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ForeRunner™ PCA-200 ATM
PCI Bus Adapter for DEC Alpha User's Manual

MANU0104 - Rev A - September, 1996

Software Version 4.0.2

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Preface

The intent of this manual is to supply users of the *ForeRunner*™ PCA-200E ATM PCI bus adapters with all the necessary information to install a PCA-200E and its accompanying software successfully. This document also provides general product information, network configuration information and information on software administration capabilities. This document was created for users with various levels of experience. Please read this document carefully before attempting to perform the procedures contained in it. If you have any questions or problems with installation or configuration, please contact FORE Systems' Technical Support.

Chapter Summaries

Chapter 1 - Introduction - Provides an overview of ATM, a PCA-200E adapter hardware and software overview, and general information to prepare for the installation of PCA-200E adapter cards.

Chapter 2 - Hardware Installation - Guides you through the installation of a PCA-200E. Included are hardware installation instructions, a test to verify the proper installation of the adapter card, and product registration information.

Chapter 3 - Software Installation and Kernel Configuration - Contains the requirements and instructions for the installation of the PCA-200E adapter card software for the Digital UNIX operating system. Also contains kernel configuration and verification information.

Chapter 4 - Network Interface Administration - Provides network configuration information such as assigning an IP address, configuring a workstation as a multi-homed or ATM-only workstation, and the dynamic and static IP routing information for an ATM-only network.

Chapter 5 - Configuring a Classical IP ATM Network - Discusses how to integrate ATM into legacy LANs.

Chapter 6 - Configuring an Emulated LAN - Provides information on the methods for configuring emulated LANs.

Chapter 7 - ATM Network Configurations - Contains examples of various physical configurations for the PCA-200E.

Chapter 8 - Additional Administration Information - Provides information about administration commands and programs and on-line manual pages.

Chapter 9 - Software Interfaces - Provides information about software interfaces supported by the PCA-200E device driver.

Chapter 10 - Troubleshooting - Provides information about tests that can isolate and locate possible problems.

Appendix A - PMD LED Indicators - Describes the physical and functional capabilities of the PMD module LED indicators**.**

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   174 Thorn Hill Road
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   or

   412-635-3700

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Typographical Styles

Throughout this manual, specific commands to be entered by the user appear on a separate line in bold typeface. In addition, use of Enter or Return keys is represented as **<ENTER>**. The following example demonstrates this convention:

cd /usr <ENTER>

Commands, menu items, or file names that appear within the text of this manual are represented in the following style: "...the atmarp command shows a user the current connections to the adapter as well as the ATM address."

As in the following example, any messages appearing on your screen during software installation and network interface administration will appear in Courier font to distinguish them from the rest of the text.

```
.... Are all three conditions true?
```

Important Information Indicators

To call your attention to safety and otherwise important information that must be reviewed to insure correct and complete installation, as well as to avoid damage to the adapter or your system, FORE Systems utilizes the following *WARNING/CAUTION/NOTE* indicators.

WARNING statements contain information that is critical to the safety of the operator and/or the system. Do not proceed beyond a ***WARNING*** statement until the indicated conditions are fully understood or met. This information could prevent serious injury to the operator and damage to the adapter, the system, or currently loaded software, and will be indicated as:

WARNING! Hazardous voltages are present. To lessen the risk of electrical shock and danger to personal health, follow the instructions carefully.



Information contained in **CAUTION** statements is important for proper installation/operation. Compliance with **CAUTION** statements can prevent possible equipment damage and/or loss of data and will be indicated as:

CAUTION You risk damaging your equipment and/or software if you do not follow these instructions.



Information contained in **NOTE** statements has been found important enough to be called to the special attention of the operator and will be set off from the text as follows:

NOTE: Steps 1, 3, and 5 are similar to the installation for the computer type above. Review the previous installation procedure before installation in your particular model.

Safety Agency Compliance

This preface provides safety precautions to follow when installing a FORE Systems, Inc., product.

Safety Precautions

For your protection, observe the following safety precautions when setting up your equipment:

- Follow all warnings and instructions marked on the equipment.
- Ensure that the voltage and frequency of your power source matches the voltage and frequency inscribed on the equipment's electrical rating label.
- Never push objects of any kind through openings in the equipment. Dangerous voltages may be present. Conductive foreign objects could produce a short circuit that could cause fire, electric shock, or damage to your equipment.

Symbols

The following symbols appear in this book.

WARNING! Hazardous voltages are present. If the instructions are not heeded, there is a risk of electrical shock and danger to personal health.



CAUTION If instructions are not followed, there is a risk of damage to the equipment.



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Do not make mechanical or electrical modifications to the equipment. FORE Systems, Inc., is not responsible for regulatory compliance of a modified FORE product.

CHAPTER 1 Introduction

This chapter provides an overview of the ATM Standard and the FORE Systems' PCA-200E adapter. It details the hardware and software requirements necessary to use the PCA-200E and also provides information on the contents of the PCA-200E package.

1.1 Overview of the ATM Standard

Asynchronous Transfer Mode, or ATM, is a communication architecture based on the switching of small fixed length packets of data called *cells*. In ATM, all data is transferred in 53-byte cells. Each cell has a 5-byte header that identifies the cell's route through the network and 48-bytes containing user data. This user data, in turn, carries any headers or trailers required by higher level protocols.

Perhaps the single most important advantage offered by ATM, in addition to data transfer speed, is its open-ended growth path. ATM is not locked into a single physical medium or speed. The fixed-size ATM cell allows traffic from multiple sources (simultaneous video, audio, and data communication) to be switched to multiple destinations by fast ATM switches. For example, a *ForeRunner* ASX-1000 ATM Switch can connect up to 96 users and has an aggregate capacity of 10 gigabits per second. Larger LANs can be built by interconnecting multiple *ForeRunner* ATM switches.

1.2 Overview of LAN Emulation

FORE Systems' *ForeThought* 4.0.2 LAN Emulation software is compliant with the ATM Forum's *LAN Emulation Over ATM Version 1.0* specification. LAN Emulation (LANE) allows higher level protocols and LAN applications to interoperate, without modifications, with an ATM network. The components of the emulated LAN (ELAN), running on the ATM network, work together to emulate an Ethernet LAN. The ELAN components resolve MAC addresses to ATM addresses, replace the connectionless operation of legacy LANs with point-to-point connections, and provide broadcast and multicast services. The ELAN consists of a LAN Emulation Client (LEC) running on each host in the ELAN, and the following LANE Services:

- the LAN Emulation Server (LES)
- the Broadcast and Unknown Server (BUS)
- the LAN Emulation Configuration Server (LECS)

In *ForeThought* 4.0.2, the LANE services operate on a FORE Systems switch or SunOS workstation.

In order to understand *ForeThought* 4.0.2, it is important to understand how these components work together to provide LAN Emulation.

