the **pvc-bundle** command is executed for each individual VC to add it to the bundle. After a VC is added and bundle-vc configuration mode is entered, precedence is set for the VC and the VC is either configured as a member of a protected group (protect group) or as an individually protected VC. A particular class is then assigned to each VC to further characterize it. Rules of hierarchy apply. Parameters of commands applied directly and discretely to a VC take precedence over the same parameters applied within a class to the VC at the bundle-vc configuration level, which take precedence over the same parameters applied to the entire bundle at the bundle configuration level.

```
bundle los-angeles
  protocol ip 1.1.1.4 broadcast
  protocol clns 49.0000.0000.4444.00 broadcast
  inarp 1
  class bundle-class
  pvc-bundle la-high 407
    precedence 7-5
    protect vc
    class premium-class
  pvc-bundle la-mid 404
    precedence 4-2
    protect group
    class priority-class
  pvc-bundle la-low 401
    precedence other
    protect group
    class basic-class
```

Command Reference

This section documents new or modified commands. All other commands used with this feature are documented in the Cisco IOS Release 12.1 command reference publications.

- **atm pvc**
- **broadcast**
- **bump**
- **bundle**
- **class**
- **debug atm bundle errors**
- **debug atm bundle events**
- **encapsulation**
- **exponential-weighting-constant**
- **inarp**
- **oam-bundle**
- **oam retry**
- **precedence (VC bundle)**
- **precedence (WRED group)**
- **protect**
- **protocol**
- **pvc**
- **pvc-bundle**
- **random-detect**
- **random-detect-group**
- **show atm bundle**
- **show atm bundle statistics**
- **show atm map**
- **show queueing interface**
- **show queueing red**
- **ubr**
- **ubr+**
- **vbr-nrt**

atm pvc

To create a permanent virtual circuit (PVC) on an ATM interface and, optionally, to generate Operation, Administration, and Maintenance (OAM) F5 loopback cells or enable Inverse ATM ARP, use the **atm pvc** interface configuration command. To apply a WRED parameter group to the created PVC, specify the **random-detect** keyword and *group-name* argument. The **no** form of this command removes the specified PVC.

Note This command is currently supported, but it will be obsoleted in the near future. We recommend that you use the new **pvc** command followed by the **encapsulation** and **random-detect attach** commands instead of the **atm pvc** command. See “pvc” on page 56 and “random-detect” on page 61 for more information.

```

atm pvc vcd vpi vci aal-encap [[midlow midhigh] [peak average [burst]]] [inarp [minutes]]
    [oam [seconds] [random-detect [group-name]]]
no atm pvc vcd vpi vci aal-encap [[midlow midhigh] [peak average [burst]]] [inarp [minutes]]
    [oam [seconds]] [random-detect [group-name]]
    
```

Syntax Description

<i>vcd</i>	Virtual circuit descriptor. A unique number that identifies to the processor which VPI-VCI pair to use for a particular packet. Valid values range from 1 to the value set with the atm maxvc command. The AIP or ATM port adapter requires this feature to manage packet transmission. The <i>vcd</i> value is not associated with the VPI-VCI pair used for the ATM network cells. The NPM has a hard coded max <i>vcd</i> value of 1023.
<i>vpi</i>	<p>ATM network virtual path identifier (VPI) of this PVC. On the Cisco 7200 and 7500 series routers, this value ranges from 0 to 255; on the Cisco 4500 and Cisco 4700 series, this value ranges from 0 to 1 less than the quotient of 8192 divided by the value set by the atm vc-per-vp command.</p> <p>The VPI is an 8-bit field in the header of the ATM cell. The VPI value is unique only on a single link, not throughout the ATM network, because it has local significance only. The VPI value must match that of the switch.</p> <p>The arguments <i>vpi</i> and <i>vci</i> cannot both be set to 0; if one is 0, the other cannot be 0.</p>
<i>vci</i>	<p>ATM network virtual channel identifier (VCI) of this PVC, in the range of 0 to 1 less than the maximum value set for this interface by the atm vc-per-vp command. Typically, lower values 0 to 31 are reserved for specific traffic (for example, F4 OAM, SVC signaling, ILMI, and so on) and should not be used.</p> <p>The VCI is a 16-bit field in the header of the ATM cell. The VCI value is unique only on a single link, not throughout the ATM network, because it has local significance only.</p> <p>The arguments <i>vpi</i> and <i>vci</i> cannot both be set to 0; if one is 0, the other cannot be 0.</p>

<i>aal-encap</i>	<p>ATM adaptation layer (AAL) and encapsulation type. When the aal5mux keyword is specified, a protocol is required. Possible values are as follows:</p> <ul style="list-style-type: none"> • aal34smds—Encapsulation for SMDS networks. This option is supported on the AIP and is not available for the ATM port adapter. • aal5nlpid—Encapsulation that allows ATM interfaces to interoperate with High-Speed Serial Interfaces (HSSIs) that are using an ATM data service unit (ADSU) and running ATM-Data Exchange Interface (DXI). • aal5mux apollo—A multiplex (MUX)-type virtual circuit. • aal5mux appletalk—A MUX-type virtual circuit. • aal5mux decnet—A MUX-type virtual circuit. • aal5mux ip—A MUX-type virtual circuit. • aal5mux ipx—A MUX-type virtual circuit. • aal5mux vines—A MUX-type virtual circuit. • aal5mux xns—A MUX-type virtual circuit. • aal5snap—Logical Link Control/Subnetwork Access Protocol (LLC/SNAP) precedes the protocol datagram. This is the only encapsulation supported for Inverse ARP. • ilmi—Used to set up communication with the ILMI; the associated <i>vpi</i> and <i>vci</i> values are ordinarily 0 and 16, respectively. • qsaal—A signaling-type PVC used for setting up or tearing down SVCs; the associated <i>vpi</i> and <i>vci</i> values are ordinarily 0 and 5, respectively.
<i>midlow</i>	<p>(Set for the aal34smds encapsulation only) (Optional) Starting message identifier (MID) number for this PVC. The default is 0. If you set the <i>peak</i> and <i>average</i> (<i>burst</i> is optional) values for aal34smds encapsulation, you must also set the <i>midlow</i> and <i>midhigh</i> values.</p> <p>This option is not available for the ATM port adapter.</p>
<i>midhigh</i>	<p>(Set for the aal34smds encapsulation only) (Optional) Ending MID number for this PVC. The default is 0. If you set the <i>peak</i> and <i>average</i> (<i>burst</i> is optional) values for aal34smds encapsulation, you must also set the <i>midlow</i> and <i>midhigh</i> values.</p> <p>This option is not available for the ATM port adapter.</p>
<i>peak</i>	<p>(Optional) Maximum rate (in kbps) at which this virtual circuit can transmit. Valid values are in the range from 1 to the maximum rate set for a rate queue. If you set this value, you must also specify the <i>average</i> (<i>burst</i> is optional) value. If you set the <i>peak</i> and <i>average</i> values for aal34smds encapsulation, you must also set the <i>midlow</i> and <i>midhigh</i> values.</p> <p>This option is not available for the ATM port adapter. It is available on the Enhanced ATM port adapter (PA-A3).</p>

<i>average</i>	<p>(Optional) Average rate (in kbps) at which this virtual circuit transmits. Valid values are platform dependent. If you set this value, you must also specify the <i>peak</i> (<i>burst</i> is optional) value. If you set the <i>peak</i> and <i>average</i> values for aal34smds encapsulation, you must also set the <i>midlow</i> and <i>midhigh</i> values.</p> <p>This option is not available for the ATM port adapter. It is available on the Enhanced ATM port adapter (PA-A3).</p>
<i>burst</i>	<p>(Optional) Value that relates to the maximum number of ATM cells the virtual circuit can transmit to the network at the <i>peak</i> rate of the PVC. On the AIP, the actual burst cells equals <i>burst</i> * 32 cells, thereby allowing for a burst size of 32 cells to 2016 cells. On the ATMZR the value is not multiplied. If you set this value, you must also specify a value for the <i>peak</i> and <i>average</i> values.</p> <p>On the AIP, <i>burst</i> can range from 1 to 63</p> <p>On the ATMZR, <i>burst</i> can range from 1 to 65535</p> <p>This option is not available for the ATM port adapter. It is available on the Enhanced ATM port adapter (PA-A3).</p>
inarp <i>minutes</i>	<p>(Set for the aal5snap encapsulation only) (Optional) Specifies how often inverse ARP datagrams are sent on this virtual circuit. The default value is 15 minutes.</p>
oam <i>seconds</i>	<p>(Optional) Specifies how often to generate an OAM F5 loopback cell from this virtual circuit. The default value is 10 seconds.</p>
random-detect <i>group-name</i>	<p>(Set for the IP to ATM Cos feature only.) (Optional) Specifies that the WRED algorithm should be applied to this PVC. If the <i>group-name</i> argument is omitted or no name match is found in the current configuration for the specified <i>group-name</i>, a set of default WRED parameters are applied to the PVC.</p> <p>Configuring a PVC without the random-detect keyword turns WRED off for the PVC.</p>

Defaults

If *peak* and *average* rate values are omitted, the PVC defaults to peak and average rates equal to the link rate. The peak and average rates are then equal. By default, the virtual circuit is configured to run as fast as possible.

The default of both the *midlow* and *midhigh* values is 0.

If the **oam** keyword is omitted, OAM cells are not generated. If the **oam** keyword is present but the *seconds* value is omitted, the default value of **oam seconds** is 10 seconds.

If the **inarp** keyword is omitted, inverse ARPs are not generated. If the **inarp** keyword is present, but the timeout value is not given, then inverse ARPs are generated every 15 minutes.

When the **random-detect** keyword is used, if the *group-name* argument is omitted or no name match is found in the current configuration for the specified *group-name*, a set of default WRED parameters are applied to the PVC.

If the **random-detect** keyword is omitted, WRED is turned off for the PVC.

Command Mode

Interface configuration

Usage Guidelines

This command first appeared in Cisco IOS Release 10.0. The *midlow* and *midhigh* arguments first appeared in Cisco IOS Release 10.3.

This command is used for single VCs, not VC bundles. However, the **atm pvc** command will be obsoleted in the near future, so we discourage use of it. See the note preceding the command syntax for information on the commands that replace it.

The **oam seconds** and **inarp minutes** arguments first appeared in Cisco IOS Release 11.0. The **random-detect** keyword first appeared in Cisco IOS Release 11.1(22)CC.

Because the ATM port adapters do not support traffic shaping, the *peak*, *average*, and *burst* rate options are not available. For more information on the ATM port adapter, refer to the *PA-A1 ATM Port Adapter Installation and Configuration* publication.

The order of command options is important. The **inarp** keyword can be specified either separately or before the **oam** keyword has been enabled. The *peak*, *average*, and *burst* arguments, if specified, cannot be specified after either the **inarp** or the **oam** keywords.

The Cisco IOS software dynamically creates rate queues as necessary to satisfy the requests of **atm pvc** commands. The software dynamically creates a rate queue when an **atm pvc** command specifies a peak or average rate that does not match any user-configured rate queue.

The **atm pvc** command creates a PVC and attaches it to the VPI and VCI specified. Both *vpi* and *vci* cannot be specified as 0; if one is 0, the other cannot be 0. The *aal-encap* argument determines the AAL mode and the encapsulation method used. The *peak* and *average* arguments determine the rate queue used.

Use one of the **aal5mux** encapsulation options to dedicate the specified virtual circuit to a single protocol; use the **aal5snap** encapsulation option to multiplex two or more protocols over the same virtual circuit. Whether you select **aal5mux** or **aal5snap** encapsulation might depend on practical considerations, such as the type of network and the pricing offered by the network. If the network's pricing depends on the number of virtual circuits set up, **aal5snap** might be the appropriate choice. If pricing depends on the number of bytes transmitted, **aal5mux** might be the appropriate choice because it has slightly less overhead.

