Multiport T1/E1 ATM Port Adapters with Inverse Multiplexing over ATM

This document describes the Cisco IOS Inverse Multiplexing for ATM (IMA) features available with the introduction of Multiport T1/E1 ATM port adapters with IMA for the Cisco 7200 series routers and Cisco 7500 series routers.

This document includes the following sections:

Feature Overview

The inverse multiplexing over ATM (IMA) port adapter is a single-width port adapter that allows Cisco 7200 series and Cisco 7500 series routers to support inverse multiplexing over ATM. These port adapters allow WAN uplinks at speeds ranging from 1.544 Mbps to 12.288 Mbps for T1 connections and from 2.048 Mbps to 16.384 Mbps for E1 connections. (For details, see the "Bandwidth Considerations" section on page 4.)

With Cisco's scalable ATM IMA solution, network designers and managers can deploy only the bandwidth they need, using multiple T1 or E1 connections instead of more expensive T3 or OC-3 lines to bridge LANs and ATM WAN applications. Enterprises and branch offices can aggregate traffic from multiple lower-bandwidth physical transmission media, such as T1 or E1 pipes, to transmit voice and data at high-bandwidth connection speeds.

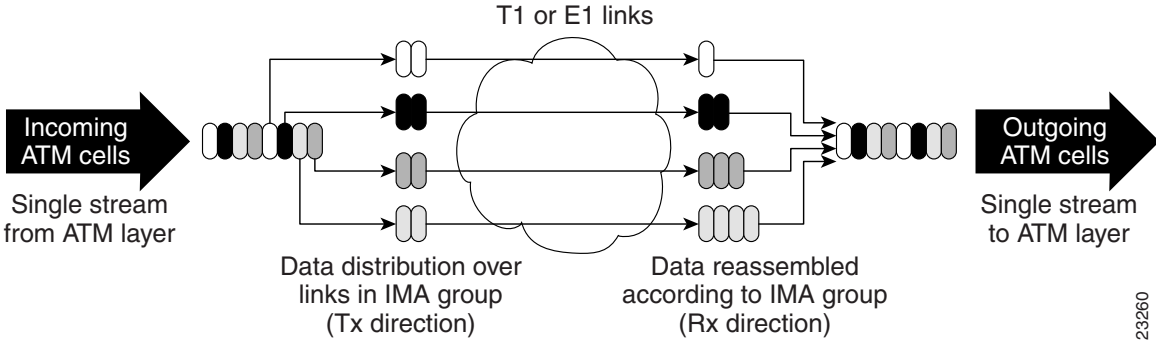
IMA Protocol Overview

In the transmit direction, IMA takes cells from the ATM layer and sends them in sequential distribution over the individual links that make up a logical link group called an IMA group (links can also be assigned as individuals rather than as group members). The IMA group performance is approximately the sum of the links, although some overhead is required for ATM header and control cells. At the receiving end, the cells are recombined to form the original cell stream and are passed up the ATM layer.

Filler cells are used to ensure a steady stream on the receiving side. IMA Control Protocol (ICP) cells control the operation of the inverse multiplexing function. For instance, using a frame length of 128 cells, one out of every 128 cells on each link is an ICP cell. The inverse multiplexing operation is transparent to the ATM layer protocols, and therefore the ATM layer can operate normally as if only a single physical interface is being used.

Figure 1 illustrates inverse multiplexing and demultiplexing with four bundled links, providing 5.52 Mbps of bandwidth for T1s for packet traffic, after subtracting the overhead of ATM cell headers and ICP cells. The transmitting side, from which cells are distributed across the links, is referred to as *Tx*, and the receiving side, where cells are recombined, is called *Rx*.

Figure 1 Inverse Multiplexing and Demultiplexing



General Description of the ATM T1/E1 IMA Feature Set

ATM networks were designed to handle the demanding performance needs of voice, video, and data, at broadband speeds of 34 Mbps and higher. However, the high cost and sporadic availability of long-distance broadband links limits broadband ATM WANs, preventing many organizations from taking advantage of ATM power. In response to these issues, the ATM Forum defined lower-speed ATM interface options for T1 or E1. However, this was not a complete solution, because a single T1 or E1 link often does not provide enough bandwidth to support either traffic among different router and switch locations or heavy end-user demand.

For this reason, many organizations find themselves caught between the bandwidth limitations of a narrowband T1 or E1 line and the much higher costs of moving to broadband links. In response to this dilemma, the ATM Forum defined IMA. Using Cisco 7200 series routers and Cisco 7500 series routers to provide ATM access gives branch offices and enterprises an affordable LAN-to-ATM interface.

ATM IMA T1 or E1 support on Cisco 7200 series routers and Cisco 7500 series routers includes the following features:

- Prioritization of ATM transport, including the following traffic classes:
  - Nonreal-time variable bit rate (VBR) connection-oriented service suitable for video and packets

  - Unspecified bit rate (UBR), as recognized by the ATM Forum, without resource allocation or quality of service (QoS) specifications
  - Available bit rate (ABR) connection-oriented service for traffic, such as LAN interconnections and TCP/IP connectivity, that works with variable delays.
- Cell-based inverse multiplexing that allows Operation, Administration, and Maintenance (OAM) cells to provide management and monitoring, which performs across the inverse multiplexed links. In this fashion, Cisco 7200 series routers and Cisco 7500 series routers with ATM IMA functionality can exchange monitoring information such as connectivity, alarm indication signals (AISs), and loopback.
- Support of permanent virtual circuits (PVCs), as well as the switched virtual connections (SVCs) being introduced by carriers. Up to 512 virtual circuits are supported on each User-Network Interface (UNI) and 512 x *n* interface virtual circuits are supported on each IMA interface where *n* is the number of links.
- Support for ATM Interim Local Management Interface (ILMI) as specified by the ATM Forum for incorporating network-management capabilities.
- Automatic and dynamic removal of failed links or those not performing according to delay standards, along with automatic and dynamic restoration when the links are up or when delays are acceptable.
- Interoperation with the Cisco LS1010, ATM interfaces on Cisco 7200 series routers and Cisco 7500 series routers, and Cisco BPX 8600 series wide-area ATM switches.
- Support of ATM adaption layer 5 (AAL5).
- Support of VP shaping for UBR virtual circuits.
- Support of IP ATM_COS for Cisco 7200 series routers.

Benefits

The following are benefits offered by the ATM T1 or E1 IMA features for Cisco 7200 series routers and Cisco 7500 series routers:

- High-bandwidth performance at a lower cost than T3 offers
- Greater internetworking design flexibility and scalability for LAN-to-WAN solutions
- Migration path to high bandwidth without the need to change transport facilities
- Efficient prioritization provided by ATM architecture

Restrictions

This section describes general restrictions and ATM aspects that the ATM IMA feature does not support, as well as bandwidth considerations.

General Limitations

The following restrictions apply to the ATM IMA feature on Cisco 7200 series routers and Cisco 7500 series routers:

- If Common Transmit Clock (CTC) is configured on an IMA interface using the **ima clock-mode common** command, then the port adapter's internal clock is used as the transmit clock source for all the links of the IMA interface.

- The bandwidth of an IMA interface is limited to the minimum number of active IMA links needed to keep the IMA interface up. If the value of this parameter is decreased, you need to make sure that all the virtual circuits (VCs) of the higher bandwidth are torn down.
- The maximum bandwidth of a User-Network Interface (UNI) T1 or E1 interface or an IMA interface with an odd number of T1 or E1 links is less than the actual available maximum bandwidth by 0.5Mbps. But an unspecified bit rate (UBR) virtual circuit configured without a specified peak rate can exploit the full bandwidth.
- The feature does not support the following ATM adaption layers: AAL1, AAL2, and AAL3/AAL4.
- The feature does not support the ATM constant bit rate (CBR) traffic class or real-time variable bit rate (rt-VBR).
- SNMP
  - IMA failure alarm trap is not supported
  - IMA support for IFMIB is not supported
  - Set operation for IMA MIB is not supported
- The IP ATM_COS feature is not supported on Cisco 7500 series routers.

Bandwidth Considerations

When planning IMA groups and payload bandwidths, consider the overhead required for ATM headers and ICP cells. Table 1 and Table 2 show approximate values for T1 and E1 IMA groups respectively, with a frame length of 128 cells, estimating ATM overhead at about 10 percent. The effective payload bandwidth varies based on packet size because the packets must be divided into an integer number of ATM cells leaving the last cell padded with filler bytes.

Note Control the bandwidth threshold to activate an IMA group by using the **ima active-links-minimum** command. For additional information, see the "ima active-links-minimum" section.

Table 1 IMA T1 AAL5 Payload Bandwidth, IMA Frame Size 128 Cells

Number of Links in the Group	Total Bandwidth	Payload Bandwidth
1	1.536	1.38
2	3.072	2.76
3	4.608	4.14
4	6.144	5.52
5	7.68	6.91
6	9.216	8.28
7	10.752	9.66
8	12.288	11.04

Table 2 E1 AAL5 Payload IMA Bandwidth, IMA Frame Size 128 Cells

Number of Links in the Group	Total Bandwidth	Payload Bandwidth
1	1.92	1.74
2	3.84	3.47
3	5.76	5.21
4	7.68	6.95
5	9.60	8.69
6	11.52	10.43
7	13.44	12.17
8	15.36	13.90

Supported Platforms

- Cisco 7200 series routers
- Cisco 7500 series routers

Supported Standards, MIBs, and RFCs

Standards

No new or modified standards are supported by this feature.