1.2.1 The ELAN Components

The emulated LAN (ELAN) includes a number of components:

LAN Emulation Client (LEC) — Runs on each end station in the ELAN. Communicates with other ELAN components (the LES and BUS) to resolve MAC addresses into ATM addresses.

LAN Emulation Configuration Server (LECS) — Runs on a Sun OS workstation or in a FORE Systems switch. Maintains information about all ELANs within the administrative domain. When the LEC successfully communicates with the LECS, the LECS provides a list of ELANs which the LEC can join.

LAN Emulation Server (LES) — Runs on a Sun OS workstation or in a FORE Systems switch. Maintains information about the LECs within a single ELAN and performs address resolution.

Broadcast and Unknown Server (BUS) Runs on a Sun OS workstation or in a FORE Systems switch. Provides services within a single ELAN allowing broadcasts, multicast, and unknown unicasts within a single ELAN.

1.2.2 An Example Configuration

The diagram in Figure 1.1 shows an example configuration of a single emulated LAN in a FORE network. The ELAN includes:

- Workstations (PCs, Macintoshes, and UNIX boxes) running a LEC. Each has a *ForeRunner* ATM adapter, the *ForeRunner* driver for the adapter, and one or more *ForeRunner* ELAN drivers installed.
- Two ASX-200 switches, on which the LANE services are running. One switch is running the LECS, the LES, and the BUS. Both switches are also running LECs.
- An LAX-20 providing access to non-ATM networks.

.

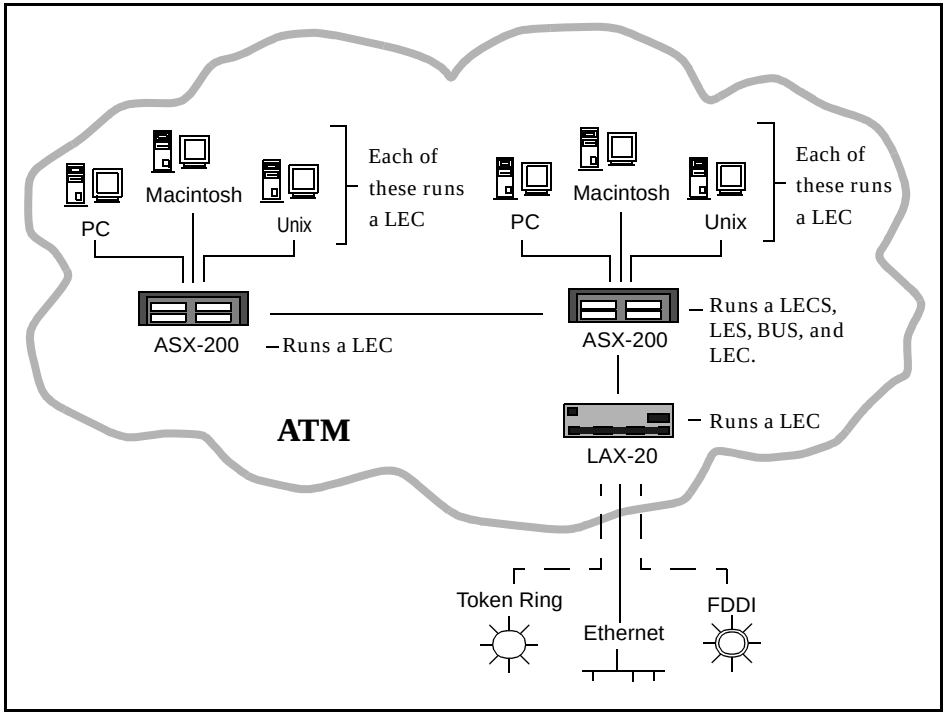


Figure 1.1 - An Example of an ELAN

1.2.3 The Initialization Process

The LAN Emulation Client (LEC) running on the workstation goes through the following process when it initializes:

1. The LEC obtains its own ATM address via address registration. (You can also manually specify the ATM address when you install the *ForeRunner* ELAN ATM driver.)
2. The LEC establishes a connection to the LECS. It gets the address through the well-known address or the permanent virtual circuit (0,17). (You can also manually specify the address of the LECS when you install the *ForeRunner* ELAN ATM driver.)
3. The LECS provides the LEC with the information necessary to join whatever ELANs it is allowed to join. The LECS has information about available ELANs, information about what ELANs each LEC can join, and which ELAN the LEC wants to attempt to join first.
4. The LEC contacts the LES for the ELAN it wants to join and registers its MAC-ATM address. It also contacts the BUS for the ELAN. At this point, the LEC and the LES have the information required to allow this host to communicate with other hosts on the ELAN as if it were an Ethernet network, and vice versa.

1.2.4 The Connection Process

To send Ethernet packets to another host on the emulated LAN:

1. The LEC calls the LES to map the MAC destination address into an ATM address. (The LES maintains a mapping table of the address of all LECs on the ELAN.)
2. If the LES finds an entry in its table for the destination MAC address, it returns the destination ATM address to the LES.
3. The LEC then opens up a point-to-point ATM connection to the destination host to send the packet.

For outgoing multicast and broadcast packets, the LEC sends them to the BUS which uses a point-to-multipoint connection to send the packet to every ATM address in the emulated LAN.

Figure 1.1 shows dotted lines from the LAX-20 to the Token Ring and FDDI networks. This is because the LAX-20 does not use LANE bridging to reach these networks but must route to them. Although the ATM Forum has defined Token Ring and FDDI LANE, *ForeThought* 4.0.2 only supports Ethernet LANE; so the LAX-20 must route to Token Ring and FDDI networks.

1.2.5 Multiple ELANs

It is possible to set up more than one emulated LAN in a FORE network. For each new emulated LAN, you must configure another LES and BUS instance for that LAN. On the access devices, bridge groups are used to associate physical Ethernet ports with emulated LANs on the ATM side.

An end station in the ELAN with a *ForeRunner* adapter can connect to up to 16 ELANs simultaneously.

1.2.6 Intelligent BUS

This feature reduces broadcast traffic by using the MAC address information in the LES. When an intelligent BUS receives a unicast frame with an unknown MAC destination address, the BUS first checks the LES's cache of addresses to see if the MAC address is registered there. If it is, the BUS routes the frame directly to the destination, instead of broadcasting.

1.2.7 Failover ELANs

To ensure that a single service failure does not cripple the entire ELAN, *ForeThought* 4.0.2 supports a simple failover mechanism. Rather than associating a single LES and BUS pair with a single ELAN, the LEC maintains an ordered list of LES and BUS pairs for each ELAN. While the LEC is only interacting with one LES at a time, it is ready to move to the next LES and BUS in the list if the current LES fails. If it is using a backup LES and BUS pair, the LEC will periodically check if the primary LES and BUS pair in the failover sequence are again available. If they are, the LEC resumes the connection to the original pair.

