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4. Configure two static ATM routes on the third-party switch, one to each of the FORE switches using the switch vendor's configuration software.

   Be sure to use a mask value of 104.

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CHAPTER 6 Configuring an Emulated LAN

6.1 Introduction

This chapter describes how to design, configure, and maintain an Emulated LAN (ELAN) over an ATM network. An ELAN provides communication of user data frames among all members of the ELAN, similar to a physical LAN. One or more ELANs may run simultaneously (and independently) on the same ATM network. Just as with physical LANs, communication between ELANs is possible only through routers or bridges.

The current software release supports emulation of Ethernet (IEEE 802.3) LANs only. Each ELAN is composed of a set of LAN Emulation Clients (LECs), a LAN Emulation Configuration Server (LECS), a LAN Emulation Server (LES), and a Broadcast and Unknown Server (BUS). Each LEC resides in an ATM host system (PC, Macintosh, Unix workstation, bridge device such as a FORE Systems LAX-20, or switch). In the current software release, the LECS, LES, and BUS may reside either in a *ForeRunner* switch, or in a Unix workstation running SunOS version 4.1.x. Additional software features include intelligent BUSs, and a LEC "failover" mechanism that can provide redundancy to an ELAN.

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6.2 Emulated LAN Components

The components of an emulated LAN include LAN Emulation Clients (LECs), and LAN Emulation Services consisting of: a LAN Emulation Configuration Server (LECS), a LAN Emulation Server (LES), and a Broadcast and Unknown Server (BUS). Each of these services may reside in the same physical system or in separate physical systems. For example, the LECS could reside in a switch, while the LES and BUS reside in a workstation. In the current *ForeThought 4.0* software, the LECS, LES, and BUS are supported only for SunOS, and for ASX-200 series and ASX-1000 switches. The functional interconnections of a simple ELAN consisting of two LECs, an LECS, LES, and BUS are shown in Figure 6.1.

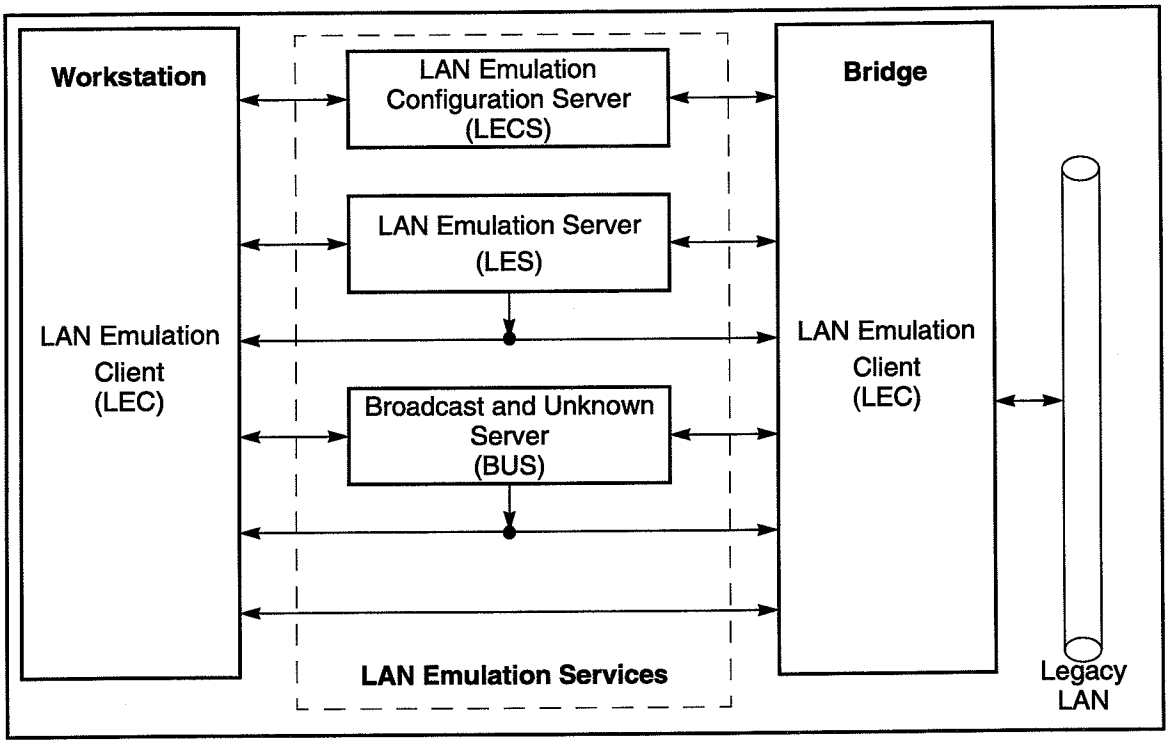


Figure 6.1 - Basic Emulated LAN Interconnections

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6.2.1 LAN Emulation Client (LEC)

The LEC is the component in an end system that performs data forwarding, address resolution, and other control functions when communicating with other components within the ELAN. It also provides a MAC level emulated Ethernet interface and appears to higher level software as though a physical Ethernet interface is present. Each LEC must register with both the LES and BUS associated with the ELAN it wishes to join before it may participate in the ELAN. *ForeThought 4.0* supports a maximum of 16 LECs per adapter card.

6.2.2 LAN Emulation Configuration Server (LECS)

The LECS is responsible for the initial configuration of LECs. It provides information about available ELANs that a LEC may join, together with the address of the LES associated with each ELAN. With *ForeThought 4.0*, the user may also use the LECS to associate multiple LESs with a given ELAN. This feature allows LECs to "failover" to a hierarchy of redundant services if the primary LES for an ELAN goes down.

6.2.3 LAN Emulation Server (LES)

The LES implements the control coordination function for the ELAN. The LES provides the service of registering and resolving MAC addresses to ATM addresses. A LEC registers its own address with the LES. A LEC also queries the LES when the client wishes to resolve a MAC address to an ATM address. The LES either responds directly to the client or forwards the query to other clients so they may respond. There is only one instance of an active LES per ELAN.

6.2.4 Broadcast and Unknown Server (BUS)

Unlike traditional shared-media LAN architectures such as Ethernet, ATM is connection based. Therefore, it has no built-in mechanism for handling connectionless traffic such as broadcasts, multicasts, and unknown unicasts. In an emulated LAN, the BUS is responsible for servicing these traffic types by accepting broadcast, multicast, and unknown unicast packets from the LECs to the broadcast MAC address (FFFFFFFFFFFF) via dedicated point-to-point connections, and forwarding the packets to all of the members of the ELAN using a single point-to-multipoint connection. Each LEC is associated with only one active BUS. *ForeThought 4.0* also supports the use of "intelligent" BUSs that allow the BUS to use the LES's registration table to direct unicast traffic.

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6.3 Emulated LAN Operation

This section describes the operation of an ELAN and its components from the point of view of a LEC. The operation of an ELAN may be divided into three phases:

1. Initialization
2. Registration and Address Resolution
3. Data Transfer

ELAN components communicate with each other using ATM connections. LECs maintain separate connections for traffic control functions and data transfer. The following connection types are used by the LEC when operating in an ELAN:

- *Configuration-Direct Connection*: a bidirectional point-to-point VCC set up by the LEC to the LECS.
- *Control-Direct Connection:* a bidirectional point-to-point VCC set up by the LEC to the LES. This connection must be maintained for the duration of the LEC's participation in the ELAN.
- *Control-Distribute Connection*: a unidirectional point-to-multipoint VCC set up by the LES to the LEC. This connection must be maintained for the duration of the LEC's participation in the ELAN.
- *Multicast-Send Connection*: a bidirectional point-to-point VCC set up by the LEC to the BUS for sending multicast data to the BUS. The LEC must attempt to maintain this connection while participating in the ELAN.
- *Multicast-Forward Connection*: a unidirectional point-to-multipoint VCC set up from the BUS to LECs participating in the ELAN. This VCC must be established before a LEC participates in an ELAN. The LEC must attempt to maintain this connection while participating in the ELAN.
- *Data-Direct Connection*: a bidirectional point-to-point VCC set up between LECs that want to exchange unicast data traffic.

For the following discussion, please refer to Figure 6.2.

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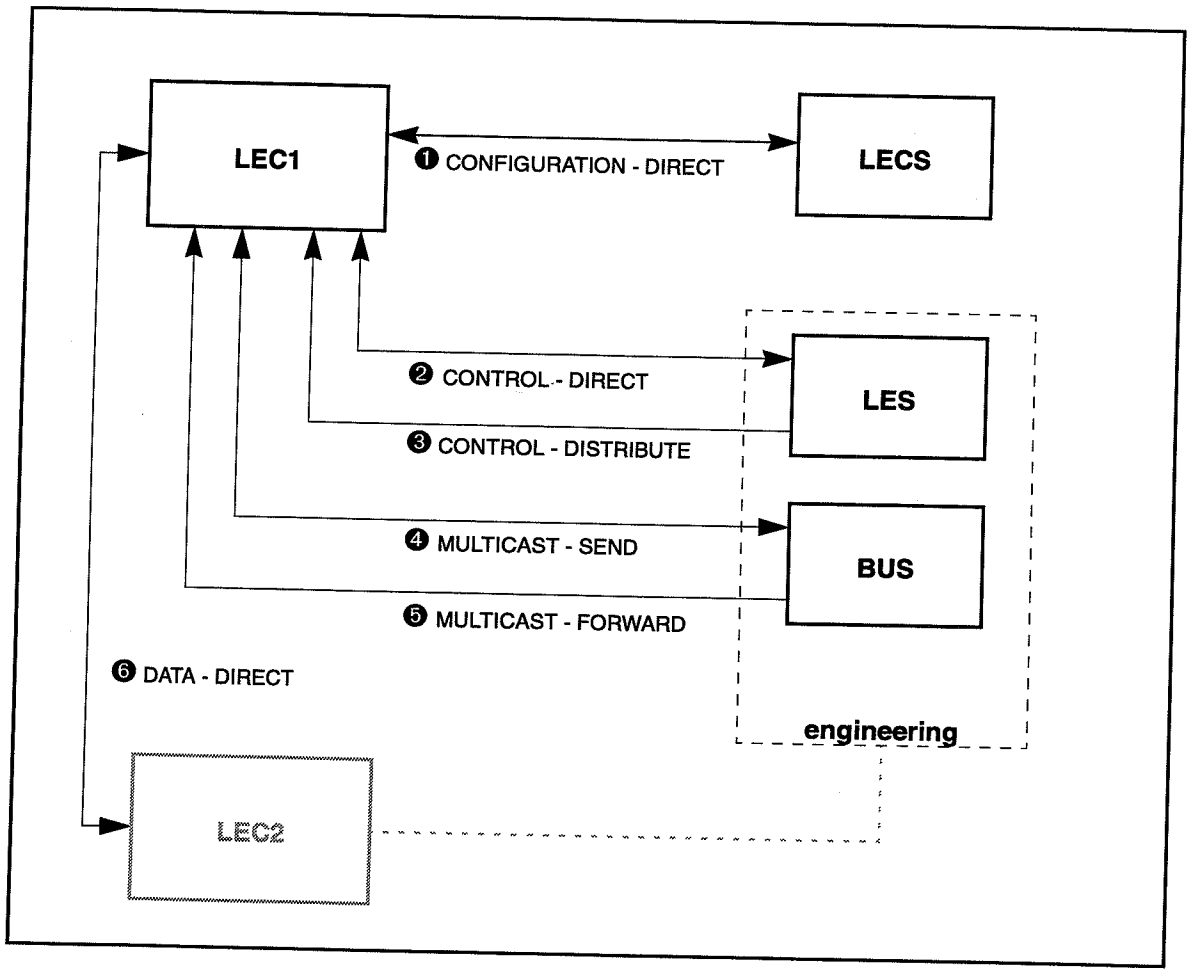


Figure 6.2 - ELAN Operation

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6.3.1 Initialization

Upon initialization, LEC1 obtains its own ATM address via address registration. LEC1 obtains the address of the LECS in one of three ways: via manual configuration, via the "well-known" address, or via PVC (0,17).

Once it knows the location of the LECS, LEC1 establishes a configuration-direct connection ❶ to the LECS. When connected, the LECS provides LEC1 with the information necessary to connect to the ELAN it wishes to join. This information includes such parameters as: the ATM address of the ELAN's LES, the type of LAN being emulated, maximum packet size, and the name of the ELAN (engineering, for example). This configuration information is contained in a configuration file that must be built and maintained by the network administrator.

6.3.2 Registration and Address Resolution

After obtaining the address of the LES, LEC1 establishes a control-direct connection ❷ to the LES. The LES then assigns LEC1 a unique identifier, and LEC1 then registers its own MAC and ATM addresses with the LES. (The LES maintains a table containing the MAC addresses and corresponding ATM addresses of all members of the ELAN.) At this point, LEC1 has "joined" the ELAN.

The LES then establishes a control-distribute connection ❸ back to LEC1. Connections ❷ and ❸ can now be used by LEC1 to send LAN Emulation ARP (LE_ARP) requests to the LES, and receive replies.

LEC1 now sends an LE_ARP request to the LES to get the ATM address of the BUS corresponding to the broadcast MAC address (FFFFFFFFFFFF). The LEC then establishes a multicast-send connection ❹ to the BUS. The BUS responds by setting up a multicast-forward connection ❺ to the LEC.

At this point, the LEC is ready to transfer data.

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6.3.3 Data Transfer

When LEC1 receives a network-layer packet from a higher layer protocol to transmit to some destination MAC address (for example, LEC2), LEC1 initially does not know the corresponding ATM address of the destination. Consequently, LEC1 transmits an LE_ARP request to the LES.

NOTE: The example shown in Figure 6.2 assumes that LEC2 has already registered with the LES, and that connections similar to those described for LEC1 already exist.

While waiting for the LES to respond, LEC1 forwards the packet to the BUS. The BUS broadcasts the packet to all LECs on the ELAN. This is done to avoid data loss, and to circumvent connection setup latency (due to the LE_ARP process) that may not be acceptable to some network protocols.

If the LE_ARP response is received, LEC1 establishes a data-direct connection ❻ to the destination address of LEC2. It is this path that will be used for subsequent data transfers. Before LEC1 begins to use this connection, it first sends a "flush" packet via the BUS to the destination, LEC2. When LEC2 acknowledges receipt of this packet, signifying that the BUS path is empty, only then does LEC1 begin to use the data-direct connection ❻ for data transfer. This process ensures that the network protocol's frames arrive in the proper order.

If no response is received to the LE_ARP, LEC1 continues to send data via the BUS, while continuing to LE_ARP until a response is received and a data-direct connection to LEC2 established.

If LEC1 already has a data-direct connection to a MAC address it wishes to reach, it need not go through the LE_ARP process again. Instead, it continues to use the current connection. This is possible because each LEC maintains a cache of MAC address to ATM address mappings that it receives in response to the LE_ARPs it has sent. Entries in this cache are "aged" out over a period of time. Data-direct connections are also cleared if they remain inactive for a period of time.

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6.4 Configuring a LEC

Currently, only local LAN Emulation Clients may be configured on hosts running under HP-UX. Two methods for configuring a LEC are presented in the following sections:

1. using the configure_lanem script
2. at the command line, using the elconfig command.

NOTE: Before configuring an LEC, make sure that the adapter's ATM address is configured. Run the configure_atm script (refer to Chapter 4) if necessary to start ILMI for address registration.

6.4.1 Using the configure_lanem Script

Before You Begin

NOTE: Before running the script, you should read through this entire section. Detailed explanations of each of the prompts appearing in the script session may be found in Section 6.4.1.1.

