

Does the PA–A1 ATM Port Adapter Support Traffic Shaping?

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Introduction

Cisco offers four ATM port adapters for the Cisco 7x00 router series. The original Cisco ATM port adapter, the PA–A1, is designed for use as a LAN campus uplink supporting LAN Emulation (LANE). This design means that:

- The PA–A1 supports the unspecified bit rate (UBR) service class only. You cannot configure other ATM service classes such as variable bit rate–nonreal time (VBR–nrt) or available bit rate (ABR) on permanent virtual circuit (PVCs). The UBR service class provides a high degree of multiplexing or bandwidth sharing, but does not provide any bounds on delay or cell loss.
- The PA–A1 does not support traffic shaping. The peak cell rate (PCR) of all virtual circuits (VCs) is the line rate, such as 155 Mbps for an Optical Carrier–3 (OC–3) interface.

Cisco introduced the PA–A3 and PA–A6 for WAN links that require native, hardware–based ATM traffic shaping to control bandwidth on the VCs. When connecting an ATM router interface to a switch network that requires traffic shaping, the PA–A3 is recommended. However, if you are constrained to using the PA–A1 in such an application, you can combine the PA–A1 with generic traffic shaping (GTS) as a workaround to using the PA–A3 with VBR–nrt PVCs.

This document describes the important disadvantages of using the PA–A1 with GTS, particularly on WAN connections through an ATM service provider. It also clarifies the important differences between native ATM–based traffic shaping in hardware and GTS in software.

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.

Determining Your Port Adapter Model

Issue one of the following two commands to determine the model of your ATM port adapter and confirm if you are using a PA-A1.

- **show diag** The PA-A1 appears as `ATM Lite PA` on the 7500 series.

```
PA Bay 1 Information:
ATM LITE PA, 1 ports, PA-A1-OC3MM
EEPROM format version 1
HW rev 1.01, Board revision A0
Serial number: 10744404 Part number: 73-1843-03
```

- **show interface atm** The PA-A1 appears as `Hardware is T11570 ATM` on a 7200 router and `Hardware is cyBus ATM` on a 7500 router. In the 7200 router series output, T11570 refers to the segmentation and reassembly (SAR) chip on the PA-A1.

Creating PVCs on the PA-A1

To illustrate the limitations of the PA-A1, an ATM PVC is created in the example below.

Note: The list of commands in VC configuration mode does not include the UBR parameter, which is how a non-default PCR is normally specified. The `class-vc` command cannot be used as a workaround.

```
7500(config)#interface atm 1/0/0.2 multi
7500(config-subif)#pvc 1/1
7500(config-if-atm-vc)#?
ATM virtual circuit configuration commands:
broadcast      Pseudo-broadcast
class-vc       Configure default vc-class name
default        Set a command to its defaults
encapsulation  Select ATM Encapsulation for VC
exit-vc        Exit from ATM VC configuration mode
ilmi           Configure ILMI management
inarp          Change the inverse arp timer on the PVC
no             Negate a command or set its defaults
oam            Configure oam parameters
oam-pvc        Send oam cells on this pvc
protocol       Map an upper layer protocol to this connection.
```

The `show atm vc` command confirms that the VC is configured with a PCR or Peak Kbps value of 155000, which matches the line rate of the OC-3 interface. The router intentionally leaves out Avg/Min Kbps and Burst Cells values since UBR VCs do not support these values.

```
7500#show atm vc
          VCD /
Interface Name VPI VCI Type Encaps  SC      Peak   Avg/Min Burst
1/0/0.2   4    1  1 PVC  SNAP   UBR    155000          Cells Sts
```

Understanding Native ATM Traffic Shaping

All other Cisco ATM router interfaces support some form of traffic shaping in hardware via the SAR chip. The ATM Forum Traffic Management Specification 4.0 defines ATM-specific traffic parameters that are used to control the amount of traffic presented to the switch network. These traffic parameters include PCR, sustained cell rate (SCR), and minimum cell rate (MCR).

The most common way to implement native ATM traffic shaping on Cisco router interfaces is by configuring an ATM VC for VBR-nrt service. Depending on the SAR, Cisco ATM hardware implements native traffic shaping in a unique way, as summarized in Understanding the VBR-nrt Service Category and Traffic Shaping for ATM VCs.

