Understanding the Available Bit Rate (ABR) Service Category for ATM VCs

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Introduction

The ATM Forum publishes multi-vendor recommendations to further the use of ATM technology. The Traffic Management Specification Version 4.0 defines five ATM service categories that describe both the traffic transmitted by users onto a network as well as the Quality of Service (QoS) that a network needs to provide for that traffic. The five service categories are listed here:

- Constant bit rate (CBR)
- Variable bit rate non-real-time (VBR-nrt)
- Variable bit rate real-time (VBR-rt)
- available bit rate (ABR)
- unspecified bit rate (UBR) and UBR+

This document focuses on ABR.

Prerequisites

Requirements

There are no specific requirements for this document.

Components Used

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

Conventions

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

What is ABR?

When you assign an ATM virtual circuit to the ABR service category it configures a router to transmit at a rate that varies with the amount of bandwidth available in the network or along the end-to-end transmission path. When the network is congested and other source devices are transmitting, there is little available or leftover bandwidth. However, when the network is not congested, bandwidth is available for use by other active devices. ABR allows end-system devices like routers to take advantage of this extra bandwidth and increase their transmission rates. Therefore, ABR uses mechanisms that allow ABR VCs to make use of any bandwidth available in the network at any point in time.

An ABR VC binds a source router to a contract with the ATM switch network. As part of this contract, a source router agrees to examine information that indicates whether or not the network is congested and, in turn, adapt the source transmission rate if required. In return, the ATM switch network agrees to drop no more than a maximum number of cells when congestion occurs. The ratio of dropped cells to transmitted cells is known as the cell loss ratio (CLR).

In addition, an ABR VC uses a closed-loop model. With a closed loop, a source router sends data cells or special cells (called forward resource management [RM] cells) into the ATM network. The switches in the ATM network mark or set bits in these cells as they flow along the end-to-end path. The destination router turns these cells around as backward RM cells. By setting certain bits or fields, the ATM network and destination router provide feedback used to control the source rate in response to bandwidth changes in the network or at the destination.

The ABR service category is designed for VCs that carry file transfers and other bursty, non-real-time traffic that requires some minimum amount of bandwidth (specified via a minimum cell rate) to be available while the VC is configured and active. With ABR, the delay or variation in delay from source to destination router can vary and can be a large value. This makes ABR unsuitable for real-time applications. The CBR and VBR service categories address applications that require tight boundaries on throughput and delay.

Resource Management Cells

RM cells are standard 53-byte ATM cells with the payload type field in the header set to a binary value of 110. Forward RM cells are sent to the destination end-system on the same VC as data cells and at an interval defined by the number of RM cells (NRM) parameter. By default, a source ABR device sends one forward RM cell for every 32 data cells.

RM cells consist of several key fields, as shown in this table:

Field	Bytes	Description
Header	1-5	ATM header
ID	6	Protocol ID
Message Type	7	Various control bits (see the list after this table)
ER	8-9	Explicit cell rate
CCR	10-11	Current cell rate
MCR	12-13	Minimum cell rate
QL	14-17	Queue length
SN	18-21	Sequence number
Rsvd	22-52	Reserved
CRC-10	52-53	CRC-10

The Message Type field consists of eight bits. The two most important bits for ABR service are:

- **Congestion indication (CI)** - Set by network switches. Set by the destination if the source decreases its current rate because of congestion in the end-to-end path.
- **No increase (NI)** - Set by network switches and/or by the destination to indicate that the source should retain its current cell rate (the source does not have to decrease its allowed cell rate). These devices typically set the NI bit when the switch predicts impending congestion.

EFCI Bit in ATM Data Cells

A standard ATM cell header consists of five bytes. The payload type identifier (PTI) field consists of three bits, each of which defines a different parameter. The first bit indicates whether the cell contains user data or control data. If the cell contains user data, the second bit indicates whether the cell experiences congestion as it moves through the network. This second bit is known as the explicit forward congestion indication (EFCI) bit.

The first flow control mechanism implemented for ATM networks used the EFCI bit. ATM switches set the EFCI bit in the headers of forward data cells to indicate congestion. When a destination router receives a data cell with the EFCI bit set, it marks the congestion indication bit in resource management cells to indicate congestion and sends the resource management cells back to the source.

ABR Parameters

Before discussing ABR rate-control methods, you first need to understand the VC parameters used with ABR service. This table describes these parameters.

VC Parameter	Description
Peak Cell Rate (PCR)	Maximum cell rate at which the source can transmit.