If you choose to specify *peak* or *average* values, you must specify both. If you set the *peak* and *average* values for **aal34smds** encapsulation, you must also specify the *midlow* and *midhigh* values. **aal34smds** encapsulation is not available for the ATM port adapter.

In the 7000 router series family (AIP), the values for *peak* and *average* indicate the bandwidth as seen on the wire.

In the 4500 router series family, (ATMizer), the values for *peak* and *average* indicate the bandwidth of the AAL5 payload (exclusive of padding).

Message identifier (MID) numbers, which are available only with **aal34smds** encapsulation, are used by receiving devices to reassemble cells from multiple packets. You can assign different *midlow* to *midhigh* ranges to different PVCs to ensure that the message identifiers are unique at the receiving end and, therefore, that messages can be reassembled correctly.

When configuring an SVC, use the **atm pvc** command to configure the PVC that handles the SVC call setup and termination. In this case, specify the **qsaal** encapsulation for the *aal-encap* keyword. See the third example that follows.

The router generates and echoes OAM F5 loopback cells, which verify connectivity. Once OAM cell generation is enabled, a cell is transmitted periodically. The remote end must respond by echoing back the cells.

The router does not generate alarm indication signal (AIS) cells, which are used for alarm surveillance functions. However, if it receives an AIS cell, it responds by sending an OAM far-end remote failure (FERF) cell.

Examples

The following example creates a PVC with VPI 0 and VCI 6. The PVC uses AAL AAL5-MUX with IP protocol.

```
atm pvc 1 0 6 aal5mux ip
```

The following example creates a PVC with VPI 0 and VCI 6. The PVC uses AAL AAL3/4-SMDS protocol.

```
atm pvc 1 0 6 aal34smds 0 15 150000 70000 10
```

The following example creates a PVC to be used for ATM signaling for an SVC. It specifies VPI 0 and VCI 5.

```
atm pvc 1 0 5 qsaal
```

Assuming that no static rate queue has been defined, the following example creates the PVC and also creates a dynamic rate queue with the peak rate set to the maximum allowed by the physical layer interface module (PLIM) and the average set to equal the peak rate:

```
atm pvc 1 1 1 aal5snap
```

Assuming that no static rate queue has been defined, the following example creates the PVC and also creates a dynamic rate queue with the peak rate set to 100 Mbps (100,000 kbps), the average rate set to 50 Mbps (50,000 kbps), and a burst size of 64 cells (2 * 32 cells):

```
atm pvc 1 1 1 aal5snap 100000 50000 2
```

The following example creates a PVC to be used for IP to ATM Class of Service (IP to ATM CoS). It specifies VPI 0 and VCI 46. The PVC uses aal5nlpid encapsulation and the WRED parameter group "sanjose" is applied to the PVC.

```
atm pvc 1 0 46 aal5nlpid random-detect sanjose
```

Related Commands

- atm aal aal3/4**
- atm maxvc**
- atm multicast**
- atm rate-queue**
- atm smds-address**
- mtu**
- random-detect-group**
- show queueing interface**
- show queueing red**

broadcast

To configure broadcast packet duplication and transmission for an ATM VC class, PVC, SVC, or VC bundle, use the **broadcast** command in the appropriate command mode. To disable broadcast forwarding for your ATM VC class, PVC, SVC, or VC bundle. Use the **no** form of this command to disable broadcast packet duplication. Use the **default** form of this command to restore the default behavior according to the description in the following “Usage Guidelines” section.

broadcast
no broadcast
default broadcast

Syntax Description

This command has no arguments or keywords.

Default

Disabled. For classical IP SVCs, broadcast is enabled.

Command Mode

Interface-ATM-VC configuration (for ATM PVCs and SVCs).

VC-class configuration (for a VC-class).

Bundle configuration (for a VC bundle).

Usage Guidelines

This command first appeared in Cisco IOS Release 11.3 T. For Cisco IOS Release 12.0(3)T, this command has been enhanced to enable configuration of broadcast packet duplication and transmission for an ATM VC bundle.

If broadcasting and multipoint signalling are enabled on an SVC, a multipoint SVC will be created to handle the SVC.

Note If you use the **broadcast** command to configure broadcasting for an ATM PVC or SVC, VC-class, or VC bundle, this configuration takes precedence over any previous configuration using the **broadcast** command.

If the **broadcast** command is not explicitly configured on an ATM PVC, SVC, or VC bundle, the VC inherits the following default configuration (listed in order of next highest precedence):

- Configuration of the **broadcast** command in a VC class assigned to the PVC, SVC, or VC bundle itself.
- Configuration of the **broadcast** command in a VC class assigned to the PVC's, SVC's, or VC bundle's ATM subinterface.
- Configuration of the **broadcast** command in a VC class assigned to the PVC's, SVC's, or VC bundle's ATM main interface.

Note When a VC is a member of a VC bundle, configuration using the **broadcast** command in VC-class configuration mode no longer applies to the VC. Bundle configuration takes precedence.

To use the **broadcast** command in bundle configuration mode, enter the **bundle** command to enact bundle configuration mode for the bundle for which you want to enable broadcast forwarding.

Examples

The following example enables the transmission of broadcast packets on an ATM PVC named router5:

```
pvc router5 1/32
 broadcast
```

The following example enables the transmission of broadcast packets on an ATM PVC bundle named chicago:

```
bundle chicago
 broadcast
```

Related Commands

- class**
- encapsulation**
- inarp**
- oam-bundle**
- oam-retry**
- protocol**
- ubr**
- ubr+**
- vbr-nrt**

bump

To configure the bumping rules for a virtual circuit (VC) class that can be assigned to a VC bundle, use the **bump** VC-class configuration command. Use the **no bump explicit** *precedence-level* form of this command to remove the explicit bumping rules for the VCs assigned this class and default them to implicit bumping. The **no bump traffic** form of this command specifies that the VC bundle members do not accept any bumped traffic.

To configure the bumping rules for a specific VC member of a bundle, use the **bump** bundle-vc configuration command. Use the **no bump explicit** *precedence-level* form of this command to remove the explicit bumping rules for the VC and default it to implicit bumping. The **no** form of this command specifies that the VC does not accept any bumped traffic.

```
bump {implicit | explicit precedence-level | traffic}
no bump {explicit precedence-level | traffic}
```

Syntax Description

implicit	Depending on the mode, applies implicit bumping rules, which is also the default, to a single VC bundle member (bundle-vc mode) or all VCs in the bundle (bundle mode). The (default) implicit bumping rule stipulates that bumped traffic is to be carried by a VC with a lower precedence.
explicit <i>precedence-level</i>	Specifies the precedence level to which traffic on a VC (bundle-vc mode) will be bumped when the VC goes down. Specifies a single number as the value of <i>precedence-level</i> .
traffic	In its positive form, specifies that the VC accepts bumped traffic. The no form stipulates that the VC does not accept any bumped traffic.

Defaults

Implicit bumping.
Bump traffic (VCs accept bumped traffic).

Command Modes

VC-class configuration (for a VC class).
Bundle-vc configuration (for a VC bundle member).

Usage Guidelines

This command first appeared in Release 12.0(3)T.

Use the **bump** command in bundle-vc configuration mode to configure bumping rules for a discrete VC bundle member or in VC class mode to configure a VC class that can be assigned to a bundle member.

The effects of different bumping configuration approaches are as follows:

- **Implicit bumping:** If you configure implicit bumping, bumped traffic is sent to the VC configured to handle the next lower precedence level. When the original VC that bumped the traffic comes back up, traffic it is configured to carry is restored to it. When no other positive forms of the bump command are configure, **bump implicit** takes effect.
- **Explicit bumping:** If you configure a VC with the **bump explicit** command, you can specify explicitly the precedence level to which traffic on a VC will be bumped when that VC goes down and the traffic will be directed to a VC mapped with that precedence level. If the VC that picks up and carries the traffic goes down, the traffic is subject to the bumping rules for that VC. You can specify only one precedence level for bumping.
- **Bumped traffic:** The VC accepts bumped traffic. You can configure bumped traffic explicitly using either **bump traffic** nor **no bump traffic**, or let the default take effect by specifying neither.
- **No bumped traffic:** To configure a discrete VC to reject bumped traffic when the traffic is directed to the VC, use with the **no bump traffic** command.

Note When no alternative VC can be found to handle bumped traffic, the bundle is declared down. To avoid this occurrence, configure explicitly the bundle member VC that has the lowest precedence level.

To use this command in vc-class configuration mode, you must enter the **vc-class atm** global configuration command before you enter this command.

To use this command to configure an individual bundle member in bundle-vc configuration mode, first enter the **bundle** command to enact bundle configuration mode for the bundle to which you want to add or modify the VC member to be configured. Then, use the **pvc-bundle** command to specify the VC to be created or modified and enter bundle-vc configuration mode.

This command has no effect if the VC class that contains the command is attached to a standalone VC, that is, if the VC is not a bundle member. In this case, the attributes are ignored by the VC.

VCS in a VC bundle are subject to the following configuration inheritance rules (listed in order of next highest precedence):

- VC configuration in bundle-vc mode
- Bundle configuration in bundle mode (with effect of assigned VC-class configuration)
- Subinterface configuration in subinterface mode

Example

The following example configures the class premium-class to define parameters applicable to a VC in a bundle. Unless overridden with a bundle-vc **bump** configuration, the VC that uses this class will not allow other traffic to be bumped onto it.

```
vc-class atm premium-class
no bump traffic
bump explicitly 7
```

Related Commands

class-vc
precedence
protect
ubr
ubr+
vbr-rt

bundle

To create a bundle or modify an existing bundle to enter bundle configuration mode, use the **bundle** subinterface configuration command. The **no** form of this command removes the specified bundle.

```
bundle bundle-name
no bundle bundle-name
```

Syntax Description

<i>bundle-name</i>	In up to 16 alphanumeric characters, specify the name of the bundle to be created.
--------------------	--

Default

None

Command Mode

Subinterface configuration

Usage Guidelines

This command first appeared in Release 12.0(3)T.

From within bundle configuration mode you can configure the characteristics and attributes of the bundle and its members, such as the encapsulation type for all virtual circuits (VCs) in the bundle, the bundle management parameters, the service type, and so on. Attributes and parameters you configure in bundle configuration mode are applied to all VC members of the bundle.

VCs in a VC bundle are subject to the following configuration inheritance rules (listed in order of next highest precedence):

- VC configuration in bundle-vc mode
- Bundle configuration in bundle mode
- Subinterface configuration in subinterface mode

To display status on bundles, use the **show atm bundle** and **show atm bundle statistics** commands.

Example

The following example configures a bundle called new-york. The example specifies the IP address of the subinterface, the router protocol—the router uses IS-IS as an IP routing protocol, then configures the bundle.

```
int a1/0.1 multipoint
  ip address 10.0.0.1 255.255.255.0
  ip router isis
  bundle new-york
```

Related Commands

class-bundle
oam-bundle
pvc-bundle

class

To assign a VC-class to an ATM main interface, subinterface, permanent virtual circuit (PVC), switched virtual circuit (SVC), a virtual circuit (VC) bundle, or VC bundle member, use the **class** command in the appropriate command mode. The **no** form of this command removes a VC class.

```
class vc-class-name  
no class vc-class-name
```

Syntax Description

<i>vc-class-name</i>	Name of the VC class you are assigning to your ATM main interface, subinterface, PVC, SVC, VC bundle, or VC bundle member.
----------------------	--

Default

No VC class is assigned.

Command Modes

Interface configuration (for ATM main and subinterfaces).