To illustrate the advantages of the PA-A3, two ATM PVCs have been created in the example below.

Note: You can specify a non-default PCR for the UBR PVC, and specify a VBR-nrt PVC with traffic-shaping values.

```
Router(config)#interface atm 5/0
Router(config-if)#pvc 1/1
Router(config-if-atm-vc)#ubr ?
<1-155000> Peak Cell Rate(PCR) in Kbps

Router(config-if-atm-vc)#ubr 10000
Router(config-if-atm-vc)#exit
Router(config-if)#pvc 2/2
Router(config-if-atm-vc)#vbr-nrt ?
<1-155000> Peak Cell Rate(PCR) in Kbps
Router(config-if-atm-vc)#vbr-nrt 10000 ?
<5-10000> Sustainable Cell Rate(SCR) in Kbps
```

The **show atm vc** command now displays a value for the Avg/Min Kbps and Burst Cells columns.

```
Router#show atm vc
          VCD /
Interface Name VPI VCI Type Encaps Peak Kbps Avg/Min Kbps Burst Cells Sts
5/0        1    1    1  PVC  SNAP  10000
5/0        2    2    2  PVC  SNAP  10000  7500    94  UP
```

Cisco IOS Alternatives to Native ATM Traffic Shaping

Cisco IOS® Software supports two traffic-regulation mechanisms: traffic policing and traffic shaping. Importantly, policers and shapers differ in how they respond to violations:

- A policer typically drops traffic. For example, the rate-limiting policer of the committed access rate (CAR) feature either drops the packet or rewrites its IP precedence in the header.
- A shaper typically delays excess traffic using a buffer, or queueing mechanism. It holds packets and shapes the flow when the data rate of the source is higher than the configured shaping values. For example, generic traffic shaping (GTS) and Class-Based Shaping use weighted fair queuing (WFQ) to delay packets in order to shape the flow.

Both mechanisms support an original command syntax and a newer command syntax that falls within the modular quality of service (QoS) command line interface (CLI) (MQC). (Refer to the document Modular Quality of Service Command-Line Interface Overview.) The MQC is a CLI structure in which you specify a traffic class with the **class-map** command, create a traffic policy by associating the traffic class with one or more QoS features using the **policy-map** command, and then attach the traffic policy to an interface or VC with the **service-policy** command.

Cisco introduced the MQC in Cisco IOS Software Release 12.0T. The original **rate-limit** and **traffic-shape** commands as well as the newer **service-policy** command are highlighted in bold in the following output from a 7500 series router running Cisco IOS Software Release 12.1(7).

```
7500(config-subif)#?
Interface configuration commands:
  apollo Apollo interface subcommands

!--- Output suppressed.

ntp      Configure NTP
pvc      Configure ATM PVC parameters
rate-limit Rate Limit
service-policy Configure QoS Service Policy
shutdown Shutdown the selected interface
smrp     Simple Multicast Routing Protocol interface subcommands
sna      SNA pu configuration
snapshot Configure snapshot support on the interface
source-bridge Configure interface for source-route bridging
sscopp   SSCOP Interface Subcommands
standby  Hot standby interface subcommands
svc      Configure ATM SVC parameters
tag-switching Tag Switching interface configuration commands
tarp     TARP interface subcommands
timeout  Define timeout values for this interface
traffic-shape Enable Traffic Shaping on an Interface or Sub-Interface
```

Refer also to the Policing and Shaping Overview in the Cisco IOS Quality of Service Solutions Configuration Guide.

Cisco IOS Traffic Shaping

Cisco IOS Software supports two forms of traffic shaping GTS and, more recently, Class-Based Shaping. Class-Based Shaping augments GTS in three key ways:

- It supports class-based WFQ (CBWFQ) for the queued packets, rather than only flow-based WFQ.
- It supports alternate match-on criteria, such as input interfaces and protocols, rather than only access control lists (ACLs).
- It supports peak rate shaping, which configures the router to send more traffic than the committed information rate (CIR). However, traffic sent above CIR can be dropped if the network becomes congested.

Both methods use the same underlying code that determines whether enough credit is in the token bucket for a packet to be sent or whether that packet must be delayed. However, the command syntax differs, as shown below.

