

Understanding Traffic Shaping and Queueing on Catalyst 5000 and 6000 ATM Modules

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Introduction

This document summarizes support for ATM-layer quality of service (QoS). This includes traffic shaping and rate queues on the Layer 2 ATM modules for the Catalyst 5000 and Catalyst 6000 Series. These modules support both permanent virtual circuits (PVCs) and LAN emulation (LANE). This document discusses QoS on PVCs only. For more information on LANE QoS, which includes how to configure UBR+ virtual circuit connections (VCCs), refer to *Configuring LANE QoS*.

Prerequisites

Requirements

There are no specific requirements for this document.

Components Used

This document is not restricted to specific software and hardware versions.

Conventions

For more information on document conventions, refer to the *Cisco Technical Tips Conventions*.

Shaped and Non-Shaped PVCs

The ATM Forum publishes standards for ATM technology. One such standard, the *Traffic Management Specification Version 4.0*, defines five service categories that describe transmitted user traffic and the QoS that a network needs in order to provide for that traffic. These are the five service categories:

- CBR
- VBR–nrt
- VBR–rt
- ABR
- UBR and UBR+

The ATM modules for the Catalyst 5000 and 6000 support a subset of these categories. This support depends on the particular line card. This table describes such support.

Service Category	Supporting ATM Module	Configuration Instructions
CBR	WS–X515x Series and WS–X5166	Specify a value for the peak cell rate (PCR). Do not specify a value for the sustainable cell rate (SCR) or maximum burst size (MBS).
	WS–X5161, WS–X5162, WS–X5165, WS–X5167, WS–X5168	Specify only a PCR value or PCR = SCR. The output of the show atm vc vcd# command does not list any shaping parameters. However, a PVC configured with these parameters is assigned internally to a higher scheduling priority than a UBR VC.
	WS–X6101	Configure PCR=SCR. Although such CBR–like PVCs appear as UBR in the output of the show atm pvc vpi/vci command, they receive a higher priority than UBR PVCs. However, they share the same priority level as VBR–nrt VCs.
VBR–nrt	WS–X5161, WS–X5162, WS–X5165, WS–X5167, WS–X5168; WS–X6101	Specify a value for both PCR and SCR.
UBR	WS–X515x Series and WS–X5166	Do not specify a value for PCR or SCR.
	WS–X5161, WS–X5162, WS–X5165, WS–X5167, WS–X5168; WS–X6101	Do not specify a value for PCR or SCR.

Configure WS–X515x and WS–5166 Modules

The WS–X515x Series and the WS–X5166 support two images. The first image supports LANE and non–shaped PVCs and the second image supports shaped PVCs. This table lists the images that support shaped PVCs.

Software Version	Image Filename
51.1(1)	cat5000-atm-pvcshape.51-1-1.bin
51.1(2)	c5atm-wbpvc.113-2.5.WA4.4m.bin
51.1(3)	c5atm-wbpvc.113-4.WA4.7.bin
51.1(4)	c5atm-wbpvc.113-6.WA4.9a.bin
51.1(5)	c5atm-wbpvc.113-6.WA4.9d.bin
12.0(10)W5(18a)	c5atm-wt-mc.120-10.W5.18a.bin
12.0(13)W5(19)	c5atm-wt-mc.120-12.W5.19.bin

Note: The first traffic–shaping image of the Cisco IOS® Software Release train 12.0W5 is 12.0(10)W5(18a). With this release, the name of the traffic shaping image changes to c5atm–wt–mz.

Configure a CBR VC

The WS–X515x Series and the WS–X5166 support the CBR service category. In order to create a CBR VC, specify a value for the PCR. The initial traffic–shaping image (Software Release 51.1) allows you to configure SCR and MBS values even though the image supports only PCR–based shaping. Current images in the Cisco IOS Software Release 11.3 and 12.0 trains support the configuration of a PCR value only, as shown in this output, for an ATM module that runs Cisco IOS Software Release 12.0(10)W5(18a).

```
atm(config-subif)#atm pvc 1000 1 100 aal5snap ?
<1-155000> Peak rate(Kbps)
oam OAM loopback enable
<cr>
atm#show atm vc 1000
atm0.100: VCD: 1000, VPI: 1, VCI: 100
PeakRate: 100000, Average Rate: 0, Burst Cells: 0
AAL5-LLC/SNAP, etype:0x0, Flags: 0x820, VCmode: 0x1
OAM frequency: 0 second(s)
InARP DISABLED
InPkts: 0, OutPkts: 0
InPRoc: 0, OutPRoc: 0
InFast: 0, OutFast: 0, InAS: 0, OutAS: 0
OAM cells received: 0
OAM cells sent: 0
Status: UP
```

Configure a UBR VC

On any ATM interface, from Catalyst ATM modules to router port adapters, if you create a PVC without any specific shaping parameters, it creates a non–shaped PVC at the line rate. The creation of a shaped PVC means that you specify a non–zero value for the PCR or the SCR. This depends on which module you use.