Interface-ATM-VC configuration (for ATM PVCs and SVCs).

Bundle configuration (for ATM VC bundles).

Bundle-vc configuration (for ATM VC bundle members).

Usage Guidelines

This command first appeared in Cisco IOS Release 11.3 T. For Cisco IOS Release 12.0(3)T, this command has been modified to support application of a class to an ATM VC bundle and an ATM VC bundle member.

Use this command to assign a previously defined set of parameters to an ATM main interface, subinterface, PVC, SVC, VC bundle, or VC bundle member. This set of parameters is defined in a VC class.

To use this command in bundle-vc configuration mode, first enter the **bundle** command to enact bundle configuration mode for the bundle to which you want to add and then configure a VC or modify an existing VC member. Then, use the **pvc-bundle** command to specify the VC to be created or modified and enter bundle-vc configuration mode.

To use this command in bundle configuration mode, you must enter the **bundle** command to create the bundle and then enter bundle configuration mode.

Examples

The following example assigns a VC class named atm-ubr to a PVC named router5. This VC class may contain uncommitted bit rate (UBR) settings that were configured using the **ubr** command.

```
pvc router5 1/32  
  class atm-ubr
```

The following example assigns a VC class named atm-svc-parameters to an SVC named lion. This VC class may contain ATM SVC default parameters.

```
svc lion 47.0091.81.000000.0040.0B0A.2501.ABC1.3333.3333.05
class atm-svc-parameters
```

The following example assigns a VC class named control-class to VC 207, which is a bundle member:

```
pvc-bundle star-control 207
class control-class
```

Related Commands

- broadcast**
- bump**
- bundle**
- encapsulation**
- inarp**
- oam-bundle**
- oam-retry**
- precedence**
- protect**
- protocol**
- pvc-bundle**
- ubr**
- ubr+**
- vbr-nrt**
- vc-class atm**

debug atm bundle errors

To enable the display of information on bundle errors, use the **debug atm bundle errors** debug command.

debug atm bundle errors

Syntax Description

This command has no arguments or keywords.

Default

None

Command Mode

Debug

Usage Guidelines

This command first appeared in Cisco IOS Release 12(0) 3T.

Use this command to enable the display of error information for a bundle, such as reports of inconsistent mapping in the bundle.

Related Commands

bump
bundle
debug atm bundle events

debug atm bundle events

To enable display of bundle events when use occurs, use the **debug atm bundle events** command in debug mode.

debug atm bundle events

Syntax Description

This command has no arguments or keywords.

Default

None

Command Mode

Debug

Usage Guidelines

This command first appeared in Cisco IOS Release 12(0)3T.

Use this command to enable the display of bundle events, such as occurrences of VC bumping, when bundles were brought up, when they were taken down, and so forth.

Related Command

debug atm bundle errors

encapsulation

To configure the ATM adaptation layer (AAL) and encapsulation type for an ATM (permanent virtual circuit) PVC, (switched virtual circuit) SVC, (virtual class) VC class, or VC bundle, use the **encapsulation** command in the appropriate command mode. The **no** form of this command removes an encapsulation from a PVC, SVC, VC class, or VC bundle.

```
encapsulation aal-encap [virtual-template number]  
no encapsulation aal-encap [virtual-template number]
```

Note To configure ILMI, QSAAL, or SMDS encapsulations for an ATM PVC, use the **pvc** command.

Syntax Description

aal-enca

AAL and encapsulation type. When **aal5mux** is specified, a protocol is required. Possible values for *aal-encap* are as follows:

aal5ciscopp—For Cisco Point-to-Point Protocol (PPP) over ATM. Supported on ATM PVCs only.

aal5mux apollo—For a multiplex (MUX)-type VC using the Apollo protocol.

aal5mux appletalk—For a MUX-type VC using the AppleTalk protocol.

aal5mux decnet—For a MUX-type VC using the DECnet protocol.

aal5mux frame—For a MUX-type VC for Frame Relay-ATM Internetworking on the Cisco MC3810 router.

aal5mux ip—For a MUX-type VC using the IP protocol.

aal5mux ipx—For a MUX-type VC using the IPX protocol.

aal5mux vines—For a MUX-type VC using the VINES protocol.

aal5mux voice—For a MUX-type VC for Voice over ATM on the Cisco MC3810 router.

aal5mux xns—For a MUX-type VC using the XNS protocol.

aal5nlpid—Allows ATM interfaces to interoperate with High-Speed Serial Interfaces (HSSIs) that are using an ATM data service unit (ADSU) and running ATM-Data Exchange Interface (DXI). Supported on ATM PVCs only.

aal5snap—The only encapsulation supported for Inverse ARP. Logical Link Control/Subnetwork Access Protocol (LLC/SNAP) precedes the protocol datagram.

virtual-template *number*

(Optional) (This argument is required for **aal5ciscopp** encapsulation only). Specifies the number used to identify the virtual template.

Default

The global default encapsulation is **aal5snap**. See the “Usage Guidelines” section for other default characteristics.

Command Modes

Interface-ATM-VC configuration (for an ATM PVC or SVC).

VC-class configuration (for a VC class).

Bundle configuration (for a VC bundle).

Usage Guidelines

This command first appeared in Cisco IOS Release 11.3 T. For Cisco IOS Release 12(0)3T, this command has been enhanced to provide encapsulation configuration for ATM VC bundles.

A VC bundle can have only one encapsulation configured for it: either **aal5snap** or **aal5mux**.

Use one of the **aal5mux** encapsulation options to dedicate the specified PVC to a single protocol; use the **aal5snap** encapsulation option to multiplex two or more protocols over the same PVC.

Whether you select **aal5mux** or **aal5snap** encapsulation might depend on practical considerations, such as the type of network and the pricing offered by the network. If the network’s pricing depends on the number of PVCs set up, **aal5snap** might be the appropriate choice. If pricing depends on the number of bytes transmitted, **aal5mux** might be the appropriate choice because it has slightly less overhead.

To use this command to configure a VC bundle, first enter the **bundle** subinterface configuration command to create a new bundle or modify an existing one and to enter bundle configuration mode.

Note When a VC is a member of a VC bundle, configuration using the **encapsulation** command in VC class mode no longer applies to the VC. Bundle configuration takes precedence.

When configuring Cisco PPP over ATM, specify the **aal5ciscoPPP** encapsulation for the *aal-encap* argument and specify the virtual template number.

It is possible to implicitly create a virtual template when configuring Cisco PPP over ATM. In other words, if the parameters of the virtual template are not explicitly defined before you configure the ATM PVC, the PPP interface will be brought up using default values from the virtual template identified. However, some parameters (such as an IP address) take effect only if they are specified before the PPP interface comes up. Therefore, we recommend that you explicitly create and configure the virtual template before configuring the ATM PVC to ensure such parameters take effect.

If you specify virtual template parameters after the ATM PVC is configured, you should enter a **shutdown** command followed by a **no shutdown** command on the ATM subinterface to restart the interface, causing the newly configured parameters (such as an IP address) to take effect.

If the **encapsulation** command is not explicitly configured on an ATM PVC, SVC, or VC bundle, the VC inherits the following default configuration (listed in order of next highest precedence):

- Configuration of the **encapsulation** command in a VC class assigned to the PVC, PVC bundle, or SVC itself.
- Configuration of the **encapsulation** command in a VC class assigned to the PVC’s, SVC’s, or VC bundle’s ATM subinterface.

Configuration Examples

- Configuration of the **encapsulation** command in a VC class assigned to the PVC's, SVC's, or VC bundle's ATM main interface.
- Global default: *aal-encap* = **aal5snap**.

Examples

The following example configures an ATM PVC with VPI 0 and VCI 33 for a MUX-type encapsulation using IP:

```
pvc 0/33
 encapsulation aal5mux ip
```

The following example configures a bundle called *chicago* for *aal5snap* encapsulation.

```
bundle chicago
 encapsulation aal5snap
```

Related Commands

broadcast
class
inarp
oam-bundle
oam retry
protocol

exponential-weighting-constant

To configure the exponential weight factor for the average queue size calculation for a WRED parameter group, use the **exponential-weighting-constant** command in random-detect-group mode. The **no** form of this command returns the group's value to the default.

```
exponential-weighting-constant exponent
no exponential-weighting-constant
```

Syntax Description

<i>exponent</i>	Exponent from 1 to 16 used in the average queue size calculation. The default is 9.
-----------------	---

Default

The weight factor is 9.

Command Mode

Random-detect-group configuration

Usage Guidelines

This command first appeared in Cisco IOS Release 11.1(22)CC. If used, this command is issued after the **random-detect-group** command.

Use this command to change the exponent used in the average queue size calculation for a WRED parameter group. The average queue size is based on the previous average and the current size of the queue. The formula is:

$$\text{average} = (\text{old_average} * (1 - 1/2^n)) + (\text{current_queue_size} * 1/2^n)$$

where n is the exponential weight factor specified in this command. Thus, the higher the factor, the more dependent the average is on the previous average.

Note The default WRED parameter values are based on the best available data. We recommend that you do not change the parameters from their default values unless you have determined that your applications would benefit from the changed values.

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

If the value of n gets too high, WRED will not react to congestion. Packets will be transmitted or dropped as if WRED were not in effect.

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

If the value of n gets too low, WRED will overreact to temporary traffic bursts and drop traffic unnecessarily.

Example

The following example configures the WRED group sanjose with a weight factor of 10:

```
random-detect-group sanjose
  exponential-weighting-constant 10
```

Related Commands

- protect**
- random-detect exponential-weighting constant**
- random-detect-group**
- show queueing interface**
- show queueing red**

inarp

To configure the Inverse ARP time period for an ATM permanent virtual circuit (PVC), (virtual circuit) VC class, or VC bundle, use the **inarp** command in the appropriate command mode. The **no** form of this command stores the default Inverse ARP time period behavior.

inarp *minutes*
no inarp *minutes*

Syntax Description

<i>minutes</i>	Number of minutes for the Inverse ARP time period. Default is 15 minutes.
----------------	---

Default

When Inverse ARP is enabled, *minutes* = 15 minutes.

Command Modes

Interface-ATM-VC configuration (for an ATM PVC).

VC-class configuration (for a VC class).

Bundle configuration (for a VC bundle).

Usage Guidelines

This command first appeared in Cisco IOS Release 11.3 T. For Cisco IOS Release 12.0(3)T, this command has been enhanced to provide support to configure the Inverse ARP time period for an ATM VC bundle.

This command is only supported for **aal5snap** encapsulation when Inverse ARP is enabled. Refer to the **encapsulation** command for configuring **aal5snap** encapsulation and the **protocol** command for enabling Inverse ARP.

If the **inarp** command is not explicitly configured on an ATM PVC, the PVC inherits the following default configuration (listed in order of next highest precedence):

- Configuration of the **inarp** command in a VC class assigned to the PVC itself.
- Configuration of the **inarp** command in a VC class assigned to the PVC's ATM subinterface.
- Configuration of the **inarp** command in a VC class assigned to the PVC's ATM main interface.
- Global default: *minutes* = 15 minutes; this default assumes that Inverse ARP is enabled.

Note As the inheritance rules imply, when a VC is a member of a VC bundle, configuration using the **inarp** command in VC class configuration mode no longer applies to that VC. Bundle configuration takes precedence.

For ATM VC bundle management, the Inverse ARP parameter can only be enabled at the bundle level and applied to all VC members of the bundle—that is, it cannot be enabled in bundle-vc configuration mode for individual VC bundle members. To use this command in bundle configuration mode, first enter the **bundle** command to create the bundle and enter bundle configuration mode.