MIBs

- DS-1 MIB
- IMA MIB (ATM Forum, AF-PHY-0086-000)

RFCs

- RFC 1406

Prerequisites

Before you can configure a Cisco 7200 series router or Cisco 7500 series router to provide ATM T1 or E1 IMA service, you must perform the following tasks:

- Obtain T1 or E1 service from your telecommunications provider.
- Install an ATM T1 or E1 IMA port adapter into your Cisco router. The following ATM T1 or E1 IMA port adapter is required for support of inverse multiplexed ATM on Cisco 7200 series routers and Cisco 7500 series routers:

  PA_HARDWARE_A3_8T1IMA—Eight-port ATM IMA port adapter that provides T1 connectivity

  PA_HARDWARE_A3_8E1IMA—Eight-port ATM IMA port adapter that provides E1 connectivity

For details about software configuration, see the Cisco IOS Release 12.0 software documents, *Wide-Area Networking Configuration Guide* and *Wide-Area Networking Command Reference*. For more information about the physical characteristics of the ATM T1 or E1 IMA port adapters for the Cisco 7200 series routers, or for instructions on how to install the port adapters, either see the *Inverse Multiplexing over ATM (IMA) Port Adapter Installation and Configuration Guide* that came with your ATM T1 or E1 IMA port adapter.

Configuration Tasks

This section describes the configuration tasks required to set up ATM IMA groups. You can also configure ATM links individually, but this feature description only includes those individual configuration steps that might pertain to ATM IMA groups. For complete information about ATM configuration, see the Cisco IOS Release 12.0 *Wide-Area Networking Configuration Guide* and *Wide-Area Networking Command Reference*.

See the following sections for configuration tasks that enable ATM inverse multiplexing. Each task in the list indicates if it is optional or required:

- Configuring the ATM Interface
- Verifying the ATM Interface Configuration
- Configuring the IMA Groups
- Verifying the IMA Group Configuration

Configuring the ATM Interface

Repeat the steps below to configure each ATM interface for ATM IMA operation. For complete information about ATM interface configuration, see the Cisco IOS Release 12.0 *Wide-Area Networking Configuration Guide*.

	Command	Purpose
Step 1	`Router# configure terminal`	Enter global configuration mode.
Step 2	`Router(config)# interface atm` *slot/port* (7200 series routers) Router (config)# **interface atm** *slot/port-adapter/port* (Cisco 7500 series)	Enters interface configuration mode and specifies the location of the interface. • *slot* indicates the router slot position of the installed port adapter. Depending upon the router, enter a slot value from 1 to 5. • *port* indicates the T1 or E1 link that you are configuring. Enter a value from 0 to 7 for the eight ports. • *port-adapter* indicates on Cisco 7500 series routers the location of the port adapter on a VIP card. The Cisco IOS software creates the interfaces automatically when a port adapter is installed.

	Command	Purpose
Step 3	`Router(config-if)# clock source {line | internal}`	Sets the clock source for a link. • **line** specifies that the link uses the recovered clock from the link and is the default setting. Generally, this setting is most reliable. • **internal** specifies that the DS-1 link uses the internal clock. **Note** You should ensure that clock settings are properly configured for each link even when you intend to use a common link for clocking all of the links in an IMA group. For more information, see the "ima clock-mode" section on page 23.

Step 4	`Router(config-if)# lbo long {gain26 | gain36} {-15db | -22.5db | -7.5db | 0db}`
	or
	`lbo short {133 | 266 | 399 | 533 | 655}`
		Sets a cable length longer than 655 feet for a T1 link.
		• **gain26** specifies the decibel pulse gain at 26 decibels. This is the default pulse gain.
		• **gain36** specifies the decibel pulse gain at 36 decibels.
		• **-15db** specifies the decibel pulse rate at -15 decibels.
		• **-22.5db** specifies the decibel pulse rate at -22.5 decibels.
		• **-7.5db** specifies the decibel pulse rate at -7.5 decibels.
		• **0db** specifies the decibel pulse rate at 0 decibels. This is the default pulse rate.
		Sets a cable length 655 feet or shorter for a T1 link. There is no default for **lbo short**.
		• **133** specifies a cable length from 0 to 133 feet.
		• **266** specifies a cable length from 134 to 266 feet.
		• **399** specifies a cable length from 267 to 399 feet.
		• **533** specifies a cable length from 400 to 533 feet.
		• **655** specifies a cable length from 534 to 655 feet.
		If you do not set the cable length, the system defaults to a setting of **lbo long gain260db (space between gain26 and 0db)**.

	Command	Purpose
Step 5	`Router(config-if)#` **no ip address**	Instead of configuring protocol parameters on the physical interface, you can set these up on the IMA group virtual interface.
Step 6	`Router(config-if)#` **no atm oversubscribe**	Enables the ATM bandwidth manager, which keeps track of bandwidth used by virtual circuits on a per-interface basis. When you specify the no form of the command, a check determines whether the ATM link is already oversubscribed. If it is, the command is rejected. Otherwise, the total bandwidth available on the link is recorded and all future connection setup requests are monitored to ensure that the link is not oversubscribed.
Step 7	`Router(config-if)#` **no scrambling cell-payload**	Randomizes the ATM cell payload frames to avoid continuous nonvariable bit patterns and improve the efficiency of ATM's cell delineation algorithms. Normally the default setting for this command is sufficient, with no specific command required. By default, scrambling is off for T1 or E1 links.
Step 8	`Router(config-if)#` **loopback [diagnostic |[payload | line] | remote [iboc | esf [payload | line]]] for T1** **loopback [diagnostic |local [payload | line]] for E1**	(For testing only) Loops all packets from the ATM interface back to the interface, as well as directs the packets to the network. The default **line** setting places the interface into external loopback mode at the line. • **remote** sets the far end T1 interface into either payload or line loopback. • **local** loops the incoming receive signal back out of the transmitter. • **diagnostic** loops the outgoing transmit signal back to the receive signal.
Step 9	`Router(config-if)#` **fdl** {**ansi** | **att**}	(Optional) Sets the Facility Data Link (FDL) exchange standard for the Channel Service Unit (CSU) controllers. The FDL is a 4-Kbps channel used with the Extended Super Frame (ESF) framing format to provide out-of-band messaging for error-checking on a T1 link. Changing the default allows better management in some circumstances, but can cause problems if your setting is not compatible with that of your service provider.
Step 10	`Router(config-if)#` **ima-group** *group-number*[1]	Specifies that the link is included in an IMA group. Enter an IMA group number from 0 to 3. You can specify up to four groups per IMA port adapter. IMA groups usually span multiple ports on a port adapter.
Step 11	`Router(config-if)#` **no shutdown**	Ensures that the link is active at the IMA level.

1. It is recommended that if the link is already a port of an IMA group then remove it from the IMA group both at the near end and far end and then move the link to a desired IMA group.

Verifying the ATM Interface Configuration

Follow the steps below to verify configuration of ATM interfaces.

Step 1 Use the privileged EXEC **show interface atm** *slot*/*port* command to verify configuration of the ATM interface. Important information appears in bold. Note that the total count of configured VCs is shown.

```
Router#show interface atm 5/0
ATM5/0 is up, line protocol is up
  Hardware is IMA PA
  Internet address is 156.0.2.0/16
  MTU 4470 bytes, sub MTU 4470, BW 1536 Kbit, DLY 20000 usec,
     reliability 255/255, txload 1/255, rxload 1/255
  Encapsulation ATM, loopback not set
  Keepalive not supported
  Encapsulation(s):AAL5
  512 maximum active VCs, 3 current VCCs
  VC idle disconnect time:300 seconds
  1 carrier transitions
  Last input 00:43:16, output 00:43:16, output hang never
  Last clearing of "show interface" counters never
  Input queue:0/75/0 (size/max/drops); Total output drops:0
  Queueing strategy:weighted fair
  Output queue:0/1000/64/0 (size/max total/threshold/drops)
     Conversations  0/0/256 (active/max active/max total)
     Reserved Conversations 0/0 (allocated/max allocated)
  5 minute input rate 0 bits/sec, 0 packets/sec
  5 minute output rate 0 bits/sec, 0 packets/sec
     4803 packets input, 5928671 bytes, 0 no buffer
     Received 0 broadcasts, 0 runts, 0 giants, 0 throttles
     0 input errors, 0 CRC, 0 frame, 0 overrun, 0 ignored, 0 abort
     4823 packets output, 5911619 bytes, 0 underruns
     0 output errors, 0 collisions, 1 interface resets
     0 output buffer failures, 0 output buffers swapped out
```