You should know the topology of the ELAN or ELANs that you want to administer. You will be prompted to supply the following information when running the configure_lanem script:

- Whether or not LECs are to use an LECS, and if so, whether they are to contact the LECS via the "well-known" address or an ATM address that you supply.
- Whether you wish LECs to use a default ELAN, and the name assigned to the default ELAN in the LECS configuration file.
- The name of each ELAN for which you will configure an LEC.
- If you choose not to use an LECS, the ATM address of the LES associated with each ELAN for which you will configure an LEC.

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Execute the configure_lanem script as follows:

1. Login as root.
2. Type the following command to run the configure_lanem script:

   /usr/etc/fore/configure_lanem

Responses to the following typical session's questions are system-specific and must be determined by the system administrator prior to configuring an ELAN. If you wish to use an LECS, the system-specific information must also be entered in the LECS configuration file.

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```
=========================================================================
                FORE Systems LAN Emulation Configuration
=========================================================================
***** No Configuration Information *****
==============================
== Local LEC Configuration ==
==============================
Would you like to use an LECS to retrieve configuration information? [y] <ENTER>
Use the "Well-Known" LECS address? [y] <ENTER>
Would you like to configure a DEFAULT ELAN? [y] <ENTER>
Name of DEFAULT ELAN? [default] <ENTER>
Enter ELAN name to configure (return to end): engineering<ENTER>
Enter LES address Manually? [n] <ENTER>
Enter ELAN name to configure (return to end): marketing<ENTER>
Enter LES address Manually? [n] <ENTER>
Enter ELAN name to configure (return to end):<ENTER>
=========================================================================
```

Information similar to the following will appear if you have configured LAN emulation clients.

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```
=========================================================================
Current client configuration:
=========================================================================
LECS ATM address:       "Well-Known"
ELAN:                    "default"
ELAN:                    engineering
ELAN:                    marketing
=========================================================================
Do You Want To Modify Configuration Information? [n]
Save Configuration Information? [y]
Saving /usr/etc/fore/fore_lanem.conf...
```

NOTE: LECs that you configure with the configure_lanem script require a functioning network interface (for example, el0). Refer to Section 4.1 of this User's Manual for information about configuring the appropriate network interface(s).

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6.4.1.1 configure_lanem Script Questions and Responses

When running the configure_lanem script, you are prompted for answers to questions that customize your ELAN configuration. During your session, you may not see all of the questions. The prompts that you do see depend on your environment and on answers to previous questions. In this section, the questions are shown first in `courier` font, and the explanations of the effects of the possible replies are shown after the questions.

```
=========================================================================
                FORE Systems LAN Emulation Configuration
=========================================================================
***** No Configuration Information *****
```

If LAN Emulation has not been configured, the No Configuration Information message appears. If ELANs have been configured, current configuration information appears.

```
Do You Want To Modify Configuration Information? [n]
```

If you wish to configure or modify LAN Emulation, respond with y. Answering n ends the LAN Emulation Configuration process.

```
============================
== Local LEC Configuration ==
============================
```

NOTE: Detailed information about the establishment of an ELAN is available in the on-line elconfig man page. The elconfig man page text is also available for reference in Chapter 8 of this manual. Note that a host may join more that one ELAN. A LEC must be configured for each ELAN that you wish to join.

```
Would you like to use an LECS to retrieve configuration information? [y]
```

Answer y to this question if you wish the local LEC to use an LECS to retrieve configuration information. Answer n if you wish the local LEC to use an LES that you specify for configuration information. The following question will not appear if you answer n.

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```
Use the "Well-Known" LECS address? [y]
```

Answer y to this question to instruct the local LEC to use the default ("well-known") ATM address for communicating with the LECS. Answer n if you wish to be prompted to enter an ATM address for the LECS manually.

```
Would you like to configure a DEFAULT ELAN? [y]
```

Answer n if you do not wish to use a DEFAULT ELAN. (The DEFAULT ELAN accepts any LEC that wants to join.) Answer y if you wish to configure the DEFAULT ELAN. You will then be presented with the following question:

```
Name of DEFAULT ELAN? [default]
```

You may supply a name for the DEFAULT ELAN or press the return key to accept the default name of default.

```
Enter ELAN name to configure (return to end):
```

The name of the ELAN that you wish to configure (for example, engineering) is entered in response to this prompt. ELAN names may be a maximum of 32 characters in length.

```
Enter LES address Manually? [n]
```

Answer y if you wish to enter the ATM address of the LES belonging to the ELAN named in response to the previous prompt. An LES address must be entered if you chose not to use an LECS for retrieving configuration information.

```
Enter ELAN name to configure (return to end):
```

If you wish to configure another ELAN, enter the ELAN name here. If you are finished configuring ELANs, press the return key to end ELAN configuration.

The script presents the current LAN emulation client configuration similar to the following:

```
================================================================================
Current client configuration:
================================================================================
LECS ATM address:       "Well-Known"
ELAN:                    "default"
ELAN:                    engineering
ELAN:                    marketing
================================================================================
```


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`Do You Want To Modify Configuration Information? [n]`

Answer y if you wish to change, delete, or add LAN emulation configuration information.

`Save Configuration Information? [y]`

Answer y if you wish to save the configuration information that you have entered. The system responds with a line indicating the configuration information is being saved in a file called fore_lanem.conf.

When you finish configuring LAN emulation, reboot the system or run /usr/etc/fore/launch_lanem for the changes to take effect.

6.4.1.2 Administering LECs

LECs are controlled from the command line with the elconfig command. A detailed explanation of the syntax and usage of the elconfig command is available on-line in the elconfig man page, or in this manual in Chapter 8.

> **NOTE:** LECs that you start with the elconfig command require a functioning network interface (for example, el0). Refer to Section 4.1 of this User's Manual for information about configuring the appropriate network interface(s).

Starting a LEC

For example, if you want to start a LEC that will attempt to join ELAN engineering, enter the following command:

elconfig add engineering

By default, the above command starts a LEC (on the local host) that attempts to contact the LECS on the "well-known" address as defined by the ATM Forum's LAN Emulation standards (47.0079.00.000000.0000.0000.0000.00A03E000001.00). This LEC, by default, has an ATM address based on the host adapter card's ATM (an unused selector byte is chosen to make the resulting ATM address unique). Consequently, each LEC "looks" like just another adapter card to other users on the network. You may also assign an ATM address to the LEC. If you

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choose to assign LEC ATM addresses manually, be careful that you assign each LEC a unique address.

Similarly, if you want to start a LEC that will attempt to join the default ELAN default (assuming that a default ELAN has been defined in the LECS configuration file), enter the following command:

elconfig add default

If you want a LEC to use an LECS running at an address other than the well-known one, enter a command similar to the following:

elconfig set -lecs *<address>*

where *<address>* is the ATM address of the LECS that you want the LEC to use.

If you do not want the LEC to use an LECS, enter the following command:

elconfig set -manual

In this case, you must specify the ATM address of the LES that you want the LEC to use when you start the LEC. For example:

elconfig add engineering -les *<address>*

where *<address>* is the ATM address of the LES that you want the LEC to use.

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Deleting a LEC

If you want to delete a LEC from an ELAN (engineering, for example), enter the following command:

```
elconfig delete engineering
```

This terminates the connections to the engineering LES and BUS and removes the network interface (e.g., el0) associated with the LEC.

CAUTION



If you configure two LECs on the same ELAN (each having IP ARP table entries for the other in their respective system ARP caches), then later remove the LECs from the ELAN; you must manually delete the system ARP cache if you want to add the LECs back again to the **same** ELAN and IP subnet. Failure to do so may result in the two systems being unable to re-establish IP connectivity.

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LEC Failover

An added feature of *ForeThought 4.0* software is the LEC failover mechanism. This feature allows multiple redundant services to be configured for an ELAN. Consequently, to start LECs that join ELAN marketing and make use of the failover mechanism set up in the sample LECS configuration file, enter the following commands:

```
elconfig add 'marketing | 0'
```

followed by,

```
elconfig add 'marketing | 1'
```

and then,

```
elconfig add 'marketing | 2'
```

NOTE: Be sure to use the single quote marks to enclose the ELAN names because of the use of the shell meta-character " | ".

The above commands start three LECs. Initially, the LEC that connects to ELAN marketing | 0 services is the active LEC. If marketing | 0 services fail, the LEC associated with ELAN marketing | 1 services becomes active. Periodically, the LEC associated with ELAN marketing | 0 attempts to re-establish service. If both marketing | 0 and marketing | 1 services fail, the LEC associated with ELAN marketing | 2 will then become active. Note that you may define as much redundancy into your system as resources allow.

CAUTION



Deleting the currently active failover LEC removes the network interface (e.g., el0) associated with **all** of the failover LECs, causing the other LECs in the failover mechanism to lose IP connectivity.

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6.4.1.3 Using elarp

The elarp command is used to display and (optionally) delete MAC-to-ATM ARP table entries used in conjunction with ELANs. (ARP table entries that are not related to ELANs may be displayed and controlled with the arp command as described in Chapter 4.)

Displaying ARP Table Information

You can display all of the current ARP table ELAN-related entries by entering the following command:

elarp show -all

Similarly, to display all of the ARP table entries for the engineering ELAN, you would enter:

elarp show -elan engineering

Finally, to display the ARP table entry for a particular host, enter:

elarp show *<address>*

where *<address>* is the MAC address of the host.

The following is the format of a typical ARP table entry displayed in response to an elarp show command:

```
00:20:48:10:0D:65 at 0x45.000580ffe1000000.f215149c002048100d65.02
ElanName=engineering flags=() vpi.vci=0.49
```

The first line gives the MAC to ATM address mapping. The second line gives the name of the ELAN, flag status, and the virtual path and channel identifiers used by the host at the mapped address.

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Deleting ARP Table Information

All ELAN-related ARP table entries may be deleted by entering the following command:

elarp delete -all

This command deletes all ELAN-related dynamic address mappings and closes the corresponding SVCs to all hosts in the table.

Likewise, to delete all ARP table entries associated with the engineering ELAN, enter:

elarp delete -elan engineering

Similarly, to delete the ARP table entry for a given MAC address, enter:

elarp delete *<MAC address>*

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CHAPTER 7 ATM Network Configurations

After installing a FORE Systems ATM adapter, there are several physical configurations (network topologies that may exist. The most likely configurations are:

- FORE adapters in a back-to-back configuration, in which they are directly connected to one another
- FORE adapters connected to a *ForeRunner* ATM Switch
- FORE adapter connected to an ATM product from a different manufacturer

This chapter describes methods for ensuring communications in all these network configurations.

7.1 Back-to-Back Adapter Configuration

7.1.1 SPANS and UNI 3.0 Signalling

When using FORE's proprietary signalling protocol, SPANS, it is possible to configure two FORE adapters in a back-to-back mode for a direct connection. To ensure proper communication, the adapter must be cabled correctly and IP addresses must be assigned (for more information on IP address assignment, see Chapter 4, Network Interface Administration). An intervening switch is NOT needed to establish this connection. This configuration is depicted in Figure 7.1.

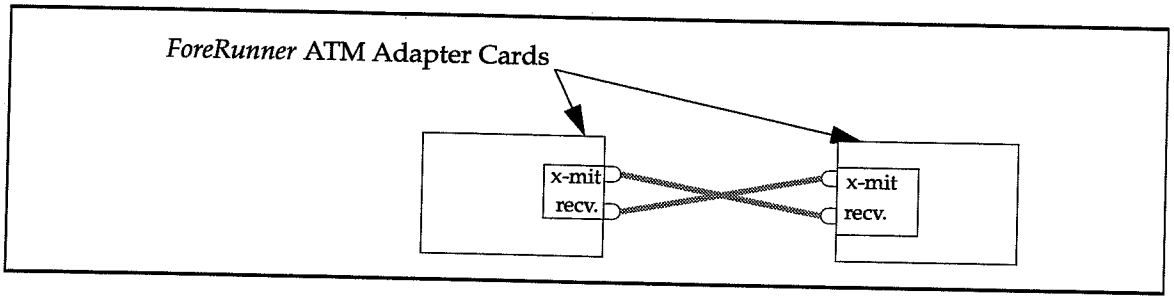


Figure 7.1 Back-to-Back Configuration with SPANS Signalling

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7.2 Adapter-to-FORE ATM Switch Configuration

ForeRunner ATM switches support the SPANS signalling protocol. If an ATM adapter is connected to a *ForeRunner* ATM switch, connections can be automatically created between the adapter and other SPANS-capable devices, such as other *ForeRunner* ATM adapters and the switch itself. In this topology, the only requirements are the physical connection between the adapter and assignment of correct IP addresses to ensure proper communication (for more information on assigning IP addresses, see Chapter 4, Network Interface Administration).

When UNI 3.0 signalling is used, it is no longer possible to connect adapters directly in a back-to-back mode because the signalling protocol UNI 3.0 does not support a direct adapter to adapter connection. Instead, a UNI 3.0 or 3.1 compliant switch, such as the FORE Systems ASX series ATM switch must be used between the two adapters. This configuration is depicted in Figure 7.2.

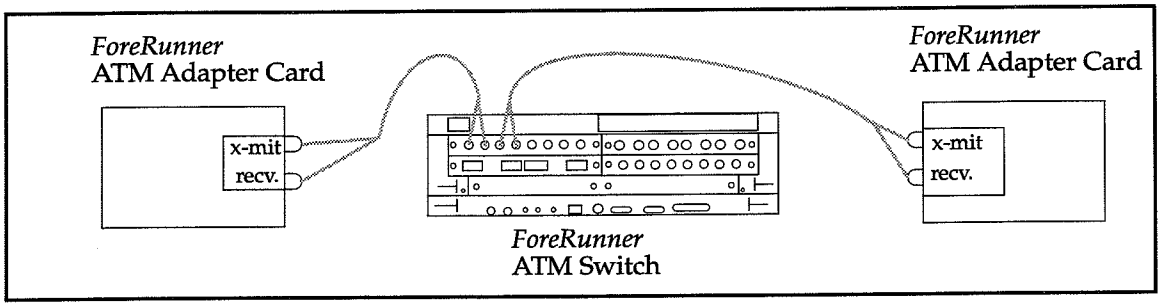


Figure 7.2 Minimum Configuration with UNI 3.0 Signalling

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7.3 Adapter-to-Other Vendor's Configuration

If an ATM adapter is connected to ATM equipment that does not support the SPANS signalling or UNI 3.0 signalling, PVCs must be used for ATM connections. In this case, the devices must be properly cabled and correct IP addresses must be assigned to the various devices. To make any connections, SPANS signalling must be disabled on the adapter and PVCs must be established over the ATM adapter. For additional information on connecting an adapter card to other vendor's equipment, please see Chapter 4, Network Interface Administration and Chapter 8, Additional Administration Information in this document.

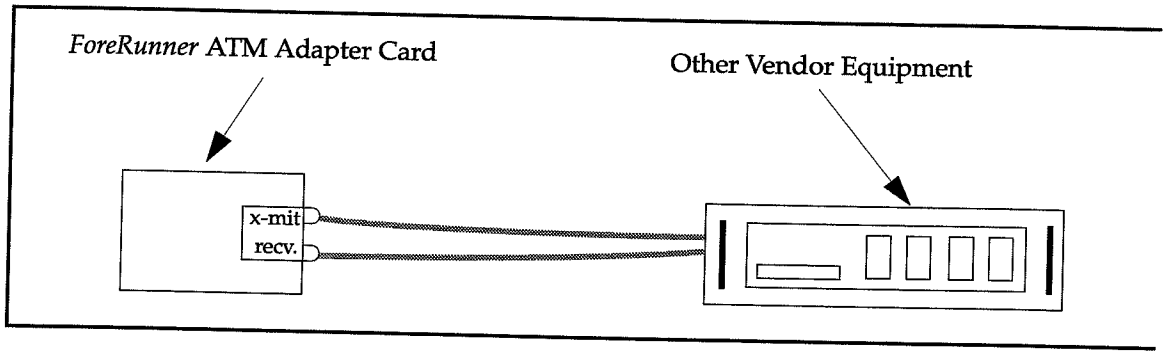


Figure 7.3 Adapter-to-Other Vendor Configuration

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CHAPTER 8 Additional Administration Information

8.1 Additional Software and Manual Pages

This *ForeRunner* HPA-200 release contains administrative and example programs, along with on-line manual pages. Please make these files accessible to ATM application programmers and system administrators as appropriate.

By adding the fore/etc directory to the PATH environment variable, the man directory to the MANPATH environment variable, and the lib directory to the LD_LIBRARY_PATH environment variable, you will make the files available from the working directories of the people who will use them.

NOTE: The paths shown above are the defaults. If you have installed your software in another directory, be sure to set the environment variables accordingly.

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8.2 HPA-200 Administrative Programs

The following *ForeRunner* HPA-200 administrative programs are included with this release of the software:

asxmon Displays the state of the switch and of all its active ports.

atmarp Shows and manipulates ATM ARP (Address Resolution Protocol) entries maintained by the HPA-200 device driver. This is also used to establish PVC connections.

atmconfig Used to enable or disable SPANS signalling. Also used to set MTU size, OC3 and various other parameters.

atmstat Shows statistics gathered about the HPA-200 by the device driver. These statistics include ATM layer and ATM adaption layer cell and error counts. This can also be used to query other hosts via SNMP.

cchan Used to manage virtual circuits on a FORE Systems ATM switch.

cpath Used to manage virtual paths on a FORE Systems ATM switch.

cport Used to monitor and change the state of ports on a FORE Systems ATM switch.

looptest Tests an ATM interface for basic cell reception and transmission functionality. It is usually used for diagnostic purposes to determine if an interface is functioning properly.

snmpd An SNMP agent for the HPA-200.

topology Displays the topology of a FORE Systems ATM network. An updated topology can be periodically re-displayed by use of the interval option.

elarp Shows and manipulates MAC and ATM address mappings for LAN Emulation Clients (LECs)

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elconfig Shows and modifies LEC configuration. Allows the user to set the ATM address of the LAN Emulation Configuration Server (LECS), display the list of Emulated LANs (ELANs) configured in the LECS for this host, display the list of ELANs locally configured along with the membership state of each, and locally administer ELAN membership.

An overview of the administrative programs listed above is found in the atm_intro (8C) manual page. For more details about these programs, please see the ATM network management manual pages located in Section 8 of the on-line manual. The man pages for LAN emulation commands are reproduced on the following pages for reference.

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8.2.1 elarp(8c)

NAME

elarp – manipulate MAC to ATM address mappings

SYNOPSIS

elarp show [**-all** | **-elan** *elan* | *MAC*]

elarp delete [**-all** | **-elan** *elan* | *MAC*] [**-unit** *unit*]

DESCRIPTION

elarp is a tool to display and delete MAC-to-ATM address table entries used in conjunction with the ATM Forum LAN Emulation Client (LEC).

COMMANDS

show
If the single argument *MAC* is given, the ARP entry for *MAC* is displayed. If the **-all** flag is used, all current ARP table entries are displayed. The **-elan** flag will display all ARP entries for elan *elan.*

delete
If the single argument *MAC* is given, the ARP entry for *MAC* is deleted. The **-all** and **-elan** flags will delete all dynamic address mappings from the ARP table and close all Switched Virtual Circuits (SVCs) to all hosts in the table, or all hosts on elan *elan,* respectively.

EXAMPLE

The following example displays an address mapping for a host on elan FORE_elan.