Example

The following example sets the Inverse ARP time period to 10 minutes:

```
inarp 10
```

Related Commands

- bundle**
- broadcast**
- class**
- encapsulation**
- oam-bundle**
- oam retry**
- protocol**

oam-bundle

To enable end-to-end F5 operation, administration, and maintenance (OAM) loopback cell generation and OAM management for a virtual circuit (VC) class that can be applied to a VC bundle, use the **oam-bundle** vc-class configuration command. The **no** form of this command removes OAM management from the class configuration.

To enable end-to-end F5 OAM loopback cell generation and OAM management for all VC members of a bundle, use the **oam-bundle** bundle configuration command. Use the **no** form of this command to remove OAM management from the bundle.

```
oam-bundle [manage] [frequency]  
no oam-bundle [manage] [frequency]
```

Syntax Description

manage	(Optional) Enables OAM management. If omitted, loopback cells are sent but the bundle is not managed.
<i>frequency</i>	(Optional) Number of seconds between transmitting OAM loopback cells. Values range from 0 to 600 seconds.

Defaults

End-to-end F5 OAM loopback cell generation and OAM management are disabled, but if OAM cells are received, they are looped back. The default value for the *frequency* is 10 seconds.

Command Modes

- VC-class configuration (for a VC class).
- Bundle configuration (for an ATM VC bundle).
- Interface configuration (for ATM main and subinterfaces).

Usage Guidelines

This command first appeared in Release 12.0(3)T.

This command defines whether a VC bundle is OAM-managed. If this command is configured for a bundle, every VC member of the bundle is OAM-managed. If OAM management is enabled, further control of OAM management is configured using the **oam retry** command.

This command has no effect if the VC class that contains the command is attached to a standalone VC, that is, if the VC is not a bundle member. In this case, the attributes are ignored by the VC.

To use this command in bundle configuration mode, enter the **bundle** subinterface configuration command to create the bundle or to specify an existing bundle before you enter this command.

To use this command in VC-class configuration mode, first enter the **vc-class atm** global configuration command.

Configuration Examples

VCs in a VC bundle are subject to the following configuration inheritance rules (listed in order of next highest precedence):

- VC configuration in bundle-vc mode
- Bundle configuration in bundle mode (with effect of assigned VC-class configuration)
- Subinterface configuration in subinterface mode

Example

The following example enables OAM management for a bundle called chicago:

```
bundle chicago
oam-bundle manage
```

Related Commands

broadcast
class-bundle
encapsulation
inarp
oam retry
protocol (ATM)

oam retry

To configure parameters related to OAM management for an ATM permanent virtual circuit (PVC), switched virtual circuit (SVC), virtual circuit (VC) class, or VC bundle, use the **oam retry** command in the appropriate command mode. The **no** form of this command removes OAM management parameters.

```
oam retry up-count down-count retry-frequency
no oam retry up-count down-count retry-frequency
```

Syntax Description

<i>up-count</i>	Number of consecutive end-to-end F5 OAM loopback cell responses that must be received in order to change a PVC connection state to up. This argument does not apply to SVCs.
<i>down-count</i>	Number of consecutive end-to-end F5 OAM loopback cell responses that are not received in order to change a PVC state to down or tear down an SVC connection.
<i>retry-frequency</i>	The frequency (in seconds) that end-to-end F5 OAM loopback cells are transmitted when a change in the up/down state of a PVC or SVC is being verified. For example, if a PVC is up and a loopback cell response is not received after the <i>frequency</i> (in seconds) specified using the oam-pvc command, then loopback cells are sent at the <i>retry-frequency</i> to verify whether the PVC is down.

Defaults

up-count = 3, *down-count* = 5, *retry-frequency* = 1 second. This set of defaults assumes that OAM management is enabled using the **oam-pvc** or **oam-svc** command. The *up-count* argument does not apply to SVCs.

Command Modes

Interface-ATM-VC configuration (for an ATM PVC or SVC).

VC-class configuration (for a VC class).

Bundle configuration mode (for a VC bundle).

Usage Guidelines

This command first appeared in Cisco IOS Release 11.3 T. For Cisco IOS Release 12.0(3)T, this command allows you to configure parameters related to OAM management for ATM VC bundles.

If the **oam retry** command is not explicitly configured on an ATM PVC, SVC, or VC bundle, the VC inherits the following default configuration (listed in order of next highest precedence):

- Configuration of the **oam retry** command in a VC class assigned to the PVC or SVC itself.
- Configuration of the **oam retry** command in a VC class assigned to the PVC's or SVC's ATM subinterface.

- Configuration of the **oam retry** command in a VC class assigned to the PVC's or SVC's ATM main interface.
- Global default: *up-count* = 3, *down-count* = 5, *retry-frequency* = 1 second. This set of defaults assumes that OAM management is enabled using the **oam-pvc** or **oam-svc** command. The *up-count* and *retry-frequency* arguments do not apply to SVCs.

To use this command in bundle configuration mode, enter the bundle command to create the bundle or to specify an existing bundle before you enter this command.

If you use the **oam retry** command to configure a VC bundle, you configure all VC members of that bundle. VCs in a VC bundle are further subject to the following inheritance rules (listed in order of next highest precedence):

- VC configuration in bundle-vc mode
- Bundle configuration in bundle mode (with effect of assigned VC-class configuration)
- Subinterface configuration in subinterface mode

Example

The following example configures the OAM management parameters with *up-count* 3, *down-count* 3, and the *retry-frequency* at 10 seconds:

```
oam retry 3 3 10
```

Related Commands

broadcast
class
encapsulation
inarp
oam-bundle
oam-pvc
oam-svc
protocol
ubr
ubr+
vbr-nrt

precedence (VC bundle)

To configure precedence levels for a virtual circuit (VC) class that can be assigned to a VC bundle and thus applied to all VC members of that bundle, use the **precedence** VC-class configuration command. The **no** form of this command removes the precedence levels from the VC class.

To configure the precedence levels for a VC member of a bundle, use the **precedence** bundle-vc configuration command. The **no** form of this command removes the precedence levels from the VC.

precedence [**other** | *range*]
no precedence

Syntax Description

other	(Optional) Any precedence levels in the range of 0 to 7 (0-7) that are not explicitly configured. This is the default.
<i>range</i>	(Optional) A single precedence level specified as a number, or a range of precedence levels, specified as a hyphenated range.

Default

Defaults to **other**, that is, any precedence levels in the range of 0 to 7 (0-7) that are not explicitly configured.

Command Mode

VC-class configuration (for a VC class).

Bundle-vc configuration (for ATM VC bundle members).

Usage Guidelines

This command first appeared in Cisco IOS Release 11.1(22)CC. For Cisco IOS Release 12.0(3)T, this command has been extended to configure precedence levels for a VC member of a bundle.

Assignment of precedence levels to VC bundle members allows you to create differentiated service because you can distribute the IP Precedence levels over the different VC bundle members. You can map a single precedence level or a range of levels to each discrete VC in the bundle, thereby enabling VCs in the bundle to carry packets marked with different precedence levels. Alternatively, you can configure a VC with the **precedence other** command to indicate that it can carry traffic marked with precedence levels not specifically configured for it. Only one VC in the bundle can be configured with **precedence other** to carry all precedence levels not specified. This VC is considered the default one.

To use this command in VC-class configuration mode, enter the **vc-class atm** global configuration command before you enter this command. This command has no effect if the VC class that contains the command is attached to a standalone VC, that is, if the VC is not a bundle member.

To use this command to configure an individual bundle member in bundle-vc configuration mode, first enter the **bundle** command to enact bundle configuration mode for the bundle to which you want to add or modify the VC member to be configured. Then, use the **pvc-bundle** command to specify the VC to be created or modified and enter bundle-vc mode.

VCS in a VC bundle are subject to the following configuration inheritance rules (listed in order of next highest precedence):

- VC configuration in bundle-vc mode
- Bundle configuration in bundle mode (with effect of assigned VC-class configuration)
- Subinterface configuration in subinterface mode

Examples

The following example configures a class called control-class that includes a **precedence** command, that, when applied to a bundle, configures all VC members of that bundle to carry IP Precedence level 7 traffic. Note, however, that VC members of that bundle can be individually configured with the **precedence** command at the bundle-vc level, which would supervene.

```
vc-class atm control-class
precedence 7
```

The following example configures PVC 401 (with the name of control-class) to carry traffic with IP Precedence levels in the range of 4-2, overriding the precedence level mapping set for the VC through VC-class configuration.

```
pvc-bundle control-class 401
precedence 4-2
```

Related Commands

bump
class-vc
protect
ubr
ubr+
vbr-nrt

precedence (WRED group)

To configure a Weighted Random Early Detection (WRED) or VIP-Distributed WRED (DWRED) group for a particular IP Precedence, use the **precedence** command in random-detect-group mode. The **no** form of this command returns the group's values to the default for the IP Precedence.

precedence *precedence min-threshold max-threshold mark-probability-denominator*
no precedence *precedence min-threshold max-threshold mark-probability-denominator*

Syntax Description

<i>precedence</i>	IP precedence number. The value range is from 0 to 7.
<i>min-threshold</i>	Minimum threshold in number of packets. The value ranges from 1 to 4096. When the average queue length reaches this number, WRED (DWRED) begins to drop packets with the specified IP Precedence.
<i>max-threshold</i>	Maximum threshold in number of packets. The value range is <i>min-threshold</i> to 4096. When the average queue length exceeds this number, WRED (DWRED) drops all packets with the specified IP Precedence.
<i>mark-probability-denominator</i>	Denominator for the fraction of packets dropped when the average queue depth is <i>max-threshold</i> . For example, if the denominator is 512, one out of every 512 packets is dropped when the average queue is at the <i>max-threshold</i> . The value is 1 to 65536. The default is 10; one out of every ten packets is dropped at the <i>max-threshold</i> .

Default

For all IP Precedences, the *mark-probability-denominator* is 10, and the *max-threshold* is based on the output buffering capacity and the transmission speed for the interface.

The default *min-threshold* depends on the IP Precedence. The *min-threshold* for IP Precedence 0 corresponds to half of the *max-threshold*. The values for the remaining IP precedences fall between half the *max-threshold* and the *max-threshold* at evenly spaced intervals. Table 1 lists the default minimum value for each IP Precedence.

Table 1 Default WRED Minimum Threshold Values

IP Precedence	Minimum Threshold Value (Fraction of Maximum Threshold Value)
0	8/16
1	9/16
2	10/16
3	11/16
4	12/16
5	13/16

Table 1 Default WRED Minimum Threshold Values (Continued)

IP Precedence	Minimum Threshold Value (Fraction of Maximum Threshold Value)
6	14/16
7	15/16

Command Mode

Random-detect-group

Usage Guidelines

WRED is a congestion avoidance mechanism that slows traffic by randomly dropping packets when congestion exists. DWRED is similar to WRED but uses the Versatile Interface Processor (VIP) instead of the Route Switch Processor (RSP).

This command first appeared in Cisco IOS Release 11.1(22)CC. If used, this command is issued after the **random-detect-group** command.

When you configure the **random-detect group** command on an interface, packets are given preferential treatment based on the IP Precedence of the packet. Use the **precedence** command to adjust the treatment for different IP Precedences.

If you want WRED (DWRED) to ignore the IP Precedence when determining which packets to drop, enter this command with the same parameters for each IP Precedence. Remember to use reasonable values for the minimum and maximum thresholds.

Note The default WRED (DWRED) parameter values are based on the best available data. We recommend that you do not change the parameters from their default values unless you have determined that your applications would benefit from the changed values.