Step 2 To get information about the physical link, use the privileged EXEC **show controller [atm [***slot*/*port***]]** command.

```
Router# show controller atm 1/ima0
Interface ATM1/ima0 is up
Hardware is IMA PA - DS1 (1Mbps)
Framer is PMC PM7344, SAR is LSI ATMIZER II
Firmware rev:G102, ATMIZER II rev:3
  idb=0x61DE9F10, ds=0x6185C0A0, vc=0x6187D3C0, pa=0x6184AF40
  slot 1, unit 9, subunit 0, fci_type 0x00BA, ticks 701720
  400 rx buffers:size=512, encap=64, trailer=28, magic=4
Curr Stats:
  rx_cell_lost=0, rx_no_buffer=0, rx_crc_10=0
  rx_cell_len=0, rx_no_vcd=0, rx_cell_throttle=0, tx_aci_err=0
Rx Free Ring status:
  base=0x3CFF0040, size=1024, write=320
Rx Compl Ring status:
  base=0x338DCE40, size=2048, read=1275
Tx Ring status:
  base=0x3CFE8040, size=8192, write=700
Tx Compl Ring status:
  base=0x338E0E80, size=2048, read=344
```

```
BFD Cache status:
  base=0x61878340, size=5120, read=5107
Rx Cache status:
  base=0x61863D80, size=16, write=11
Tx Shadow status:
  base=0x618641C0, size=8192, read=687, write=700
Control data:
  rx_max_spins=12, max_tx_count=25, tx_count=13
  rx_threshold=267, rx_count=11, tx_threshold=3840
  tx bfd write indx=0x27, rx_pool_info=0x61863E20
Control data base address:
       rx_buf_base = 0x038A15A0        rx_p_base = 0x6185CB40
            rx_pak = 0x61863AF0              cmd = 0x6185C320
       device_base = 0x3C800000     ima_pa_stats = 0x038E2FA0
        sdram_base = 0x3CE00000       pa_cmd_buf = 0x3CFFFC00
       vcd_base[0] = 0x3CE3C100      vcd_base[1] = 0x3CE1C000
         chip_dump = 0x038E3D7C       dpram_base = 0x3CD80000
   sar_buf_base[0] = 0x3CE4C000  sar_buf_base[1] = 0x3CF22000
       bfd_base[0] = 0x3CFD4000      bfd_base[1] = 0x3CFC0000
       acd_base[0] = 0x3CE88360      acd_base[1] = 0x3CE5C200
     pci_atm_stats = 0x038E2EC0
ATM1/ima0 is up
        hwgrp number = 1
grp tx up reg= 0x5, grp rx up reg= 0x3, rx dcb reg= 0xD4 0x4, tx links grp reg=
0x3, scci reg= 0x3C, ima id reg= 0x0, group status  reg= 0xA2, tx timing reg= 0x
20, tx test reg= 0x21, tx test pattern reg= 0x41, rx test pattern reg= 0x42, icp
 cell link info  reg= 0xFC, icp cell link info  reg= 0xFC, icp cell link info  r
eg= 0x0, icp cell link info  reg= 0x0, icp cell link info  reg= 0x0, icp cell li
nk info  reg= 0x0, icp cell link info  reg= 0x0, icp cell link info  reg= 0x0
```

Configuring the IMA Groups

The **ima-group** command configures links on an ATM interface as IMA group members. When IMA groups have been set up in this way, you can configure settings for each group.

Verifying the IMA Group Configuration

	Command	Purpose
Step 1	`Router# configure terminal`	Enters global configuration mode.
Step 2	`Router(config)# interface atm` *slot*`/ima<`*group number*`>` (7200 series routers) `Router(config)# interface atm` *slot/port-adapter/ima* `<`*group number*`>` `(Cisco 7500 series routers)`	Enters interface configuration mode and specify the slot location of the interface and IMA group number. • *slot* indicates the router slot where the port adapter is located. Depending upon the router, enter a slot value from 1 to 5. • *group-number* is the IMA group label. Enter a value from 0 to 3. There should be no space between "**ima**" and the group number. • *port-adapter* indicates the physical port adapter slot on the VIP2. • *port* identifies the interface port on the IMA port adapter.
Step 3	`Router(config-if)# ip address` *ip-address*	Sets protocol parameters for the whole group.
Step 4	`Router(config-if)# pvc` *vpi/vci* `ilmi`	If you are going to use SVCs, create an ATM PVC for ILMI management purposes and enter VC configuration mode. To set up communication with the ILMI, use a value of **ilmi** for ATM adaptation layer encapsulation; the associated *vpi* and *vci* values are ordinarily 0 and 16, respectively.[1]
Step 5	`Router(config-if-atm-vc)# pvc` *vpi/vci* `qsaal`	Enables the signaling for setup and tear-down of SVCs by specifying the Q.SAAL[2] encapsulations; the associated *vpi* and *vci* values are ordinarily 0 and 5, respectively. **Note** You can also set up PVCs for sending information.
Step 6	`Router(config-if-atm-vc)# exit`	To complete configuration of a PVC, exit VC configuration mode.
Step 7	`Router(config-if)# svc` *name* `nsap` *nsap-address*	Sets up SVCs for sending ATM information. Once you specify a name for an SVC, you can reenter the interface-ATM-VC configuration mode by simply entering **svc** *name*. *nsap-address* is a 40-digit hexadecimal number.

	Command	Purpose
Step 8	`Router(config-if-atm-vc)# protocol ip` *address* `broadcast`	Specifies a protocol address for the SVC. **Note** The default AAL5 layer and SNAP[3] encapsulation is used in this example, so the **encapsulation** *aalencap* command is unnecessary.
Step 9	`Router(config-if-atm-vc)# exit`	Exits VC configuration mode and returns to interface configuration mode.
Step 10	`Router(config-if)# ima clock-mode {common` <*port*> | `independent}`[4]	Sets the transmit clock mode for the group. If all the links in the group should share a clock source, use the **common** keyword. If each link uses a different clock source, use the **independent** clock source keyword. Using the *port* keyword, you can specify a link for common clocking. The default uses the common clock as the transmit clock source.
Step 11	`Router(config-if)# ima active-links-minimum` *number*	When used with a number value from 1 to 8, specifies how many transmit links must be active in order for the IMA group to be operational. The setting you choose depends upon your performance requirements as well as the total number of links in the group. If fewer than the preset minimum are active, the group is automatically rendered inactive until the minimum number of links are up again. The default value is 1.

	Command	Purpose
Step 12	`Router(config-if)# ima differential-delay-maximum` *msec*	Specifies the differential timing delay among the links in an IMA group by entering a milliseconds value from 25 to 250 for T1 and 25 to 190 for E1. If a link delay exceeds the specified maximum, the link is dropped; otherwise, the IMA feature adjusts for differences in delays so that all links in a group are aligned. A shorter value provides less resiliency in adjusting for variations than a higher value. However, a higher value might affect overall group performance, because increased differential delay adds more latency to the traffic that is transmitted across the group.
Step 13	`Router(config-if)# ima test [link` *port*] [**pattern** *pattern-id*]	Troubleshoots or diagnoses physical link connectivity. The IMA feature performs ongoing tests on all links in a group, to verify link connectivity. Use this command to specify a link to use for testing as well as a test pattern. The pattern is sent from the specified link and looped back from the receiving end in the multiplexing-demultiplexing process. A byte in the ICP cell identifies the pattern.

1. This command is new to Cisco 7200 series routers, but was introduced for other platforms in earlier releases. For more information about the command, see the Cisco IOS Release 12.0 documents, *Wide Area Networking Configuration Guide* and *Wide Area Networking Command Reference*.
2. Q Signalling ATM adaptation Layer
3. Subnetwork Access Protocol
4. To form an IMA group with independent clock mode, use the **no shut** command in the IMA interface only. To change the mode to independent from an already existing IMA group, use the **no ima** command on the IMA group links. Next, change the mode, add all the links, and then issue the **no shut** command in the IMA interface.

Step 1 Use the privileged EXEC **show ima interface atm** [*slot*] **/ima[group-number]** [**detail**] command to get information about IMA group interfaces. First, the group information appears. Then, information about each link in the group (there are two in this example) is displayed under "IMA Detailed Link Information."

Important information is shown in bold.

Note If you do not enter the **detail** keyword, you do not see the information beginning with "Detailed group Information:" in the example below.

```
Router# show ima interface atm 1/ima0 detail
ATM1/ima0 is up
        ImaGroupState:NearEnd = operational, FarEnd = operational
        ImaGroupFailureStatus  = noFailure
IMA Group Current Configuration:
        ImaGroupMinNumTxLinks = 2    ImaGroupMinNumRxLinks = 2
        ImaGroupDiffDelayMax  = 25   ImaGroupNeTxClkMode   = common(ctc)
        ImaGroupFrameLength   = 128  ImaTestProcStatus     = disabled
        ImaGroupTestLink      = 0    ImaGroupTestPattern   = 0xFF
IMA MIB Information:
        ImaGroupSymmetry        = symmetricOperation
```

```
        ImaGroupFeTxClkMode     = common(ctc)
        ImaGroupRxFrameLength   = 128
        ImaGroupTxTimingRefLink = 0     ImaGroupRxTimingRefLink = 0
        ImaGroupTxImaId         = 0     ImaGroupRxImaId         = 0
        ImaGroupNumTxCfgLinks   = 2     ImaGroupNumRxCfgLinks   = 2
        ImaGroupNumTxActLinks   = 2     ImaGroupNumRxActLinks   = 2
        ImaGroupLeastDelayLink  = 1     ImaGroupDiffDelayMaxObs = 0
IMA group counters:
        ImaGroupNeNumFailures   = 78    ImaGroupFeNumFailures   = 68
        ImaGroupUnAvailSecs     = 441453        ImaGroupRunningSecs     =
445036
IMA Detailed Link Information:

ATM1/0 is up
        ImaLinkRowStatus = LinkRowStatusUnknown
        ImaLinkIfIndex   = 0            ImaLinkGroupIndex = 0
        ImaLinkState:
                NeTx = active
                NeRx = active
                FeTx = active
                FeRx = active
        ImaLinkFailureStatus:
                NeRx = noFailure
                FeRx = noFailure
        ImaLinkTxLid           = 0      ImaLinkRxLid           = 0
        ImaLinkRxTestPattern   = 65     ImaLinkTestProcStatus  = disabled
        ImaLinkRelDelay        = 0
IMA Link counters :
        ImaLinkImaViolations   = 1
        ImaLinkNeSevErroredSec = 41     ImaLinkFeSevErroredSec = 34
        ImaLinkNeUnavailSec    = 441505 ImaLinkFeUnAvailSec    = 28
        ImaLinkNeTxUnusableSec = 2      ImaLinkNeRxUnUsableSec = 441542
        ImaLinkFeTxUnusableSec = 74     ImaLinkFeRxUnusableSec = 57
        ImaLinkNeTxNumFailures = 0      ImaLinkNeRxNumFailures = 15
        ImaLinkFeTxNumFailures = 4      ImaLinkFeRxNumFailures = 3

ATM1/1 is up
        ImaLinkRowStatus = LinkRowStatusUnknown
        ImaLinkIfIndex   = 1            ImaLinkGroupIndex = 0
        ImaLinkState:
                NeTx = active
                NeRx = active
                FeTx = active
                FeRx = active
        ImaLinkFailureStatus:
                NeRx = noFailure
                FeRx = noFailure
        ImaLinkTxLid           = 1      ImaLinkRxLid           = 1
        ImaLinkRxTestPattern   = 65     ImaLinkTestProcStatus  = disabled
        ImaLinkRelDelay        = 0
IMA Link counters :
        ImaLinkImaViolations   = 1
        ImaLinkNeSevErroredSec = 40     ImaLinkFeSevErroredSec = 42
        ImaLinkNeUnavailSec    = 441389 ImaLinkFeUnAvailSec    = 38
        ImaLinkNeTxUnusableSec = 2      ImaLinkNeRxUnUsableSec = 441427
        ImaLinkFeTxUnusableSec = 99     ImaLinkFeRxUnusableSec = 99
        ImaLinkNeTxNumFailures = 0      ImaLinkNeRxNumFailures = 16
        ImaLinkFeTxNumFailures = 4      ImaLinkFeRxNumFailures = 4
```