Minimum Cell Rate (MCR)	Rate at which a source router can always send.
Initial Cell Rate (ICR)	Rate at which a source router should send when the interface first becomes active and when it begins transmitting again after an idle period.
Available or Allowed Cell Rate (ACR)	Current permitted rate at which the source router can send, based on dynamic feedback from the network.
Rate Increase Factor (RIF)	Amount by which the transmission rate increases after the source interface receives a RM cell with NI and CI set to zero. Specified as a (negative) power of two (2x) with values between 1/32768 and one.
Rate Decrease Factor (RDF)	Amount by which the transmission rate decreases after the source interface receives an RM cell with the CI bit set to one. Specified as a power of two (2x) with values between one and 1/32768.
Number of RM Cells (NRM)	Number of data cells sent between RM cells. By default, the source sends one RM cell for every 32 data cells. Specified as a power of two with (2x) values between two and 256.
Transient Buffer Exposure (TBE)	Number of cells that a source can transmit before receiving feedback from the network via a returned RM cell.
Fixed Round Trip Time (FRTT)	Estimate of the round trip time or the amount of time it takes for an RM cell to be transmitted from the source to the destination and back.

Note: Although the rate parameters use the term "cell rate," Cisco routers operate in bits per second only, not in cells per second. The values in this table should reflect bits per second when configured on the interface.

ABR Flow Control Mechanisms

ABR supports these three methods of communicating congestion information from ATM switches and destination end-systems back to a source device:

- **Binary** - Uses the EFCI bit in ATM data cells. See EFCI Bit in ATM Data Cells.

- **Relative Rate** - Uses the NI and CI bits in either forward (to the destination) or backward (to the source) RM cells. No actual rate is set in any RM cell rate fields.
- **Explicit Rate (ER)** - Uses the explicit rate field in backward RM cells to indicate at which rate the source router can transmit. More specifically, with the explicit rate flow-control method, a source router places its current transmission rate in the commitment, concurrency, and recovery (CCR) field. Intermediate switches explicitly communicate the rate at which the source is allowed to send at that given moment by placing a value in the ER field. The source router reads the ER field and adjusts its CCR to match the ER as long as the calculated rate is not less than the minimum cell rate.

These flow-control methods are rate-based, in which the ATM switch network communicates the rate at which the source can transmit. Rate-based mechanisms contrast with credit-based mechanisms, in which the network communicates the amount of buffer space available for a given VC. The source device transmits only if it knows that the network can buffer the data.

Explicit rate ABR is typically deployed in ATM WAN switches, and is used in products like the Cisco 8400 IGX and 8800 MGX ATM switches. Relative rate ABR is more effectively deployed in the campus and is supported by the Cisco LightStream 1010 and Catalyst 8510 ATM switch routers. The Catalyst 8540 supports EFCI marking only. EFCI is typically used for backward compatibility with legacy ATM switches that support neither explicit rate nor relative rate ABR.

Congestion control schemes operate best when the latency of the feedback path is minimized. Relative rate mode can greatly reduce feedback delays and deliver better performance than the EFCI mode. This is because of its ability for switches to source backward RM cells to send the congestion indicator rather than relying on the destination end system to turn around forward RM cells and map the EFCI bit to the CI bit in the backward RM cells.

Cisco ATM router interfaces implement all three ABR rate-control mechanisms. Note that there is no option to select a specific mechanism. Instead, the router adapts to the format and indications received in the incoming RM cells. Therefore, the mechanism used depends on the configuration of the ATM switches.

ABR Configuration Parameters

You can use either the old-style or new-style PVC command to assign a PVC to the ABR service category. The old-style PVC command places all configuration options on a single line, as shown in this example:

```
interface atm slot/port
 atm abr rate-factor <1/RIF> <1/RDF>
 atm pvc     abr
```

The new-style PVC command places you in VC configuration mode, from which you configure two sets of values, as shown here.

```
interface ATM slot/port
 PVC /
  abr
  abr rate-factor <1/RIF> <1/RDF>
```

With the new-style command output, the first configuration line specifies kbps rates for the PCR and MCR. The PCR is the maximum rate at which a source router is allowed to transmit. The MCR

can be set to zero or can be used to guarantee a minimum amount of bandwidth to the source router even during periods of congestion.

The second configuration line defines values that control the rate at which the ACR is increased or decreased. The default values for both RIF and RDF are 1/16. Cisco recommends that you use the default values.