Example

The following example specifies parameters for WRED parameter group sanjose for the different IP precedences:

```
random-detect-group sanjose
precedence 0 32 256 100
precedence 1 64 256 100
precedence 2 96 256 100
precedence 3 128 256 100
precedence 4 160 256 100
precedence 5 192 256 100
precedence 6 224 256 100
precedence 7 256 256 100
```

Related Commands

- exponential-weighting-constant**
- random-detect (per-VC)**
- random-detect-group**
- random-detect precedence**
- show queueing**
- show queueing interface**

protect

To configure a virtual circuit (VC) class with protected group or protected VC status for application to a VC bundle member, use the **protect** command in VC-class configuration mode. The **no** form of this command removes the protected status from the VC class.

To configure a specific VC as part of the bundle's protected group or configure it as an individually protected VC bundle member, use the **protect** command in bundle-vc configuration mode. The **no** form of this command removes the protected status from the VC.

```
protect {group | vc}
no protect {group | vc}
```

Syntax Description

group	Configures the VC bundle member to be part of the bundle's protected group.
vc	Configures the VC member as individually protected.

Defaults

The VC neither belongs to the bundle's protected group nor is it an individually protected VC.

Command Modes

VC-class configuration (for a VC class).

Bundle-vc configuration (for ATM VC bundle members).

Usage Guidelines

This command first appeared in Release 12.0(3)T.

Use this command in vc-class configuration mode to configure a VC class to contain protected group or individual protected VC status. When the class is applied to the VC bundle member, that VC is characterized by the protected status. You can also apply this command directly to a VC in bundle-vc configuration mode.

When a protected VC goes down, it takes the bundle down. When all members of a protected group go down, the bundle goes down.

To use this command in vc-class configuration mode, enter the **vc-class atm** global configuration command before you enter this command.

This command has no effect if the VC class that contains the command is attached to a standalone VC, that is, if the VC is not a bundle member.

To use this command in bundle-vc configuration mode, first enter the **bundle** command to enact bundle configuration mode for the bundle containing the VC member to be configured. Then enter the **pvc-bundle** configuration command to add the VC to the bundle as a member of it.

VCS in a VC bundle are subject to the following configuration inheritance rules (listed in order of next highest precedence):

- VC configuration in bundle-vc mode
- Bundle configuration in bundle mode (with effect of assigned VC-class configuration)
- Subinterface configuration in subinterface mode

Example

The following example configures a class called control-class to include a **protect** command, which, when applied to a VC bundle member, configures the VC as an individually protected VC bundle member. When this protected VC goes down, it takes the bundle down.

```
vc-class atm control-class
protect vc
```

Related Commands

bump
class-vc
precedence (VC bundle)
ubr
ubr+
vbr-rrt

protocol

Use the **protocol** command in the appropriate command mode to do one or both of the following:

- Configure a static map for an ATM (permanent virtual circuit) PVC, (switched virtual circuit) SVC, (virtual circuit) VC class, or VC bundle.
- Enable Inverse ARP or Inverse ARP broadcasts on an ATM PVC by either configuring Inverse ARP directly on the PVC, on the VC bundle, or in a VC class (applies to IP and IPX protocols only).

The **no** form of this command removes a static map or disables Inverse ARP.

```
protocol protocol {protocol-address | inarp} [[no] broadcast]  
no protocol protocol {protocol-address | inarp} [[no] broadcast]
```

Syntax Description

<i>protocol</i>	Choose one of the following keywords:
	aarp —AppleTalk ARP
	apollo —Apollo domain
	appletalk —AppleTalk
	arp —IP ARP
	bridge —Bridging
	bstun —Block serial tunnel
	cdp —Cisco Discovery Protocol
	clns —ISO CLNS
	clns_es —ISO CLNS end system
	clns_is —ISO CLNS intermediate system
	cmns —ISO CMNS
	compressedtcp —Compressed TCP
	decnet —DECnet
	decnet_node —DECnet node
	decnet_prime_router —DECnet prime router
	decnet_router-l1 —DECnet router L1
	decnet_router-l2 —DECnet router L2
	dls —Data-link switching
	ip —IP
	ipx —Novell IPX
	llc2 —llc2

	pad —PAD links
	qlle —Qualified Logical Link Control protocol
	rsrb —Remote source-route bridging
	snapshot —Snapshot routing support
	stun —Serial tunnel
	vines —Banyan VINES
	xns —Xerox Network Systems protocol
<i>protocol-address</i>	Destination address that is being mapped to a PVC.
inarp	(Only valid for IP and IPX protocols on PVCs.) Use this keyword to enable Inverse ARP on an ATM PVC. If you specify a <i>protocol-address</i> instead of inarp , Inverse ARP is automatically disabled for that protocol.
[no] broadcast	(Optional) broadcast indicates that this map entry is used when the corresponding protocol sends broadcast packets to the interface, for example, IGRP updates. Pseudobroadcasting is supported. The broadcast keyword of the protocol command takes precedence if you previously configured the broadcast command on the ATM PVC or SVC.

Default

Inverse ARP is enabled for IP and IPX if the protocol is running on the interface and no static map is configured.

Command Modes

Interface-ATM-VC configuration (for an ATM PVC or SVC).

VC-class configuration (for a VC class).

Bundle configuration (for a VC bundle).

Usage Guidelines

This command first appeared in Cisco IOS Release 11.3 T. For Cisco IOS Release 12.0(3)T, this command has been enhanced to configure a static map for an ATM VC bundle or to enable Inverse ARP or Inverse ARP broadcasts on a VC bundle.

If the **protocol** command is not explicitly configured on an ATM PVC, SVC, or VC bundle, the VC inherits the following default configuration (listed in order of next highest precedence):

- Configuration of the **protocol ip inarp** or **protocol ipx inarp** command in a VC class assigned to the PVC or SVC itself.
- Configuration of the **protocol ip inarp** or **protocol ipx inarp** command in a VC class assigned to the PVC's or SVC's ATM subinterface.

- Configuration of the **protocol ip inarp** or **protocol ipx inarp** command in a VC class assigned to the PVC's or SVC's ATM main interface.
- Global default: Inverse ARP is enabled for IP and IPX if the protocol is running on the interface and no static map is configured.

Note As the inheritance rules imply, when a VC is a member of a VC bundle, configuration using the **protocol** command in VC-class configuration mode no longer applies to that VC. Bundle configuration takes precedence.

VCs in a VC bundle are subject to the following configuration inheritance rules (listed in order of next highest precedence):

- VC configuration in bundle-vc mode
- Bundle configuration in bundle mode (with effect of assigned VC-class configuration)
- Subinterface configuration in subinterface mode

Examples

The following example creates a static map on a VC, indicates that 192.68.34.237 is connected to this VC, and sends ATM pseudobroadcasts:

```
protocol ip 192.68.34.237 broadcast
```

The following example enables Inverse ARP for IPX and does not send ATM pseudobroadcasts:

```
protocol ipx inarp no broadcast
```

The following example removes a static map from a VC and restores the default behavior for Inverse ARP (refer to the “Default” section):

```
no protocol ip 192.68.34.237
```

The following example configures a class called bundle-class to include a protocol command that specifies use of Inverse ARP to resolve IP addresses. This command will be used to configure all of the VC members of a bundle if the bundle-class VC class is applied to the bundle.

```
vc-class atm bundle-class
  protocol ip inarp
```

Related Commands

bundle
encapsulation
inarp
oam-bundle
oam retry
ubr
ubr+
vbr-nrt

pvc

Use the **pvc** interface configuration command to do one or more of the following:

- Create an ATM PVC on a main interface or subinterface.
- Assign a name to an ATM PVC.
- Specify ILMI, QSAAL, or SMDS as the encapsulation type on an ATM PVC. (To configure other encapsulations types, see the **encapsulation** command).
- Enter interface-ATM-VC configuration mode.

To remove an ATM PVC, use the **no** form of this command.

```
pvc [name] vpi/vci [ilmi | qsaal | smds]
no pvc [name] vpi/vci [ilmi | qsaal | smds]
```

Syntax Description

<i>name</i>	(Optional) The name of the PVC or map. The name can be up to 16 characters long.
<i>vpi</i>	<p>ATM network virtual path identifier (VPI) for this PVC. The absence of the “/” and a <i>vpi</i> value defaults the <i>vpi</i> value to 0.</p> <p>On the Cisco 7200 and 7500 series routers, this value ranges from 0 to 255; on the Cisco 4500 and 4700 routers, this value ranges from 0 to 1 less than the quotient of 8192 divided by the value set by the atm vc-per-vp command.</p> <p>The arguments <i>vpi</i> and <i>vci</i> cannot both be set to 0; if one is 0, the other cannot be 0.</p>
<i>vci</i>	<p>ATM network virtual channel identifier (VCI) for this PVC. This value ranges from 0 to 1 less than the maximum value set for this interface by the atm vc-per-vp command. Typically, lower values 0 to 31 are reserved for specific traffic (for example, F4 OAM, SVC signaling, ILMI, and so on) and should not be used.</p> <p>The VCI is a 16-bit field in the header of the ATM cell. The VCI value is unique only on a single link, not throughout the ATM network, because it has local significance only.</p> <p>The arguments <i>vpi</i> and <i>vci</i> cannot both be set to 0; if one is 0, the other cannot be 0.</p>
ilmi	(Optional) Used to set up communication with the ILMI; the associated <i>vpi</i> and <i>vci</i> values are ordinarily 0 and 16, respectively.

qsaal	(Optional) A signaling-type PVC used for setting up or tearing down SVCs; the associated <i>vpi</i> and <i>vci</i> values are ordinarily 0 and 5, respectively.
smds	(Optional) Encapsulation for SMDS networks. If you are configuring an ATM PVC on the ATM Interface Processor (AIP), you must configure AAL3/4SMDS using the atm aal aal3/4 command before specifying smds encapsulation. If you are configuring an ATM network processor module (NPM), the atm aal aal3/4 command is not required. SMDS encapsulation is not supported on the ATM port adapter.

Default

No PVC is defined. When a PVC is defined, the global default of the **encapsulation** command applies (*aal-encap* = **aal5snap**).

Command Mode

Interface configuration

Usage Guidelines

This command first appeared in Cisco IOS Release 11.3 T.

The **pvc** command replaces the **atm pvc** command, which, although still supported and available, will be obsoleted in the near future. Use the **pvc** command to configure a single ATM VC only, not a VC that is a bundle member. We recommend that you use the **pvc** command in conjunction with the **encapsulation** and **random-detect attach** commands instead of the **atm pvc** command.

The Cisco IOS software dynamically creates rate queues as necessary to satisfy the requests of the **pvc** commands.

The **pvc** command creates a PVC and attaches it to the VPI and VCI specified. Both *vpi* and *vci* cannot be simultaneously specified as 0; if one is 0, the other cannot be 0.

When configuring an SVC, use the **pvc** command to configure the PVC that handles SVC call setup and termination. In this case, specify the **qsaal** keyword. See the second example that follows.

Once you specify a *name* for a PVC, you can reenter the interface-ATM-VC configuration mode by simply entering **pvc name**. You can remove a PVC and any associated parameters by entering **no pvc name** or **no pvc vpi/vci**.

Note After configuring the parameters for an ATM PVC, you must exit the interface-ATM-VC configuration mode in order to create the PVC and enable the settings.

If **ilmi**, **qsaal**, or **smds** encapsulation is not explicitly configured on the ATM PVC, the PVC inherits the following default configuration (listed in order of next highest precedence):

- Configuration of the **encapsulation** command in a VC class assigned to the PVC itself.
- Configuration of the **encapsulation** command in a VC class assigned to the PVC's ATM subinterface.

- Configuration of the **encapsulation** command in a VC class assigned to the PVC's ATM main interface.
- Global default: The global default of the **encapsulation** command applies. *aal-encap* = **aal5snap**.