Step 2 Use the privileged EXEC **show atm vc** command to see how SVCs and PVCs are set up.

```
Router# show atm vc
VCD /                                        Peak  Avg/Min Burst
Interface   Name       VPI   VCI  Type   Encaps   SC   Kbps   Kbps   Cells  Sts
```

```
1/1        1            0    50   PVC    SNAP     UBR     1000                INAC
1/IMA3     2            0     5   PVC    SAAL     UBR     4000                  UP
1/IMA3     3            0    16   PVC    ILMI     UBR     4000                  UP
1/IMA3     first        1    13   PVC    MUX      VBR      640    320   80     UP
1/IMA3     4            0    34   SVC    SNAP     VBR-RT   768    768          UP
```

Troubleshooting Tips

To troubleshoot ATM configuration and IMA group configuration, use the **ping** EXEC (user) or privileged EXEC command that checks host reachability and network connectivity. This command can confirm basic network connectivity on AppleTalk, International Organization for Standardization (ISO), Connectionless Network Service (CLNS), IP, Novell, Apollo, Virtual Integrated Network Service (VINES), DECnet, or Xerox Network Systems (XNS) networks.

For IP, the **ping** command sends Internet Control Message Protocol (ICMP) Echo messages. If a station receives an ICMP Echo message, it sends an ICMP Echo Reply message back to the source.

The extended command mode of the **ping** command permits you to specify the supported IP header options. This allows the router to perform a more extensive range of test options. To enter **ping** extended command mode, enter **yes** at the extended commands prompt of the **ping** command.

For detailed information on using the **ping** and extended **ping** commands, refer to the Cisco IOS Release 12.0 *Configuration Fundamentals Command Reference*.

If a **ping** command fails, check the following possible reasons for the connectivity problem:

- The interface is down, causing a “no ip route” error message.
- The PVC or SVC does not include proper mapping configured for the destination address, causing an “encapsulation failure” error. For more information about the VC encapsulation command, see the “Configuring the IMA Groups” section on page 11 and the Cisco IOS Release 12.0 *Wide-Area Networking Command Reference*.
- If there is a firmware problem, the privileged EXEC **show controller [atm** [*slot*/*port*]] command shows whether an interface is able to transmit and receive cells. For sample output, see the “Verifying the ATM Interface Configuration” section on page 9“. For command details, see the “show controllers atm” section on page 36.

Tips It is a good idea to use the **ping** command when the network is functioning properly to see how the command works under normal conditions and so that you can compare the results when troubleshooting.
If a communication session is closing when it should not, an end-to-end connection problem can be the cause. The **debug ip packet** command is useful for analyzing the messages traveling between the local and remote hosts. IP debugging information includes packets received, generated, and forwarded. Because the **debug ip packet** command generates a significant amount of output, use it only when traffic on the IP network is low, so other activity on the system is not adversely affected.

Monitoring and Maintaining ATM Inverse Multiplexing

Command	Purpose
Router# **show ima interface atm** [*slot*]/**ima[group-number]** [**detail**]	Displays general or detailed information about IMA groups and the links in those groups.
Router# **show controllers** [**atm** *slot*/**ima***group-number*]	Displays information about current settings and performance at the physical level.

Configuration Examples

This section shows one sample configuration for a router that is set up for ATM T1 or E1 IMA.

T1 IMA Configuration

The following configuration example shows the setup of ATM interfaces, IMA groups, PVCs, and SVCs for T1 IMA.

```
version 12.0
service timestamps debug uptime
service timestamps log uptime
no service password-encryption
no service dhcp
!
hostname router
!
!
!
!
!
!
ip subnet-zero
!
!
!
!
!
```

There are four links in IMA group 3. ATM interface 0/1 has a PVC configured on it, set to the default AAL5 SNAP encapsulation. The **no scrambling cell-payload** command is actually unnecessary, as this is the default for T1 links. Because the T1 default binary-eight zero substitution (B8ZS) line encoding is normally sufficient for proper cell delineation, this is the usual setting for T1 links, The scrambling setting must match the far-end receiver.

```
interface ATM0/0
 no ip address
 no ip directed-broadcast
 loopback line
 no atm ilmi-keepalive
 ima-group 3
 no scrambling cell-payload
 no fair-queue
!
interface ATM0/1
 ip address 21.1.1.2 255.0.0.0
```

```
 no ip directed-broadcast
 no atm ilmi-keepalive
 pvc 0/50
  protocol ip 21.1.1.1 broadcast
 !
 ima-group 3
 no scrambling-payload
 no fair-queue
!
interface ATM1/2
 no ip address
 no ip directed-broadcast
 no atm ilmi-keepalive
 ima-group 3
 no scrambling-payload
 no fair-queue
!
interface ATM0/3
 no ip address
 no ip directed-broadcast
 no atm ilmi-keepalive
 ima-group 3
 no scrambling-payload
 no fair-queue
!
!
```

IMA group 3 has PVCs that are set up for SVC management and signaling. Two SVCs and a communications PVC are also set up on the group interface.

```
interface ATM0/IMA3
 no ip address
 no ip directed-broadcast
 no atm ilmi-keepalive
 pvc 0/16 ilmi
 !
 pvc 0/5 qsaal
 !
 !
 pvc first 1/13
  vbr-nrt 640 320 80
  encapsulation aal5mux ip
 !
 !
svc nsap 47.0091810000000002F26D4901.444444444444.01
 !
```

The group commands below specify that three links must be active for the group to be operational. The common clock source is the first link, ATM 0/0, and ATM 0/1 is the test link. The differential delay maximum is set to 50 milliseconds (ms).

```
 ima active-links-minimum 3
 ima clock-mode common 0
 ima differential-delay-maximum 50
 ima test link 1
!
interface Ethernet1/0
 no ip address
 no ip directed-broadcast
 shutdown
```

```
!
interface Ethernet1/1
 no ip address
 no ip directed-broadcast
 shutdown
!
ip classless
no ip http server
!
!
!
line con 0
 exec-timeout 0 0
 transport input none
line aux 0
line vty 0 4
 login
!
!
end
```

Command Reference

This section documents new or modified commands. All other commands used with this feature are documented in the Cisco IOS Release 12.0 command reference publications.

- **bert pattern**
- **framing**
- **ima active-links-minimum**
- **ima clock-mode**
- **ima differential-delay-maximum**
- **ima frame-length**
- **ima-group**
- **ima test**
- **interface atm ima**
- **lbo**
- **loopback**
- **national reserve**
- **scrambling cell-payload**
- **show controllers atm**
- **show ima interface**
- **yellow**

bert pattern

To enable a bit error rate (BER) test pattern on a T1 or E1 line, use the **bert** controller configuration command. To disable a BER test pattern, use the **no** form of this command.

bert pattern {2^23 | 2^20 | 2^20-QRSS | 2^15 | 2^11 | 1s | 0s |alt-0-1} interval ***time***

[no] bert pattern {2^23 | 2^20 | 2^20-QRSS | 2^15 | 2^11 | 1s | 0s |alt-0-1} interval ***time***

Syntax Description

pattern {2^23 | 2^20 | QRSS | 2^15 | 2^11 | 1s | 0s |alt-0-1}	Specifies the length of the repeating BER test pattern. Values are: • 2^23—Pseudo-random 0.151 test pattern that is 8,388,607 bits in length. • 2^20—Pseudo-random O.153 test pattern that is 1,048,575 bits in length. • 2^20-QRSS—Pseudo-random quasi-random signal sequence (QRSS) 0.151 test pattern that is 1,048,575 bits in length. • 2^15—Pseudo-random O.151 test pattern that is 32,768 bits in length. • 2^11—Pseudo-random test pattern that is 2,048 bits in length. • 1s—Repeating pattern of ones (...111...). • 0s—Repeating pattern of zeros (...000...). • alt-0-1—Repeating alternating pattern of zeros and ones (...01010...).
interval *time*	Specifies the duration of the BER test. The interval can be a value from 1 to 1440 minutes.

Defaults

Disabled

Command Modes

Controller configuration

Command History

Release	Modification
11.1CC	The command was introduced.
12.0(5)XE	The command was enhanced as an ATM interface configuration command

Usage Guidelines

BER testing is supported on each of the T1 or E1 links and is done only over an unframed T1 or E1 signal, run on only one port at a time.