- **traffic-shape rate** Original command. Implements GTS.

```
7500(config-subif)#traffic-shape ?
group configure token bucket: group <access-list> CIR (bps) [Bc (bits) [Be( bits)]]
rate configure token bucket: CIR (bps) [Bc (bits) [Be (bits)]]
```

- **shape {average / peak} mean-rate [burst-size [excess-burst-size]]** New command via MQC. Implements Class-Based Shaping.

Note: Only some ATM router interfaces support GTS. The ATM modules for the 2600 and 3600 series do not. Refer to Traffic Shaping with Cisco 2600/3600 and 4000/4500 Router Series using E3/T3/OC3 ATM Interfaces.

VBR–nrt PVCs Compared to Cisco IOS Traffic Shaping

If you are constrained to using the PA–A1 with a PVC provisioned as VBR–nrt, it is recommended to consider the following differences and disadvantages of native ATM shaping compared to Cisco IOS shaping:

- Cisco IOS traffic shaping uses a different traffic descriptor. It has no concept of a PCR.
 - ◆ Cisco IOS traffic shaping supports either average rate shaping, which limits the transmission rate to the CIR, or peak rate shaping, which configures the router to send more traffic than the CIR. However, traffic sent above CIR typically is not guaranteed within the traffic contract and can be dropped if the network becomes congested.
 - ◆ Cisco IOS peak rate shaping is very different from the ATM definition of PCR for VBR–nrt PVCs. With peak rate shaping, everything above the CIR is eligible for discard. VBR–nrt PVCs support a PCR parameter, which fully grants the right to send above the SCR for a defined duration.
- Cisco IOS traffic shaping allows traffic to burst at any time during the time interval.
 - ◆ Within a time interval, the bit rate may be faster than the mean rate at any given time. In other words, Cisco IOS traffic shaping may transmit all committed bits in a burst at the start of the interval and then no bits for the remainder of the interval. Such scheduling can produce clumps of cells and cause the ATM switch to determine that the bit rate is violating the traffic contract.
 - ◆ ATM switch interfaces count on a relatively consistent intercell gap or adjacent cell arrival time. They police this consistency through a configurable value, cell delay variation tolerance (CDVT).
- Cisco IOS traffic shaping is implemented in software.
 - ◆ Cisco IOS traffic shaping uses greater CPU resources than native ATM traffic shaping.
 - ◆ Native ATM traffic shaping is implemented in hardware via the SAR chip of the interface. It scales well with a large number of VCs configured on a single interface.

Comparing Traffic Descriptors

The most important difference and disadvantage of Cisco IOS traffic shaping is the traffic descriptor. The two traffic descriptors are compared below.

- Cisco IOS traffic shaping:
 - ◆ CIR Specifies how much data can be sent or forwarded per unit of time on average.
 - ◆ Committed burst (Bc) Specifies in bits (or bytes) per burst how much traffic can be sent within a given unit of time to not create scheduling concerns. (For a shaper, such as GTS, it specifies bits per burst.)
 - ◆ Excess burst (Be) Corresponds to the number of noncommitted bits (those outside the CIR) that are still accepted by a network switch, but which may be marked as discard eligible. In other words, the Be size allows more than the burst size to be sent during a time interval in certain situations.
- Native ATM traffic shaping with VBR–nrt PVCs:
 - ◆ SCR Defines the sustained rate at which you expect to transmit data, voice and video.
 - ◆ PCR Defines the maximum rate at which you expect to transmit data, voice and video.
 - ◆ Maximum burst size (MBS) Defines the amount of time (in kbps) or the duration at which the router sends at the PCR.

The concepts and terminology used in traffic shaping can be confusing. They are clarified below.

1. Every physical line rate breaks down into a number of cells or cell timeslots per second. Use the following formula to determine this value:

$$\blacklozenge \text{ line rate} / 424 \text{ bits per cell} = \text{number of cell timeslots per second}$$

2. A T1 (DS-1) with framing overhead has a bit rate of 1.544 Mbps.

$$\blacklozenge 1,544,000 \text{ bits per second} / 424 \text{ bits per cell} = 3622.64 \text{ cell timeslots per second}$$

To simplify the discussion of traffic shaping, this value is round down to 3600.