```
example% elarp show -elan FORE_elan
00:20:48:10:0D:65 at 0x45.000580ffe1000000.f215149c002048100d65.02
    ElanName=FORE_elan flags=() vpi.vci=0.49
```

RELEASE

FORE Systems Release: A_ForeThought_4.0.0 (1.32)+d

Release Date: Tue Feb 13 16:29:07 EST 1996

SEE ALSO

arp(8C)

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8.2.2 elconfig(8c)

NAME

elconfig – ATM Forum LAN Emulation configuration tool

SYNOPSIS

elconfig show *elan* "|"-all|-configured|-lecs [**-unit** *unit]*

elconfig add *elan* [**-if** *interface*] [**-lec** *ATMaddress*] [**-les** *ATMaddress* [**-unit** *unit*]

elconfig delete *elan* "|"-lecs [**-unit** *unit*]

elconfig set -lecs *ATMaddress* | "-wellknown"|-manual [**-unit** *unit*][**-sel** *selector_byte*]

DESCRIPTION

elconfig is a tool to display and modify FORE Systems' ATM Forum LAN Emulation Client (LEC) configuration. **elconfig** allows the super-user to set the ATM address of the LAN Emulation Configuration Server (LECS), display the list of Emulated LANs (ELANs) configured in the LECS for this host, display the list of ELANs locally configured along with the membership state of each, and locally administer ELAN membership.

COMMANDS

show

If the single flag **-all** is used, the name and LES's ATM address for each ELAN returned by the LECS is displayed. To display the name, the ATM addresses of the LE Services, and the local network interface name of each ELAN currently configured in the system, the -configured flag is used. Since the LE Services' ATM addresses may be acquired dynamically, only those addresses that have been learned will be displayed. In addition, if connections exist to the LE Services, the VPI/VCI pairs for each connection are displayed. Alternatively, a single ELAN's configuration information may be displayed by specifying the single argument *elan*. To retrieve the ATM address of the current LECS, the -lecs flag is used.

add

The add command enables the user to join a particular ELAN and specify certain configuration parameters. The **-if** flag maps *elan* to the network interface *interface* (e.g. **el0**), providing a mapping between ELAN name and network interface name. The **-les** flag allows the specification of the LES's ATM address as *ATMaddress* for joining ELANs whose configuration information is either not returned by the LECS, the LECS is not specified, or one is not available. **-lec** sets the LEC's ATM address to *ATMaddress* for communication with this ELAN's services. If not specified, the LEC will base the ATM address on the adapter's ATM address choosing an unused selector-byte. The **-unit** option may be specified to add an ELAN on a physical interface other than the first. This is only valid when used with the **-les** flag.

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delete
Used with *elan*, unjoin the specified ELAN, terminating connections to both its LES and BUS and removing the network interface associated with this ELAN. Some systems do not delete the system arp cache entries, when the network interface is deleted. On such systems if the interface is brought down or deleted, and the remote system's MAC address changes, then when the interface is brought up connectivity may not be established due to wrong arp cache entries. The system administrator must delete such arp cache entries manually. Used with the **-lecs** flag, remove the current LECS from the configuration. This command is only allowed if no ELANs are currently configured from this LECS.

set
If the single argument, *ATMaddress* is used, set the ATM address of the LECS to *ATMaddress* and mark this LECS as current. If another set command is invoked with a different LECS address, this LECS is now marked as current. The add and delete commands may only be applied to ELANs returned by the current LECS. The **-manual** flag places the host in a manual configuration mode, configuration information will not be retrieved from the LECS and the addition of ELANS will require the user to set the LES address.

RELEASE

FORE Systems Release: A_ForeThought_4.0.0 (1.32)+d

Release Date: Tue Feb 13 16:29:07 EST 1996

SEE ALSO

ifconfig(8C)

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CHAPTER 9 Software Interfaces

9.1 Berkeley Socket Interface

The HPA-200 device driver supports network communication using the Internet protocol family, via the user-level Berkeley socket interface. System functions that use the socket interface, such as NFS and NIS, as well as socket-based applications, will work as is, over your ATM network.

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9.2 Application Programming Interface

The HPA-200 device driver also supports FORE Systems' user-level ATM API (Application Programming Interface). This interface allows you to develop an application that creates a connection with another ATM API application on the ATM network. Once a connection is established, data may be transmitted, via the ATM API from one ATM application to another. An in-depth description of the ATM API can be found in the atm_intro (4N) manual page. Please consult the ATM API manual pages located in Section 4 of the on-line manual for more information.

9.2.1 Concurrent Server Model for the API

The Application Programmers Interface (API) now supports the concurrent server model, as well as the iterative server model. A concurrent server can handle multiple client requests simultaneously. As each new client connection is established, the server spawns a new process to handle the connection. The new server process communicates with the client exclusively and then terminates when complete. The original server process is free to listen for new client connections during this interval.

The restriction in earlier releases that the listening file descriptor and the accepting file descriptor arguments to atm_accept(4N) must be identical is removed. The descriptor arguments may now be different, but they do not have to be different. To implement a concurrent server, once a call to atm_listen(4N) returns, the server should obtain a new file descriptor from atm_open(4N) to use in order to accept the connection. atm_accept should then be called with the listening descriptor as well as the new accepting descriptor. After atm_accept returns successfully, fork(2V) can be called to spawn a new process to handle the new connection. All calls to the atm_recv(4N) and atm_send(4N) family of functions within the new process should use the new accepting descriptor.

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9.3 Rate Control

Traffic is submitted to the network such that the specified peak cell rate (PCR) is not exceeded. Rate control can be specified for the following types of connections:

- All PVCs
- FORE IP SVCs
- FORE API

An option has been added to atmarp to set the PCR for FORE IP PVCs and Classical IP PVCs (see atmarp(8c) on page 4-22). The Quality of Service (QOS) parameter is used to specify the PCR for FORE API connections (only the peak_bandwidth argument within the QOS parameter is interpreted by the ATM layer).

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9.4 AAL NULL Support for 200-Series Adapters

All FORE API connections can be segmented and reassembled using no AAL. The AAL null software implements a procedure known as header coalescing. All cells received on an AAL null connection with identical headers will be grouped together into batches. These batches of cells are then delivered to the application as a group. The maximum number of cells in a group can be controlled though atm_setbatchsize(4n) (the default is one cell).

The net effect is that cells received on an AAL null connection will be buffered in the driver until either a cell arrives on that same connection with a different header, or the number of cells buffered equals the current batch size. AAL null cells are received by an application through atm_recv_null(4n), with the most significant four bytes of the ATM header (the header excluding the HEC) returned in the last argument. See atm_recv_null(4n) for more information.

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CHAPTER 10 Troubleshooting

The troubleshooting tests detailed in this chapter will clearly indicate and identify the most common problems in establishing ATM networks. Therefore, before calling FORE Systems Technical Support, perform these tests to correct or at least pinpoint the problem.

If you need to call Technical Support, please have the results of these tests ready, in addition to the information requested in Section 10.4, when reporting your problem.

10.1 Adapter Hardware Troubleshooting

The flowchart in Figure 10.1 illustrates the tests used to check the basic hardware functionality of a FORE Systems adapter, with the adapter card isolated from the network. The tools used to perform the tests are provided by FORE Systems and the computer hardware vendor. Each of the tests, indicated by the diamond-shaped blocks in Figure 10.1, is described individually in the following subsections.

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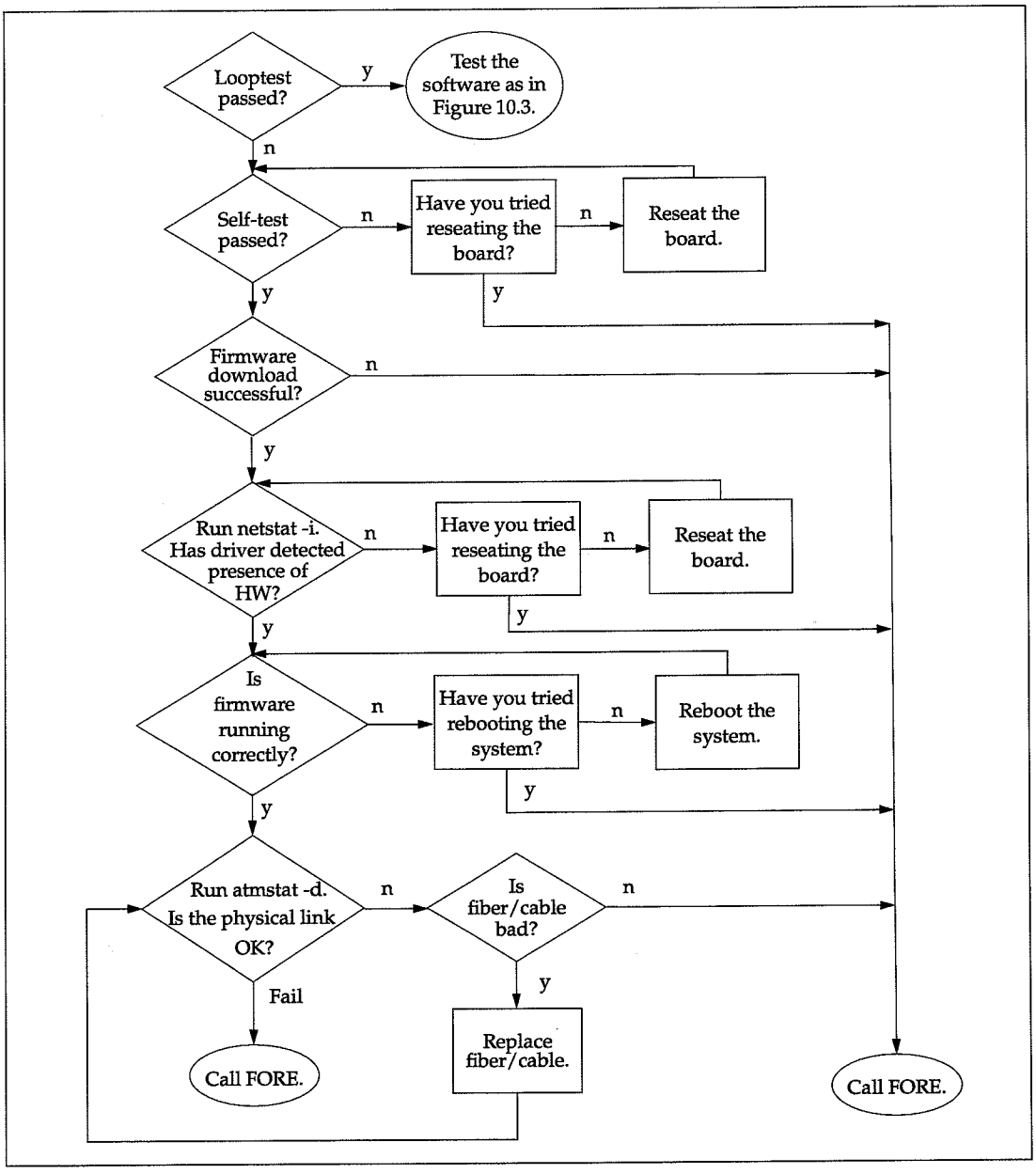


Figure 10.1 Adapter Hardware Troubleshooting Flowchart

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10.1.1 Run Looptest

To determine if an interface is functioning properly, run the looptest utility on a host that has been disconnected and isolated from the network.

NOTE: Before running looptest, you must couple the Receive and Transmit connectors on the backplate of the card to each other using a short loop of fiber-optic cable, or a UTP connector wired for loopback, as applicable to your adapter. This cable should remain on throughout this test.

The looptest utility uses FORE Systems' ATM user-level Application Programming Interface. For proper operation, looptest requires read/write access to the ATM device. To run looptest, enter the following command at the system prompt in the working directory:

```
looptest fa0
```

where fa0 is the default device name for a single ATM adapter.

The looptest utility verifies that the board of an adapter is operating correctly. Correct operation means that all of the following conditions are true:

1. The self-test has been passed successfully.
2. The firmware has been downloaded successfully.
3. The driver has detected the existence of the hardware.
4. The firmware is running.
5. The physical link is up.

If looptest passes, then the board hardware of the adapter is OK. The next step is to test the software as shown in Figure 10.3.

If looptest fails, the point of failure will be indicated by messages generated for each of the five items above. Refer to the following subsections for instructions about testing the individual items.

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10.1.2 Check Self-Test (Automatically Performed)

During a system boot, the ATM adapter automatically performs a self-test of the hardware, running a low-level diagnostic which checks memory read/write capability. Upon completion of the self-test, a message is printed to the console of the workstation indicating whether or not the hardware failed.

If the self-test is successful, proceed to the instructions regarding the firmware download as described in the next subsection.

If the self-test fails, reseat the board by performing the following steps to ensure that failure was not due to improper insertion of the board:

1. Halt the system, being sure to follow the procedures outlined in Chapter 2 of the User's Manual for the adapter.
2. Open the computer as shown in Chapter 2 of the User's Manual for the adapter, and reseat the board.
3. Reboot the system.

If the board still fails after a reseat, then it should be returned for repair. Call FORE Systems Technical Support for further assistance.

10.1.3 Firmware Download (Automatically Performed)

Before operating as an ATM interface, the firmware is automatically downloaded from the system RAM to the onboard i960 processor during host system boot. A message similar to: "XXX-200 initializing..." is displayed on the console, indicating that the board is being initialized. When the initialization is complete, success is indicated with the message "done" and failure is indicated with the message "failed".

If the download is successful, check to see if the hardware has been detected by the driver as described in the next subsection.

If the firmware failed to download, then there is most likely a hardware problem. Call FORE Systems Technical Support for further assistance.

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10.1.4 Hardware Detected by Driver

To determine if the driver software on the host has detected the presence of an ATM adapter board, issue the following command once the host system has come up completely:

netstat -i

If the driver has located the ATM board, the screen output shows fa0 (or the interface name supplied during installation) in response to the netstat command. If there is more than one adapter card, the next board will be named fa1, and so on. If you have configured a Classical IP interface, this will also be shown. The option -i shows the state of interfaces that were auto-configured, as happens when the FORE software is loaded and run upon system boot. Interfaces statically configured in a system, but not located at boot time, are not shown.

If the driver does not see the ATM board, no response will be given. Reseat the board by performing the following steps to ensure that failure was not due to improper insertion of the board:

1. Halt the system, being sure to follow the procedures outlined in Chapter 2 of the User's Manual for the adapter.
2. Open the computer as shown in Chapter 2 of the User's Manual for the adapter, and reseat the board.
3. Reboot the system.

If the board still fails after a reseat, then it should be returned for repair. Call FORE Systems Technical Support for further assistance.

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10.1.5 Check Firmware

To check whether or not the firmware is running correctly, issue the following command:

atmstat fa0 1

In this command, the last parameter "1" causes the command to be repeated at one-second intervals.

If the firmware is running correctly, the response will show Input, Output, and Error Statistics for the adapter in the following format:

```
PHY/ATM/AAL statistics:
     Output                Input                              Errors
   ATM      AAL*        ATM      AAL*     4B5B     4B5B      ATM      AAL*     AAL*
  Cells   CS-PDUs      Cells  CS-PDUs Framing Hdr-CRC VPI/VCI Pay-CRC   Proto
 161747    153692     142289   134685       0       0       20       0        0
```

If the firmware is not running correctly, atmstat hangs, and nothing is returned, indicating either a problem with the firmware, a problem with the board, or a severe software failure. Call FORE Systems Technical Support for further assistance.

If the input shows zeros for all possible values, check the carrier state per the instructions in Section 10.1.6.

If the output shows zeros for all possible values, the firmware may not have been initialized. Try rebooting the system. If there is still a problem, call FORE Systems Technical Support for further assistance.

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10.1.6 Check Physical Link

To see the carrier state of the board, issue the following command:

atmstat -d fa0

The -d option displays device statistics in the following format:

```
Device statistics:
      Buffer Allocation Failures
        Type 1              Type 2
    Small     Large     Small     Large     Receive Queue Full     Carrier
                0         0         0         0                      0          ON
```

If ON is displayed in the Carrier field, then the physical link is fine.

If the board does not see a carrier (OFF is displayed in the Carrier field), then there is either a problem with the loopback fiber or there is a hardware problem with the optical drivers on the board. Check the fiber. If the fiber is bad, replace the fiber and run looptest again. If the fiber is not bad, then call FORE Systems Technical Support for further assistance.

Alternatively, if you have access to the back of the host and can see the LED displays on the adapter backplate, a red LED on the R (Receive port) also indicates carrier failure.

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10.2 Testing Network Connectivity Using PVCs

The network connectivity tests require that two ATM adapters are connected to an ATM switch with PVCs (as shown in Figure 10.2). The carrier lights should be unlit on the boards and on the switch, indicating that the fibers are OK.

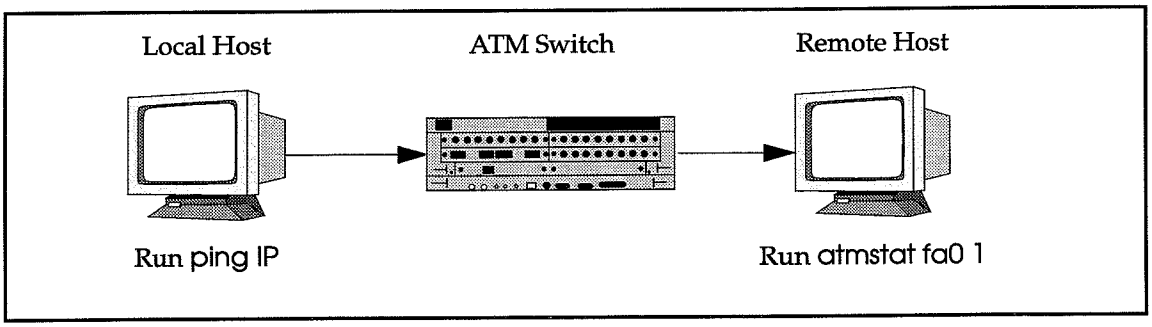


Figure 10.2 Hardware Configuration for Checking PVCs

The network connectivity test suite, shown in Figure 10.3, examines higher level functionality after basic adapter board performance has been verified by passing all the tests and checks shown in Figure 10.1.

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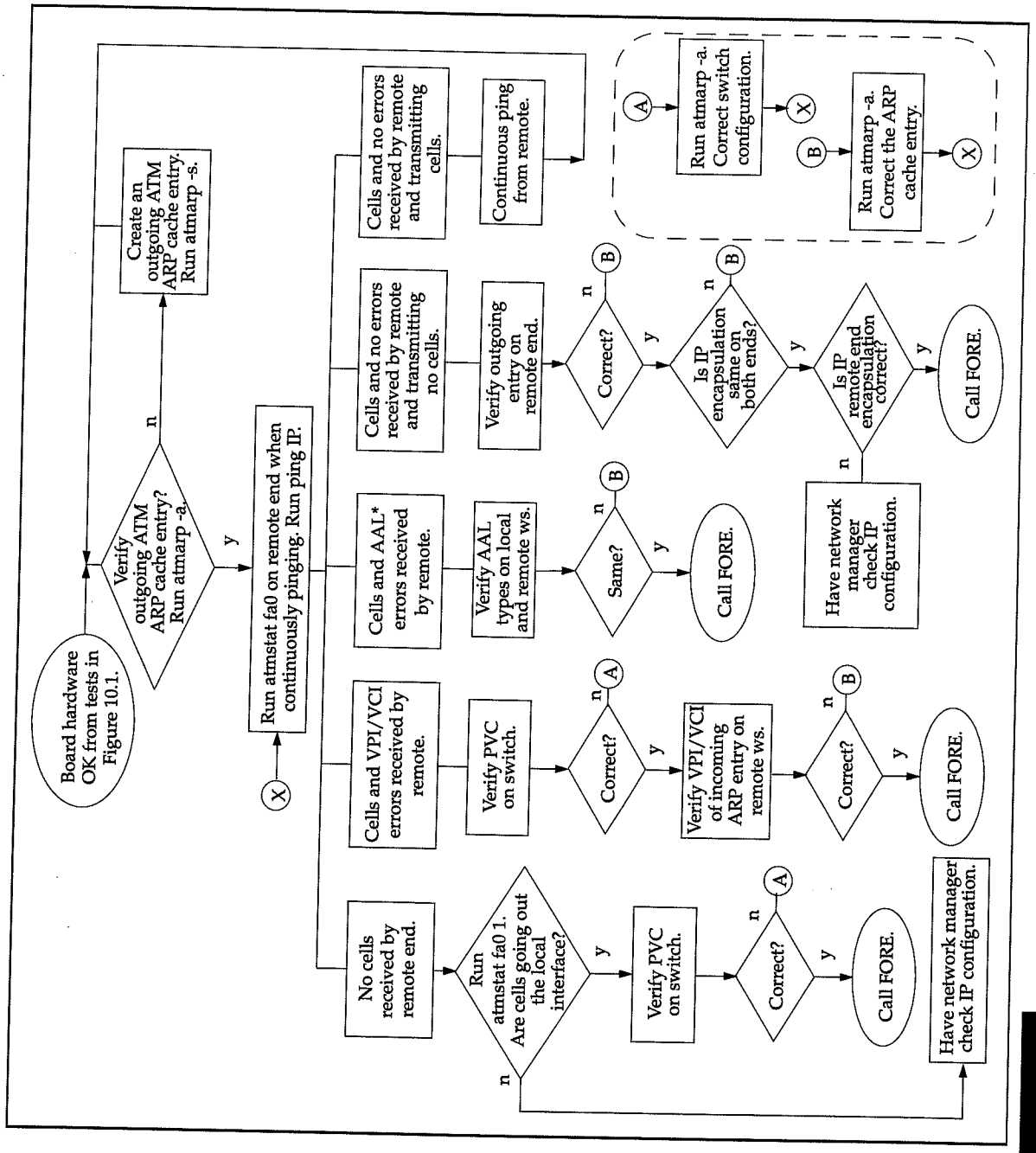


Figure 10.3 Networking Connectivity Using PVCs

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This test sequence requires that the switch be configured with a valid PVC and the end stations have the proper IP configuration and ATM ARP cache entries. See the atmarp man page and Chapter 4 of the ASX switch manual to determine if the PVCs are correctly configured. The tests in Figure 10.3 assume that a ping was tried and there was no response (ping failed).

The tests in Figure 10.3 also require that if a switch is used, it is a FORE Systems switch on which SPANS has been disabled on both the ports of the switch and the ATM endstations. SPANS must be disabled because it automatically creates ATM connections, which may alter the test results.

All of the test conditions are checked by running a continuous ping with the following command:

ping <IP_address_of_remote_workstation>

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10.2.1 Verifying the Outgoing ATM ARP Entry

To verify the outgoing ATM ARP cache entry for the endstation originating the ping, enter the following command on the host:

atmarp -a

The following is an example of a typical ATM ARP cache display:

```
Outgoing connections:
fa0: ws2-atm (198.29.21.74): vpi.vci=0.100 aal=5
        switch.port=-.-
        flags=(PVC) encapsulation=NULL peak rate=(unlimited)
fa0: ws3-atm (198.29.21.94): vpi.vci=0.200 aal=5
        switch.port=-.-
        flags=(PVC) encapsulation=NULL peak rate=(unlimited)
Incoming connections:
fa0: switch.port=-.- vpi.vci=0.100 aal=5 flags=(PVC) decapsulation=NULL
fa0: switch.port=-.- vpi.vci=0.200 aal=5 flags=(PVC) decapsulation=NULL
```

Make sure the ARP cache entry does indeed match the IP address of the remote endstation and is using the PVC configured on the switch.

If the prompt is returned with no information displayed, this indicates that the ATM ARP cache is empty.

Use the following two commands to create a PVC on the host:

./atmarp -s <hostname> <device> <vpi> <vci> <aal>

./atmarp -l <device> <vpi> <vci> <aal>

If the ATM ARP cache entry is valid, then perform the instructions in the next subsection for atmstat.

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10.2.2 atmstat

To determine a particular failure state, enter the following command on the remote workstation while continuously pinging:

atmstat fa0 1