1.2.8 The Default ELAN

To simplify configuration of the ELAN, *ForeThought* 4.0.2 supports a default ELAN named default. This is the first ELAN in the list of ELANs provided by the LECS to the LEC. Unless you specify otherwise, the LEC initially attempts to join default and succeeds if the LECS is available, the proper LES address for default has been specified in the LECS, and the LES and BUS are available.

1.3 The *ForeRunner* PCA-200E Adapter

The PCA-200E is a high performance adapter designed for use in DEC Alpha systems. The PCA-200E adapter provides ATM connectivity for the host systems, and is able to support evolving signalling and AAL standards. The adapter features FORE Systems' Advanced Cell Processing architecture, providing maximum network performance to all running applications. In addition, the PCA-200E provides transparent support for TCP/IP, Switched Virtual Circuits (SVCs) through the SPANS and UNI 3.0 signalling protocols, Permanent Virtual Circuits (PVCs), Classical IP, LAN emulation, an ATM Applications Programmer Interface (API), and an SNMP agent for network management.

The PCA-200E supports high-quality image, full-motion video, CD-quality audio, and high speed data communications over a single ATM network connection. Each physical connection in an ATM LAN is a point-to-point link between switches and/or hosts.

1.4 Hardware Overview

The PCA-200E features FORE's Advanced Cell Processing Architecture which utilizes a dedicated embedded Intel i960 RISC processor along with special-purpose AAL5 and 3/4 Segmentation and Reassembly (SAR) hardware and scatter-gather DMA. With the PCA-200E, users can add ATM networking capabilities to their applications, leaving the low-level ATM cell processing, segmentation and reassembly, and signalling to the PCA-200E hardware and device driver.

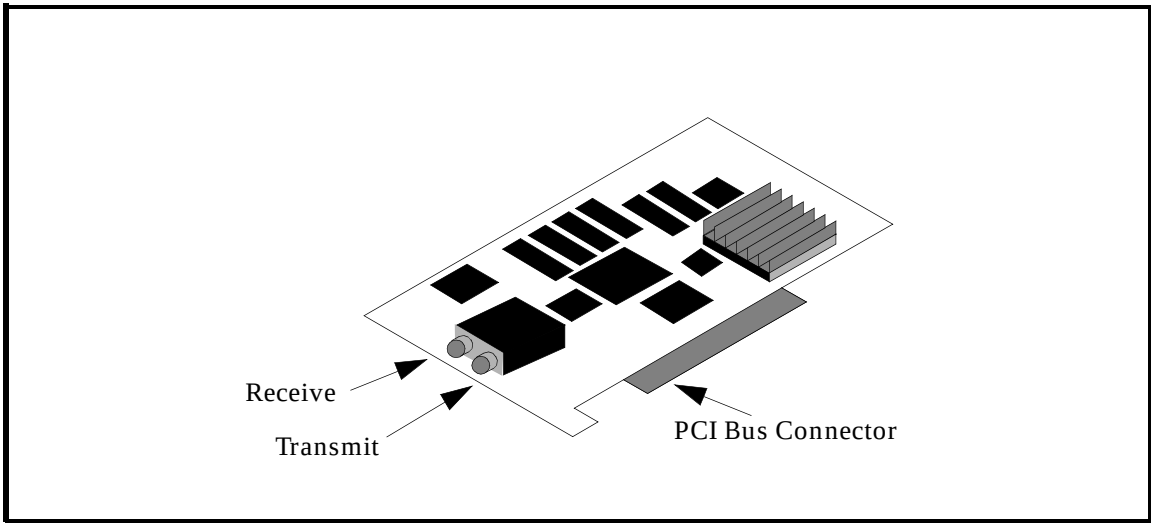


Figure 1.2 - PCA-200E Adapter Card

1.5 Software Overview

The PCA-200E adapter uses *ForeThought's* market-proven support for TCP/IP protocols (see Figure 1.3), allowing existing applications to operate with no modifications. Major advantages include high-performance network throughput delivered to applications, and the flexibility for future upgrades.

The PCA-200E software driver implements the SPANS Switched Virtual Circuits (SVC) signalling protocol to give applications end-to-end ATM connectivity including on-demand access to *ForeRunner* ATM switch multicast functions. An ATM Forum-compliant SNMP Management Information Base (MIB) is accessible by any SNMP network management system. The software supports the UNI 3.0 signalling standards. The current revision of software, *ForeThought 4.0.2*, is also compliant with the ATM Forum's *LAN Emulation over ATM, Version 1.0* standard.

The *ForeRunner* API library supplied with the PCA-200E offers applications access to the unique features of ATM such as guaranteed bandwidth reservation, per-connection selection of AAL5 or 3/4, and multicasting with dynamic addition and deletion of recipients.

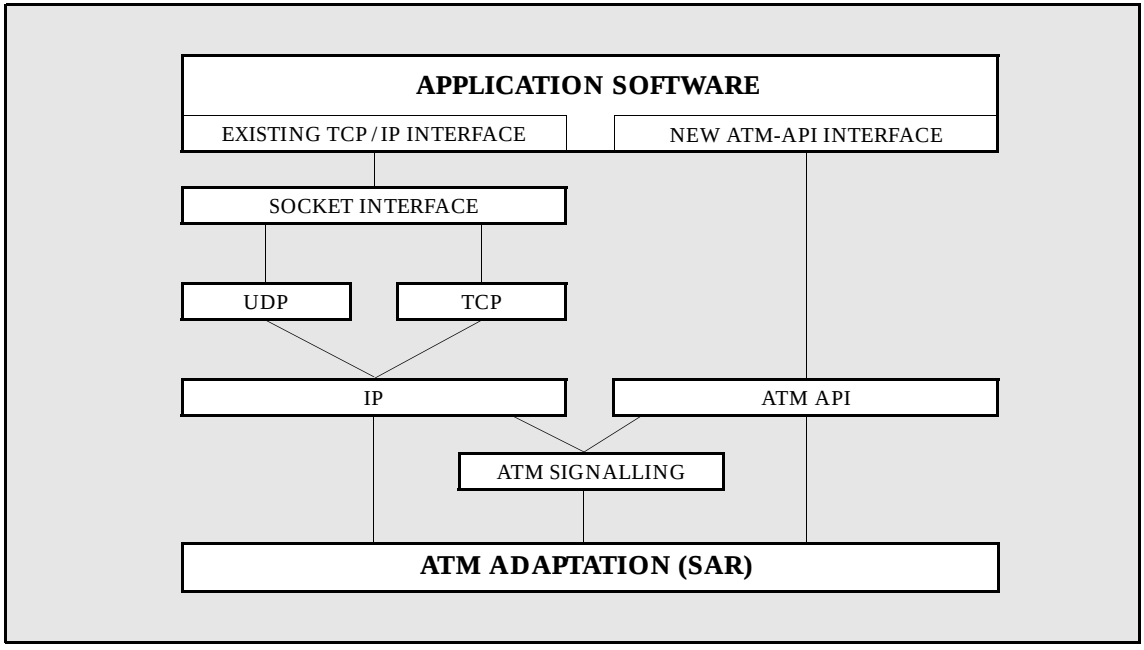


Figure 1.3 - Software Architecture

1.5.1 PCA-200E Advanced Cell Processor Architecture

The PCA-200E's Advanced Cell Processor Architecture provides optimized on-board cell processing functions including segmentation and reassembly. The software device driver provides a high-performance packet-level interface to the cell-processing engine. The driver identifies the data packets to be communicated over ATM; the cell-processing engine does the rest.