Examples

The following example creates a PVC with VPI 0 and VCI 16, and communication is set up with the ILMI:

```
pvc cisco 0/16 ilmi
exit
```

The following example creates a PVC used for ATM signaling for an SVC. It specifies VPI 0 and VCI 5:

```
pvc cisco 0/5 qsaal
exit
```

Related Commands

atm vc-per-vp

pvc-bundle

To add a virtual circuit (VC) to a bundle as a member of the bundle and enter bundle-vc configuration mode in order to configure that VC bundle member, use the **pvc-bundle** bundle configuration command. The **no** form of this command removes the VC from the bundle.

```
pvc-bundle pvc-name [vpi/] [vci]
no pvc-bundle pvc-name [vpi/] [vci]
```

Syntax Description

<i>pvc-name</i>	The name of the PVC.
<i>vpi/</i>	<p>(Optional) ATM network virtual path identifier (VPI) for this PVC. The absence of the “/” and a <i>vpi</i> value defaults the <i>vpi</i> value to 0.</p> <p>On the Cisco 7200 and 7500 series routers, this value ranges from 0 to 255; on the Cisco 4500 and 4700 routers, this value ranges from 0 to 1 less than the quotient of 8192 divided by the value set by the atm vc-per-vp command.</p> <p>The arguments <i>vpi</i> and <i>vci</i> cannot both be set to 0; if one is 0, the other cannot be 0.</p>
<i>vci</i>	<p>(Optional) ATM network virtual channel identifier (VCI) for this PVC. This value ranges from 0 to 1 less than the maximum value set for this interface by the atm vc-per-vp command. Typically, lower values 0 to 31 are reserved for specific traffic (for example, F4 OAM, SVC signaling, ILMI, and so on) and should not be used.</p> <p>The VCI is a 16-bit field in the header of the ATM cell. The VCI value is unique only on a single link, not throughout the ATM network, because it has local significance only.</p> <p>The arguments <i>vpi</i> and <i>vci</i> cannot both be set to 0; if one is 0, the other cannot be 0.</p>

Default

None

Command Mode

Bundle configuration

Usage Guidelines

This command first appeared in Release 12.0(3)T.

Each bundle can contain multiple VCs having different QoS attributes. This command associates a VC with a bundle, making it a member of that bundle. Before you can add a VC to a bundle, the bundle must exist. Use the **bundle** command to create a bundle. You can also use this command to configure a VC that already belongs to a bundle. You enter the command in the same way, giving the name of the VC bundle member.

The **pvc-bundle** command enters into bundle-vc configuration mode in which you can specify VC-specific and VC class attributes for the VC.

Example

The following example specifies an existing bundle named `chicago`, and enters into bundle configuration mode. Then, it adds two VCs to the bundle. For each added VC, bundle-vc mode is entered and a VC class is attached to the VC to configure it.

```
bundle chicago
pvc-bundle chicago-control 207
  class control-class
pvc-bundle chicago-premium 206
  class premium-class
```

Related Commands

- atm vc-per-vp**
- bump**
- class-bundle**
- class-vc**
- precedence (VC bundle)**
- protect**
- ubr**
- ubr+**
- vbr-nrt**

random-detect

To enable per-VC Weighted Random Early Detection (WRED) or per-VC Distributed WRED (DWRED), use the **random-detect** VC submode command. The **no** form of this command disables WRED and DWRED for the VC or specified group, if any.

```
random-detect [attach group-name]  
no random-detect [attach group-name]
```

Syntax Description

attach *group-name* (Optional) The name of the DWRED group.

Default

WRED and DWRED are disabled by default.

Command Mode

VC submode

Usage Guidelines

This command first appeared in Cisco IOS Release 12.0(3)T.

WRED (DWRED) is a congestion avoidance mechanism that slows traffic by randomly dropping packets when congestion exists. WRED (DWRED) is most useful with protocols like TCP that respond to dropped packets by backing off, that is, decreasing the transmission rate. For IP to ATM, WRED and DWRED are configurable at the per-VC levels. The VC level WRED or DWRED configuration will override the interface-level configuration if WRED (or DWRED) is also configured at the interface level.

You can use this command to configure a single ATM VC or a VC that is a member of a bundle. To configure per-VC WRED or per-VC DWRED as a drop policy for the specified WRED or DWRED group, use the **attach** *group-name* argument. The **random-detect** command produces the same results as does the **random-detect** keyword to the **atm pvc** command. That is, it specifies that the WRED (or DWRED) algorithm should be applied to the VC. The **random-detect attach** *group-name* command, however, attaches the specified group to the VC.

Note The **atm pvc** command will be obsoleted in the near future. We recommend that you use the **pvc** command instead.

When this command is used to configure an interface-level WRED (or DWRED) group to include per-VC WRED (or per-VC DWRED) as a drop policy, the configured WRED (or DWRED) group parameters, including this one, are inherited under the following conditions:

- All existing VCs—including RSVP SVCs that are not specifically configured with a VC-level WRED (or DWRED) group—will inherit the interface-level WRED or DWRED group parameters.
- Excepting the VC used for signalling and the Interim Local Management Interface (ILMI) VC, any VCs created after the configuration of an interface-level DWRED group will inherit the parameters.

When an interface-level WRED (or DWRED) group configuration is removed, per-VC WRED or per-VC DWRED parameters are removed from any VC that inherited them from the configured interface-level DWRED group.

When an interface-level WRED (or DWRED) group configuration is modified, per-VC WRED (or DWRED) parameters are modified accordingly if the WRED (or DWRED) parameters were inherited from the configured interface-level WRED (or DWRED) group configuration.

If the WRED (or DWRED) group specified as the **attach** *group-name* value does not exist, the VC is configured with default WRED (or DWRED) arguments.

This command is only supported on interfaces that are capable of VC-level queuing. The only currently supported interface is the PA-A3 ATM PA.

To use WRED (or DWRED), Distributed Cisco Express Forwarding (DCEF) switching must first be enabled on the interface. For more information on DCEF, refer to the *Cisco IOS Switching Services Configuration Guide* and the *Cisco IOS Switching Services Command Reference*.

The router automatically determines parameters to use in the WRED calculations. To change these parameters, use the **precedence** command in random-detect-group mode.

The DWRED feature is only supported on Cisco 7000 series routers with an RSP7000 card and Cisco 7500 series routers with a VIP2-40 or higher interface processor. A VIP2-50 interface processor is strongly recommended when the aggregate line rate of the port adapters on the VIP is greater than DS3. A VIP2-50 interface processor is required for OC-3 rates.

Examples

The following example configures per-VC WRED for the pvc called cisco:

```
pvc cisco 46
  random-detect
```

The following part of the example creates a DWRED group called Paris.

```
RouterA# config terminal
RouterA(config)# random-detect-group Rome
RouterA(cfg-red-group)# precedence rsvp 1 1 10
RouterA(cfg-red-group)# precedence 1 1 2000 30
RouterA(cfg-red-group)# precedence 2 1 3000 40
RouterA(cfg-red-group)# precedence 3 1 4000 50
RouterA(cfg-red-group)# precedence 4 1 3000 60
RouterA(cfg-red-group)# precedence 5 1 3000 60
RouterA(cfg-red-group)# precedence 6 1 4000 60
RouterA(cfg-red-group)# precedence 7 1 4000 60
RouterA(cfg-red-group)# exit
RouterA(config)# exit
```

The following example creates a PVC on an ATM interface and applies the WRED group Rome to that PVC:

```
pvc cisco 46
  encapsulation aal5snap
  random-detect attach Rome
```

The following **show queueing** command displays the current settings for each of the IP Precedences following configuration of per-VC DWRED:

```
router# show queueing random-detect interface atm 0/0/0 vc 46
Current random-detect configuration:
VC 0/46
random-detect Rome

exponential weight 9
class      min-threshold  max-threshold  mark-probability
0          -            -              1/10
1          1            2000           1/30
2          1            3000           1/40
3          1            4000           1/50
4          1            3000           1/60
5          1            3000           1/60
6          1            4000           1/60
7          1            4000           1/60
rsvp      1            1              1/10
```

Related Commands

random-detect exponential-weighting-constant

random-detect-group

random-detect precedence

show interfaces

show queue

show queueing

random-detect-group

To define the Weighted Random Early Detection (WRED) or VIP-Distributed WRED (DWRED) parameter group, use the **random-detect group** global configuration command. The **no** form of this command deletes the WRED parameter group.

```
random-detect-group group-name
no random-detect-group group-name
```

Syntax Description

group-name Name for the WRED (or DWRED) parameter group.

Default

No WRED /DWRED parameter group exists.

Command Mode

Global configuration

Usage Guidelines

This command first appeared in Cisco IOS Release 11.1(22)CC.

WRED is a congestion avoidance mechanism that slows traffic by randomly dropping packets when there is congestion. DWRED is similar to WRED but uses the Versatile Interface Processor (VIP) instead of the Route Switch processor (RSP). WRED and DWRED are most useful when the traffic uses protocols such as Transmission Control Protocol (TCP), that respond to dropped packets by decreasing the transmission rate.

The router automatically determines parameters to use in the WRED calculations. If you want to change these parameters for a group, use the **exponential-weighting-constant** or **precedence** command.

Example

The following example defines the WRED parameter group sanjose:

```
random-detect-group sanjose
precedence 0 32 256 100
precedence 1 64 256 100
precedence 2 96 256 100
precedence 3 128 256 100
precedence 4 160 256 100
precedence 5 192 256 100
precedence 6 224 256 100
precedence 7 256 256 100
```

Related Commands

exponential-weighting-constant
precedence (WRED group)
random detect (per VC)
show queueing
show queueing interface

show atm bundle

To show the bundle attributes assigned to each bundle virtual circuit (VC) member and the current working status of the VC members, use the **show atm bundle** privileged EXEC command.

show atm bundle *bundle-name*

Syntax Description

bundle-name The name of the bundle whose member information is displayed. This is the bundle name specified by the **bundle** command when the bundle was created.

Command Mode

Privileged EXEC

Usage Guidelines

This command first appeared in Cisco IOS Release 12.0(3) T.

Sample Display

The following is sample output from the **show atm bundle** command (* indicates that this VC is the VC for all precedence levels not explicitly configured):

```
Router# show atm bundle

new-york on atm1/0.1 Status: UP

Name          VPI/VCI      Config. Active  Bumping  PG/ Peak  Avg/Min  Burst
Preced. Preced. Predec./ PV  kbps  kbps     Cells  Status
                Accept

ny-control    0/207        7          7        4 /Yes   pv  10000  5000    32     UP
ny-premium    0/206        6-5        6-5      7 /No    pg  20000  10000   32     UP
ny-priority   0/204        4-2        4-2      1 /Yes   pg  10000  3000    3000   UP
ny-basic*     0/201        1-0        1-0      - /Yes   pg  10000          10000   UP

los-angeles on atm1/0.1 - Status: UP

Name          VPI/VCI      Config. Active  Bumping  pg/ Peak  Avg/Min  Burst
Preced. Preced. Predec./ pv  kbps  kbps     Cells  Status
                Accept

la-high       0/407        7-5        7-5      4 /Yes   pv  20000  5000    32     UP
la-med        0/404        4-2        4-2      1 /Yes   pg  10000  3000    3000   UP
```

la-low* 0/401 1-0 1-0 - /Yes pg 10000 UP

san-francisco on atm1/0.1 - Status: UP

Name	VPI/VCI	Config. Preced.	Active Preced.	Bumping Predec./ Accept	pg/ pv	Peak kbps	Avg/Min kbps	Burst Cells	Status
sf-control	0/307	7	7	4/Yes	pv	10000	5000	32	UP
sf-premium	0/306	6-5	6-5	7/No	pg	20000	1000	32	UP
sf-priority	0/304	4-2	4-2	1/Yes	pg	10000	300		UP
sf-basic*	0/301	1-0	1-0	-/Yes	pg	10000			UP

Name	VPI/VCI	Config. Preced.	Active Preced.	Bumping Predec./ Accept	pg/ pv	Peak kbps	Avg/Min kbps	Burst Cells	Status
sf-control	0/307	7	7	4/Yes	pv	10000	5000	32	UP
sf-premium	0/306	6-5	6-5	7/No	pg	20000	10000	32	UP
sf-priority	0/304	4-2	4-2	1/Yes	pg	10000			UP
sf-basic*	0/301	1-0	1-0	-/Yes	pg	10000			UP

Related Commands

- show atm bundle statistics
- show atm map

show atm bundle statistics

To show statistics or detailed statistics on the specified bundle, use the **show atm bundle statistics** privileged EXEC command.

show atm bundle *bundle-name* statistics [detail]

Syntax Description

bundle-name Specifies the name of the bundle whose member information is displayed. This is the bundle name specified by the **bundle** command when the bundle was created.

detail (Optional) Displays detailed statistics.