To view the BER test results, use the **show controller atm** EXEC command. The BERT results include the following information:

- Type of test pattern selected

- Status of the test
- Interval selected
- Time remaining on the BER test
- Total bit errors
- Total bits received

When the T1 or E1 line has a BER test running, the line state is DOWN and the status field shows the current/last result of the test.

The **bert pattern** command is not written to NVRAM. This command is only used to test the T1 or E1 line for a short predefined interval and to avoid accidentally saving the command, which could cause the interface not to come up the next time the router reboots.

Examples

In the following example on a Cisco 7200 series router, a BER test pattern of all zeros is run for 30 minutes on T1 line 0 on the port adapter in slot 9:

```
int atm 9/0
 bert pattern 0s interval 30
```

Related Commands

Command	Description
show controllers atm *slot/port*	Displays information about T1/E1 links in Cisco 7200 series routers.
show controllers atm *slot/port-adapter/port*	Displays information about the T1/E1 links in 7500.

framing

Use the **framing** controller configuration command to select the frame type for the T1 or E1 data line.

framing {sfadm | esfadm} (for T1 lines)

framing {crc4adm | pcm30adm | clear e1} (for E1 lines)

Syntax Description

sfadm	Specifies Superframe as the T1 channel.
esfadm	Specifies Extended Superframe as the T1 channel.
crc4adm	Specifies CRC4 frame as the E1 channel.
pcm30adm	Specifies CRC4 disabled framing mode as the E1 channel.
clear e1	Specifies clear-e1 framing mode for the E1 channel.

Defaults

Extended Superframe (ESF) (for a T1 line)

Pcm30adm (for an E1 line)

Command Modes

Controller configuration

Command History

Release	Modification
11.3	This command was introduced.
12.0(5)XE	The command was enhanced as an ATM interface configuration command.

Usage Guidelines

Use this command in configurations where the router or access server is intended to communicate with T1 or E1 fractional data line. The service provided determines which framing type, either **sf**, **esf**, or **crc4**, is required for your T1 or E1 circuit.

Examples

The following example selects Extended Superframe as the T1 frame type:

```
framing esf
```

Related Commands

Command	Description
lbo	Specifies the distance of the cable from the routers to the network equipment.
linecode	Selects the line-code type for a T1 or E1 line.

ima active-links-minimum

To set the minimum number of links that must be operational in order for an ATM IMA group to remain in service, execute the IMA interface configuration command **ima active-links-minimum**. The **no** form of the command removes the current configuration and sets the value to the default.

ima active-links-minimum *number*

no ima active-links-minimum *number*

Syntax Description

number	Enter a value from 1 to 8.

Defaults

One link

Command Modes

Interface configuration

Command History

Release	Modification
12.0(5)XE	This command was introduced.

Usage Guidelines

The minimum number of links that should be active for continued group operation depends upon the applications you are using and the speeds they require. ATM frame size and the number of links in a group affect the overhead required by ATM.

When planning, you should assume that only the bandwidth supplied by the minimal number of links will be available. If you decrease the value set in this command, make sure that virtual circuits of a higher bandwidth than the minimum supported by the command are torn down as necessary.

Examples

On Cisco 7200 series routers, the following example specifies that two links in IMA group 2 must be operational for the group to remain in service:

```
interface atm 2/ima2
 ima active-links-minimum 2
```

ima clock-mode

To set the transmit clock mode for an ATM IMA group, execute the **ima clock-mode** IMA interface configuration command. If all the links in the group share a clock source, use the **common** keyword. If all the links use different clock sources, use the **independent** clock source keyword. The **no** form of the command removes the current configuration.

ima clock-mode {common <*link_number*> **| independent}**

no ima clock-mode

Syntax Description

common	Specifies that transmit clocks for all the links in the group are derived from the same source.
link_number	When you choose a common clock source, you should also specify the link number that is to provide clocking for the IMA group, called the common link. If the common link fails, the system automatically chooses one of the remaining active links to provide clocking.
independent	Specifies that the transmit clock source for at least one link in the IMA group is different from the clock source used by the other links.

Defaults

The default value is **common**. If no port is specified, the system automatically chooses an active link to provide clocking.

Command Modes

Interface configuration

Command History

Release	Modification
12.0(5)XE	This command was introduced.

Usage Guidelines

This command controls the clock for the IMA group as a whole. When the **independent** keyword is set, the **clock source** ATM interface configuration command is used under each interface to determine clocking individually. When the **common** keyword is set, the **clock source** ATM interface configuration command for the common link determines clocking for all the links in the group.

Because the system automatically chooses a replacement for the common link when it fails, any link in an IMA group potentially can provide the recovered transmit clock. For this reason, even when the common keyword is set with a specific link stipulated by the port value, it is a good idea to make sure that the clock source is configured correctly on each interface in the IMA group, using the ATM interface configuration **clock-source** command.

Examples

On Cisco 7200 series routers, the following example specifies that the links in IMA group 2 use a common clock source on link 0:

```
interface atm 1/ima2
 ima clock-mode common 0
```

Related Commands

Command	Description
clock-source {**line** | **internal**}	This ATM interface configuration command sets the clock source for a link. **line** specifies that the link uses the recovered clock from the link and is the default setting. **internal** specifies that the DS-1 link uses the internal clock.
show ima interface atm [*slot*] /ima[group-number] [**detail**]	This command shows clock source information about an IMA group as a whole and about the links included in it.

ima differential-delay-maximum

To specify a maximum differential timing delay among the links in an IMA group, use the **ima differential-delay-maximum** IMA interface configuration command. If a link delay exceeds the specified maximum, the link is dropped; otherwise, the IMA feature, while multiplexing and demultiplexing, adjusts for differences in delays so that all links in a group are aligned. The **no** form of the command restores the default setting.

ima differential-delay-maximum *msec*

no ima differential-delay-maximum *msec*

Syntax Description

msec	Specifies a value from 25 to 250 milliseconds for T1 and 25 to 190 for E1), to define the differential delay.

Defaults

25 milliseconds for T1

90 milliseconds for E1

Command Modes

Interface configuration

Command History

Release	Modification
12.0(5)XE	This command was introduced.

Usage Guidelines

This command controls latency in an IMA group by setting a limit on how much latency a slow link can introduce when links are aligned. Setting a high value allows a slow link to continue operating as part of the group, although such a setting means there is more potential for latency when a link is slow. A low setting provides better guaranteed bandwidth on active links and more resiliency than a high setting, although it can mean that the system takes a slow link out of operation.

When a link has been removed from service, it is automatically placed back in service when it meets the delay differential standard.

Examples

On Cisco 7200 series routers, the following example specifies that the links in IMA group 2 have a maximum differential delay of 50 ms:

```
interface atm 1/ima2
 ima differential-delay-maximum 50
```

Related Commands

Command	Description
show ima interface atm [*slot*] /ima[*group-number*] [**detail**]	Displays differential delay information about an IMA group.

ima frame-length

To specify the number of cells in IMA frames, use the **ima frame-length** command. IMA frames are numbered sequentially and each contains an IMA Control Protocol (ICP) cell at a specific position. The **no** form of the command removes the current setting and restores the default value.

ima frame-length {**32** | **64** | **128** | **256**}

no ima frame-length {**32** | **64** | **128** | **256**}

Syntax Description

32	Specifies a value of 32 cells.
64	Specifies a value of 64 cells.
128	Specifies a value of 128 cells.
256	Specifies a value of 256 cells.

Defaults

The default value is 128 cells in a frame.

Command Modes

Interface configuration

Command History

Release	Modification
12.0(5)XE	This command was introduced.

Usage Guidelines

Frame length can affect performance, because the greater the total number of frames required to communicate a given number of cells, the greater the overhead for header and other control cells. In addition, shorter frame lengths might diminish performance when translated ATM-Frame Relay interworking occurs.

Examples

On Cisco 7200 series routers, the following example specifies that the links in IMA group 2 have a frame length of 64 cells:

```
interface atm 1/ima2
ima frame-length 64
```

ima-group

To define physical links as IMA group members, execute the **ima-group** configuration command for each group member. When you first perform the configuration or when you change the group number, the interface is automatically disabled, moved to the new group, and then enabled. The **no** form of the command removes the port from the group.

ima-group *group-number*

no ima-group *group-number*

Syntax Description

group-number	Enter an IMA group number from 0 to 3. IMA groups can span multiple ports on a port adapter but cannot span port adapters.

Defaults

Physical links are not part of IMA group by default.

Command Modes

Interface configuration

Command History

Release	Modification
12.0(5)XE	This command was introduced.

Examples

On Cisco 7200 series routers, the following example makes interface 1 on the ATM port adapter in slot 1 a member of IMA group 1:

```
interface atm 1/1
 ima-group 1
```

Related Commands

Command	Description
interface atm *slot/port*	Configures physical links for ATM on Cisco 7200 series routers and Cisco 7500 series routers.
interface atm *slot*/**ima** *group-number*	Configures an ATM IMA group. You set the various interface parameters for the group as a whole.
show ima interface atm [*slot*] /ima[*group-number*] [**detail**]	Displays the links that are included in an IMA group—use the **detail** keyword.
shutdown	Disables or enables (**no** form) the interface without deleting the configuration.

ima test

To specify an interface and a test pattern, execute the **ima test** IMA configuration command. To verify link connectivity, the pattern is sent from the specified link and looped back from the receiving end in the multiplexing-demultiplexing process. This can help troubleshoot physical link connectivity or configuration problems at the remote end. All links in the group are tested, and testing is continuous. An ICP cell in each frame identifies the pattern. The **no** form of the command returns to default settings.

ima test [link *port*] [**pattern** *pattern-id*]

no ima test [link *port*] [**pattern** *pattern-id*]

Syntax Description

port	(Optional) The identifier for the interface (as in *slot/port*) where the physical link is located.
pattern-id	(Optional) A value from 0 to 255, identifying a pattern to be sent to the far end of the link.