1.5.2 Software Features

The 4.0.2 release of *ForeThought* software supports the ATM Forum *LAN Emulation Over ATM, Version 1.0* standard. The particular features supported include:

- LAN Emulation Clients
- LEC failover
- Multiple Virtual LANs
- Ethernet emulation

Each of these features is detailed in the appropriate chapters throughout the manual.

1.6 Hardware Requirements

The PCA-200E can be installed in an available PCI Bus slot in any of the supported platforms.

1.6.1 PCA-200E Supported Platforms

The following are the supported platforms for the PCA-200E adapter cards:

- AlphaStation 200
- AlphaStation 250
- AlphaStation 255
- AlphaStation 400
- AlphaStation 600
- AlphaServer 1000
- AlphaServer 2000
- AlphaServer 2100
- AlphaServer 8200
- AlphaServer 8400

1.7 Software Requirements

The supplied *ForeRunner* PCA-200E device driver supports Digital UNIX version 4.0.

1.8 Unpacking Information

Before unpacking your PCA-200E, inspect the package for any damage that may have occurred during shipping. If the package shows any signs of external damage or rough handling, notify your carrier's representative.

When unpacking the PCA-200E, be sure to keep all original packing materials. They may be needed for storing, transporting, or returning the product.

CAUTION



All products returned to FORE Systems, under warranty, must be packed in their original packing materials.

CAUTION



The PCA-200E contains static-sensitive devices. Keep the adapter in its protective bag until installation.

The *ForeRunner* PCA-200E adapter package contains the following:

- PCA-200E Adapter
- PCA-200E Software on CD-ROM with license
- *ForeRunner* PCA-200E ATM Adapter User's Manual (this manual)
- Anti-static Grounding Strap
- Warranty Registration Card

If any of the above items are missing or damaged, please contact FORE Systems' Technical Support immediately.

CAUTION



Keep the PCA-200E in its anti-static protective bag until installation. Electronic components are subject to damage from even small amounts of static discharge. Therefore, be sure to have your equipment properly grounded.

1.9 PCA-200E Technical Specifications

The capabilities and physical parameters of the PCA-200E are detailed in the table below.

Table 1.1 - PCA-200E Technical Specifications

Hardware	
Architecture	On-board 25 mHz i960 cell processor
AAL Support	Special purpose, on-board hardware for HEC, CRC, and AAL5 and 3/4 calculations
UNI (Physical Layer)	155 Mbits/sec SONET STS-3c/SDH STM-1
Form Factor	Single-slot PCI Bus
Compliance	ATM cell processing per ANSI T1S1.5/92-002R3, ITU I.361, and ATM Forum v3.0 UNI specification
Cabling	Duplex 62.5/125 micron multi-mode fiber (2,000 meters maximum, 10 dB loss); 2-pair 100 ohm Category 5, or Category 5 screened, UTP copper (100 meters maximum)
Connectors	ST and SC Types for multi-mode fiber; RJ-45 for Category 5 UTP copper
Memory	256 kbytes on-board RAM
DMA Support	32-bit burst mode, bus master; "Fly-by," scatter-gather DMA support; Supports block transfers up to 12816 words; Full 32-bit datapath

Table 1.1 - PCA-200E Technical Specifications (Continued)

Software	
Transparent TCP/IP protocol interface.	
Enhanced-performance ATM Application Programming Interface (API) Library.	
SPANS Switched Virtual Circuit (SVC) signalling protocol	
Permanent Virtual Circuits (PVC)	
Application-controlled multicasting and broadcasting with recipient add and delete capabilities.	
Supports up to 1024 Virtual Circuit Identifiers (VCIs)	
Support for UNI 3.0 signalling	
Support for ILMI (Interim Local Management Interface)	
Support for Classical IP Interfaces	
SNMP MIB access to adapter status, ATM cell statistics, cell errors, and VPI/VCI information.	
Support for LAN Emulation Clients	
General	
Dimensions	0.5” H x 3.3” W x 5.8” D (1.3 cm x 8.4 cm x 14.7 cm)
Weight	6 oz. (170 g)
Power Requirements	2 A (maximum) @ +5V
Operating Temperature	32° F to 104° F (0° C to 40° C)
Operating Humidity	20% to 80%, non-condensing @ 40° C
Compliance	FCC Part15, Class A Verification (UTP); FCC Class B Certification (fiber-optic connectors)

1.10 Cable Specifications

The following tables list the recommended cable specifications to ensure optimal adapter and switch performance:

Table 1.2 - Multi-Mode Fiber-Optic Cable Specifications

Description	Specification
Core Diameter	62.5 µm
Fiber Diameter	125 µm
Wavelength	1310 nm
Loss characteristic	~0.5 dB / km
Connector Style	SC or ST
Power Budget	11 dB(1)
Maximum run	approximately 2 km
Transmit Power	-19 dBm (minimum)
Receive Power	-30 dBm (minimum)

(1) If a 50 µm core fiber is used, the power budget should be derated by 4dB.

The PCA-200E is available with UTP connectors. The requirements and pinouts for this cabling are given below.

Table 1.3 - CAT 5 UTP Cable Specifications

Description	Specification
AWG	24
Impedance (Ω)	100 + / - 15%
Attenuation (dB / 1000 ft. Max)	25 dB @ 16 mHz 52 dB @ 62.5 mHz 67 dB @ 100 mHz
Maximum Run	100 m(1)
Connector Type	RJ-45

(1) Within a 100 meter run, a maximum of two connections are permissible.

The pinouts for the RJ-45 connector on an PCA are as follows:

Table 1.4 - CAT 5 UTP Pinouts

Pin	Signal
1	Transmit (+)
2	Transmit (-)
3	Not Used
4	Not Used
5	Not Used
6	Not Used
7	Receive (+)
8	Receive (-)

1.11 Product Registration Information

Please fill out the enclosed product registration card for your PCA-200E ATM adapter, and return it to FORE Systems.

CHAPTER 2 Hardware Installation

This section is designed to guide you through the installation of the PCA-200E in an Alpha station or Alpha server. The procedures contain step-by-step instructions for the successful installation of the PCA into any available PCI slot in a system. Read *all* of this information carefully before attempting installation.

2.1 Required Tools

Installation of the PCA may require the following tools, depending on the system in which the card is to be installed.

1. The anti-static grounding strap included with the adapter card should be used during installation.
2. A flat blade or Phillips screwdriver is needed to remove the retaining screws on the cases.