Command Mode

Privileged EXEC

Usage Guidelines

This command first appeared in Cisco IOS Release 12.0(3)T.

Sample Display

The following is sample output from the **show atm bundle statistics** command:

```
Router# show atm bundle san-jose statistics

Bundle Name: Bundle State: UP
AAL5-NLPID
OAM frequency : 0 second(s), OAM retry frequency: 1 second(s)
OAM up retry count: 3, OAM down retry count: 5
BUNDLE is not managed.
InARP frequency: 15 minute(s)
InPkts: 3, OutPkts: 3, Inbytes: 1836, Outbytes: 1836
InPRoc: 3, OutPRoc: 0, Broadcasts: 3
InFast: 0, OutFast: 0, InAS: 0, OutAS: 0

Router# show atm bundle san-jose statistics detail

Bundle Name: Bundle State: UP
AAL5-NLPID
OAM frequency: 0 second(s), OAM retry frequency: 1 second(s)
OAM up retry count: 3, OAM down retry count: 5
BUNDLE is not managed.
InARP frequency: 15 minute(s)
InPkts: 3, OutPkts: 3, InBytes: 1836, OutBytes: 1836
InPRoc: 3, OutPRoc: 0, Broadcasts: 3
InFast: 0, OutFast: 0, InAS: 0, OutAS: 0

ATM1/0.52: VCD: 6, VPI: 0 VCI: 218, Connection Name: sj-basic
UBR, PeakRate: 155000
AAL5-LLC/SNAP, etype:0x0, Flags: 0xC20, VCmode: 0xE00
OAM frequency: 0 second(s), OAM retry frequency: 1 second(s)
OAM up retry count: 3, OAM down retry count: 5
OAM Loopbavk status: OAM Disabled
```

```
OMA VC state: Not Managed
ILMI VC state: Not Managed
InARP frequency: 15 minute(s)
InPkts: 3, OutPkts: 3, InBytes: 1836, OutBytes: 1836
InProc: 3, OutProc: 0, Broadcasts: 3
InFast: 0, OutFast: 0, InAS: 0, OutAS: 0
OAM cells received: 0
F5 InEndloop: 0, F5 InSegloop: 0, F5 InAIS: 0, F5 InRDI: 0
F4 InEndloop: 0, F4 OutSegloop: 0, F4 InAIS: 0, F4 InRDI: 0
OAM cells sent: 0
F5 OutEndloop: 0, F5 OutSegloop: 0, F5 Out RDI: 0
F4 OutEndloop: 0, F4 OutSegloop: 0, F4 OutRDI: 0
OAM cell drops: 0
Status: UP

ATM1/0.52: VCD: 4, VPI: 0 VCI: 216, Connection Name: sj-premium
UBR, PeakRate: 155000
AAL5-LLC/SNAP, etype: 0x0, Flags: 0xC20, VCmode: 0xE000
OAM frequency: 0 second(s), OAM retry frequency: 1 second(s)
OAM up retry count: 3, OAM down retry count: 5
OAM Loopback status: OAM Disabled
OAM VC state: Not Managed
ILMI VC state: Not Managed
InARP frequency: 15 minute(s)
InPkts: 0, OutPkts: 0, InBytes: 0, OutBytes: 0
InProc: 0, OutProc: 0, Broadcasts: 0
InFast: 0, OutFast: 0, InAS: 0
OAM cells received: 0
F5 InEndloop: 0, F4 InSegloop: 0, F4 InAIS: 0, F4 InRDI: 0
F4 OutEndloop: 0, F4 OutSegloop: 0, F4 OutRDI: 0
OAM cell drops: 0
Status: UP
```

Related Commands

show atm bundle
show atm map

show atm map

To show the list of all configured ATM static maps to remote hosts on an ATM network and on ATM bundle maps, use the **show atm map** privileged EXEC command.

```
show atm map
```

Syntax Description

This command has no arguments or keywords.

Command Mode

Privileged EXEC

Usage Guidelines

This command first appeared in Cisco IOS Release 10.0.

This command was modified in Cisco IOS Release 11.1CA to include a sample display for the ATM-CES port adapter (PA).

This command was modified in Cisco IOS Release 12.0(3)T to include display for ATM bundle maps. An ATM bundle map identifies a bundle and all of its related VCs.

Sample Displays

The following is sample output from the **show atm map** command for a bundle called san-jose (0/122, 0/123, 0/124, and 0/126 are the virtual path and virtual channel identifiers of the bundle members):

```
Router# show atm map

Map list san-jose_B_ATM1/0.52 : PERMANENT
ip 1.1.1.1. maps to bundle san-jose, 0/122, 0/123, 0/124, 0/126, ATM1/0.52, broadcast
```

The following is sample output from the **show atm map** command for an ATM-CES PA on the Cisco 7200 series router:

```
Router# show atm map

Map list alien: PERMANENT
ip 128.1.1.1 maps to VC 6
ip 128.1.1.2 maps to VC 6
```

The following is sample output from the **show atm map** command that displays information for a bundle called new-york:

```
Router# show atm map

Map list atm:
vines 3004B310:0001 maps to VC 4, broadcast
ip 172.21.168.110 maps to VC 1, broadcast
clns 47.0004.0001.0000.0c00.6e26.00 maps to VC 6, broadcast
appletalk 10.1 maps to VC 7, broadcast
decnet 10.1 maps to VC 2, broadcast
Map list new-york: PERMANENT
ip 10.0.0.2 maps to bundle new-york, 0/200, 0/205, 0/210, ATM1/0.1
```

The following is sample output from the **show atm map** command for a multipoint connection:

```
Router# show atm map

Map list atm_pri: PERMANENT
ip 4.4.4.4 maps to NSAP CD.CDEF.01.234567.890A.BCDE.F012.3456.7890.1234.12, broadcast,
aal5mux, multipoint connection up, VC 6
ip 4.4.4.6 maps to NSAP DE.CDEF.01.234567.890A.BCDE.F012.3456.7890.1234.12, broadcast,
aal5mux, connection up, VC 15, multipoint connection up, VC 6

Map list atm_ipx: PERMANENT
ipx 1004.ddd.ddd.ddd maps to NSAP
DE.CDEF.01.234567.890A.BCDE.F012.3456.7890.1234.12, broadcast, aal5mux, multipoint
connection up, VC 8
ipx 1004.cccc.cccc.cccc maps to NSAP
CD.CDEF.01.234567.890A.BCDE.F012.3456.7890.1234.12, broadcast, aal5mux, multipoint
connection up, VC 8

Map list atm_apple: PERMANENT
appletalk 62000.5 maps to NSAP CD.CDEF.01.234567.890A.BCDE.F012.3456.7890.1234.12,
broadcast, aal5mux, multipoint connection up, VC 4
appletalk 62000.6 maps to NSAP DE.CDEF.01.234567.890A.BCDE.F012.3456.7890.1234.12,
broadcast, aal5mux, multipoint connection up, VC 4
```

The following is sample output from the **show atm map** command if you configure an ATM PVC using the **pvc** command:

```
Router# show atm map

Map list endA: PERMANENT
ip 148.11.11.1 maps to VC 4, VPI 0, VCI 60, ATM0.2
```

Table 2 describes the fields shown in the displays.

Table 2 show atm map Field Descriptions

Field	Description
Map list	Name of map list.
PERMANENT	This map entry was entered from configuration; it was not entered automatically by a process.
<i>protocol address maps to VC x</i> or <i>protocol address maps to NSAP...</i>	Name of protocol, the protocol address, and the VCD or NSAP that the address is mapped to (for ATM VCs configured with the atm pvc command).
broadcast	Indicates pseudobroadcasting.
<i>protocol address maps to VPI x, VCI x, ATM x.x</i> or <i>protocol address maps to NSAP...</i>	Name of protocol, the protocol address, the virtual path identifier (VPI) number, the virtual channel identifier (VCI) number, and the ATM interface or subinterface (for ATM PVCs configured using the pvc command). or Name of the protocol, the protocol address, and the NSAP that the address is mapped to (for ATM switched virtual circuits (SVCs) configured using the svc command).
aal5mux	Indicates the encapsulation used, a multipoint or point-to-point VC, and the number of the virtual circuit.
multipoint connection up	Indicates that this is a multipoint VC.

Table 2 show atm map Field Descriptions (Continued)

Field	Description
VC 6	Number of the VC.
connection up	Indicates a point-to-point VC.
VPI	Virtual path identifier for the VC.
VCI	Virtual channel identifier for the VC.
ATMx.x	ATM interface or subinterface number.
Map list new-york :	Name of the bundle whose mapping information follows.
ip <i>address</i> maps to bundle <i>bundle-name</i> <i>vc-members</i>	IP address of bundle and VC members that belong to the bundle.

Related Commands

- show atm bundle**
- show atm bundle stat**

show queueing interface

To show the queueing statistics of an interface, use the **show queueing interface** privileged EXEC command.

```
show queueing interface interface-number [vc [[vpi/] vci]]
```

Syntax Description

<i>interface-number</i>	Specifies the interface.
vc	(Optional) Shows the weighted random early detection (WRED) parameters associated with a specific virtual circuit (VC). If desired, both the virtual path identifier (VPI) and virtual circuit identifier (VCI) values, or just the VCI value, can be specified.
<i>vpi</i>	(Optional) Specifies the VPI. If <i>vpi</i> is omitted, 0 is used as the VPI value for locating the permanent virtual circuit (PVC). If <i>vpi</i> is specified, the / separator is required.
<i>vci</i>	(Optional) Specifies the VCI.

Command Mode

Privileged EXEC

Usage Guidelines

This command first appeared in Cisco IOS Release 11.1(22)CC.

Related Commands

```
atm pvc  
exponential-weighting-constant  
precedence (WRED group)  
random-detect-group  
show queueing  
show queueing red
```

show queueing red

To show the configured weighted random early detection (WRED) parameters, use the **show queueing red** privileged EXEC command.

```
show queueing red [interface atm_subinterface [vc[[vpi]/ vci]]]
```

Syntax Description

interface <i>atm_subinterface</i>	(Optional) Shows the WRED parameters of every virtual circuit (VC) with WRED enabled on the specified ATM subinterface.
vc	(Optional) Shows the WRED parameters associated with a specific VC. If desired, both the virtual path identifier (VPI) and virtual circuit identifier (VCI) values, or just the VCI value, can be specified.
<i>vpi</i>	(Optional) Specifies the VPI. If <i>vpi</i> is omitted, 0 is used as the VPI value for locating the permanent virtual circuit (PVC). If <i>vpi</i> is specified, the / separator is required.
<i>vci</i>	(Optional) Specifies the VCI.