Defaults

There is no default for the *port* value. The default value for *pattern-id* is 0xFF (255).

Command Modes

Interface configuration

Command History

Release	Modification
12.0(5)XE	This command was introduced

Usage Guidelines

When a link is not transmitting or receiving a pattern correctly, the command reports the link number where the problem exists.

Examples

On Cisco 7200 series routers, the following example configures link 4 to send test pattern 56.

```
interface atm 1/ima 2
 ima test link 4 pattern 5
```

Related Commands

Command	Description
show ima interface atm [*slot*] /ima[*group-number*] [**detail**]	Shows the currently configured test link and test pattern for an IMA group.

interface atm ima

To configure an ATM IMA group and enter interface configuration mode, use the **interface atm ima** global configuration command. If the group does not exist when the command is issued, the command automatically creates the group.

interface atm *slot*/**ima**<***group-number***>

Syntax Description

slot	Specifies the slot location of the ATM IMA port adapter. The values range from 1 to 5 depending upon the router.
group-number	Enter an IMA group number from 0 to 3. You can create up to four groups.

Defaults

By default there are no IMA groups, only individual ATM links.

Command Modes

Global configuration

Command History

Release	Modification
12.0(5)XE	This command was introduced.

Usage Guidelines

When a port is configured for IMA functionality, it no longer operates as an individual ATM link.

Specifying ATM links as members of a group using the ima group interface command does not enable the group. You must use the **interface atm** *slot*/**ima**<*group-number*> command to create the group.

Examples

On Cisco 7200 series routers, the following example configures IMA group 0 on the port adapter in slot 1:

```
interface atm 1/ima0
 ip address 255.255.255.0
```

Related Commands

Command	Description
ima-group *group-number*	Configures the physical links as IMA group members; execute this interface configuration command for each physical link that you include in an IMA group.
interface atm *slot/port*	Configures physical links for ATM.
show ima interface atm [*slot*] /ima<*group-number*> [**detail**]	Displays general and detailed information about IMA groups and the links they include.
shutdown	Disables or enables (no form) the interface without deleting the configuration.

lbo

To set a cable length longer than 655 feet for a DS-1 link, use the **lbo** interface configuration command on the interface for a T1 link. The **no** form of this command deletes the **lbo long** value.

lbo {long {gain26 | gain36} {-15db | -22.5db | -7.5db | 0db} | short {133 | 266 | 399 | 533 | 655}}

no lbo

Syntax Description

gain26	Specifies the decibel pulse gain at 26 decibels. This is the default pulse gain.
gain36	Specifies the decibel pulse gain at 36 decibels.
-15db	Specifies the decibel pulse rate at –15 decibels.
-22.5db	Specifies the decibel pulse rate at –22.5 decibels.
-7.5db	Specifies the decibel pulse rate at –7.5 decibels.
0db	Specifies the decibel pulse rate at 0 decibels. This is the default.
133	Specifies a cable length from 0 to 133 feet.
266	Specifies a cable length from 133 to 266 feet.
399	Specifies a cable length from 266 to 399 feet.
533	Specifies a cable length from 399 to 533 feet.
655	Specifies a cable length from 533 to 655 feet.

Defaults

Gain26 and **0db**

Command Modes

Interface configuration

Command History

Release	Modification
11.3 MA	This command was introduced as a Cisco MC3810 controller configuration command.
12.0(5)XE	The command was introduced as an ATM interface command.

Usage Guidelines

This command is supported on T1 links only.

Each T1 port can operate in long-haul or short-haul mode. In long haul mode the user must specify the gain and the line build out. In short-haul mode, the user must specify the cable length in feet.

The transmit attenuation value is best obtained by experimentation. If the signal received by the far-end equipment is too strong, reduce the transmit level by entering additional attenuation.

Examples

On Cisco 7200 series routers, the following example specifies a pulse gain of 36 and a decibel pulse rate of –7.5 decibels:

```
interface atm 1/2
 lbo long gain36 -7.5db
```

loopback

To loop packets back to the interface for testing, enter the **loopback** interface configuration command with or without an optional keyword. The **no** form of the command removes the loopback.

loopback {diagnostic | local {payload | line} | remote {iboc | esf {payload | line}}} (for T1 lines)

loopback {diagnostic | local {payload | line}} (for E1 lines)

no loopback

Syntax Description

diagnostic	Loops the outgoing transmit signal back to the receive signal.
line	Places the interface into external loopback mode at the line.
local	Places the interface into local loopback mode.
payload	Places the interface into external loopback mode at the payload level.
remote	Keeps the local end of the connection in remote loopback mode.
iboc	Sends an in-band code to the far-end receiver to cause it to go into line loopback.
esf	Specifies the FDL loopbacks. FDL should be configured on the link.

Defaults

No loopback

Command Modes

Interface configuration

Command History

Release	Modification
11.1	This command was introduced as a controller configuration command for the Cisco MC3810.
12.0(5)XE	The command was introduced as an ATM interface configuration command.

Usage Guidelines

You can use a loopback test on lines to detect and distinguish equipment malfunctions caused either by line and channel service unit/data service unit (CSU/DSU) or by the interface. If correct data transmission is not possible when an interface is in loopback mode, the interface is the source of the problem.

The local loopback does not generate any packets automatically. Instead, the **ping** command is used.

Examples

On Cisco 7200 series routers, the following example sets up local loopback diagnostics:

```
interface atm 1/0
loopback local line
```

national reserve

To set the E1 national bit, enter the **national reserve** interface configuration command. To return to the default E1 national bit, use the **no** form of this command.

national reserve <0-1><0-1><0-1><0-1><0-1><0-1>

no national reserve

Syntax Description

This command has no arguments or keywords.

Defaults

111111

Command Modes

Interface configuration

Command History

Release	Modification
12.0(5)XE	This command was introduced.

Usage Guidelines

This command applies only for E1. This command not only sets the national reserve bits but also the international bit as well. The far left digit represents the international bit. All six digits must be present for the pattern to be valid.

Examples

On Cisco 7200 series routers, the following example sets the national bit on interface 1 on the port adapter in slot 0 to no scrambling:

```
interface atm1/0
 national reserve 011011
```

scrambling cell-payload

Scrambling improves data reliability by randomizing the ATM cell payload frames to avoid continuous nonvariable bit patterns and improve the efficiency of ATM cell delineation algorithms. The **no** form disables scrambling.

scrambling cell-payload

no scrambling cell-payload

Syntax Description

This command has no arguments or keywords.

Defaults

No scrambling

Command Modes

Interface configuration

Command History

Release	Modification
12.0(5)XE	This command was introduced.

Usage Guidelines

Normally, you do not issue the **scrambling-payload** command explicitly, because the default value is sufficient. On T1 links, the default b8zs line encoding normally assures sufficient reliability. The default for E1 is hdb3.

The scrambling setting must match that of the far-end receiver.

Examples

On Cisco 7200 series routers, the following example sets the link on interface 1 on the port adapter in slot 0 to no scrambling:

```
interface atm0/1
 no scrambling cell-payload
```

show controllers atm

Use the privileged EXEC **show controllers** command to see information about an IMA group. Important information is shown in bold.

show controllers [atm *slot*/*port-adapter*/*port***]** (physical port hardware information) (for Cisco 7500 series routers)

show controllers [atm *slot*/*port-adapter*/**ima***group-number***]** (IMA group hardware information) (for Cisco 7500 series)

show controller [atm *slot*/*port***]** (for the Cisco 7200 series routers)

show controllers [atm *slot*/**ima***group-number***]** (for Cisco 7200 series routers)

Syntax Description

slot/port-adapter/port	**[Optional] Specifies the slot location and port number of the ATM IMA port adapter. The values range from 1 to 5 depending upon the router.**
group-number	**Enter an IMA group number from 0 to 3. Do not insert a space between ima and the number.**

Defaults

No default behavior or values.

Command Modes

Privileged EXEC

Command History

Release	Modification
12.0(5)XE	This command was introduced.

Usage Guidelines

Use this command to monitor and diagnose ATM IMA links and groups.