2.2 General Installation Procedures

Installation of the PCA-200E into an available AlphaStation / AlphaServer PCI Bus slot differs slightly for the various systems. Because there are wide variations in the procedures used to open the various system units, an exact procedure may not be presented for your particular system. Therefore, the instructions focus on the steps common to all models.

WARNING!



It is highly recommended that you use the included grounding strap when handling the adapter card, or any other computer component. The wrist grounding strap is just one portion of maintaining a static free environment. Be sure to follow all necessary precautions to prevent an accidental static discharge which may damage the computer or any of its components.

Handle the PCA by the edges, avoiding all components and metal parts.

NOTE: Whenever installing a PCA into your system unit, please refer to the Operator Guide that came with your system for installation information specific to your model.

NOTE: On Digital AlphaServer 8200 and 8400 machines, the PCI bus implementation requires that the PCA-200E be installed in either slot 8, 9, 10, or 11.

2.2.1 Halting the System

Before installing the PCA-200E, your AlphaStation/Server must be halted and powered down.

CAUTION



The AlphaStation/Server should be halted in an orderly manner. Always close all open files and quit user processes before halting. Improperly aborting an application may damage files. For additional information about halting your AlphaStation/Server, please refer to the *user documentation supplied with your system*.

The system should be halted as follows:

1. Save all work, quit all open applications and halt the system.
2. When the system is halted, power down the devices in this order:
   a. any attached external devices, (disk drives, etc.)
   b. the AlphaStation/Server system
   c. the monitor
3. Unplug the power cord attached to the system.

2.2.2 Opening the System Unit

CAUTION



Electronic components are extremely sensitive to static electricity. To prevent electrostatic discharge damage to the PCA adapter and other static-sensitive components, wear a properly grounded anti-static wrist strap while installing the adapter card.

Perform the following steps to open the system unit:

1. Halt the system as described in Section 2.2.1.
2. Follow the instructions in the your system's Operator Guide to allow access to the system's PCI bus slots (Figure 2.1).

.

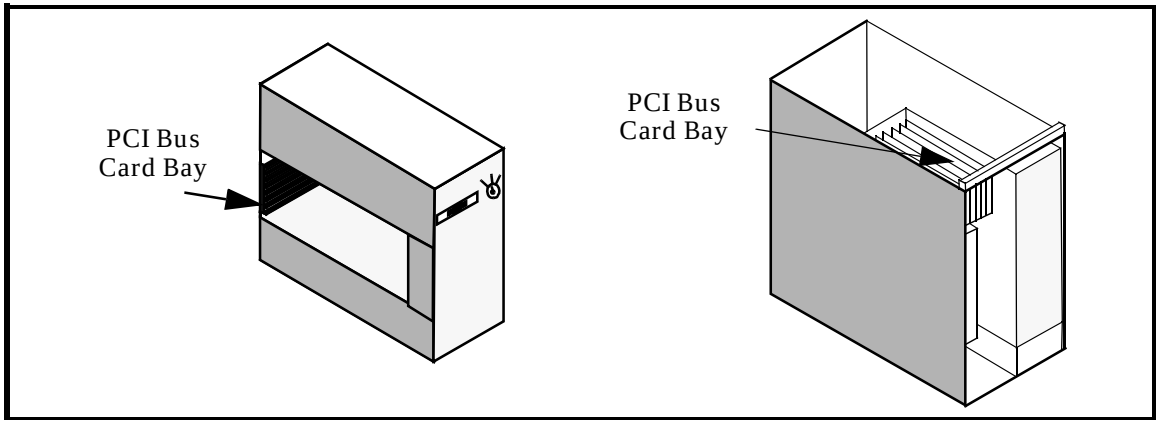


Figure 2.1 Typical System Unit Card Bay Locations

2.2.3 Installing the PCA-200E Adapter

Because of the wide variations in procedures used to open the different system unit models, the following instructions focus on the steps common to the various models. Refer to the Operator Guide for your particular system for additional installation information.

Perform the following steps to install the PCA:

1. Open the system unit as described in Section 2.2.2.
2. Ground yourself to a metal part of the system unit chassis using the supplied grounding wrist strap.
3. Locate the PCI bus slots.

NOTE: On Digital AlphaServer 8200 and 8400 machines only, the PCI bus implementation requires that the PCA-200E be installed in either slot 8, 9, 10, or 11.

4. If necessary, remove the blank cover plate for the slot you have chosen.
5. Align the fiber-optic or UTP connectors on the board with the connector opening of the chosen slot in the back of the system unit. Align the opposite end of the PCA with the card guide of the chosen slot.
6. Push the board into the PCI bus slot until the PCA's connector is firmly seated. Secure the adapter in the slot by tightening the retaining screws that hold the board to the system unit chassis.
7. Close the system unit per the instruction given in your system unit's Operator Guide.
8. Attach the appropriate network cables.

CHAPTER 3 Software Installation and Kernel Configuration

The following instructions detail the software installation and kernel configuration procedures for the PCA-200E adapter software and device driver. In order to take full advantage of the PCA-200E, a new Digital UNIX kernel must be created, containing the PCA-200E device driver. The kernel must contain the PCA-200E device driver to enable the card to support the Internet Protocol suite and the user-level ATM API *(Application Programming Interface)*.

3.1 Software Installation Requirements

The following are requirements to ensure proper software installation for a PCA-200E:

- Digital UNIX 4.0
- Root Password
- 7.6 MB of space in the installation directory
- 2.5 MB of space in the root directory
- 2.5 MB of space for PCA-200E initialization programs
- 3.1 MB of space for utilities and man pages
- PCA-200E adapter card must be installed

3.2 Software Installation and Kernel Configuration

3.2.1 Before You Begin

Before installing FORE software and configuring a Classical IP interface or configuring LAN emulation, you should read through the entire installation, Classical IP configuration instructions, and LAN Emulation configuration instructions for the OS running on your workstation. For Digital UNIX, these instructions begin in Section 3.2.2.

> **NOTE:** Detailed explanations of the various questions and answers that may appear in the installation and configuration scripts are found in Section 3.2.3.2 for Digital UNIX.

Please note that LAN Emulation need not be configured as part of installation. You may configure LAN Emulation separately by running `configure_lanem` as described in Chapter 6. If you are unsure of the responses to the questions on network configuration, please contact your network administrator. If you are a network administrator and are unsure of the responses to the questions, please call FORE Systems' Technical Support.

For many installations, you will need to configure the software once. However, in some situations, you may need to establish a temporary kernel configuration and then, based on information obtained from the temporary configuration, reconfigure the software to establish the desired network setup.

3.2.1.1 Temporary Configuration

There is one case for which the software may require a second Classical IP configuration:

- If the host into which the adapter was installed will be the ARP server and the ARP server ATM address is assigned via ILMI

For this case, the suggested procedure is to perform an initial Classical IP configuration answering most questions by accepting the defaults. The exceptions are the ATM address of the ARP server and the configuration of a Classical IP interface. For the ATM address, use a temporary number. For the Classical IP interface, respond `y` and configure just one, `qaa0`. These steps are more fully explained in Section 3.2.3.2.