Upon receipt of an RM cell, a source router first looks at the CI bit. If the CI bit is set, the source reduces its ACR by at least ACR x RDF, but no lower than the MCR value. If the CI bit is not set, the source increases its ACR by no more than RIF x PCR to a maximum of the PCR value. The source next looks at the NI bit. If the NI equals zero, the source does not increase the ACR. Finally, if the source router is using explicit rate, it looks at the ER field (after it calculates the new ACR based on the CI bit) and adjusts its rate to whichever is lower (the new ACR or the ER).

The **abr negotiation** command specifies the minimum rates to use during parameter negotiation for a switched VC (SVC). The router sends these parameters in the minimum acceptable traffic descriptor information element (IE) in the Q.2931 signaling SETUP message. If the network cannot satisfy the request, the call is cleared.

The **no abr negotiation** command specifies that no ABR rate negotiation should occur on the affected SVC. This means that the minimum acceptable traffic descriptor IE is not included in the SETUP message.

ABR Interface Hardware

In Cisco IOS® Software Release 11.1CA and 12.0(x)T, Cisco introduced support for ABR VCs on a select number of ATM router interfaces, which now include these:

- PA-A2
- PA-A3-OC3/DS3/E3 (in the 7200 Series, 7500 Series, and FlexWAN) and the PA-A3-8T1/E1-IMA. The PA-A3-OC12 does not support ABR. Refer to PA-A3-OC12 Frequently Asked Questions.
- NM-1A-OC3
- NM-1A-T3 and NM-1A-E3
- NM-4T1/8T1-IMA and NM-4E1/8E1-IMA
- AIM-ATM and AIM-ATM-VOICE 30

These sections discuss how ABR is implemented on each interface type.

ABR on the PA-A3

Cisco IOS Software Releases 12.0(4)T and 12.0(5)S introduced support for the ABR service class on the PA-A3 adapter for the 7x00 series. ABR is now available in Cisco IOS Software Releases 12.1 mainline, 12.1T and 12.1E trains.

Note: It is not available in Cisco IOS Software Release 12.0 mainline.

If your router is running the Cisco IOS Software Release 12.0T train, Cisco recommends using at least Cisco IOS Software Release 12.0(7)T (which became 12.1(x) mainline) or Cisco IOS Software Release 12.0(8)S. Otherwise, the PA-A3 may receive forward RM cells, but fail to respond to these cells by generating backward RM cells. This problem is documented in Cisco

bug ID CSCdp31471 (registered customers only) . The output of the **show atm vc *{vcd}*** command shows that no forward RM cells have been received.

If your router is running Cisco IOS Software Release 12.1 mainline, Cisco suggests that you run Cisco IOS Software Release 12.1(5) or later to avoid the problems documented in Cisco bug IDs CSCds01236 (registered customers only) and CSCds35103 (registered customers only) .

ABR service on the PA-A3 implements all three modes of rate control. This mode is selected automatically as the PA-A3 adapts to the format and indications received in the incoming RM cells.

ABR on the Network Modules

The ATM network modules for the 2600 and 3600 series of multiservice routers support up to 100 ABR VCs. Each module supports a select number of PCR values, as shown in this table. These values changed with the resolution for Cisco bug ID CSCdt57977 (registered customers only) . The router rounds down any other configured values to one of the supported values. All values are in bits per second.

Module	Supported PCR Values
NM-8E1-IMA	15170700, 13238948, 11501092, 9544357, 7585350, 5750546, 3792675, 1896337, 63591
NM-4E1-IMA	7585350, 5750546, 3792675, 1896337, 63591
NM-8T1-IMA	12136561, 10736991, 9106850, 7589042, 6127890, 4553425, 3063945, 4553425, 3063945, 1531973, 63541
NM-4T1-IMA	6068280, 4553425, 3063945, 1531973, 63541
NM-1A-OC3	148772272, 124871490, 99962664, 74971680, 43978976, 25595184, 15975589, 9991030, 3993897, 1919647, 1535728, 767864, 383929, 64016
AIM-ATM AIM-ATM-VOICE 30	Any value from 32000 to line rate with increments of 1 kbps

In addition, when you configure an ABR VC in a VC class or in VC mode, the MCR value you enter is ignored. An MCR of zero is used, even though this is not apparent from the configuration.