Command Mode

Privileged EXEC

Usage Guidelines

This command first appeared in Cisco IOS Release 11.1(22)CC.

If no keyword is entered, this command displays the parameters of every WRED-enabled VC on every ATM interface in the system.

Related Commands

```
atm pvc  
exponential-weighting-constant  
precedence (WRED group)  
random-detect-group  
show queueing  
show queueing interface
```

ubr

To configure unspecified bit rate (UBR) quality of service (QoS) and specify the output peak cell rate (PCR) for an ATM permanent virtual circuit (PVC), switched virtual circuit (SVC), virtual circuit (VC) class, or VC bundle member, use the **ubr** command in the appropriate command mode. The **no** form of this command removes the UBR parameter.

```
ubr output-pcr [input-pcr]  
no ubr output-pcr [input-pcr]
```

Syntax Description

<i>output-pcr</i>	The output PCR in kilobits per second (kbps).
<i>input-pcr</i>	(Optional for SVCs only) The input peak cell rate (PCR) in kilobits per second. If this value is omitted, the <i>input-pcr</i> will equal the <i>output-pcr</i> .

Default

UBR QoS at the maximum line rate of the physical interface.

Command Modes

Interface-ATM-VC configuration (for an ATM PVC or SVC).
VC-class configuration (for a VC class).
Bundle-vc configuration (for ATM VC bundle members).

Usage Guidelines

This command first appeared in Cisco IOS Release 11.3 T.

For Cisco IOS Release 12.0(3)T, this command has been enhanced to support selection of UBR QoS and configuration of output PCR for ATM VC bundles and ATM VC bundle members.

To configure ATM SVCs with an output PCR and an input PCR that differ from each other, you must expressly configure an output value and an input value using the *output-pcr* and *input-pcr* arguments, respectively.

Configure QoS parameters using the **ubr**, **ubr+**, or **vbr-nrt** command. The last command you enter will apply to the PVC or SVC you are configuring.

If the **ubr** command is not explicitly configured on an ATM PVC, SVC, or VC bundle member, the VC inherits the following default configuration (listed in order of next highest precedence):

- Configuration of any QoS command (**ubr**, **ubr+**, or **vbr-nrt**) in a VC class assigned to the PVC or SVC itself.
- Configuration of any QoS command (**ubr**, **ubr+**, or **vbr-nrt**) in a VC class assigned to the PVC's or SVC's ATM subinterface.
- Configuration of any QoS command (**ubr**, **ubr+**, or **vbr-nrt**) in a VC class assigned to the PVC's or SVC's ATM main interface.
- Global default: UBR QoS at the maximum line rate of the PVC or SVC.

To use this command in VC-class configuration mode, enter the **vc-class atm** global configuration command. This command has no effect if the VC class that contains the command is attached to a standalone VC, that is, if the VC is not a bundle member.

To use this command in bundle-vc configuration mode, first enter the **bundle** command to specify the bundle, then enter bundle configuration mode. Then enter the **pvc-bundle** configuration command to add the VC to the bundle as a member of it and enter bundle-vc configuration mode.

VCs in a VC bundle are subject to the following configuration inheritance rules (listed in order of next highest precedence):

- VC configuration in bundle-vc mode
- Bundle configuration in bundle mode (with effect of assigned VC-class configuration)
- Subinterface configuration in subinterface mode

Examples

The following example specifies the *output-pcr* for an ATM PVC to be 100,000 kbps:

```
pvc 1/32
ubr 100000
```

The following example specifies the *output-pcr* and *input-pcr* for an ATM SVC to be 10,000 kbps and 9000 kbps, respectively:

```
svc lion nsap 47.0091.81.000000.0040.0B0A.2501.ABC1.3333.3333.05
ubr 10000 9000
```

Related Commands

abr
broadcast
bump
bundle
class
encapsulation
inarp
oam-bundle
oam-retry
precedence
protect
protocol
pvc-bundle
ubr+
vbr-nrt

ubr+

To configure unspecified bit rate (UBR) quality of service (QoS) and specify the output peak cell rate and output minimum guaranteed cell rate for an ATM permanent virtual circuit (PVC), switched virtual circuit (SVC), virtual circuit (VC) class, or VC bundle member, use the **ubr+** command in the appropriate command mode. The **no** form of this command removes the UBR+ parameters.

```
ubr+ output-pcr output-mcr [input-pcr] [input-mcr]  
no ubr+ output-pcr output-mcr [input-pcr] [input-mcr]
```

Syntax Description

<i>output-pcr</i>	The output PCR in kilobits per second (kbps).
<i>output-mcr</i>	The output minimum guaranteed cell rate in kbps.
<i>input-pcr</i>	(Optional for SVCs only) The input PCR in kbps. If this value is omitted, the <i>input-pcr</i> will equal the <i>output-pcr</i> .
<i>input-mcr</i>	(Optional for SVCs only) The input minimum guaranteed cell rate in kbps. If this value is omitted, the <i>input-mcr</i> will equal the <i>output-mcr</i> .

Default

UBR QoS at the maximum line rate of the physical interface.

Command Modes

Interface-ATM-VC configuration (for an ATM PVC or SVC).

VC-class configuration (for a VC class).

Bundle-vc configuration (for ATM VC bundle members).

Usage Guidelines

This command first appeared in Cisco IOS Release 11.3 T.

For Cisco IOS Release 12.0(3)T, this command has been enhanced to support selection of UBR+ QoS and configuration of output PCR and output minimum guaranteed cell rate ATM VC bundles, and VC bundle members.

To configure ATM SVCs with an output PCR and an input PCR that differ from each other, you must expressly configure an output value and an input value using the *output-pcr*, *output-mcr*, *input-pcr*, and *input-mcr* arguments, respectively.

Configure QoS parameters using the **ubr**, **ubr+**, or **vbr-nrt** command. The last command you enter will apply to the PVC or SVC you are configuring.

If the **ubr+** command is not explicitly configured on an ATM PVC or SVC, the VC inherits the following default configuration (listed in order of next highest precedence):

- Configuration of any QoS command (**ubr**, **ubr+**, or **vbr-nrt**) in a VC class assigned to the PVC or SVC itself.

- Configuration of any QoS command (**ubr**, **ubr+**, or **vbr-nrt**) in a VC class assigned to the PVC's or SVC's ATM subinterface.
- Configuration of any QoS command (**ubr**, **ubr+**, or **vbr-nrt**) in a VC class assigned to the PVC's or SVC's ATM main interface.
- Global default: UBR QoS at the maximum line rate of the PVC or SVC.

To use this command in VC-class configuration mode, enter the **vc-class atm** global configuration command before you enter the **ubr+** command. This command has no effect if the VC class that contains the command is attached to a standalone VC, that is, if the VC is not a bundle member.

To use this command in bundle-vc configuration mode, first enter the **bundle** command to specify the bundle the VC member belongs to, then enter bundle configuration mode. Then enter the **pvc-bundle** bundle configuration command to add the VC to the bundle as a member of it.

VCS in a VC bundle are subject to the following configuration inheritance rules (listed in order of next highest precedence):

- VC configuration in bundle-vc mode
- Bundle configuration in bundle mode (with effect of assigned VC-class configuration)
- Subinterface configuration in subinterface mode

Examples

The following example specifies the *output-pcr* for an ATM PVC to be 100,000 kbps and the *output-mcr* to be 3000 kbps:

```
pvc 1/32
ubr+ 100000 3000
```

The following example specifies the *output-pcr*, *output-mcr*, *input-pcr*, and *input-mcr* for an ATM SVC to be 10,000 kbps, 3000 kbps, 9000 kbps, and 1000 kbps, respectively:

```
svc lion nsap 47.0091.81.000000.0040.0B0A.2501.ABC1.3333.3333.05
ubr+ 10000 3000 9000 1000
```

Related Commands

abr
broadcast
bump
bundle
class
encapsulation
inarp
oam-bundle
oam-retry
precedence
protect
protocol
pvc-bundle
ubr
vbr-nrt

vbr-nrt

To configure the variable bit rate-nonreal time (VBR-NRT) quality of service (QoS) and specify output peak cell rate (PCR), output sustainable cell rate, and output maximum burst cell size for an ATM permanent virtual circuit (PVC), switched virtual circuit (SVC), virtual circuit (VC) class, or VC bundle member, use the **vbr-nrt** command in the appropriate command mode. The **no** form of this command removes the VBR-NRT parameters.

```
vbr-nrt output-pcr output-scr output-mbs [input-pcr] [input-scr] [input-mbs]
no vbr-nrt output-pcr output-scr output-mbs [input-pcr] [input-scr] [input-mbs]
```

Syntax Description

<i>output-pcr</i>	The output PCR in kilobits per second (kbps).
<i>output-scr</i>	The output SCR in kbps.
<i>output-mbs</i>	The output maximum burst cell size expressed in number of cells.
<i>input-pcr</i>	(Optional for SVCs only) The input PCR in kbps.
<i>input-scr</i>	(Optional for SVCs only) The input SCR in kbps.
<i>input-mbs</i>	(Optional for SVCs only) The input maximum burst cell size expressed in number of cells.

Default

UBR QoS at the maximum line rate of the physical interface.

Command Modes

Interface-ATM-VC configuration (for an ATM PVC or SVC).

VC-class configuration (for a VC class).

Bundle-vc configuration (for ATM VC bundle members).

Usage Guidelines

This command first appeared in Cisco IOS Release 11.3 T.

For Cisco IOS Release 12.0(3)T, this command has been enhanced to support configuration of VBR-NRT QoS and specification of output PCR, output SCR, and output maximum burst cell size for ATM bundles and VC bundle members.

Configure QoS parameters using the **ubr**, **ubr+** or **vbr-nrt** command. The last command you enter will apply to the PVC or SVC you are configuring.

If the **vbr-nrt** command is not explicitly configured on an ATM PVC or SVC, the VC inherits the following default configuration (listed in order of next highest precedence):

- Configuration of any QoS command (**ubr**, **ubr+**, or **vbr-nrt**) in a VC class assigned to the PVC or SVC itself.
- Configuration of any QoS command (**ubr**, **ubr+**, or **vbr-nrt**) in a VC class assigned to the PVC's or SVC's ATM subinterface.

- Configuration of any QoS command (**ubr**, **ubr+**, or **vbr-nrt**) in a VC class assigned to the PVC's or SVC's ATM main interface.
- Global default: UBR QoS at the maximum line rate of the PVC or SVC.

To use this command in VC-class configuration mode, enter the **vc-class atm** global configuration command before you enter the **vbr-nrt** command. This command has no effect if the VC class that contains the command is attached to a standalone VC, that is, if the VC is not a bundle member.

To use this command in bundle-vc configuration mode, first enter the **pvc-bundle** configuration command to add the VC to the bundle as a member of it, then and enter bundle-vc configuration mode.

VCS in a VC bundle are subject to the following configuration inheritance rules (listed in order of next highest precedence):

- VC configuration in bundle-vc mode
- Bundle configuration in bundle mode (with effect of assigned VC-class configuration)
- Subinterface configuration in subinterface mode

Examples

The following example specifies the *output-pcr* for an ATM PVC to be 100,000 kbps, the *output-scr* to be 50,000 kbps, and the *output-mbs* to be 64:

```
pvc 1/32
vbr-nrt 100000 50000 64
```

The following example specifies the VBR-NRT output and input parameters for an ATM SVC:

```
svc lion nsap 47.0091.81.000000.0040.0B0A.2501.ABC1.3333.3333.05
vbr-nrt 10000 5000 32 20000 10000 64
```

Related Commands

abr
broadcast
bump
bundle
class
encapsulation
inarp
oam-bundle
oam-retry
precedence
protect
protocol
pvc-bundle
ubr
ubr+