Examples

On Cisco 7200 series routers, the following example displays detailed information about IMA group hardware related information. It includes the configuration of IMA hardware and IMA alarms.

```
Router# show controller atm 1/ima0
Interface ATM1/ima0 is up
Hardware is IMA PA - DS1 (1Mbps)
Framer is PMC PM7344, SAR is LSI ATMIZER II
Firmware rev:G102, ATMIZER II rev:3
  idb=0x61DE9F10, ds=0x6185C0A0, vc=0x6187D3C0, pa=0x6184AF40
  slot 1, unit 9, subunit 0, fci_type 0x00BA, ticks 701720
  400 rx buffers:size=512, encap=64, trailer=28, magic=4
Curr Stats:
  rx_cell_lost=0, rx_no_buffer=0, rx_crc_10=0
  rx_cell_len=0, rx_no_vcd=0, rx_cell_throttle=0, tx_aci_err=0
Rx Free Ring status:
  base=0x3CFF0040, size=1024, write=320
Rx Compl Ring status:
```

```
  base=0x338DCE40, size=2048, read=1275
Tx Ring status:
  base=0x3CFE8040, size=8192, write=700
Tx Compl Ring status:
  base=0x338E0E80, size=2048, read=344
BFD Cache status:
  base=0x61878340, size=5120, read=5107
Rx Cache status:
  base=0x61863D80, size=16, write=11
Tx Shadow status:
  base=0x618641C0, size=8192, read=687, write=700
Control data:
  rx_max_spins=12, max_tx_count=25, tx_count=13
  rx_threshold=267, rx_count=11, tx_threshold=3840
  tx bfd write indx=0x27, rx_pool_info=0x61863E20
Control data base address:
       rx_buf_base = 0x038A15A0        rx_p_base = 0x6185CB40
            rx_pak = 0x61863AF0              cmd = 0x6185C320
       device_base = 0x3C800000     ima_pa_stats = 0x038E2FA0
        sdram_base = 0x3CE00000       pa_cmd_buf = 0x3CFFFC00
       vcd_base[0] = 0x3CE3C100      vcd_base[1] = 0x3CE1C000
         chip_dump = 0x038E3D7C       dpram_base = 0x3CD80000
   sar_buf_base[0] = 0x3CE4C000  sar_buf_base[1] = 0x3CF22000
       bfd_base[0] = 0x3CFD4000      bfd_base[1] = 0x3CFC0000
       acd_base[0] = 0x3CE88360      acd_base[1] = 0x3CE5C200
     pci_atm_stats = 0x038E2EC0
ATM1/ima0 is up
        hwgrp number = 1
grp tx up reg= 0x5, grp rx up reg= 0x3, rx dcb reg= 0xD4 0x4, tx links grp reg=
0x3, scci reg= 0x3C, ima id reg= 0x0, group status  reg= 0xA2, tx timing reg= 0x
20, tx test reg= 0x21, tx test pattern reg= 0x41, rx test pattern reg= 0x42, icp
 cell link info  reg= 0xFC, icp cell link info  reg= 0xFC, icp cell link info  r
eg= 0x0, icp cell link info  reg= 0x0, icp cell link info  reg= 0x0, icp cell li
nk info  reg= 0x0, icp cell link info  reg= 0x0, icp cell link info  reg= 0x0,
```

Related Commands

Command	Description
show ima interface atm [*slot*] /ima[*group-number*] [**detail**]	Displays general and detailed information about IMA groups and the links they include.

show ima interface

The **show ima interface** command provides information about all configured IMA groups or a specific group.

show ima interface [atm *slot/port-adapter/slot*] [**detail**] (for Cisco 7500 series routers)

show ima interface [**atm** *slot/port-adapter/***ima** *group-number***]** [**detail**] (for Cisco 7500 series routers)

show ima interface [**atm** *slot/port*] [**detail**] (for Cisco 7200 series routers)

show ima interface [**atm** *slot/port-adapter/***ima** *group-number*] [**detail**] (for Cisco 7200 series routers)

Syntax Description

atm slot/port	(Optional) Specifies ATM slot number and port number.
slot/port-adapter/slot	Specifies the slot location of the ATM IMA port adapter. The values range from 1 to 5 depending upon the router.
ima *group-number*	Enter an IMA group number from 0 to 3. Do not insert a space between **ima** and the number.
detail	[Optional] To obtain detailed information, use this keyword.

Defaults

No default behavior or values.

Command Modes

Privileged EXEC

Command History

Release	Modification
12.0(5)XE	This command was introduced.

Usage Guidelines

Use this command to monitor the status of IMA group links.

Examples

On Cisco 7200 series routers, the following example displays detailed information about IMA group 0 on ATM interface 2. If you do not enter the **detail** keyword, the information beginning with "Detailed group Information:" does not appear.

```
Router#sh ima int atm 5/ima0 detail
ATM5/ima0 is up
        ImaGroupState:NearEnd = operational, FarEnd = operational
        ImaGroupFailureStatus  = noFailure
IMA Group Current Configuration:
        ImaGroupMinNumTxLinks = 2    ImaGroupMinNumRxLinks = 2
        ImaGroupDiffDelayMax  = 250  ImaGroupNeTxClkMode   = common(ctc)
        ImaGroupFrameLength   = 128  ImaTestProcStatus     = disabled
```

```
        ImaGroupTestLink      = 0    ImaGroupTestPattern   = 0xFF
IMA MIB Information:
        ImaGroupSymmetry        = symmetricOperation
        ImaGroupFeTxClkMode     = common(ctc)
        ImaGroupRxFrameLength   = 128
        ImaGroupTxTimingRefLink = 0     ImaGroupRxTimingRefLink = 0
        ImaGroupTxImaId         = 0     ImaGroupRxImaId         = 0
        ImaGroupNumTxCfgLinks   = 2     ImaGroupNumRxCfgLinks   = 2
        ImaGroupNumTxActLinks   = 2     ImaGroupNumRxActLinks   = 2
        ImaGroupLeastDelayLink  = 0     ImaGroupDiffDelayMaxObs = 0
IMA group counters:
        ImaGroupNeNumFailures   = 1     ImaGroupFeNumFailures   = 2
        ImaGroupUnAvailSecs     = 18    ImaGroupRunningSecs     = 241
IMA Detailed Link Information:

ATM5/0 is up
        ImaLinkRowStatus = active
        ImaLinkIfIndex   = 1            ImaLinkGroupIndex = 47
        ImaLinkState:
                NeTx = active
                NeRx = active
                FeTx = active
                FeRx = active
        ImaLinkFailureStatus:
                NeRx = noFailure
                FeRx = noFailure
        ImaLinkTxLid           = 0      ImaLinkRxLid           = 0
        ImaLinkRxTestPattern   = 64     ImaLinkTestProcStatus  = disabled
        ImaLinkRelDelay        = 0
IMA Link counters :
        ImaLinkImaViolations   = 1
        ImaLinkNeSevErroredSec = 10     ImaLinkFeSevErroredSec = 10
        ImaLinkNeUnavailSec    = 7      ImaLinkFeUnAvailSec    = 8
        ImaLinkNeTxUnusableSec = 17     ImaLinkNeRxUnUsableSec = 16
        ImaLinkFeTxUnusableSec = 17     ImaLinkFeRxUnusableSec = 16
        ImaLinkNeTxNumFailures = 0      ImaLinkNeRxNumFailures = 2
        ImaLinkFeTxNumFailures = 1      ImaLinkFeRxNumFailures = 1

ATM5/1 is up
        ImaLinkRowStatus = active
        ImaLinkIfIndex   = 2            ImaLinkGroupIndex = 47
        ImaLinkState:
                NeTx = active
                NeRx = active
                FeTx = active
                FeRx = active
        ImaLinkFailureStatus:
                NeRx = noFailure
                FeRx = noFailure
        ImaLinkTxLid           = 1      ImaLinkRxLid           = 1
        ImaLinkRxTestPattern   = 64     ImaLinkTestProcStatus  = disabled
        ImaLinkRelDelay        = 0
IMA Link counters :
        ImaLinkImaViolations   = 1
        ImaLinkNeSevErroredSec = 10     ImaLinkFeSevErroredSec = 10
        ImaLinkNeUnavailSec    = 7      ImaLinkFeUnAvailSec    = 8
        ImaLinkNeTxUnusableSec = 16     ImaLinkNeRxUnUsableSec = 16
        ImaLinkFeTxUnusableSec = 16     ImaLinkFeRxUnusableSec = 16
        ImaLinkNeTxNumFailures = 0      ImaLinkNeRxNumFailures = 2
        ImaLinkFeTxNumFailures = 1      ImaLinkFeRxNumFailures = 1
```

Related Commands

Command	Description
show controllers [**atm** *slot*//**ima** *group-number*]	Displays detailed information about IMA groups and the links they include, as well as about current queues and ATM QoS settings.

show ima interface atm

The **show ima interface atm** command provides information about all configured IMA groups or a specific group.

show ima interface atm [*slot*] **/ima**[*group-number*] [**detail**]

Syntax DescriptionS

slot	[Optional] Specifies the slot location of the ATM IMA port adapter. The values range from 1 to 5 depending upon the router.
group-number	Enter an IMA group number from 0 to 3. Do not insert a space between **ima** and the number.
detail	[Optional] To obtain detailed information, use this keyword.

Defaults

No default behavior or values.

Command Modes

Privileged EXEC

Command History

Release	Modification
12.0(5)XE	This command was introduced.

Usage Guidelines

Use this command to monitor the status of IMA group links.

