Traffic Shaping on ATM Line Cards for the Cisco 12000 Series

Document ID: 12141

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Introduction

This document reviews both traffic shaping and traffic management options for the ATM line cards for the Cisco 12000 Series.

Prerequisites

Requirements

There are no specific requirements for this document.

Conventions

Refer to Cisco Technical Tips Conventions for more information on document conventions.

ATM Service Category Support

The ATM Forum defines five service categories in the Traffic Management Specification Version 4.0. These services are Constant Bit Rate (CBR), Variable Bit Rate Real−time (VBR−rt), Variable Bit Rate Non−Real−Time (VBR−nrt), Unspecified Bit Rate (UBR), and Available Bit Rate (ABR). Each ATM service category supports a unique set of traffic management parameters. The GSR ATM line cards support two of these service categories:

- VBR−nrt Refer to Understanding the VBR−nrt Service Category and Traffic Shaping for ATM VCs.
- UBR Refer to Understanding the UBR Service Category for ATM Virtual Circuits.

This table summarizes ATM service category support for the GSR ATM line cards:

	VBR−nrt	UBR	VBR−rt	CBR
	Yes*	Yes		

4xOC3/STM−1 ATM Line Card				
1xOC12/STM−4c ATM Line Card	Yes*	Yes		
4xOC12/STM−4 ATM Line Card	No			
4−Port OC−3c/STM−1c ATM ISE Line Card	Yes	Yes	Yes	Yes
4−Port OC−12c/STM−4c ATM ISE Line Card	Yes	Yes	Yes	Yes
8−Port OC−3c/STM−1c ATM Line Card	Yes			

* These line cards are designed to serve as large−bandwidth pipes in a network core. VBR−nrt traffic shaping is not recommended for low−speed VCs (virtual circuits). When you configure low−speed VCs, consider the restrictions described in Understanding Per−VC Queuing Options on the 4xOC3 ATM Line Card. Next−generation ATM line cards are designed for edge applications and support low−speed VCs.

Old Style Vs New Style PVC Commands

The GSR ATM line cards support both the old−style and the new−style commands to configure ATM PVCs (permanent virtual connections). The new syntax is described in Configuring ATM.

The old syntax is illustrated here:

```
router(config−if)# atm pvc vcd vpi vci aal−encap [peak average burst] [oam seconds]
```

Parameter	Description
vcd	Per−interface unique index value that describes this virtual circuit in the range of 1 to the value set with the **atm maxvc** command.
vpi	ATM network VPI to use for this virtual circuit, in the range of 0 through 255. *
vci	ATM network VCI to use for this virtual circuit, in the range of 0 through 65,535.*
aal−encap	ATM Adaptation Layer (AAL) encapsulation type, typically AAL5SNAP. The number of overhead bytes varies with the chosen encapsulation type.
peak	(Optional) Maximum rate at which a VC can transmit data. Specified in kbps.
average	(Optional) Average rate at which this virtual circuit transmits data. Specified in kbps.
burst	(Optional) Specifies the maximum number of ATM cells the virtual circuit can transmit to a network at the peak rate of the PVC. Supported values range from 1 to 256 in units of one cell.

oam	(Optional) Specifies how often to generate an OAM F5 loopback cell from this virtual circuit. The default value is 10 seconds.

* The supported range of values varies with the **atm vc−per−vp** command. Refer to Understanding the Maximum Number of Active Virtual Circuits on Cisco ATM Router Interfaces.

In order to support high−bandwidth applications, GSR ATM line cards support UBR VCs with a peak cell rate (PCR) at the line−rate only. In order to configure non−line−rate kbps value for PCR on a UBR VC, use the new−style **vbr−nrt** command and configure the PCR and sustained cell rate (SCR) as the same value (PCR=SCR). For example, on a VC with a PCR of two MB, replace **ubr 2000** with **vbr−nrt 2000 2000 94**. The Maximum Burst Size (MBS) in cells is specified by 94.

Note: In early versions of 12.0S, the command line interface (CLI) accepts the **ubr** and **ubr+** commands. However, this configuration is not supported. The **ubr** and **ubr+** commands have been removed from the CLI.

1xOC12

The 1xOC12 supports a maximum PCR or SCR of 311000 kbps, or half the line rate, on VBR−nrt VCs. This holds true for the UBR+ with PCR configured, as well. If you configure a non−supported value, it produces this error message:

```
%ALC−4−HIRATE: Interface (Int#): SAR limits VBR VC PCR to 311000 kbps, opening UBR VC inst
```

Although it supports VBR−nrt traffic shaping, the 1xOC12 is recommended for use as a high−speed pipe in the network core. The 1xOC12 does not support per−VC queueing or the VC−isolation techniques of the 4xOC−3 card like segmentation and reassembly (SAR) pools and tx−queue−limits. One congested VC can fill the packet buffers shared by all other VCs configured on the same card. Symptoms of this problem include delayed and dropped packets.

Refer to Cisco 12000 Series ATM Line Card Installation and Configuration.