```
PHY/ATM/AAL statistics:
      Output                 Input                              Errors
    ATM      AAL*         ATM      AAL*     4B5B     4B5B      ATM     AAL*     AAL*
  Cells   CS-PDUs       Cells   CS-PDUs Framing Hdr-CRC VPI/VCI Pay-CRC   Proto
 161747    153692      142289    134685       0       0      20       0       0
```

The failure states are determined by examining the output from the atmstat fa0 1 command string. The failures are classified by whether or not cells are sent (or received) and whether or not errors are received. The output shown above is typical of the first response from the atmstat fa0 1 command string. Succeeding lines of data continue in the same column format. Refer to the following subsections for a description of each type of failure.

10.2.2.1 No Cells Received by Remote End

If no cells are received by the remote end (the Input ATM Cells field displays zero), then run the following command on the local machine to verify that cells are going out the ATM interface:

atmstat fa0 1

If there are no cells going out (the ATM Output Cells field shows zero), then there is most likely an IP routing problem rather than an ATM problem. Please have your network administrator check the IP configuration.

If cells are going out (the ATM Output Cells field shows a value other than zero), then the PVC on the switch may be configured incorrectly. Check the PVC configuration. If it is not set up properly, then correct the PVC and rerun the test. If the PVC is configured correctly and the error persists, call FORE Systems Technical Support for further assistance.

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10.2.2.2 Cells and VPI/VCI Errors Received by Remote

If the remote workstation is receiving cells and is receiving VPI/VCI errors, then this indicates that cells are coming into the workstation, but are on a VPI/VCI that may not be configured correctly.

Check the PVC configuration. If it is not set up properly, then correct the PVC and rerun the test. If the PVC is configured correctly and the error persists, then the incoming ARP entry on the remote workstation is most likely the problem. List the ATM ARP cache using atmarp -a and check the incoming ARP entry for that connection.

If the incoming ARP entry is not configured properly, then correct the configuration and rerun the test. If the incoming ARP entry is configured properly and the error persists, then call FORE Systems Technical Support for further assistance.

10.2.2.3 Cells and AAL* Errors Received by Remote

If the remote workstation is receiving cells and AAL* errors, then the AAL types of the outgoing entry on the local workstation and the incoming entry on the remote workstation probably do not match. Check both ATM AAL types using atmarp to see if they match. If they are different, set the AAL parameter to the same type and rerun the test. If they match and the error persists, then call FORE Systems Technical Support for further assistance.

10.2.2.4 Cells and No Errors Received by Remote and Transmitting No Cells

If the remote workstation is receiving cells with no errors, but is not transmitting any cells, then either the outgoing IP address on the remote end is incorrect or the IP encapsulation does not match on both ends. (A Classical IP PVC uses LLC/SNAP encapsulation while a FORE IP PVC uses AAL5 based Multiplexing (NULL) encapsulation.)

First, check the outgoing IP address on the remote end using atmarp -a. If it is not configured properly, then correct the configuration and rerun the test. If the outgoing ARP entry is configured properly, then check to see if the IP encapsulation matches on both ends using atmarp -a.

If the IP encapsulation does not match on both ends, then correct the configuration and rerun the test. If the IP encapsulation matches on both ends and the error persists, then there may be an IP routing problem on the remote host.

The network administrator should verify the IP routing. If there is still a problem, then call FORE Systems Technical Support for further assistance.

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10.2.2.5 Cells and No Errors Received by Remote and Transmitting Cells

If the remote end is receiving cells with no errors and is transmitting cells in response, then the remote end is OK. Looking at Figure 10.2, reverse the direction. From the remote host, start a continuous ping and then run these same tests starting again with Section 10.2.1. Watch the results of these tests on the local host.

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10.3 LAN Emulation Troubleshooting

The following procedures provide a top-down series of troubleshooting procedures for LAN emulation from the point of view of the host in which your adapter resides. Troubleshooting procedures for the host system, as well as for equipment to which your adapter may be connected, are referenced as necessary. If you have any questions about troubleshooting LAN emulation as employed with this adapter, contact FORE Systems Technical Support.

10.3.1 Troubleshooting Procedures

If your host system is unable to communicate with other members of the ELAN, review the following questions and procedures for possible solutions.

Before You Begin

Before attempting to troubleshoot suspected LAN emulation problems, perform the following:

- Ensure that the host hardware (switches, workstations, adapters, etc.) that is running the various LAN emulation software processes (LECS, LES, BUS, LEC) is correctly connected, powered-up, and functional.
- Perform the appropriate hardware troubleshooting.

NOTE: Section 10.1 of this manual provides adapter hardware troubleshooting procedures. Refer to the documentation supplied with your host system, as well as any hardware involved in running LAN emulation processes, for appropriate hardware troubleshooting.

- Obtain the appropriate network parameters from your system administrator that define how your host should be configured for the ELAN that you are troubleshooting. This information should include:
  - the ELAN name
  - the name assigned to your interface
  - the IP address assigned to your interface
  - the ATM address of the system on which the ELAN's services is running

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Is the ELAN state "Operational?"

How to check -

Enter the command elconfig show -configured and check if the ELAN state is "Operational." Also note the "Last Error" from the output.

Possible Solutions -

If the state is "Operational":

1. Ensure that the interface is assigned the correct IP address and is UP.
2. Check routing entries: Make sure that the Destination and Gateway addresses are correct. Make sure that the default route is correct (i.e. default Gateway address is correct). Please refer to Chapter 4 of this manual for IP interface configuration.
3. Follow IP troubleshooting procedures, supplied with your system OS Network troubleshooting guide.
4. Call FORE Technical Support.

If the state is **NOT** "Operational," proceed to the next question.

Is the ATM address assigned?

How to check -

Enter the command atmarp -z qaa0 and check if the ATM address is assigned.

Possible Solutions -

If the ATM address is **NOT** assigned.

1. Ensure that FORE snmpd or ilmid is running. (Check syslog file to see if ILMI has registered ATM address with the switch)
   - If not running, reinstall the software OR call FORE Technical Support.
2. Enter the command atmstat fa0 and observe response.
   - If atmstat does not respond, call FORE Technical Support.
   - If atmstat responds with cell counts, **and** if you are using a non-FORE switch, make sure that the switch's address registration is working properly.

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If you are using a FORE switch, call FORE Technical Support.

If the ATM address **is** assigned, proceed to the next question.

What is the "Last Error" appearing in the output of the elconfig show -configured command?

How to check -

Enter the elconfig show -configured command and note the last error message in the output.

Possible Solutions -

Last error messages and corrective actions are mentioned with each case below.

- *LES address is zero (only in autoconfig mode) or VCI not assigned for LES (only in manual configuration).*

1. **"LECS failed to find ELAN"**

   Ensure ELAN name is correct and registered with LECS (in case of auto-configuration only).

2. **"LECS failed to respond"**

   If in auto-configuration mode, make sure LECS is started and running.

3. **"failed to connect to LES"** or
   "Could not connect to the BUS"

   Make sure services (LES,BUS) are up and the services machine is connected to the switch. Make sure that the ATM address of the services machine is correct in the LECS database.

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4. If services are UP, check syslog file (if enabled) for any ERROR conditions and make corrections as appropriate. If services are UP but syslog is not enabled, call FORE Technical Support.
5. Enter the command atmstat fa0 1 and observe response.
    a. If atmstat does not respond, call FORE Technical Support.
    b. If atmstat responds, check if you can troubleshoot the switch. Otherwise, call FORE Technical Support.

- *LES address is assigned (in auto-configuration mode only)* ***and*** *BUS address is not assigned*

1. **"LE_ARP for BUS failed"** or
   "BUS connection dropped" or
   "LES connection dropped"

   Check for 'direct vpi.vci' to LES in elconfig output. Make sure LES is running if vpi.vci is not assigned.

   Check LES log (if enabled) and contact FORE Tech. Support for any ERROR conditions.

- *All addresses are assigned but VCIs are not assigned.*

1. **"LES connection dropped"** or
   "BUS connection dropped"

   Make sure services are running.

2. Enter the command atmstat fa0 1 and observe the response.
    a. If atmstat does not respond, call FORE Technical Support.
    b. If atmstat responds, troubleshoot the switch. Otherwise, call FORE Technical Support.

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10.4 Collecting Additional Information

Once basic adapter installation and network connectivity have been tested, this section explains how to obtain all of the additional information that you need to have ready before calling FORE Systems Technical Support. This information should exist either on-line (by redirecting the output to a file) or in hard copy form.

10.4.1 Basic Information

The following basic network information is very useful in helping FORE's Technical Support staff troubleshoot your problem:

1. Host platform configuration:
   - Vendor name
   - Platform type
   - RAM (MB)
   - Disk drive size (approximate)
2. Patches installed
3. Network topology (physical configuration)
   - Sketch and FAX in, if possible

Please have your support contract ID number and serial number ready also.

10.4.2 Adapter Information

On the host, at a command line, type the following six commands and note the responses:

- `uname -a` (Shows operating system, and platform names and versions)
- `ifconfig fa0` (Shows adapter interface configuration)
- `netstat -nr` (Shows routing table with destinations, gateways, and flags)
- `netstat -in` (Shows device names and addresses, and usage information)
- `adinfo fa0` (Shows adapter device name and version information)
- `atmstat -d fa0` (Shows carrier state and a variety of error counters)

Typical responses are shown under each command. The responses from these commands enable support to gather sufficient information to resolve the majority of problems.

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NOTE: The assumed adapter name in the examples is fa0. On your particular system, the adapter may have a different designation. To check the name of your adapter, use the command: netstat -in.

uname -a

```
HP-UX manta-ray A.09.03 E 9000/735 2006186656 8-user license
```

ifconfig fa0

```
fa0: flags=863<UP,BROADCAST,NOTRAILERS,RUNNING,MULTICAST>
        inet 198.29.38.206 netmask 0xffffff00 broadcast 198.29.38.255
```

netstat -nr

```
Routing tables
Destination         Gateway            Flags    Refcnt Use       Interface
127.0.0.1             127.0.0.1          UH       3      2264661   lo0
198.29.24.0           198.29.16.74       UG       1      9751      fa0
default               192.88.243.19      UG       3      123714    ie0
198.29.16.0           198.29.16.54       U        29     10892307  fa0
204.95.89.0           198.29.16.28       UG       0      2080      fa0
198.29.25.0           192.88.243.19      UG       0      0         ie0
198.29.26.0           192.88.243.19      UG       0      2696      ie0
198.29.27.0           192.88.243.19      UG       0      7853      ie0
198.29.19.0           198.29.16.85       UG       0      0         fa0
192.88.243.0          192.88.243.54      U        350    9188789   ie0
204.120.44.0          192.88.243.19      UG       1      1677      ie0
198.29.28.0           198.29.16.8        UG       0      87706     fa0
198.29.29.0           198.29.16.2        UG       0      0         fa0
198.29.31.0           198.29.16.75       UG       5      16417     fa0
198.29.23.0           192.88.243.53      UG       6      122731    ie0
```


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netstat -in

```
Name Mtu   Network     Address            Ipkts Ierrs    Opkts Oerrs  Coll
ec0  1500  192.88.243  192.88.243.171   1173050 39926   509363      0 107115
fa0  9188  198.29.38   198.29.38.206          0     0        0     0      0
qaa0 9180  198.29.22   198.29.22.206          0     0        0     0      0
qaa1*9180  none        none                   0     0        0     0      0
qaa2*9180  none        none                   0     0        0     0      0
qaa3*9180  none        none                   0     0        0     0      0
lo0  8304  127         127.0.0.1          32048     0    32048     0      0
```

adinfo fa0

```
FORE Systems Release: ForeThought_4.0.0
fa0: hpa-200 media=4b5b-100 hw=1.0.0 fw=2.3.0 serial=2 slot=0
```

atmstat -d fa0

```
Device statistics:
      Buffer Allocation Failures
        Type 1           Type 2
    Small     Large     Small     Large     Receive Queue Full     Carrier
        0         0         0         0                      0          ON
```


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10.4.3 Switch Information

On the host, at a command line, type the following commands and note the responses:

- atmstat fa0 command
- netstat -ai command
- asxmon command
- cport command

Log in to the ATM Management Interface to check the following:

- configuration spans show
- configuration port show
- configuration uni30 show
- Configuration of Network Modules (TAXI, DS-3, DS-1, OC-3c, E-3, and/or J-2)

Typical responses are shown under each command. The responses from these commands enables support to gather sufficient information to resolve the majority of problems.

atmstat fa0

```
PHY/ATM/AAL statistics:
     Output                Input                          Errors
   ATM      AAL*        ATM      AAL*     4B5B    4B5B     ATM     AAL*     AAL*
 Cells   CS-PDUs      Cells   CS-PDUs Framing Hdr-CRC VPI/VCI Pay-CRC   Proto
476058    469354     276580    273789       0       0       0       0       0
```

netstat -ai

```
Name Mtu   Network     Address            Ipkts Ierrs    Opkts Oerrs  Coll
ec0  1500  fore        gar-eth          1174803 39928   509563     0 107117
                         ALL-SYSTEMS.MCAST.N
                         08:00:69:07:e3:93
fa0  9188  198.29.38   198.29.38.206         0     0        0     0      0
                         ALL-SYSTEMS.MCAST.N
qaa0 9180  fore-sw     198.29.22.206         0     0        0     0      0
qaa1*9180  none        none                  0     0        0     0      0
lo0  8304  loopback    localhost         32072     0    32072     0      0
                         ALL-SYSTEMS.MCAST.N
```


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asxmon <switch_name>

```
ASX-200 switch up 3:35, 17 ports (9 active), software 2.3.5, hardware 1.1
port name          uptime VPs/max VCs/max    Kb/s    free     max   total Mb
 B1  198.29.22.34     2:57    1/1     5/5       0       0  140000        847
 B2  198.29.22.18     3:35    1/1     3/3       0       0  140000        141
 C1  198.29.22.27     3:35    1/1     4/4       0       0  140000      83035
 C2  198.29.22.3      3:35    1/1     4/4       0       0  140000         11
 D1  198.29.22.2      3:35    1/1     2/2       0       0  100000         11
 D2  198.29.22.11     3:35    1/1     3/3       0       0  100000         11
CTL 198.29.22.37      3:35    1/1    36/36      0       0   80000        203
```

NOTE: In the output above, the Kb/s and free columns do not contain valid data.

cport <switch_name>

```
Input                                  Output
Port Type Mb/s State Time          VPs  VCs   BW      Cells  VPs  VCs   BW      Cells
 B1  user  100 down  19:08:15       1    2  100          0    1    2  100     137783
 B2  user  100 down  19:08:15       1    2  100          0    1    2  100     137784
 B3  user  100 up    19:08:15       1    3  100     141332    1    4  100     149078
 B4  user  100 down  19:08:15       1    2  100          0    1    2  100     137784
 C1  user  140 up    19:08:15       1    4  140     140569    1    3  140     148928
 C2  net   140 up    02:44:38       1    7  140    1046 M     1    6  140     193732
 C3  net   140 up    19:08:15       1    5  140    1297 M     1    6  140     455400
 C4  user  140 up    19:06:57       1    5  140     138800    1    5  140    1046 M
CTL  user   80 up    19:08:13       1   22   80       1 M     1   22   80       1 M
```


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The following commands are run by logging in to the AMI on the switch. The next three commands show switch configuration and status.

configuration spans show

```
Port    VPI   Sig   Cls     AAL State      CDVT Policing Type RemoteAddress
1C1       0    15    14       4 down       1000 tag      uni
1C2       0    15    14       4 down       1000 tag      uni
1C3       0    15    14       4 up         1000 tag      nni  169.144.12.69
1C4       0    15    14       4 down       1000 tag      uni
1D1       0    15    14       4 down       1000 tag      uni
1D2       0    15    14       4 down       1000 tag      uni
1D3       0    15    14       4 down       1000 tag      uni
1D4       0    15    14       4 down       1000 tag      uni
1D5       0    15    14       4 down       1000 tag      uni
1D6       0    15    14       4 down       1000 tag      uni
1CTL      0    15    14       4 up         1000 tag      uni  169.144.12.58
```

configuration port show

```
Port Carrier   Mb/s iVPs iVCs    iBW  iCells oVPs oVCs    oBw  oCells Model
1C1  no       155.0    1    4  155.0       0    1    4  155.0   18845 OC3
1C2  no       155.0    1    4  155.0       0    1    4  155.0   18845 OC3
1C3  yes      155.0    1    5  155.0  118885    1    4  155.0  115145 OC3
1C4  no       155.0    1    4  155.0       0    1    4  155.0   18847 OC3
1D1  no       100.0    1    4  100.0       0    1    4  100.0   18848 TAXI-100
1D2  no       100.0    1    4  100.0       0    1    4  100.0   18848 TAXI-100
1D3  no       100.0    1    4  100.0       0    1    4  100.0   18848 TAXI-100
1D4  no       100.0    1    4  100.0       0    1    4  100.0   18848 TAXI-100
1D5  no       100.0    1    4  100.0       0    1    4  100.0   18848 TAXI-100
1D6  no       100.0    1    4  100.0       0    1    4  100.0   18849 TAXI-100
1CTL yes       80.0    1   46   80.0  330531    1   47   80.0  164630 ASX
```


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configuration uni30 show

Port	VPI	Sig	AAL	State	ILMI	UNIside	ConfigType	OperType
1A1	0	5	5	down	up	network	auto	spansNNI
1A2	0	5	5	up	up	network	auto	spansNNI
1A3	0	5	5	up	up	network	auto	spansNNI
1A4	0	5	5	up	up	network	auto	spansNNI
1B1	0	5	5	down	up	network	auto	spansNNI
1B2	0	5	5	down	down	network	auto	privateUNI
1B3	0	5	5	down	down	network	auto	privateUNI
1B4	0	5	5	down	down	network	auto	privateUNI
1C1	0	5	5	down	down	network	auto	privateUNI
1C2	0	5	5	down	down	network	auto	privateUNI
1CTL	0	5	5	up	down	network	auto	privateUNI

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The following commands are run by logging in to the ATM Management Interface on the switch. Enter the following parameters at the prompt for the type of network modules that are installed on your switch:

configuration port taxi show

```
Port Carrier    State       Obuf Version Loopback   Model
1A1  yes        up           256       6 none       NM-TAXI-100-4
1A2  no         down         256       6 none       NM-TAXI-100-4
1A3  no         down         256       6 none       NM-TAXI-100-4
1A4  no         down         256       6 none       NM-TAXI-100-4
1A5  no         down         256       6 none       NM-TAXI-100-4
1A6  no         down         256       6 none       NM-TAXI-100-4
```

configuration port ds3 show

```
Port Carrier Status Mode Framing  Loopback ClockSource  Scrambling IdleCells
1C1  no      0x672  plcp cbit     payload  network      on         unassigned
1C2  no      0x1    plcp cbit     none     internal     off        unassigned
```

configuration port ds1 show