Examples

On Cisco 7200 series routers, the following example displays detailed information about IMA group 0 on ATM interface 2. If you do not enter the **detail** keyword, the information beginning with "Detailed group Information:" does not appear.

```
Router#sh ima int atm 5/ima0 detail
ATM5/ima0 is up
        ImaGroupState:NearEnd = operational, FarEnd = operational
        ImaGroupFailureStatus  = noFailure
IMA Group Current Configuration:
        ImaGroupMinNumTxLinks = 2    ImaGroupMinNumRxLinks = 2
        ImaGroupDiffDelayMax  = 250  ImaGroupNeTxClkMode   = common(ctc)
        ImaGroupFrameLength   = 128  ImaTestProcStatus     = disabled
        ImaGroupTestLink      = 0    ImaGroupTestPattern   = 0xFF
IMA MIB Information:
        ImaGroupSymmetry        = symmetricOperation
        ImaGroupFeTxClkMode     = common(ctc)
        ImaGroupRxFrameLength   = 128
        ImaGroupTxTimingRefLink = 0     ImaGroupRxTimingRefLink = 0
        ImaGroupTxImaId         = 0     ImaGroupRxImaId         = 0
        ImaGroupNumTxCfgLinks   = 2     ImaGroupNumRxCfgLinks   = 2
        ImaGroupNumTxActLinks   = 2     ImaGroupNumRxActLinks   = 2
        ImaGroupLeastDelayLink  = 0     ImaGroupDiffDelayMaxObs = 0
IMA group counters:
        ImaGroupNeNumFailures   = 1     ImaGroupFeNumFailures   = 2
```

```
        ImaGroupUnAvailSecs     = 18    ImaGroupRunningSecs     = 241
IMA Detailed Link Information:

ATM5/0 is up
        ImaLinkRowStatus = active
        ImaLinkIfIndex   = 1            ImaLinkGroupIndex = 47
        ImaLinkState:
                NeTx = active
                NeRx = active
                FeTx = active
                FeRx = active
        ImaLinkFailureStatus:
                NeRx = noFailure
                FeRx = noFailure
        ImaLinkTxLid           = 0      ImaLinkRxLid           = 0
        ImaLinkRxTestPattern   = 64     ImaLinkTestProcStatus  = disabled
        ImaLinkRelDelay        = 0
IMA Link counters :
        ImaLinkImaViolations   = 1
        ImaLinkNeSevErroredSec = 10     ImaLinkFeSevErroredSec = 10
        ImaLinkNeUnavailSec    = 7      ImaLinkFeUnAvailSec    = 8
        ImaLinkNeTxUnusableSec = 17     ImaLinkNeRxUnUsableSec = 16
        ImaLinkFeTxUnusableSec = 17     ImaLinkFeRxUnusableSec = 16
        ImaLinkNeTxNumFailures = 0      ImaLinkNeRxNumFailures = 2
        ImaLinkFeTxNumFailures = 1      ImaLinkFeRxNumFailures = 1

ATM5/1 is up
        ImaLinkRowStatus = active
        ImaLinkIfIndex   = 2            ImaLinkGroupIndex = 47
        ImaLinkState:
                NeTx = active
                NeRx = active
                FeTx = active
                FeRx = active
        ImaLinkFailureStatus:
                NeRx = noFailure
                FeRx = noFailure
        ImaLinkTxLid           = 1      ImaLinkRxLid           = 1
        ImaLinkRxTestPattern   = 64     ImaLinkTestProcStatus  = disabled
        ImaLinkRelDelay        = 0
IMA Link counters :
        ImaLinkImaViolations   = 1
        ImaLinkNeSevErroredSec = 10     ImaLinkFeSevErroredSec = 10
        ImaLinkNeUnavailSec    = 7      ImaLinkFeUnAvailSec    = 8
        ImaLinkNeTxUnusableSec = 16     ImaLinkNeRxUnUsableSec = 16
        ImaLinkFeTxUnusableSec = 16     ImaLinkFeRxUnusableSec = 16
        ImaLinkNeTxNumFailures = 0      ImaLinkNeRxNumFailures = 2
        ImaLinkFeTxNumFailures = 1      ImaLinkFeRxNumFailures = 1
```

Related Commands

Command	Description
show controllers [atm *slot*/**ima** *group-number*]	Displays detailed information about IMA groups and the links they include, as well as about current queues and ATM QoS settings.

yellow

The **yellow** command enables generation and detection of yellow alarm. This command is applicable to the T1 IMA port adapter.

yellow {*generation* | *detection*}

Syntax DescriptionS

generation	This setting enables or disables generation of the yellow alarm.
detection	This setting enables or disables detection of the yellow alarm.

Defaults

Yellow alarm generation and detection are enabled.

Command Modes

Configuration mode

Command History

Release	Modification
12.0(5)XE	This command was introduced.

Usage Guidelines

Use this command to generate and detect yellow alarms.

Examples

The following example displays yellow generation and detection enabled on a Cisco 7500 series router:

```
interface atm 3/1/0
    yellow generation
    yellow detection
```

Related Commands

Command	Description
show controllers [atm *slot***/ima** *group-number***]**	Displays detailed information about IMA groups and the links they include, as well as about current queues.

Glossary

AAL1—ATM adaptation layer 1. One of four AALs recommended by the ITU-T. AAL1 is used for connection-oriented, delay-sensitive services requiring constant bit rates, such as uncompressed video and other isochronous traffic.

AAL5—ATM adaptation layer 5. One of four AALs recommended by the ITU-T. AAL5 supports connection-oriented VBR services and is used predominantly for the transfer of classical IP over ATM and LANE traffic. AAL5 uses simple and efficient AAL (SEAL) and is the least complex of the current AAL recommendations. It offers low bandwidth overhead and simpler processing requirements in exchange for reduced bandwidth capacity and error-recovery capability.

ABR—available bit rate. QoS class defined by the ATM Forum for ATM networks. ABR is used for connections that do not require timing relationships between source and destination. ABR provides no guarantees in terms of cell loss or delay, providing only best-effort service. Traffic sources adjust their transmission rate in response to information they receive describing the status of the network and its capability to successfully deliver data.

AIS—alarm indication signal. In a T1 transmission, an all-ones signal transmitted in lieu of the normal signal to maintain transmission continuity and to indicate to the receiving terminal that there is a transmission fault that is located either at, or upstream from, the transmitting terminal.

ATM—Asynchronous Transfer Mode. International standard for cell relay in which multiple service types (such as voice, video, or data) are conveyed in fixed-length (53-byte) cells. Fixed-length cells allow cell processing to occur in hardware, thereby reducing transit delays. ATM is designed to take advantage of high-speed transmission media such as E3, SONET, and T3.

B8ZS—binary 8-zero substitution. Line-code type, used on T1 circuits, in which a special code is substituted whenever 8 consecutive zeros are sent over the link. This code is then interpreted at the remote end of the connection. This technique guarantees ones density independent of the data stream.

CPCS—common part convergence sublayer. One of the two sublayers of any AAL. The CPCS is service-independent and is further divided into the CS and the SAR sublayers. The CPCS is responsible for preparing data for transport across the ATM network, including the creation of the 48-byte payload cells that are passed to the ATM layer.

CS—convergence sublayer. One of the two sublayers of the AAL common part convergence sublayer (CPCS), which is responsible for padding and error checking. PDUs passed from the service specific convergence sublayer (SSCS) are appended with an 8-byte trailer (for error checking and other control information) and padded, if necessary, so that the length of the resulting PDU is divisible by 48. These PDUs are then passed to the SAR sublayer of the CPCS for further processing.

ESF—Extended Superframe. Framing type used on T1 circuits that consists of 24 frames of 192 bits each, with the 193rd bit providing timing and other functions. ESF is an enhanced version of SF.

FDL—Facility Data Link. A 4-Kbps channel, provided by the Extended SuperFrame (ESF) T1 framing format. The FDL performs outside the payload capacity and allows a service provider to check error statistics on terminating equipment, without intrusion.

ICP—IMA control protocol

ICMP—Internet Control Message Protocol. Network layer Internet protocol that reports errors and provides other information relevant to IP packet processing. Documented in RFC 792.

ILMI—Interim Local Management Interface. Specification developed by the ATM Forum for incorporating network-management capabilities into the ATM User-Network Interface (UNI).

IMA—Inverse Multiplexing for ATM, a standard protocol defined by the ATM Forum in 1997.

IMA group—Physical links grouped to form a higher-bandwidth logical link whose rate is approximately the sum of the individual link rates.

ISDN—Integrated Services Digital Network. Communication protocol, offered by telephone companies, that permits telephone networks to carry data, voice, and other source traffic.

OAM cell—Operation, Administration, and Maintenance cell. ATM Forum specification for cells used to monitor virtual circuits. OAM cells provide a virtual circuit-level loopback in which a router responds to the cells, demonstrating that the circuit is up, and the router is operational.

PDU—protocol data unit.

POTS—Plain Old Telephone Service. Basic telephone service supplying standard single-line telephones, telephone lines, and access to the public switched telephone network.

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

QoS—quality of service. Measure of performance for a transmission system that reflects its transmission quality and service availability.

SAR—segmentation and reassembly. One of the two sublayers of the AAL CPCS, responsible for dividing (at the source) and reassembling (at the destination) the PDUs passed from the CS. The SAR sublayer takes the PDUs processed by the CS and, after dividing them into 48-byte pieces of payload data, passes them to the ATM layer for further processing.

SF—Super Frame. Common framing type used on T1 circuits. SF consists of 12 frames of 192 bits each, with the 193rd bit providing error checking and other functions. SF is superseded by ESF, but is still widely used. Also called D4 framing.

SONET—Synchronous Optical Network. High-speed (up to 2.5 Gbps) synchronous network specification developed by Bellcore and designed to run on optical fiber. STS-1 is the basic building block of SONET.

SSCS—service specific convergence sublayer. One of the two sublayers of any AAL. SSCS, which is service dependent, offers assured data transmission. The SSCS can be null as well, in classical IP over ATM or LAN emulation implementations.

SVC—switched virtual circuit. Virtual circuit that is dynamically established on demand and is torn down when transmission is complete. SVCs are used in situations where data transmission is sporadic. Called a switched virtual connection in ATM terminology.

T3—Digital WAN carrier facility. T3 transmits DS-3-formatted data at 44.736 Mbps through the telephone switching network.

UBR—unspecified bit rate. Quality of Service (QoS) class defined by the ATM Forum for ATM networks. UBR allows any amount of data up to a specified maximum to be sent across the network, but there are no guarantees in terms of cell loss rate and delay.

UNI—User-Network Interface. ATM Forum specification that defines an interoperability standard for the interface between ATM-based products (a router or an ATM switch) located in a private network and the ATM switches located within the public carrier networks. Also used to describe similar connections in Frame Relay networks.

VBR—variable bit rate. QoS class defined by the ATM Forum for ATM networks. VBR is subdivided into a real time (RT) class and non-real time (NRT) class. VBR (RT) is used for connections in which there is a fixed timing relationship between samples. VBR (NRT) is used for connections in which there is no fixed timing relationship between samples, but that still need a guaranteed QoS.

VC—virtual circuit. Logical circuit created to ensure reliable communication between two network devices. A virtual circuit is defined by a VPI/VCI pair, and can be either permanent (PVC) or switched (SVC). Virtual circuits are used in Frame Relay and X.25. In ATM, a virtual circuit is called a virtual channel.