NOTE: If you will be using a host as an ARP server, this host MUST be configured first.

On the ARP server, once the software has been installed, and the system has rebooted, use the `atmarp -z qaa0` command to obtain the host's ATM address. Write down the ATM address or store this data in a file. It is easier to do a "cut-and-paste" from a file rather than retype a 40 character ATM address.

With the ATM address, you can perform the full installation on the ARP server and all client hosts, using all of the desired configuration parameters. If you ever need to reconfigure the network again, please remember that it is easier to obtain the ARP server address from a running system.

3.2.2 Software Installation for Digital UNIX Systems

The PCA-200E device driver for the Digital UNIX operating system, ATM API library, installation and administration programs, and on-line manual pages are contained on the software distribution CD-ROM. The README file on the CD-ROM contains information about the appropriate files that you need to copy onto your system before installing the software.

1. To load the FORE Systems *ForeRunner* PCA-200E software onto your system, log in as root. After you log in, create a read-only directory on which the CD-ROM file system will be mounted (e.g. /cdrom).
2. Insert the CD-ROM into the system's CD-ROM drive and execute the following command:

mount -r device_filename directory_filename <ENTER>

where device_filename is the name of your CD-ROM (e.g. /dev/rz6c), and directory_filename is the name of the directory you created in step 1.

3. Create a directory: e.g., /usr/tmp/fore and copy the *ForeThought* 4.0.2 for Digital UNIX tar file into it.
4. Untar the file in the /usr/tmp/fore directory by entering the following command:

tar xvf file_name <ENTER>

where file_name is the name of the tar file that you copied from the CD-ROM.

5. Change directory to the parent of the /usr/tmp/fore directory and enter the following command to install the FORE software:

setld -l fore <ENTER>

6. The following screen appears:

NOTE: User input to the prompt you receive is indicated in bold; e.g., **y<ENTER>**.

```
*** Enter subset selections ***
The following subsets are mandatory and will be installed automatically
unless you choose to exit without installing any subsets:
      * FORE Systems, Inc PCA-200E
You may choose one of the following options:
     1) ALL of the above
     2) CANCEL selections and redisplay menus
     3) EXIT without installing any subsets
Enter your choices or press RETURN to redisplay menus.
Choices (for example, 1 2 4-6): 1 <ENTER>
You are installing the following mandatory subsets:
        FORE Systems, Inc PCA-200E
You are installing the following optional subsets:
Is this correct? (y/n): y
1 subset(s) will be installed.
Loading 1 of 1 subset(s)....
FORE Systems, Inc PCA-200E
   Copying from fore (disk)
   Verifying
1 of 1 subset(s) installed successfully.
Linking /usr/opt/AFTBASE402/fore to /usr/fore
Configuring "FORE Systems, Inc PCA-200E" (AFTBASE402)
```


At this point, the software has been installed, but not yet configured. The script continues as presented in the following section.

3.2.3 Kernel Configuration for Digital UNIX

A configuration session similar to the following occurs before a new kernel may be configured and built.

3.2.3.1 Typical FORE ATM Adapter Configuration Session

The following screens address questions that must be answered for proper kernel configuration, and contain samples of the text that will appear on your screen during file modification and configuration. User inputs to prompts you receive are indicated in bold; e.g., **`AFT400 <ENTER>`**.

> **NOTE:** If there is a default response to a given prompt, it will appear in brackets [ ]. The user may accept the default response by pressing the **<ENTER>** key.

This example assumes that only one PCA-200E card has been installed in your system, that the adapter has not been previously installed, and that you are configuring LAN emulation clients. The actual session for your installation will reflect the configuration that you wish to implement. Detailed explanations of the questions and answers presented below follow in Section 3.2.3.2.

```
FORE ATM Adapter Configuration
------------------------------
*** No Configuration Information ****
Would you like to use FORE's SNMP agent?  [y] <ENTER>
Would you like to use the standard UDP ports for SNMP(160/161)?  [y] <ENTER>
Will ILMI be used for Address Registration? (for qaa only) [y] <ENTER>
Would you like to configure CLASSICAL IP?  [n] y <ENTER>
------------------------------
ARP Server ATM Address not assigned for qaa0.
ARP Server ATM Address not assigned for qaa1.
ARP Server ATM Address not assigned for qaa2.
ARP Server ATM Address not assigned for qaa3.
```

```
-----------------------
Would you like to (re)configure ATM address of qaa0 ARP server? [n] y <ENTER>
Enter the ATM address for the ARP server
0x47.0005.80.ffe100.0000.f21c.01f8.0800093d1002.00 <ENTER>
Would you like to (re)configure ATM address of qaa1 ARP server? [n] <ENTER>
Would you like to (re)configure ATM address of qaa2 ARP server? [n] <ENTER>
Would you like to (re)configure ATM address of qaa3 ARP server? [n] <ENTER>
Would you like to configure Lan Emulation? [n] y <ENTER>
```

The following portion of the script represents a typical new LAN Emulation configuration. If you answered [n] to the previous question, this section of the installation script will not appear. Responses to the following questions are system-specific and must be determined by the system administrator prior to configuring an emulated LAN.

```
---------------------------------
LAN Emulation Configuration
***** No Configuration Information *****
Do You Want To Modify The Above Configuration? [n] y <ENTER>
============================
== 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>
Current client configuration:
LECS ATM address:   "Well-Known"
ELAN:               "default"
ELAN:                engineering
ELAN:                marketing
=========================================================================
Do You Want To Modify The Above Configuration?  [n] <ENTER>
```

This ends the LAN emulation configuration part of the script. The remaining portion of the script will appear whether you chose to configure LAN emulation or not.

```
Save Configuration Information? [y] <ENTER>
Saving /usr/fore/etc/fore_lanem.conf ...
```