The AIM-ATM and AIM-ATM-VOICE 30 support CBR, VBR-nrt, VBR-rt, ABR, and UBR. Requests to transmit packets (or cells) are sent via open "channels". Use the **show controller atm** command to see the channel per VC. Channels may be configured with one of four priorities and one of three traffic classes (CBR, VBR, ABR). ATM Forum classes (CBR, VBR-rt, VBR-nrt, UBR, UBR+) may be configured by using combinations of channel priority and traffic class. CBR is assigned the highest priority level. The AIM does not support the **transmit-priority** command.

ABR on Cisco ATM Switch Routers

The Catalyst 8540 supports EFCI marking only. The Catalyst 8510 and LightStream 1010 ATM switch routers support the EFCI marking and relative rate flow-control methods for ABR VCs. The **atm abr-mode {efci | relative-rate | all}** command determines which method the ATM switch router uses for rate management on ABR connections. This example shows how to configure the entire switch to set the EFCI bit whenever a cell arrives on a congested ABR connection:

```
Switch(config)#atm abr-mode efci
```

Use the **show atm resource** command to display the ABR congestion notification mode configuration.

```
Switch>show atm resource
Resource configuration:
Over-subscription-factor 8 Sustained-cell-rate-margin-factor 1%
 Abr-mode: efci

 Service Category to Threshold Group mapping:
   cbr 1 vbr-rt 2 vbr-nrt 3 abr 4 ubr 5

 Threshold Groups:
 Group Max    Max Q  Min Q   Q  thresholds Cell  Name
       cells  limit  limit   Mark Discard  count
       instal instal instal
 ------------------------------------------------
 1     65535   63     63     25 %   87 %   0  cbr-default-tg
 2     65535   127    127    25 %   87 %   0  vbrrt-default-tg
 3     65535   511    31     25 %   87 %   0  vbrnrt-default-tg
 4     65535   511    31     25 %   87 %   0  abr-default-tg
 5     65535   511    31     25 %   87 %   0  ubr-default-tg
 6     65535   1023   1023   25 %   87 %   0  well-known-vc-tg
```

Your ATM switch router must have a feature card per-flow queuing (FC-PFQ) and Cisco IOS Software Release 11.2(8) or later to configure a non-zero minimum cell rate (MCR) for ABR VCs. If your switch has feature card per-class queueing (FC-PCQ or FC1) installed on the route processor, a non-zero MCR is not supported.

ABR on WAN Switches

On Cisco Stratacom WAN switches, you can configure ABR VCS as one of two types:

- ABR standard (ABRSTD).
- ABR with Foresight (ABRFST).

ABRSTD is the default ABR connection type when neither ABRFST nor ABRSTD with VS/VD have been enabled using the **cnfswfunc** command. ABRSTD with VS/VD builds on the ABRSTD connection by adding virtual endpoints for increased congestion control. The ABRSTD connection parameters are limited and will be addressed in the ABRSTD with VS/VD section. The ABRFST or ABRSTD with VS/VD feature only needs to be enabled on one BPX to propagate to all nodes.

More information on configuring ABR on Stratacom switches is available in the Stratacom Configuration guides.

- ATM Connection Configuration and Troubleshooting for the Cisco BPX 8600 Series Switch -

ABR Connections
- White Paper - BPX Congestion Avoidance

Virtual Source/Virtual Destination

The ABR model acts as a closed-loop feedback mechanism, in which intermediate switches as well as destination end-systems use bits in data and RM cells to communicate network congestion and specific rates at which the source should transmit. In some applications, it may be desirable to divide the end-to-end path of an ABR VC into separately controlled segments that close the feedback loop at some intermediate point. In this configuration, the intermediate devices are said to be a virtual source or a virtual destination.

The ATM Forum's Traffic Management Specification 4.0 describes the virtual source/virtual destination (VS/VD) concept. It lists two potential benefits of VS/VD:

- Set administrative boundaries due to the preferences of network operators.
- Reduce the length and thus the round-trip delay between the two ends.

VS/VD behavior is not supported on the Catalyst 8500 or LightStream 1010 series of ATM switches.

Related Information

- **Understanding the CBR Service Category for ATM VCs**
- **Understanding the VBR-nrt Service Category and Traffic Shaping for ATM VCs**
- **Understanding the Variable Bit Rate Real Time (VBR-rt) Service Category for ATM VCs**
- **Understanding the UBR Service Category for ATM VCs**
- **Understanding the UBR+ Service Category for ATM VCs**
- **ATM Technology Support Pages**
- **Technical Support & Documentation - Cisco Systems**