4xOC12

The 4−port OC−12 (4xOC12) ATM line card only supports UBR PVCs. It does not support the VBR−nrt service category. Refer to Quad OC−12c/STM−4c Asynchronous Transfer Mode Line Card Installation and Configuration.

4xOC3

The 4xOC3 ATM line card features a high−performance programmable SAR component. You can adapt this for a number of different applications, which include traffic management, cell scheduling, and integrated buffer management.

4xOC3 ATM line cards support the transmission of ATM cells over a Synchronous Optical Network/Synchronous Digital Hierarchy (SONET/SDH) or dark fiber.

Line cards are available in single−mode or multi−mode fiber versions. Both of these versions support these key ATM features:

- UBR and VBR−nrt service categories

- VBR−nrt virtual path (VP) shaping. Refer to Configuring VP Shaping on the 4xOC3 ATM Line Card for the GSR.
- VBR−nrt VC−level traffic shaping on up to four VCs per port, or 16 VCs per line card
- Accurate traffic shaping with granular PCR and SCR values

Refer to Understanding the Maximum Number of Active Virtual Circuits on Cisco ATM Router Interfaces for information on the supported VPI and VCI values.

Understanding Traffic Shaping Accuracy

Both the 1xOC12 and the 4xOC3 ATM line cards use a SAR chip which runs microcode or firmware with SAR−specific software instructions. The SAR microcode is bundled with the Cisco IOS® image that runs on the gigabyte route processor (GRP) and on the ATM line card.

The SAR handles the ATM−layer shaping functions. A shaping algorithm is controlled by a scheduler, which ensures that individual VCs are shaped accurately and a downstream ATM switch does not need to police any non−conforming cells. Let us look at how the scheduler operates with the 1xOC12 and 4xOC3 SAR.

In general, every physical line rate breaks down into a number of cells or cell timeslots per second. You can use this formula to determine this value:

```
line rate / 424 bits per cell = number of cell timeslots per second
```

For example, a SONET link with STS−3c framing has a bit rate of 155 Mbps (or 149.76Mbps without framing overhead) and consists of 353,207 cells (with framing overhead included).

The SAR uses a concept called a "scoreboard" to represent the cell transmission slots on an ATM link. The 1xOC12 uses a single scoreboard, while the 4xOC3 uses a unique scoreboard for each of the four physical interfaces. A VC is scheduled onto the scoreboard based on its rate of transmission and on the output port. The ID of the VC is written into a bit position on the scoreboard. When the scheduler reaches the scoreboard location of a particular VC, it places the VC's data in the output queue and schedules another cell for that VC if there is another cell to send. A cell is not scheduled until the previous cell of a VC is serviced.

The SAR supports a single "priority" for all VCs, but the SAR considers UBR VCs as best effort and services such VCs only when no data for shaped VCs are scheduled on the scoreboard.

If we configure a VC with a cell rate that is less than the line rate, the SAR ideally must choose cell timeslots that have an even intercell gap. The SAR refers to the number of slots between adjacent cell transmissions as the intercell interval, and builds a rate table based on the speed of the physical interface. SAR uses the rate table to convert the desired cell rate (in cells per second) to an intercell emission interval. The scheduling algorithm dynamically schedules a cell from a VC into a slot on the scoreboard with the intercell emission interval. For example, on an OC−3 SONET link, the SAR must schedule a VC with a PCR of 50 Mbps at roughly every third cell timeslot (TS). Such an even intercell gap is illustrated in the figure below.

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

Figure 1: Scheduling of VC cells into timeslots on the scoreboard with an even intercell emission interval.

In other words, when you configure a VBR−nrt VC, you enter the PCR and SCR parameters. The SAR

converts these rates into a cell transmission rate (N) with an ideal intercell gap.

The granularity of the supported shaping rates on the 1xOC12 and 4xOC3 ATM line cards varies with the microcode version that runs on the SAR. This table lists these differences.

Microcode Version	Supported Shaping Granularity	Shaping Details	Supported Line Card
2.1	N = Integer or whole number only.	The VC transmits every Nth cell, which results in a rate of line rate / N. The requirement of the use of whole numbers results in shaping inaccuracies for some rates. For example, a PCR of 250 Mbps has an ideal intercell interval of 2.4, which is a non−integer. In order to avoid cell drops by a policing ATM switch, the SAR rounds to the nearest integer, N=3, which yields an actual PCR of 200 Mbps.	No longer used.
3.1	N = Integer *and a fractional portion.*	The fractional portion adds extra granularity in the intercell interval and provides a	4xOC3

		shaping accuracy of better than 1% for a VC if there is no competition for the same cell timeslots.	
3.2	N = Integer *and a fractional portion.*	The fractional portion adds extra granularity in the intercell interval. In addition, version 3.2 includes a VBR (variable bit rate) recovery algorithm, which is designed to "recover" lost bandwidth when two VCs compete for a single slot on the scheduling system. In this condition, one VC's cell is delayed and ultimately cannot be serviced −− which results in reduced throughput −− if it cannot be rescheduled within a certain time.	1xOC12

		Note: Since the VBR recovery algorithm requires additional CPU cycles, only the 1xOC12 line card supports version 3.2.	