3. Configure a VBR-nrt PVC on the T1 interface. Assign these traffic-shaping values:

$$\blacklozenge \text{ SCR} = 500 \text{ kbps}$$

$$\blacklozenge \text{ PCR} = 750 \text{ kbps}$$

4. Calculate how many cell timeslots are needed to reach SCR.

$$\blacklozenge 500,000 \text{ bits per second} / 424 \text{ bits per cell} = 1200 \text{ cell timeslots per second}$$

In other words, to achieve SCR, the PVC needs roughly one third of the cell timeslots since the kbps rate is roughly one third of the line rate.

5. Calculate how many cell timeslots are needed to reach PCR.

$$\blacklozenge 750,000 \text{ bits per second} / 424 \text{ bits per cell} = 1800 \text{ cell timeslots per second}$$

In other words, to achieve PCR, the PVC needs roughly half of the cell timeslots since the kbps rate is roughly half of the line rate.

6. Which timeslots will the PVC use to reach these traffic-shaping rates? Does it use any of the 3600 timeslots per second? Ideally, the ATM interface should schedule the cells at an even pace. For example, recall from above that the SCR of 500 kbps needs one third of the cell timeslots. Ideally, the ATM interface should schedule the SCR in every third timeslot (TS), as illustrated below.

TS1	TS2	TS3	TS4	TS5	TS6	TS7	TS8	TS9
-	-	X	-	-	X	-	-	X

It is important to understand that the kbps value is inferred from the intercell gap or the number of timeslots between adjacent cells.

7. Assume that a UBR PVC is configured on the PA-A1. The traffic contract with the provider calls for a VBR-nrt PVC with SCR of 256k. Use the commands of generic traffic shaping to configure the closest equivalent value.

```
7500(config-subif)#traffic-shape rate 256000 ?
<0-100000000> bits per interval, sustained
<cr>
```

```
7500(config-subif)#traffic-shape rate 256000 8000 ?
<0-100000000> bits per interval, excess in first interval
<cr>
```

```
7500(config-subif)#traffic-shape rate 256000 8000 8000
```

```
7500#show traffic-shape
```

Interface AT1/0/0.5		Access Target	Byte	Sustain	Excess	Interval	Increment
VC	List	Rate	Limit	bits/int	bits/int	(ms)	(bytes)
-		256000	2000	8000	8000	31	1000

8. Cisco IOS traffic shaping uses a "derived" time interval from this formula:

◆ **Target Rate / Sustain bits/int = Interval (ms) or number of intervals**

256000 / 8000 = 31 intervals

9. During each interval, Cisco IOS shaping allows an Increment (bytes) value of 1000 bytes, derived from the Sustain bits/int value of 8000 bits.

◆ **8000 bits / 424 bits per cell = about 18 cells**

Cisco IOS traffic shaping does not think in terms of cell timeslots. It is not aware of the need to have an even intercell gap. Thus, in a worst-case scenario, Cisco IOS traffic shaping can lead to the ATM scheduler sending all 18 cells in back-to-back timeslots. On the physical wire, the back-to-back cells appear as:

TS1	TS2	TS3	TS4	TS5	TS6	TS7	TS8	TS9
X	X	X	X	X	X	X	X	X

Recall that the kbps rate is derived from the intercell gap. Thus, a cell clump or burst of back-to-back cells for a relatively long duration is likely to violate the CDVT value on the switch. CDVT implements a "forgiveness" factor when an end system sends clumps of cells into the switch network. Depending on the CDVT value, the switch is likely to drop some number of noncompliant cells, producing cyclic redundancy check (CRC) errors and retransmissions, and generally inducing slow performance on the ATM PVC.

The following table summarizes the differences between native ATM traffic-shaping with nrt-VBR PVCs and generic traffic shaping with Cisco IOS features.

Features	Native ATM Shaping	Generic Traffic Shaping
Implemented in:	Hardware. SAR chip includes a scheduler function. Scales well with large number of PVCs.	Software. Consumes CPU resources.
Applied to:	Individual PVC	Subinterface. Configure one VC per subinterface to implement unique values per VC.
Time interval:	Cell interval	Derived value based on the committed information rate and the committed burst values.

Related Information

- [Traffic Shaping on ATM Line Cards for the Cisco 12000 Series](#)
 - [Traffic Shaping with Cisco 2600/3600 and 4000/4500 Router Series using E3/T3/OC3 ATM Interfaces](#)
 - [ATM Technology Support Pages](#)
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