In this example, two PVCs are created. PVC 100 is a shaped PVC with a peak rate of 100 Mbps. PVC 101 is a non–shaped PVC with a peak rate of the physical line rate. Use the **show atm vc vcd#** command in order to view the traffic parameters of each PVC.

```

interface atm0
  logging event subif-link-status
  atm vc-per-vp 128
  atm preferred phy A
  atm pvc 1 0 5 qsaal
  atm pvc 2 0 16 ilmi
  no atm ilmi-keepalive
  !
  interface atm0.5 point-to-point
  atm pvc 100 5 100 aal5snap 100000
  !
  interface atm0.6 point-to-point
  atm pvc 101 5 101 aal5snap

atm#show atm vc 100
atm0.5: VCD: 100, VPI: 5, VCI: 100
PeakRate: 100000, Average Rate: 0, Burst Cells: 0
AAL5-LLC/SNAP, etype:0x0, Flags: 0x820, VCmode: 0x1
OAM frequency: 0 second(s)
InARP DISABLED
InPkts: 0, OutPkts: 0
InPRoc: 0, OutPRoc: 0
InFast: 0, OutFast: 0, InAS: 0, OutAS: 0
OAM cells received: 0
OAM cells sent: 0
Status: UP

atm#show atm vc 101
atm0.6: VCD: 101, VPI: 5, VCI: 101
PeakRate: 155000, Average Rate: 0, Burst Cells: 0
AAL5-LLC/SNAP, etype:0x0, Flags: 0xC20, VCmode: 0x201
OAM frequency: 0 second(s)
InARP DISABLED
InPkts: 0, OutPkts: 0
InPRoc: 0, OutPRoc: 0
InFast: 0, OutFast: 0, InAS: 0, OutAS: 0
OAM cells received: 0
OAM cells sent: 0
Status: UP

```

```

atm#show atm vc
          VCD /
Interface Name  VPI  VCI  Type  Encaps  Peak  Avg/Min  Burst
          0     1     0    5   pvc   SAAL    0     0     INAC
          0     2     0   16   pvc   ILMI    0     0     INAC
0.5
100
   5 100   pvc  SNAP  100000  0  0  UP
0.6   101    5  101  pvc  SNAP  155000  0  0  UP

```

Understand Rate Queues and Scheduling

The WS-X515x Series and the WS-X5166 use rate queues, which are created dynamically as you configure PVCs with shaping values. In other words, each rate queue supports VCs of a particular shaping value. Up to ten such queues are available.

The number of queues per range of supported PCR values varies between the Digital Signal Level 3 (DS-3) and the Optical Carrier Level 3 (OC-3) ATM modules. This table describes these values:

PCR Range	# of Rate Queues
-----------	------------------

OC-3	2081 kbps to 155,000 kbps	8
	1 – 2080 kbps	2
DS-3	2354 kbps to 45,000 kbps	8
	1 – 2353 kbps	2

Note: The configuration of more than two rate queues with PCR values less than 2080 Kbps for OC-3 is not possible. An example of that uses the Catalyst switch 5500 and WS-X5157 card is shown in this output:

```

interface atm0(config)#
atm(config-if)#atm pvc 3 2 34 aal5snap 2000 oam 3
atm(config-if)#atm pvc 4 2 35 aal5snap 128 oam 3
atm(config-if)#atm pvc 5 2 36 aal5snap 1000 oam 3

```

Not creating vc:5 interface: ATM0 is out of rate queues.

This example attempts to configure three rate queues (2000 Kbps, 128 Kbps and 1000 Kbps). The workaround for this limitation of the ability to only configure two rate queues is to configure the first rate queue at 2081 kbps or higher (instead of 2000 Kbps) so that it falls in the PCR range of 2081 to 155,000 Kbps. In this way you have two other rate queues available for 128 and 1000.

In Cisco IOS Software Releases prior to 12.0(16)W5(21), the **show atm interface atm0** command did not display the rate queues with PCR values less than 2081 kbps for OC-3 interfaces and less than 2354 kbps for DS3 interfaces. This issue is resolved in current Cisco IOS Software Releases. If you use an earlier Cisco IOS Software Release, use the **write terminal** command in order to display the VCs configured for these special rate queues.