Use this command to display the SAR microcode version of the ATM line card on your Cisco 12000 Series:

```
GSR#execute-on slot 1 show controller
TX SAR (Patch 3.2.2) is Operational;
RX SAR (Patch 3.2.2) is Operational;
Interface Configuration Mode:
        STS-12c

[output omitted]
```

As noted, two or more VCs can experience scoreboard collisions when their respective intercell emission intervals are not integer multiples of each other. For example, assume a scenario with two PVCs, one with a PCR of 50 Mbps and one with a PCR of 40 Mbps. Since the line rate for OC3 is 155Mbps, 50Mbps translates to an intercell interval (ICI) of 3.1 and 40Mbps translates to an ICI of approximately 3.9. With these rates, the collisions occur frequently when both VCs transmit. When there is a collision, the lower−rate PVC is allowed to send first, and the higher−rate PVC is bumped back to the next scoreboard slot. These collisions can occur with any rate of PVC, but are especially noticeable with high−rate PVCs since the intercell intervals are inversely proportional to the rates of the PVCs. In other words, the higher the rate, the smaller the ICI, and the greater the likelihood to be "bumped" back in a collision amid congestion.

The 4xOC3 ATM uses 3.1.3 as the latest SAR firmware version.

Note: Some earlier versions of Cisco IOS bundled SAR firmware version of 3.2.2, but the recommended SAR version is 3.1.3.

This version of microcode provides optimal throughput for the 4xOC3 ATM line card. As a workaround to the issue of scoreboard collisions, configure rates that do not "collide" with each other. For example, try to configure rates that are all multiples of each other and that result in natural intercell intervals. In addition, you can try to increase the maximum burst size (MBS) value of the higher−bandwidth PVC.

In contrast, the 1xOC12 ATM line card uses 3.2.2 as the latest SAR firmware version. As a solution to the issue of scoreboard collisions, this version includes the VBR recovery algorithm, which avoids the problem of reduced throughput (CSCdr78649).

The table details traffic shaping accuracy on the 4xOC3 ATM line card compared to the shaping rate. In each case, we sent traffic to the ATM card (with between one and four ports) at the full OC−3 line rate with 1500−byte packets. The variation in shaping accuracy results from the use of a single SAR to support four physical interfaces on the 4xOC3 line card. In order to configure the VCs on all four interfaces, it means that the SAR must cycle through and service these interfaces. The SAR cannot service all the VCs a sufficient number of times at very high shaping rates.

Selecting PCR and SCR Rates

When you configure a VBR−nrt VC, it is important to ensure that you choose PCR and SCR values that provide an equivalent amount of data bandwidth minus any overhead. An ATM interface includes both fixed and variable overhead, as listed in this table. Note that the number of header bytes varies with the AAL encapsulation type and is not always eight bytes.

Overhead Field	Predictable	Variable
5−byte cell header (cell tax)	X	–
8−byte AAL5 trailer	X	–
8−byte LLC/SNAP header	X	–
Up to 47 bytes of AAL5 padding	–	X

In addition, at the CLI, the 4xOC3 ATM line card allows you to configure a maximum PCR or SCR value of 155 Mbps. The SAR internally converts this number to a maximum value of 149.76 Mbps, which is the bandwidth minus the framing overhead. Refer to Configuring Framing Overhead in the ATM Switch Router Software Configuration Guide.

Given this overhead, we recommend that you consider this when when you choose values for a VBR−nrt VC:

- SCR: This rate must be the one you pick if your traffic was constrained to a constant bit−rate circuit and you did not care about latency. Look on this as the true bandwidth of the VC.
- MBS: This number of cells must accommodate the typical burst size you expect for "bursty" traffic. Choose a value that is at least one MTU−sized frame.
- PCR: This rate must be derived in combination with MBS in order to achieve the desired latency for "bursty" traffic. Look on this as a means to decrease the latency of a VC rather than to increase its bandwidth.

Related Information

- **Traffic Management Specification Version 4.0**
- **Understanding the VBR−nrt Service Category and Traffic Shaping for ATM VCs**
- **Understanding the UBR Service Category for ATM Virtual Circuits**
- **Understanding the Maximum Number of Active Virtual Circuits on Cisco ATM Router Interfaces**
- **Cisco 12000 Series ATM Line Card Installation and Configuration**
- **Quad OC−12c/STM−4c Asynchronous Transfer Mode Line Card Installation and Configuration**
- **Configuring VP Shaping on the 4xOC3 ATM Line Card for the GSR**
- **Maximizing Per−VC Queueing Performance on the 4xOC3 ATM Line Card for the GSR**
- **Technical Support & Documentation − Cisco Systems**

Updated: Feb 03, 2006 Document ID: 12141