```
Port Carrier Status Mode  Framing  Loopback ClockSource  IdleCells
1A1  no      0x96   hcs   N/A      none     internal     unassigned
1A2  yes     0x1    hcs   N/A      none     internal     unassigned
```

configuration port oc3 show

```
Port Carrier Status Line Mode  Loopback ClockSource  Scrambling IdleCells
1A1  no      0x1    SMM  sonet none     internal     on         idle
1A2  no      0x1    SMM  sonet none     internal     on         idle
1A3  no      0x1    SMM  sonet none     internal     on         idle
1A4  no      0x1    SMM  sonet none     internal     on         idle
```


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configuration port e3 show

```
Port Carrier Status Mode Loopback ClockSource  Scrambling IdleCells
1D1  no      0x72   hcs  none     internal     off        unassigned
1D2  no      0x72   hcs  none     internal     off        unassigned
```

configuration port j2 show

```
Port LineLength   Loopback     ClockSource
1D1  short        none         internal
1D2  short        none         internal
1D3  short        none         internal
1D4  short        none         internal
```


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APPENDIX A PMD LED Indicators

This Appendix describes the physical and functional capabilities of the PMD module LED indicators.

A.1 LED Location

The figures below show the appearance of the face plate.

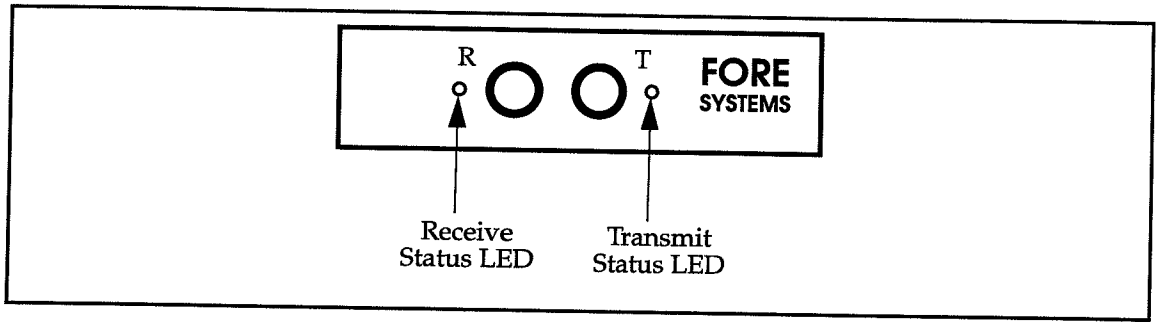


Figure A.1 - ST Connector Face Plate Configuration

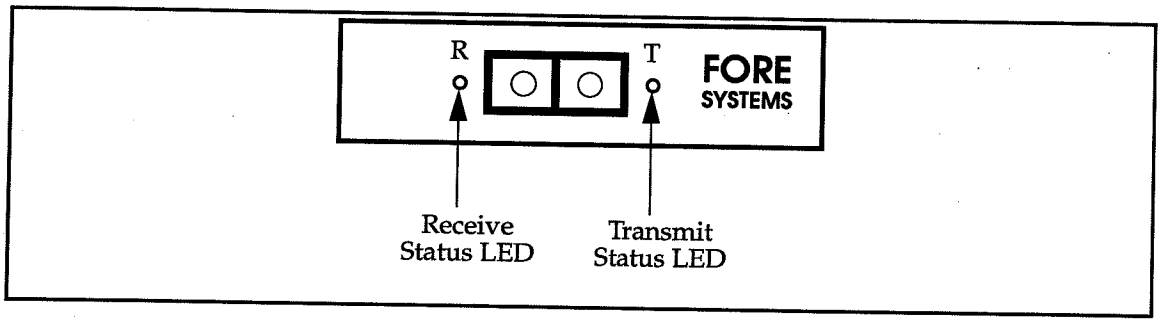


Figure A.2 - SC Connector Face Plate Configuration

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A.2 LED Descriptions

The LEDs have the following meanings:

Table A.1 - Transmit LED

LED Color	Meaning
green	Transmitting data
off	Idle
yellow	SONET alarm condition declared (indicates trouble with the receiving device) (Applicable to OC-3 only)

Table A.1 - Receive LED

LED Color	Meaning
green	Receiving data
off	Idle
red	No carrier

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GLOSSARY

802.1d Spanning Tree Bridging - the IEEE standard for bridging; a MAC layer standard for transparently connecting two or more LANs (often called subnetworks) that are running the same protocols and cabling. This arrangement creates an extended network, in which any two workstations on the linked LANs can share data.

802.3 Ethernet - the IEEE standard for Ethernet; a physical-layer standard that uses the CSMA/CD access method on a bus-topology LAN.

802.5 Token Ring - the IEEE physical-layer standard that uses the token-passing access method on a ring-topology LAN.

AAL (ATM Adaptation Layer) - the AAL divides the user information into segments suitable for packaging into a series of ATM cells. There are several types of AALs in use. FORE Systems currently supports AAL 5 and AAL 3/4. AAL 3/4 supports connection-oriented VBR data transfer and connectionless VBR data transfer, respectively. AAL 5 is defined as Simple and Efficient Adaptation Layer (SEAL).

AAL Connection - an association established by the AAL between two or more next higher layer entities.

ABR (Available Bit Rate) - a type of traffic for which the ATM network attempts to meet that traffic's bandwidth requirements. It does not guarantee a specific amount of bandwidth and the end station must retransmit any information that did not reach the far end.

Address Mask - a bit mask used to identify which bits in an address (usually an IP address) are network significant, subnet significant, and host significant portions of the complete address. This mask is also known as the subnet mask because the subnetwork portion of the address can be determined by comparing the binary version of the mask to an IP address in that subnet. The mask holds the same number of bits as the protocol address it references.

Agent (SNMP) - a component of network- and desktop-management software, such as SNMP, that gathers information from MIBs.

AIS (Alarm Indication Signal) - a line AIS is asserted when a 111 binary pattern is detected in bits 6, 7, 8 of the K2 byte for five consecutive frames. A line AIS is removed when any pattern other than 111 is detected in these bits for five consecutive frames.

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AMI (ATM Management Interface) - the user interface to FORE Systems' *ForeThought* switch control software (SCS). AMI lets users monitor and change various operating configurations of FORE Systems switches and network module hardware and software, IP connectivity, and SNMP network management.

ANSI (American National Standards Institute) - a private organization that coordinates the setting and approval of some U.S. standards. It also represents the United States to the International Standards Organization.

API (Application Program Interface) - a language format that defines how a program can be made to interact with another program, service, or other software; it allows users to develop custom interfaces with FORE products.

APP (application program) - a complete, self-contained program that performs a specific function directly for the user.

AppleTalk - a networking protocol developed by Apple Computer for communication between Apple's products and other computers. Independent of the network layer, AppleTalk runs on LocalTalk, EtherTalk and TokenTalk.

ARP (Address Resolution Protocol) - a method used to resolve higher level protocol addressing (such as IP) into the appropriate header data required for ATM; i.e., port, VPI, and VCI; also defines the AAL type to be used.

ASCII (American Standard Code for Information Interchange) - a standard character set that (typically) assigns a 7-bit sequence to each letter, number, and selected control characters.

Assigned Cell - a cell that provides a service to an upper layer entity or ATM Layer Management entity (ATMM-entity).

asxmon - a FORE program that repeatedly displays the state of the switch and of all its active ports.

Asynchronous time division multiplexing - a multiplexing technique in which a transmission capability is organized into a priori, unassigned time slots. The time slots are assigned to cells upon request of each application's instantaneous real need.

ATM (Asynchronous Transfer Mode) - a transfer mode in which the information is organized into cells. It is asynchronous in the sense that the recurrence of cells containing information from an individual user is not necessarily periodic.

ATM Forum - an international non-profit organization formed with the objective of accelerating the use of ATM products and services through a rapid convergence of interoperability specifications. In addition, the Forum promotes industry cooperation and awareness.

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ATM Layer link - a section of an ATM Layer connection between two adjacent active ATM Layer entities (ATM-entities).

ATM Link - a virtual path link (VPL) or a virtual channel link (VCL).

ATM Peer-to-Peer Connection - a virtual channel connection (VCC) or a virtual path connection (VPC) directly established, such as workstation-to-workstation. This setup is not commonly used in networks.

ATM Traffic Descriptor - a generic list of parameters that can be used to capture the intrinsic traffic characteristics of a requested ATM connection.

ATM User-to-User Connection - an association established by the ATM Layer to support communication between two or more ATM service users (i.e., between two or more next higher layer entities or between two or more ATM entities). The communication over an ATM Layer connection may be either bidirectional or unidirectional. The same Virtual Channel Identifier (VCI) is used for both directions of a connection at an interface.

atmarp - a FORE program that shows and manipulates ATM ARP entries maintained by the given device driver. This is also used to establish PVC connections.

atmconfig - a FORE program used to enable or disable SPANS signalling.

atmstat - a FORE program that shows statistics gathered about a given adapter card by the device driver. These statistics include ATM layer and ATM adaptation layer cell and error counts. This can also be used to query other hosts via SNMP.

Backbone - the main connectivity device of a distributed system. All systems that have connectivity to the backbone connect to each other. This does not stop systems from setting up private arrangements with each other to bypass the backbone for cost, performance, or security.

Bandwidth - usually identifies the capacity or amount of data that can be sent through a given circuit; may be user-specified in a PVC.

BGP (Border Gateway) Protocol - used by gateways in an internet, connecting autonomous networks. It is derived from experiences learned using the EGP.

BIP (Bit Interleaved Parity) - an error-detection technique in which character bit patterns are forced into parity, so that the total number of one bits is always odd or always even. This is accomplished by the addition of a one or zero bit to each byte, as the byte is transmitted; at the other end of the transmission, the receiving device verifies the parity (odd or even) and the accuracy of the transmission.

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B-ISDN (Broadband Integrated Services Digital Network) - a common digital network suitable for voice, video, and high-speed data services running at rates beginning at 155 Mbps.

Bridge - a device that expands a Local Area Network by forwarding frames between data link layers associated with two separate cables, usually carrying a common protocol. Bridges can usually be made to filter certain packets (to forward only certain traffic).

Broadband - a service or system requiring transmission channels capable of supporting rates greater than the Integrated Services Digital Network (ISDN) primary rate.

Broadband Access - an ISDN access capable of supporting one or more broadband services.

Brouter (bridging/router) - a device that routes some protocols and bridges others based on configuration information.

BUS (Broadcast and Unknown Server) - in an emulated LAN, the BUS is responsible for accepting broadcast, multicast, and unknown unicast packets from the LECs to the broadcast MAC address (FFFFFFFFFFFF) via dedicated point-to-point connections, and forwarding the packets to all of the members of the ELAN using a single point-to-multipoint connection.

CAC (Connection Admission Control) - the procedure used to decide if a request for an ATM connection can be accepted based on the attributes of both the requested connection and the existing connections.

Call - an association between two or more users or between a user and a network entity that is established by the use of network capabilities. This association may have zero or more connections.

CBR (Constant Bit Rate) - a type of traffic that requires a continuous, specific amount of bandwidth over the ATM network (e.g., digital information such as video and digitized voice).

cchan - a FORE program used to manage virtual channels on a FORE Systems ATM switch running asxd.

CCITT (International Telephone and Telegraph Consultative Committee) - the international standards body for telecommunications.

CDV (Cell Delay Variation) - a quantification of cell clumping for a connection. The cell clumping CDV (y_k) is defined as the difference between a cell's expected reference arrival time (c_k) and its actual arrival time (a_k). The expected reference arrival time (c_k) of cell k of a specific connection is $\max\ [c_{\{k-1\}} + T, a_k]$. T is the reciprocal of the negotiated peak cell rate.

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CE (Connection Endpoint) - a terminator at one end of a layer connection within a SAP.

CEI (Connection Endpoint Identifier) - an identifier of a CE that can be used to identify the connection at a SAP.

Cell - an ATM Layer protocol data unit (PDU).

Cell Header - ATM Layer protocol control information.

Cell Transfer Delay - the transit delay of an ATM cell successfully passed between two designated boundaries.

CLP (Cell Loss Priority) - the last bit of byte four in an ATM cell header; indicates the eligibility of the cell for discard by the network under congested conditions. If the bit is set to 1, the cell may be discarded by the network depending on traffic conditions.

Concentrator - a communications device that offers the ability to concentrate many lower-speed channels into and out of one or more high-speed channels.

Connection - the concatenation of ATM Layer links in order to provide an end-to-end information transfer capability to access points.

Connectionless Service - a type of service in which no pre-determined path or link has been established for transfer of information, supported by AAL 4.

Connection-Oriented Service - a type of service in which information always traverses the same pre-established path or link between two points, supported by AAL 3.

Corresponding Entities - peer entities with a lower layer connection among them.

cpath - a FORE program used to manage virtual paths on a FORE Systems ATM switch running asxd.

cport - a FORE program used to monitor and change the state of ports on a FORE Systems ATM switch running asxd.

CRC (Cyclic Redundancy Check) - an error detection scheme in which a number is derived from the data that will be transmitted. By recalculating the CRC at the remote end and comparing it to the value originally transmitted, the receiving node can detect errors.

CS (Convergence Sublayer) - a portion of the AAL. Data is passed first to the CS where it is divided into rational, fixed-length packets or PDUs (Protocol Data Units). For example, AAL 4 processes user data into blocks that are a maximum of 64 kbytes long.

DARPA (Defense Advanced Research Projects Agency) - the US government agency that funded the ARPANET.

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DCS (Digital Cross-connect System) - an electronic patch panel used to route digital signals in a central office.

Demultiplexing - a function performed by a layer entity that identifies and separates SDUs from a single connection to more than one connection. (See multiplexing.)

DIP Switch (Dual In-line Package) - a device that has two parallel rows of contacts that let the user switch electrical current through a pair of those contacts to on or off. They are used to reconfigure components and peripherals.

Domain Name Server - a computer that converts names to their corresponding Internet numbers. It allows users to telnet or FTP to the name instead of the number.

DNS (Domain Name System) - the distributed name and address mechanism used in the Internet.

DSn (Digital Standard n (0, 1, 1C, 2, and 3)) - a method that defines the rate and format of digital hierarchy.

Asynchronous data rates are defined as follows:

DS0	64kb/s	1 voice channel
DS1	1.544Mb/s	24 DS0s
DS1C	3.152 Mb/s	2 DS1s
DS2	6.312 Mb/s	4 DS1s
DS3	44.736 Mb/s	28 DS1s

Synchronous data rates (SONET) are defined as:

STS-1/OC-1	51.84 Mb/s	28 DS1s or 1 DS3
STS-3/OC-3	155.52 Mb/s	3 STS-1s byte interleaved
STS-3c/OC-3c	155.52 Mb/s	Concatenated, indivisible payload
STS-12/OC-12	622.08 Mb/s	12 STS-1s, 4 STS-3cs, or any mixture
STS-12c/OC-12c	622.08 Mb/s	Concatenated, indivisible payload
STS-48/OC-48	2488.32 Mb/s	48 STS-1s, 16 STS-3cs, or any mixture

EGP (Exterior Gateway) Protocol - used by gateways in an internet, connecting autonomous networks.

EISA (Extended Industry Standard Architecture) - a bus architecture for desktop computers that provides a 32-bit data passage while maintaining compatibility with the ISA or AT architecture.

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elarp - a FORE program that shows and manipulates MAC and ATM address mappings for LAN Emulation Clients (LECs).

elconfig - a FORE program that shows and modifies LEC configuration. Allows the user to set the ATM address of the LAN Emulation Configuration Server (LECS), display the list of Emulated LANs (ELANs) configured in the LECS for this host, display the list of ELANs locally configured along with the membership state of each, and locally administer ELAN membership.

EPROM - Erasable Programmable Read Only Memory (See PROM.)

ES (End System) - a system in which an ATM connection is terminated or initiated. An originating end system initiates the ATM connection, and a terminating end system terminates the ATM connection. OAM cells may be generated and received.

Ethernet - a 10-Mbps, coaxial standard for LANs in which all nodes connect to the cable where they contend for access.

Fairness - as related to Generic Flow Control (GFC), fairness is defined as meeting all of the agreed quality of service (QoS) requirements by controlling the order of service for all active connections.

FCC - a board of commissioners appointed by the President under the Communications Act of 1934, with the authority to regulate all interstate telecommunications originating in the United States, including transmission over phone lines.

FDDI (Fiber Distributed Data Interface) - high-speed data network that uses fiber-optic as the physical medium. Operates in similar manner to Ethernet or Token Ring, only faster.

FDM (Frequency Division Multiplexing) - a method of dividing an available frequency range into parts with each having enough bandwidth to carry one channel.

FEBE (Far End Block Error) - an error detected by extracting the 4-bit FEBE field from the path status byte (G1). The legal range for the 4-bit field is between 0000 and 1000, representing zero to eight errors. Any other value is interpreted as zero errors.

FERF (Far End Receive Failure) - a line error asserted when a 110 binary pattern is detected in bits 6, 7, 8 of the K2 byte for five consecutive frames. A line FERF is removed when any pattern other than 110 is detected in these bits for five consecutive frames.