To configure and build a new kernel, enter the following command:

doconfig <ENTER>

Text similar to the following appears. In this example, the name AFT400 is used for the kernel configuration file (the default name is the name of your system). You may substitute a name of your choice when prompted for a kernel configuration file name. Also, select the kernel options applicable to your system.

```
*** KERNEL CONFIGURATION AND BUILD PROCEDURE ***
Enter a name for the kernel configuration file. [MYSYSTEM]: AFT400
You want to name the configuration file 'AFT400'
Is that correct? (y/n) [y]: <ENTER>
*** KERNEL OPTION SELECTION ***
    Selection   Kernel Option
-----------------------------------------------------------------
             1      System V Devices
             2      Logical Volume Manager (LVM)
             3      NTP V3 Kernel Phase Lock Loop (NTP_TIME)
             4      Kernel Breakpoint Debugger (KDEBUG)
             5      Packetfilter driver (PACKETFILTER)
             6      Point-to-Point Protocol (PPP)
             7      STREAMS pckt module (PCKT)
             8      Data Link Bridge (DLPI V2.0 Service Class 1)
             9      X/Open Transport Interface (XTISO, TIMOD, TIRDWR)
             10     File on File File System (FFM)
             11     ISO 9660 Compact Disc File System (CDFS)
             12     Audit Subsystem
             13     ACL Subsystem
             14     All of the above
             15     None of the above
             16     Help
             17     Display all options again
-----------------------------------------------------------------
Enter the selection number for each kernel option you want.
For example, 1 3 [15]: 4 8 11 <ENTER>
You selected the following kernel options:
             Kernel Breakpoint Debugger (KDEBUG)
             Data Link Bridge (DLPI V2.0 Service Class 1)
             ISO 9660 Compact Disc File System (CDFS)
Is that correct? (y/n) [y]: <ENTER>
Do you want to edit the configuration file? (y/n) [n]: y <ENTER>
Using vi to edit the configuration file.  Press return when ready,
or type 'quit' to skip the editing session: <ENTER>
```

The configuration file that appears for editing includes a section that looks something like the following (the list that you see will contain your system's options):

```
[...]
options             UERF
options             OSF
options             _LMF_
options             BIN_COMPAT
options             COMPAT_43
options             MACH
options             MACH_IPC_TCACHE
options             MACH_IPC_WWA
options             MACH_IPC_XXXHACK
options             BUFCACHE_STATS
[...]
```

Edit the above list to include the following line of text:

```
options             AFTBASE402
```

When finished editing, exit the editor. Text similar to the following displays indicating the new kernel build. This process may take several minutes.

```
*** PERFORMING KERNEL BUILD ***
A log file listing special device files is located in /dev/MAKEDEV.log
             Working....Mon Aug 12 14:13:27 EDT 1996
             Working....Mon Aug 12 14:15:30 EDT 1996
The new kernel is /sys/AFT400/vmunix
```

NOTE: The new kernel name will be the name that you chose (instead of AFT400 as shown in the above example). Make sure that you use your kernel's name in place of AFT400 in the following command.

After the new kernel is built, enter the following commands:

cp /sys/AFT400/vmunix / <ENTER>

reboot <ENTER>

After the machine successfully reboots, you must configure the network interfaces in accordance with Section 4.1 of this User's Manual.

3.2.3.2 Kernel Configuration Script Questions and Responses for Digital UNIX

While running the configuration script with the setld command, you will be prompted for responses to a number of questions that will customize your ATM kernel configuration. These questions are shown below in courier font. During your individual software installation, 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 question will be shown first, and the explanations of effects of the possible replies are shown after the questions. A typical configuration session is shown in Section 3.2.3.1.

```
*** No Configuration Information ****
```

This text appears if you have not previously configured your PCA-200E adapter.

```
What is the name of the configuration you wish to make ? [ATM.3.0.2]
```

This question allows you to name the kernel. If the name already exists from a prior installation, you will be prompted as shown below to be sure the kernel is not accidentally reconfigured.

```
Are you sure you want to modify ATM.3.0.2 [n]:
```

Answering y to this prompt will cause the old version of the kernel configuration to be overwritten. If you answer n, you will see the previous question.

```
Would you like to use FORE's SNMP agent? [y]
```

If you use the SNMP agent supplied by FORE Systems, you will have access to the FORE Systems Management Information Base (MIB). Using this in conjunction with applications such as ForeView, or other network management applications, enables you to remotely monitor your PCA-200E adapter card. Answering y to this question causes snmpd to run. It is started from the script S99snmpd.fore in the directory /sbin/rc3.d or the user specified directory. Answering n to this question suppresses execution of snmpd, and circumvents the next question in the installation script.

```
Would you like to use the standard UDP ports for SNMP (160/161)? [y]
```

SNMP agents generally use port 160 to receive queries, and port 161 to receive trap messages. Only one agent can bind to these ports at a time. Therefore, in order to run a vendor-supplied SNMP agent at the same time as FORE's SNMP agent, one agent must run on a different set of ports. If you do not wish to run both SNMP agents, reply to this question with a y. If you must run both, reply to this question with a n and continue with the next two questions.

```
Will ILMI be used for Address Registration? (for qaa only) [y]
```

The Interim Local Management Interface (ILMI) is a protocol used to dynamically assign an ATM address to a UNI 3.0 port. This ATM address is used in UNI 3.0 signalling messages to identify the workstation. If you plan to use UNI 3.0 signalling, it is recommended that you respond y to this question. If you choose to reply n and you will be using UNI 3.0 signalling, you will need to manually configure an ATM address in the host and in the switch to which it is connected. You will be prompted for the ATM address of the host later in the installation process.

ILMI is implemented as part of FORE Systems' SNMP agent. If you have chosen not to run this agent, you can still use ILMI. In this case, snmpd is renamed to ilmid, and only the ILMI protocol will be active. If you have chosen to run FORE Systems' SNMP agent as well as ILMI, both protocols will be active. Either snmpd or ilmid is executed on bootup from the script rc.PCA200 in the directory /usr/etc/fore or in the user-specified directory.

```
Would you like to configure CLASSICAL IP? [n]
```

Classical IP is a standard method for sending and receiving IP traffic over an ATM network. This protocol utilizes UNI 3.0 signalling to set up and tear down connections to other IP stations. If you would like to use this protocol, respond y to the question. Otherwise, respond with n.

```
ARP Server ATM Address not assigned for qaa0.
ARP Server ATM Address not assigned for qaa1.
ARP Server ATM Address not assigned for qaa2.
ARP Server ATM Address not assigned for qaa3.
```

The above messages appear if the ARP server ATM address(es) have not been assigned. You are then asked the following:

```
Would you like to (re)configure ATM address of qaa0 ARP server? [n]
```

If you answer n, a similar question appears for each remaining qaa interface for which no address has been assigned. If you answer y, the following prompt appears:

```
Enter the ATM address for the ARP server
```

The ARP server ATM address must be configured into each workstation (including the ARP server itself). It is recommended that you first configure the ARP server, and then configure all other hosts with the ARP server's ATM address. ARP server configuration is covered in detail in Chapter 5.

Any FORE Systems host or switch has the ability to be the ARP server for a network. You must have exactly one ARP server on each Classical IP network. You configure a host or switch to be the ARP server by specifying its ATM address as the ARP server's ATM address. When the host or switch sees that its ATM address matches the ARP server's ATM address, it starts acting as the ARP server for that Classical IP network.

The ATM address may be supplied by your system administrator or may come from querying the host itself. It is a 20-byte number, and must be unique. You should input it using 40 hexadecimal digits. You may precede the ATM address with a "0x", and you may use dots (periods) as separators, but neither is necessary. As an example:

```
0x47.0005.80.ffe100.0000.f115.0bab.002048102fe4.00

47.0005.80.ffe100.0000.f115.0bab.002048102fe4.00

47000580ffe1000000f1150bab002048102fe400
```

are all valid ATM addresses. If not using ILMI, you must also configure this ATM address in the switch to which this host is directly connected.