The WS-X515x Series and the WS-X5166 use Weighted Round Robin (WRR) scheduling which depends on the PCR. WRR is similar to round robin with the difference that each rate-queue is assigned a unique weight which depends on the PCR. The weight then increases or decreases the frequency with which the rate-queue is scheduled.

They do not consider the number of PVCs with the same rate for weight age. As a result, if you configure many PVCs with a high rate and only a few PVCs with a low rate, the low-rate VCs can get a greater throughput rate. The reason is that the scheduler does not assign a weight age to the number of PVCs with the same rate. The WRR scheduling depends purely on the configured PCRs. This table shows an example to help explain this concept:

PCR Value	# of PVCs at This PCR	Expected Output Rate per PVC
75 Mbps	10	The data rate is shared across all ten PVCs. The actual data rate you can expect for each PVC with a PCR of 75 Mbps is equal to: $75 / 10 \text{ Mbps} = 7.5$
25 Mbps	2	The data rate is shared across the two PVCs. The actual data rate you can expect for each PVC with a PCR of 25 Mbps is equal to: $25 / 2 \text{ Mbps} = 12.5 \text{ Mbps}$

This example shows that the configuration of many VCs with the same PCR value affects the output rate of each VC. In other words, each of the 25 Mbps PVCs in this example receive higher throughput than each of the 75 Mbps PVCs. Cisco recommends that you distribute your PVCs equally across all ten rate queues in order to ensure maximum throughput.

Use the **show atm interface atm0** command in order to display the currently active rate queues and the number of PVCs in each queue. In this sample output, Rate-Queue 0 has one shaped VCC with a PCR of 100 Mbps, and Rate-Queue 1 has two non-shaped VCCs with PCR set to the physical line rate.

You can monitor the rate queues with the **show atm interface atm0** command (the output does not correspond to the example which precedes):

```
atm#show atm interface atm0
atm interface atm0:
AAL enabled: AAL5 , Maximum VCs: 4096, Current VCCs: 3
Maximum Transmit Channels: 0
Max. Datagram Size: 1580
PLIM Type:SONET - 155Mbps, TX clocking: LINE
0 input, 12 output, 0 IN fast, 0 OUT fast
Rate-Queue 0 set to 100000Kbps, reg=0x0 DYNAMIC, 1 VCC
Rate-Queue 1 set to 155000Kbps, reg=0x0 DYNAMIC, 2 VCCs
Config. is ACTIVE
```

Configure Shaping and Queueing on WS-X516x Modules

The WS-X516x Series (all modules other than the WS-X5166) supports the CBR, VBR-nrt, and UBR ATM service categories. In order to create a CBR PVC, configure PCR=SCR. (You cannot enter a value of 0 or leave SCR unconfigured.) In order to create a UBR VC, enter the virtual path identifier (VPI) and virtual channel identifier (VCI) values and do not specify any shaping parameters.

In order to configure a VBR-nrt VC on these modules, use this command:

```
atm pvc vcd vpi vci [aal5snap | ilmi | qsaal] [peak_rate average_rate] [burst_size] [oam s
```

These ATM modules support a particular set of PCR and SCR values. When you configure any other values, the Catalyst ATM software rounds down and chooses the next lowest supported value. Thus, the values you specify at the command-line can differ from the actual values that the module applies to the PVC.

The official set of values is derived from this formula:

$$\text{Output Rate} = \text{Line Rate} / N$$

In this equation, **N** is an integer or whole number without fractions or decimals. **Line Rate** is a full 155 Mbps for the OC-3 and a full 45 Mbps for the DS-3. Use the **show atm interface atm0** command in order to view the line rate.

```
console> show atm interface atm0
atm interface atm0:
AAL enabled: AAL5 , Maximum VCS: 4096, Current VCCs: 12
Tx buffers 32, Rx buffers 32, Exception Queue: 32, Raw Queue: 32
VP Filter: 0x0, VCIs per VPI: 1024, Max. Datagram Size:1580
PLIM Type:SONET - 155Mbps, TX clocking: LINE
1323970 input, 1135820 output, 0 IN fast, 0 OUT fast
Config. Is ACTIVE
console>
```

In this example, you need to configure six queues at the rate of 100M, 50M, 30M, 10M and 1M on an OC-3

module. With the Output Rate = Line Rate / N formula, you can derive the actual values:

```
100M: 155/2 = 77.5
50M: 155/3=51.67 or 38.75
30M: 155/5 = 31 or 155/6 25.8
10M: 155/15 = 10.33 or 9.69
5M: 155/31 = 5
1M: 155/155 = 1
```

The WS-X516x Series (other than the WS-X5166) also uses WRR in order to schedule frames from the VCCs. It assigns a default (non-configurable) transmit priority which depends on the ATM service category, such as CBR, VBR, and UBR. When it calculates the weight, the scheduler considers the SCR of an individual PVC. It then provides a higher transmission rate for PVCs with higher SCR values.