FIFO (First-In, First-Out) - a method of coordinating the sequential flow of data through a buffer.

Flag - a specific bit pattern used to identify the beginning or end of a frame.

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Frame - a variable length group of data bits with a specific format containing flags at the beginning and end to provide demarcation.

Frame Relay - a fast packet switching protocol based on the LAPD protocol of ISDN that performs routing and transfer with less overhead processing than X.25.

FT-PNNI (*ForeThought* PNNI) - a FORE Systems routing and signalling protocol that uses private ATM addresses; a precursor to ATM Forum PNNI (see PNNI).

ftp (File Transfer Protocol) - a TCP/IP protocol that lets a user on one computer access, and transfer data to and from, another computer over a network. ftp is usually the name of the program the user invokes to accomplish this task.

GCRA (Generic Cell Rate Algorithm) - an algorithm which is employed in traffic policing and is part of the user/network service contract. The GCRA is a scheduling algorithm which ensures that cells are marked as *conforming* when they arrive when expected or later than expected and *non-conforming* when they arrive sooner than expected.

GFC (Generic Flow Control) - the first four bits of the first byte in an ATM cell header. Used to control the flow of traffic across the User-to-Network Interface (UNI), and thus into the network. Exact mechanisms for flow control are still under investigation and no explicit definition for this field exists at this time. (This field is used only at the UNI; for NNI-NNI use (between network nodes), these four bits provide additional network address capacity, and are appended to the VPI field.)

GIO - a proprietary bus architecture used in certain Silicon Graphics, Inc. workstations.

Header - protocol control information located at the beginning of a protocol data unit.

HEC (Header Error Control) - a CRC code located in the last byte of an ATM cell header that is used for checking cell integrity only.

HIPPI (High Performance Parallel Interface) - an ANSI standard that extends the computer bus over fairly short distances at speeds of 800 and 1600 Mbps.

HPUX - the Hewlett-Packard version of UNIX.

HSSI (High-Speed Serial Interface) - a serial communications connection that operates at speeds of up to 1.544 Mbps.

Hub - a device that connects to several other devices, usually in a star topology.

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I/O Module - FORE's interface cards for the LAX-20 LAN Access Switch, designed to connect Ethernet, Token Ring, and FDDI LANs to *ForeRunner* ATM networks.

ICMP (Internet Control Message Protocol) - the protocol that handles errors and control messages at the IP layer. ICMP is actually a part of the IP protocol layer. It can generate error messages, test packets, and informational messages related to IP.

IEEE (Institute of Electrical and Electronics Engineers) - the world's largest technical professional society. Based in the U.S.A., the IEEE sponsors technical conferences, symposia & local meetings worldwide, publishes nearly 25% of the world's technical papers in electrical, electronics & computer engineering, provides educational programs for its members, and promotes standardization.

IETF (Internet Engineering Task Force) - a large, open, international community of network designers, operators, vendors and researchers whose purpose is to coordinate the operation, management and evolution of the Internet to resolve short- and mid-range protocol and architectural issues.

ILMI (Interim Local Management Interface) - the standard that specifies the use of the Simple Network Management Protocol (SNMP) and an ATM management information base (MIB) to provide network status and configuration information.

Interface Data - the unit of information transferred to/from the upper layer in a single interaction across a SAP. Each Interface Data Unit (IDU) controls interface information and may also contain the whole or part of the SDU.

internet - while an internet is a network, the term "internet" is usually used to refer to a collection of networks interconnected with routers.

Internet - (note the capital "I") the largest internet in the world including large national backbone nets and many regional and local networks worldwide. The Internet uses the TCP/IP suite. Networks with only e-mail connectivity are not considered on the Internet.

Internet Addresses - the numbers used to identify hosts on an internet network. Internet host numbers are divided into two parts; the first is the network number and the second, or local, part is a host number on that particular network. There are also three classes of networks in the Internet, based on the number of hosts on a given network. Large networks are classified as Class A, having addresses in the range 1-126 and having a maximum of 16,387,064 hosts. Medium networks are classified as Class B, with addresses in the range 128-191 and with a maximum of 64,516 hosts. Small networks are classified as Class C, having addresses in the range 192-254 with a maximum of 254 hosts.

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Addresses are given as dotted decimal numbers in the following format:

nnn.nnn.nnn.nnn

In a Class A network, the first of the numbers is the network number, the last three numbers are the local host address.

In a Class B network, the first two numbers are the network, the last two are the local host address.

In a Class C network, the first three numbers are the network address, the last number is the local host address.

The following table summarizes the classes and sizes:

Class	First #	Max# Hosts
A	1-126	16,387,064
B	129-191	64,516
C	192-223	254

Network mask values are used to identify the network portion and the host portion of the address. For:

Class A - the default mask is 255.0.0.0

Class B - the default mask is 255.255.0.0

Class C - the default mask is 255.255.255.0

Subnet masking is used when a portion of the host ID is used to identify a subnetwork. For example, if a portion of a Class B network address is used for a subnetwork, the mask could be set as 255.255.255.0. This would allow the third byte to be used as a subnetwork address. All hosts on the network would still use the IP address to get on the Internet.

IP (Internet Protocol) - a connectionless, best-effort packet switching protocol that offers a common layer over dissimilar networks.

IPX Protocol (Internetwork Packet Exchange) - a NetWare protocol similar to the Xerox Network Systems (XNS) protocol that provides datagram delivery of messages.

IS (Intermediate system) - a system that provides forwarding functions or relaying functions or both for a specific ATM connection. OAM cells may be generated and received.

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ISA Bus - a bus standard developed by IBM for expansion cards in the first IBM PC. The original bus supported a data path only 8 bits wide. IBM subsequently developed a 16-bit version for its AT class computers. The 16-bit AT ISA bus supports both 8- and 16-bit cards. The 8-bit bus is commonly called the PC/XT bus, and the 16-bit bus is called the AT bus.

ISDN (Integrated Services Digital Network) - an emerging technology that is beginning to be offered by the telephone carriers of the world. ISDN combines voice and digital network services into a single medium or wire.

ISO (International Standards Organization) - a voluntary, non treaty organization founded in 1946 that is responsible for creating international standards in many areas, including computers and communications.

Isochronous - signals carrying embedded timing information or signals that are dependent on uniform timing; usually associated with voice and/or video transmission.

Jumper - a patch cable or wire used to establish a circuit, often temporarily, for testing or diagnostics; also, the devices, shorting blocks, used to connect adjacent exposed pins on a printed circuit board that control the functionality of the card.

LAN (Local Area Network) - a data network intended to serve an area of only a few square kilometers or less. Because the network is known to cover only a small area, optimizations can be made in the network signal protocols that permit higher data rates.

lane - a program that provides control over the execution of the LAN Emulation Server (LES), Broadcast/Unknown Server (BUS), and LAN Emulation Configuration Server (LECS) on the local host.

LAN Access Concentrator - a LAN access device that allows a shared transmission medium to accommodate more data sources than there are channels currently available within the transmission medium.

LAX-20 - a FORE Systems LAN Access Switch, designed to connect Ethernet, Token Ring, and FDDI LANs to *ForeRunner* ATM networks. The LAX-20 is a multiport, multiprotocol internetworking switch that combines the advantages of a high-performance LAN switch and a full-featured ATM interface capable of carrying LAN traffic.

Layer Entity - an active layer within an element.

Layer Function - a part of the activity of the layer entities.

Layer Service - a capability of a layer and the layers beneath it that is provided to the upper layer entities at the boundary between that layer and the next higher layer.

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Layer User Data - the information transferred between corresponding entities on behalf of the upper layer or layer management entities for which they are providing services.

le - a FORE program that implements both the LAN Emulation Server (LES) and the Broadcast/Unknown Server (BUS).

LEC (LAN Emulation Client) - the component in an end system that performs data forwarding, address resolution, and other control functions when communicating with other components within an ELAN.

lecs - a FORE program that implements the assignment of individual LECs to different emulated LANs.

LECS (LAN Emulation Configuration Server) - the LECS is responsible for the initial configuration of LECs. It provides information about available ELANs that a LEC may join, together with the addresses of the LES and BUS associated with each ELAN.

leq - a FORE program that provides information about an ELAN. This information is obtained from the LES, and includes MAC addresses registered on the ELAN together with their corresponding ATM addresses.

LES (LAN Emulation Server) - the LES implements the control coordination function for an ELAN. The LES provides the service of registering and resolving MAC addresses to ATM addresses.

LLC (Logical Link Control) - a protocol developed by the IEEE 802 committee for data-link-layer transmission control; the upper sublayer of the IEEE Layer 2 (OSI) protocol that complements the MAC protocol; IEEE standard 802.2; includes end-system addressing and error checking.

LOF (Loss Of Frame) - a type of transmission error that may occur in wide-area carrier lines.

looptest - a program that tests the interface for basic cell reception and transmission functionality. It is usually used for diagnostic purposes to determine if an interface is functioning properly.

LOP (Loss Of Pointer) - a type of transmission error that may occur in wide-area carrier lines.

LOS (Loss Of Signal) - a type of transmission error that may occur in wide-area carrier lines.

MAC (Media Access Control) - a media-specific access control protocol within IEEE 802 specifications; currently includes variations for Token Ring, token bus, and CSMA/CD; the lower sublayer of the IEEE's link layer (OSI), which complements the Logical Link Control (LLC).

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Metasignalling - an ATM Layer Management (LM) process that manages different types of signalling and possibly semipermanent virtual channels (VCs), including the assignment, removal, and checking of VCs.

Metasignalling VCs - the standardized VCs that convey metasignalling information across a User-to-Network Interface (UNI).

MIB (Management Information Base) - the set of parameters an SNMP management station can query or set in the SNMP agent of a networked device (e.g., router).

MIC (Media Interface Connector) - the optical fiber connector that joins the fiber to the FDDI controller.

MicroChannel - a proprietary 16- or 32-bit bus developed by IBM for its PS/2 computers' internal expansion cards; also offered by others.

MTU (Maximum Transmission Unit) - the largest unit of data that can be sent over a type of physical medium.

Multi-homed - a device that has both an ATM and another network connection, typically Ethernet.

Multiplexing - a function within a layer that interleaves the information from multiple connections into one connection. (See demultiplexing.)

Multipoint Access - user access in which more than one terminal equipment (TE) is supported by a single network termination.

Multipoint-to-Point Connection - a Point-to-Multipoint Connection may have zero bandwidth from the Root Node to the Leaf Nodes, and non-zero return bandwidth from the Leaf Nodes to the Root Node. Such a connection is also known as a Multipoint-to-Point Connection.

Multipoint-to-Multipoint Connection - a collection of associated ATM VC or VP links, and their associated endpoint nodes, with the following properties:

1. All N nodes in the connection, called Endpoints, serve as a Root Node in a Point-to-Multipoint connection to all of the (N-1) remaining endpoints.

2. Each of the endpoints on the connection can send information directly to any other endpoint, but the receiving endpoint cannot distinguish which of the endpoints is sending information without additional (e.g., higher layer) information.

Network Module - ATM port interface cards which may be individually added or removed from any *ForeRunner* ATM switch to provide a diverse choice of connection alternatives. Each network module provides between one and six full-duplex ATM physical connections to the *ForeRunner* switch.

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NMS (Network Management Station) - the system responsible for managing a network or a portion of a network. The NMS talks to network management agents, which reside in the managed nodes.

NNI (Network-to-Network Interface or Network Node Interface) - the interface between two public network pieces of equipment.

NuBus - a high-speed bus used in the Macintosh family of computers, structured so that users can put a card into any slot on the board without creating conflict over the priority between those cards

OAM (Operation and Maintenance) Cell - a cell that contains ATM LM information. It does not form part of the upper layer information transfer.

OpenView - Hewlett-Packard's network management software.

OSI (Open Systems Interconnection) - the 7-layer suite of protocols designed by ISO committees to be the international standard computer network architecture.

OSPF (Open Shortest Path First) Protocol - a routing algorithm for IP that incorporates least-cost, equal-cost, and load balancing.

Out-of-Band Management - refers to switch configuration via the serial port or over Ethernet, not ATM.

Packet Switching - a communications paradigm in which packets (messages) are individually routed between hosts with no previously established communications path.

PBX (Private Branch Exchange) - a private phone system (switch) that connects to the public telephone network and offers in-house connectivity. To reach an outside line, the user must dial a digit like 8 or 9.

PCI (Peripheral Component Interconnect) - a local-bus standard created by Intel.

PCM (Pulse Code Modulation) - a modulation scheme that samples the information signals and transmits a series of coded pulses to represent the data.

PDN (Public Data Network) - a network designed primarily for data transmission and intended for sharing by many users from many organizations.

PDU (Protocol Data Unit) - a unit of data specified in a layer protocol and consisting of protocol control information and layer user data.

Peak Cell Rate - at the PHY Layer SAP of a point-to-point VCC, the Peak Cell Rate R_p is the inverse of the minimum inter-arrival time T_0 of the request to send an ATM-SDU.

Peer Entities - entities within the same layer.

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PHY (Physical Layer) - the actual cards, wires, and/or fiber-optic cabling used to connect computers, routers, and switches.

Physical Layer (PHY) Connection - an association established by the PHY between two or more ATM-entities. A PHY connection consists of the concatenation of PHY links in order to provide an end-to-end transfer capability to PHY SAPs.

PMD (Physical Medium Dependent) - a sublayer concerned with the bit transfer between two network nodes. It deals with wave shapes, timing recovery, line coding, and electro-optic conversions for fiber based links.

PNNI (Private Network Node Interface or Private Network-to-Network Interface) - a protocol that defines the interaction of private ATM switches or groups of private ATM switches

ping (Packet Internet Groper) - a program used to test reachability of destinations by sending them an ICMP echo request and waiting for a reply.

Point-to-Multipoint Connection - a collection of associated ATM VC or VP links, with associated endpoint nodes, with the following properties:

1. One ATM link, called the Root Link, serves as the root in a simple tree topology. When the Root node sends information, all of the remaining nodes on the connection, called Leaf nodes, receive copies of the information.

2. Each of the Leaf Nodes on the connection can send information directly to the Root Node. The Root Node cannot distinguish which Leaf is sending information without additional (higher layer) information. (See the following note for Phase 1.)

3. The Leaf Nodes cannot communicate directly to each other with this connection type.

Note: Phase 1 signalling does not support traffic sent from a Leaf to the Root.

Point-to-Point Connection - a connection with only two endpoints.

Primitive - an abstract, implementation-independent interaction between a layer service user and a layer service provider.

PROM (Programmable Read-Only Memory) - a chip-based information storage area that can be recorded by an operator but erased only through a physical process.

Protocol - a set of rules and formats (semantic and syntactic) that determines the communication behavior of layer entities in the performance of the layer functions.

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Protocol Control Information - the information exchanged between corresponding entities using a lower layer connection to coordinate their joint operation.

Proxy - the process in which one system acts for another system to answer protocol requests.

Proxy Agent - an agent that queries on behalf of the manager, used to monitor objects that are not directly manageable.

PSN (Packet Switched Network) - a network designed to carry data in the form of packets. The packet and its format is internal to that network.

PT (Payload Type) - bits 2...4 in the fourth byte of an ATM cell header. The PT indicates the type of information carried by the cell. At this time, values 0...3 are used to identify various types of user data, values 4 and 5 indicate management information, and values 6 and 7 are reserved for future use.

PVC (Permanent Virtual Circuit (or Channel)) - a circuit or channel through an ATM network provisioned by a carrier between two endpoints; used for dedicated long-term information transport between locations.

Q.2931 - Derived from Q.93B, the narrowband ISDN signalling protocol, an ITU standard describing the signalling protocol to be used by switched virtual circuits on ATM LANs.

Relaying - a function of a layer by means of which a layer entity receives data from a corresponding entity and transmits it to another corresponding entity.

RFCs (Requests For Comment) - IETF documents suggesting protocols and policies of the Internet, inviting comments as to the quality and validity of those policies. These comments are collected and analyzed by the IETF in order to finalize Internet standards.

RFI (Radio Frequency Interference) - the unintentional transmission of radio signals. Computer equipment and wiring can both generate and receive RFI.

RIP (Routing Information Protocol) - a distance vector-based protocol that provides a measure of distance, or hops, from a transmitting workstation to a receiving workstation.

RISC (Reduced Instruction Set Computer) - a generic name for CPUs that use a simpler instruction set than more traditional designs.

Router - a device that forwards traffic between networks or subnetworks based on network layer information.

SBus - hardware interface for add-in boards in later-version Sun 3 workstations.

SAP (Service Access Point) - the point at which an entity of a layer provides services to its LM entity or to an entity of the next higher layer.

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SAR (Segmentation And Reassembly) - the SAR accepts PDUs from the CS and divides them into very small segments (44 bytes long). If the CS-PDU is less than 44 bytes, it is padded to 44 with zeroes. A two-byte header and trailer are added to this basic segment. The header identifies the message type (beginning, end, continuation, or single) and contains sequence numbering and message identification. The trailer gives the SAR-PDU payload length, exclusive of pad, and contains a CRC check to ensure the SAR-PDU integrity. The result is a 48-byte PDU that fits into the payload field of an ATM cell.

SCSI (Small Computer Systems Interface) - a standard for a controller bus that connects disk drives and other devices to their controllers on a computer bus. It is typically used in small systems.

SDLC (Synchronous Data Link Control) - IBM's data link protocol used in SNA networks.

SDU (Service Data Unit) - a unit of interface information whose identity is preserved from one end of a layer connection to the other.

SEAL (Simple and Efficient Adaptation Layer) - also called AAL 5, this ATM adaptation layer assumes that higher layer processes will provide error recovery, thereby simplifying the SAR portion of the adaptation layer. Using this AAL type packs all 48 bytes of an ATM cell information field with data. It also assumes that only one message is crossing the UNI at a time. That is, multiple end-users at one location cannot interleave messages on the same VC, but must queue them for sequential transmission.

Segment - a single ATM link or group of interconnected ATM links of an ATM connection.

Semipermanent Connection - a connection established via a service order or via network management.

SGMP (Simple Gateway Management Protocol) - the predecessor to SNMP.

Shaping Descriptor - *n* ordered pairs of GCRA parameters (I,L) used to define the negotiated traffic shape of an APP connection. The traffic shape refers to the load-balancing of a network. In this context, load-balancing means configuring the data flows to maximize the efficiency of the network.

SIR (Sustained Information Rate) - the long-term average data transmission rate across the User-to-Network Interface.

SMDS (Switched Multimegabit Data Service) - a high-speed, datagram-based, public data network service expected to be widely used by telephone companies in their data networks.

SMTP (Simple Mail Transfer Protocol) - the Internet electronic mail protocol used to transfer electronic mail between hosts.

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SNAP - SubNetwork Access Protocol

SNMP (Simple Network Management Protocol) - the Internet standard protocol for managing nodes on an IP network.

snmpd - an SMNP agent for a given adapter card.

SONET (Synchronous Optical Network) - a new and growing body of standards that defines all aspects of transporting and managing digital traffic over optical facilities in the public network.

Source Traffic Descriptor - a set of traffic parameters belonging to the ATM Traffic Descriptor used during the connection set-up to capture the intrinsic traffic characteristics of the connection requested by the source.

Spanning Tree Protocol - provides loop-free topology in a network environment where there are redundant paths.

SPANS (Simple Protocol for ATM Network Signalling) - FORE Systems' proprietary signalling protocol used for establishing SVCs between FORE Systems equipment.

SPARC (Scalable Processor Architecture Reduced instruction set Computer) - a powerful workstation similar to a reduced-instruction-set-computing (RISC) workstation.

SPE (Synchronous Payload Envelope) - the payload field plus a little overhead of a basic SONET signal.

SPVC (Smart PVC) - a generic term for any communications medium which is permanently provisioned at the end points, but switched in the middle. In ATM, there are two kinds of SPVCs: smart permanent virtual path connections (SPVPCs) and smart permanent virtual channel connections (SPVCCs).

Static Route - a route that is entered manually into the routing table.

STM (Synchronous Transfer Mode) - a transport and switching method that depends on information occurring in regular and fixed patterns with respect to a reference such as a frame pattern.

STP (Shielded Twisted Pair) - two or more insulated wires that are twisted together and then wrapped in a cable with metallic braid or foil to prevent interference and offer noise-free transmissions.

STS (Synchronous Transport Signal) - a SONET electrical signal rate.

Sublayer - a logical subdivision of a layer.

SVC (Switched Virtual Circuit (or Channel)) - a channel established on demand by network signalling, used for information transport between two locations and lasting only for the duration of the transfer; the datacom equivalent of a dialed telephone call.

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Switched Connection - a connection established via signalling.

Symmetric Connection - a connection with the same bandwidth value specified for both directions.

Synchronous - signals that are sourced from the same timing reference and hence are identical in frequency.

Systems Network Architecture (SNA) - a proprietary networking architecture used by IBM and IBM-compatible mainframe computers.

Tachometer - in *ForeView,* the tachometer shows the level of activity on a given port. The number in the tachometer shows the value of a chosen parameter in percentage, with a colored bar providing a semi-logarithmic representation of that percentage.

TAXI - Transparent Asynchronous Transmitter/Receiver Interface

TC (Transmission Convergence) - generates and receives transmission frames and is responsible for all overhead associated with the transmission frame. The TC sublayer packages cells into the transmission frame.

TCP (Transmission Control Protocol) - a specification for software that bundles and unbundles sent and received data into packets, manages the transmission of packets on a network, and checks for errors.

TCP/IP (Transmission Control Protocol/Internet Protocol) - a set of communications protocols that has evolved since the late 1970s, when it was first developed by the Department of Defense. Because programs supporting these protocols are available on so many different computer systems, they have become an excellent way to connect different types of computers over networks.

TDM (Time Division Multiplexing) - a traditional digital multiplexing in which a signal occupies a fixed, repetitive time slot within a higher-rate signal.

Token Ring - a network access method in which the stations circulate a token. Stations with data to send must have the token to transmit their data.

topology - a program that displays the topology of a FORE Systems ATM network. An updated topology can be periodically re-displayed by use of the interval command option.

Traffic - the calls being sent and received over a communications network. Also, the packets that are sent on a data network.

Trailer - the protocol control information located at the end of a PDU.

Transit Delay - the time difference between the instant at which the first bit of a PDU crosses one designated boundary, and the instant at which the last bit of the same PDU crosses a second designated boundary.

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trap - a program interrupt mechanism that automatically updates the state of the network to remote network management hosts. The SNMP agent on the switch supports these SNMP traps.

UBR (Unspecified Bit Rate) - a type of traffic that is not considered time-critical (e.g., ARP messages, pure data), allocated whatever bandwidth is available at any given time. UBR traffic is given a "best effort" priority in an ATM network with no guarantee of successful transmission.

UDP (User Datagram Protocol) - the TCP/IP transaction protocol used for applications such as remote network management and name-service access; this lets users assign a name, such as "RVAX*2,S," to a physical or numbered address.

Unassigned Cells - a cell identified by a standardized virtual path identifier (VPI) and virtual channel identifier (VCI) value, which has been generated and does not carry information from an application using the ATM Layer service.

UNI (User-to-Network Interface) - the physical and electrical demarcation point between the user and the public network service provider.

UNI 3.0 - the User-to-Network Interface standard set forth by the ATM Forum that defines how private customer premise equipment interacts with private ATM switches.

UTP (Unshielded Twisted Pair) - a cable that consists of two or more insulated conductors in which each pair of conductors are twisted around each other. There is no external protection and noise resistance comes solely from the twists.

VBR (Variable Bit Rate) - a type of traffic that, when sent over a network, is tolerant of delays and changes in the amount of bandwidth it is allocated (e.g., data applications).

VC (Virtual Channel (or Circuit)) - a communications path between two nodes identified by label rather than fixed physical path.

VCC (Virtual Channel Connection) - a unidirectional concatenation of VCLs that extends between the points where the ATM service users access the ATM Layer. The points at which the ATM cell payload is passed to, or received from, the users of the ATM Layer (i.e., a higher layer or ATMM-entity) for processing signify the endpoints of a VCC.

VCI (Virtual Channel Identifier) - the address or label of a VC.

VCL (Virtual Channel Link) - a means of unidirectional transport of ATM cells between the point where a VCI value is assigned and the point where that value is translated or removed.

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VINES (Virtual Network Software) - Banyan's network operating system based on UNIX and its protocols.

Virtual Channel Switch - a network element that connects VCLs. It terminates VPCs and translates VCI values. The Virtual Channel Switch is directed by Control Plane functions and relays the cells of a VC.

Virtual Path Switch - a network element that connects VPLs, it translates VPI (not VCI) values and is directed by Control Plane functions. The Virtual Path Switch relays the cells of a Virtual Path.

VPT (Virtual Path Terminator) - a system that unbundles the VCs of a VP for independent processing of each VC.

VP (Virtual Path) - a unidirectional logical association or bundle of VCs.

VPC (Virtual Path Connection) - a concatenation of VPLs between virtual path terminators (VPTs). VPCs are unidirectional.

VPDN (Virtual Private Data Network) - a private data communications network built on public switching and transport facilities rather than dedicated leased facilities such as T1s.

VPI (Virtual Path Identifier) - the address or label of a particular VP.

VPL (Virtual Path Link) - a means of unidirectional transport of ATM cells between the point where a VPI value is assigned and the point where that value is translated or removed.

VPN (Virtual Private Network) - a private voice communications network built on public switching and transport facilities rather than dedicated leased facilities such as T1s.

VT (Virtual Tributary) - a structure used to carry payloads such as DS1s that run at significantly lower rates than STS-1s.

WAN (Wide-Area Network) - a network that covers a large geographic area.

X.25 - a well-established data switching and transport method that relies on a significant amount of processing to ensure reliable transport over metallic media.

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A

adapter-switch, configuration 7-2
API 9-2
Application Programming Interface 9-2
ARP reply 5-8
ARP request 5-8
ARP restrictions 5-9
ARP server 5-6
ARP server NSAP address 4-8
asxmon 8-2
ATM, definition 1-1
atmarp 8-2
atmconfig 8-2
ATM-only 4-12
atmstat 8-2, 10-21

B

back-to-back 7-1
Berkeley socket interface 9-1
Broadcast and Unknown Server 6-3
BUS 6-3

C

cchan 8-2
Classical IP 4-8
Classical IP ATM network 5-1
Classical IP Operation 5-8
Classical IP PVC 5-10
Classical IP virtual network interface 5-2
Classical IP, unsupported 5-9
configuration
    adapter to other vendor 7-3
configuration, adapter-switch 7-2
configure_atm 4-6
connection
    Configuration-Direct 6-4
    Control-Direct 6-4
    Control-Distribute 6-4
    Data-Direct 6-4
    Multicast-Forward 6-4
    Multicast-Send 6-4
connection process, LEC 1-4
cpath 8-2
cport 8-2
CRX graphics board 2-6

D

debugging 5-12
display current configuration 4-14
DVMA 1-7
dynamic IP 4-13

E

ELAN 6-1
elarp 8-2
elconfig 8-3
Emulated LAN 6-1
    Address Resolution 6-6
    Components 6-2
    Data Transfer 6-7
    Initialization 6-6
    Operation 6-4
    Registration 6-6
emulated LAN (ELAN)
    components of 1-2
    illustration 1-3
enable SPANS signalling 4-14

F

ftp 4-11

H

hardware overview 1-7
hardware requirements 1-10
host NSAP address 5-6

I

illustration
    emulated LAN, example 1-3
ILMI 4-7, 5-4
ILMI support 5-5
ILMI, address registration 5-5
incoming IP PVC 4-17
installation
    general procedures 2-1
    Series 700, Model 715 2-5
    Series 700, Model 720, 730 or 735 . . . 2-9
    Series 700, Model 755 2-12
Interim Local Management Interface 5-4
IP address 7-2
IP address, reboot 4-3
IP addressing 4-10

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IRQ 3-8

K

kernel configuration 3-7
kernel verification 3-7

L

LAN emluation configuration server (LECS) 1-4
LAN Emulation Client 6-3
LAN emulation client (LEC) 1-4
LAN Emulation Configuration Server 6-3
LAN Emulation Server 6-3
LAN Emulation Services 6-2
LEC 6-3
LECS 6-3
legacy LAN 5-1
LES 6-3
LIS 5-2
Logical IP Subnet (LIS) 5-2
looptest 8-2

M

MIB 4-7
multicast PVC 4-19
multicasting 4-18
multi-homing 4-11

N

network interface configuration 4-1
network topology 7-1
no Classical IP support 5-9
NSAP address 5-4

O

outgoing IP PVC 4-16

P

PVC 7-3
PVC verification 4-18

Q

Q.2931 5-1
qaa0 4-8

R

reboot
    IP address 4-3
RFC-1577 5-2

S

SNMP agent 4-7
snmpd 8-2
software overview 1-8
SPANS 7-3
SPANS interface 5-3
static IP routing 4-13

T

TCP/IP 4-10
test
    AAL* error 10-13
    atmstat 10-12
    carrier 10-7
    driver 10-5
    firmware 10-4
    hardware 10-4
    looptest 10-3
    network connectivity 10-10
    no cell transmission 10-13
    no cells received 10-12
    physical link 10-7
    self-test 10-4
    VPI/VCI error 10-13
topology 8-2
Troubleshooting
    adinfo 10-21
    atmstat 10-21
    ifconfig 10-20
    netstat 10-20
    uname 10-20
troubleshooting 10-1

U

UDP ports 4-7
unpacking 1-12

V

validate SVC 5-8
verify PVC 4-18

W

well-know address, LECS 1-4

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