If you choose to configure the SCR values of your VBR-nrt VCs such that you oversubscribe the line rate, the Catalyst ATM module accepts this configuration and does not print an error or warning indication. In the case of oversubscription, packets are dropped in proportion to the rate, such as PCR for a CBR VC and SCR for a VBR VC, across all the PVCs.

On these modules, there is no rate queue concept and no limit on the number of rates you can configure. Queues of the same shaping parameters are not placed in the same queue. Instead, each PVC maintains a packet queue. Queues are created as VCs are created. Thus, the output of the **show atm interface atm0** command does not display any rate queues.

Configure Shaping and Queueing on the WS-X6101

The WS-X6101 supports the VBR-nrt and UBR ATM service categories. The SAR assigns a lower internal priority value to UBR VCs than VBR-nrt VCs. The SAR first schedules a cell from a VBR-nrt VC in an available cell timeslot. If no VBR VCs have data for transmission or if the interface supports a single VC, then the entire link bandwidth is available for the UBR VC. If the network leg of your PVC is provisioned as CBR, you can configure CBR-like PVCs on the WS-X6101 by the configuration of a VBR-nrt VC with PCR = SCR. With this configuration, the CBR-like VC is given a higher SAR scheduling priority than UBR VCs.

If a particular PVC is provisioned as CBR or VBR-rt in the ATM network in order to support real-time traffic like VoIP and you need to provide equivalent support on the WS-X6101, Cisco recommends one of these approaches:

- The SAR on the WS-X6101 schedules cells at a constant inter-cell gap. Thus, it maintains very low jitter and consistent scheduling which the VoIP requires. In order to configure a CBR-like PVC, configure PCR=SCR, as shown here:

```
atm(config-if)#atm pvc 35 0 35 aa15 10000 10000
```

Although such CBR-like PVCs appear as UBR in the output of the **show atm pvc vpi/vci** command, they receive a higher priority than UBR PVCs. However, they share the same priority level as VBR-nrt VCs. (In other words, shaped PVCs (CBR and VBR) are given higher priority over unshaped PVCs (UBR). The WS-X6101 modules are Layer 2 only and do not support IP to ATM Class of Service (CoS) features, such as class-based weighted fair queueing (CBWFQ) and low latency queueing (LLQ).

- Use a FlexWAN module with a PA-A3. The PA-A3 supports four priority levels, which you can tune for each VC with the **transmit-priority** command. In addition, the PA-A3 supports IP to ATM CoS. Refer to Configuring Per-VC Queueing and IP to ATM CoS on the PA-A3 and FlexWAN.

For further information on how the maintenance of a constant inter-cell gap in SAR scheduling provides equivalent CBR-like performance, refer to Understanding Router Support for ATM Real-Time Service Categories.

Throttle an Interface with the atm traffic-shape rate Command

In addition to shaping at the PVC level, you also can shape at the interface level with the **atm traffic-shape rate** command. Specify any whole number from 1 to 155.

This example shows how to throttle or limit the output of an ATM interface to 50 Mbps:

```
atm(config-if)#atm traffic-shape rate 50
```

This command can be useful if you must use the LANE and non-shaping Cisco IOS image, such as c5atm-wl-mc.120-12.W5.19.bin, on the WS-X515x Series and the WS-X5166. Otherwise, Cisco recommends that you specify a PCR value with the **atm pvc** command in order to use native ATM shaping.

Configure the traffic-shape rate Command

In Cisco IOS Software Releases prior to 12.0(16)W5(21), the command-line interface (CLI) on the Catalyst ATM modules allows you to configure the **traffic-shape rate** command. This command implements generic traffic shaping (GTS), which is a Cisco IOS feature available for many interface types. Although you can see matches in the packets and bytes columns of the **show traffic-shape statistics** command if you configure GTS, the ATM modules never supported GTS. The **traffic-shape rate** command no longer appears at the CLI in current releases of Cisco IOS Software for the Catalyst ATM modules.

Cisco recommends that you configure native ATM shaping in order to avoid unexpected cell drops in an ATM network cloud, particularly if the provider implements policing. For more information on the differences between GTS and native ATM shaping, refer to the discussion of this issue in Does the PA-A1 ATM Port Adapter Support Traffic Shaping?.

Related Information

- [Traffic Shaping on ATM Line Cards for the Cisco 12000](#)
- [Traffic-Shaping and Soft-VCs on the ATM Route Module \(ARM\)](#)
- [Configuring the ATM Traffic-Shaping Carrier Module](#)
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