When using ILMI for address registration on the ARP server, you will not know the ATM address that ILMI has assigned until installation is complete and the machine has rebooted. Until then, you should enter a temporary ATM address, such as 11111111111111111111111111111111111111111, (a 40 character string of ones) in response to this prompt. You can then continue with the installation and reboot the machine.

After rebooting, determine the ATM address for the host by issuing the following command:

/usr/fore/etc/atmarp -z qaa0

Use the command:

/usr/fore/etc/atmarp -g qaa0

to get the ATM address of the ARP server.

Then, rerun the kernel configuration script, entering the correct ATM address in response to the prompt. In either case, reboot your machine again so that the change takes effect.

NOTE: Write down the ARP server ATM address, because you will need it to configure each of your workstations.

If you are not using ILMI for address registration, your system administrator will be able to supply you with the ATM address of the ARP server. Use this number in response to the prompt.

```
Would you like to configure LAN Emulation? [n]
```

If you answer y, the configure_lanem script is executed. The sample session shown in Section 3.2.3.1 is described as follows:

```
---------------------------------
LAN Emulation Configuration
***** No Configuration Information *****
```

If LAN Emulation has not been configured previously, the No Configuration Information message appears, followed by the next question. If emulated LANs have been configured, current configuration information appears, followed by the next question.

```
Do You Want To Modify The Above Configuration? [n]
```

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

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

NOTE: Detailed information about the establishment of an emulated LAN (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: A host may join more than 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 LAN Emulation Client (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 does not appear if you answer n.

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

Answering y to this question instructs the local LEC to use the default ("well known") ATM address for communicating with the LECS. If you answer n, you are prompted to enter the ATM address of the LECS that the LEC is to use.

`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 are then 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):`

Enter the name of the emulated LAN that you wish to configure (for example, engineering).

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

Answer y if you wish to enter the ATM address that the ELAN named in the previous prompt is to use when communicating with the LES. Answer n if you wish ELAN members to use the LECS to discover the ATM address of the ELAN's LES.

```
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 then presents the current LAN emulation configuration similar to the following:

```
Current client configuration:
LECS ATM address:    "Well-Known"
ELAN:                "default"
ELAN:                 engineering
ELAN:                 marketing
======================================================================
Do You Want To Modify The Above Configuration?  [n]
```

Answer y if you wish to change, delete, or add LAN emulation configuration information. Answering n produces the following prompt.

```
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. Answer n if you wish to abort the LAN emulation configuration information that you have entered.

3.2.4 Kernel Verification

After the new kernel configuration routine is complete, it should be verified to ensure that it is functioning properly. To check your new kernel, simply reboot the system and watch the boot messages that appear on the screen. If the new kernel configuration is correct, you should see a reference to PCA-200fa0, or PCA-200fa0 and PCA-200fa1 (2 PCA-200E cards installed). The message that appears depends on the number of PCA-200E cards installed in your system. If you see either of these references, and no error messages related to these device names appear, you are ready to use the PCA-200E for network traffic.

If you encounter any problems with the new kernel configuration, contact FORE Systems' Technical Support.

CHAPTER 4 Network Interface Administration

This chapter provides network configuration information such as assigning an IP address, configuring your workstation as a multi-homed or ATM only workstation, and dynamic and static IP routing information for a multi-homed workstation.

4.1 Network Interface Configuration

After installating the PCA-200E hardware and software, some additional configuration tasks must be performed before using the PCA-200E as an ATM network interface. First, a unique, legal IP address must be assigned to the network interface. The Internet address that is assigned to the PCA-200E interface should be within the subnet that is assigned to the ATM LAN by the system administrator.

If you are unsure of how to do so, it is strongly recommended that you consult the Digital Owner's Guide for your particular system for more information about creating and configuring subnets. You should also consult your system administrator for additional help.

NOTE: The adapter cards receive only on VPI=0 (incoming virtual path). The incoming VCI may be from 1 through 1023.

4.1.1 Network Interface Naming Conventions

The default name for a FORE IP interface is fa0. Subsequent interface names are fa1, fa2, and so on, depending on the number of installed adapter cards.

The default name for an emulated LAN interface is el0. Subsequent interface names are el1, el2, and so on, depending on the number of installed ELANs.

For a Classical IP interface, the naming convention begins with the prefix qa. Subsequent letters or numbers denote the physical unit number and/or the interface number:

- All Classical IP interfaces associated with physical unit zero have a as the next letter.
- All of the Classical IP interfaces associated with physical unit one have b as the next letter, and so forth.
- Each Classical IP interface has its virtual interface number as a suffix.

For example, using this naming convention, the name of the third Classical IP interface (virtual unit 2) on physical unit one is qab2.

> **NOTE:** Throughout this chapter, when an example uses the interface name fa0, any qaxx, or elx interface name could also be used.

4.1.2 Bringing up the PCA-200E Network Interface

After you have successfully installed the PCA-200E, configured the kernel, and established an Internet address for the PCA-200E interface, you can configure the PCA-200E network interface by typing:

ifconfig fa0 <*internet address***> netmask <***netmask_value***> broadcast <***broadcast_value***> up**

Please note that the ifconfig line may differ from this example if you are using a separate subnet for your ATM LAN. Specifically, the arguments for netmask and broadcast may be different from this example.

Once you have configured the interface, use the ping command to verify your connection and to confirm the presence of others connected to the network.

4.1.3 Assigning IP Addresses During Reboots

To have your workstation correctly assign the IP addresses during reboots, follow the example in Section 4.1.3.1 for fa and qa interfaces, or Section 4.1.3.2 for el interfaces.

4.1.3.1 Configuring fa and qa Interfaces

To configure fa or qa interfaces, enter the following command:

/usr/sbin/netsetup <ENTER>

A session similar to the following appears. The actual screen output that you see depends on your system's configuration. User input is shown in **bold** courier type. The responses shown in the example are typical for a session that configures the fa0 interface. Substitute responses appropriate for configuring your system where necessary.

```
***** CONFIGURE/DELETE NETWORK INTERFACES *****
You can configure or delete network interfaces.  Configuration information
is updated in /etc/rc.config and /etc/hosts.  Choose "configure" or "delete"
at the prompt.
Enter whether you want to "(c)onfigure" or "(d)elete" network interfaces.
If you are finished, press the RETURN key: c <ENTER>
You want to "configure" interfaces.  Is this correct [yes]? <ENTER>
You will now be asked a series of questions about the system.
Default answers are shown in square brackets ([]).  To use a
default answer, press the RETURN key.
This machine contains the following network interfaces:
       fa0
       qaa0
       qaa1
       qaa2
       qaa3
       fa1
       qab0
       qab1
       qab2
       qab3
       tu0
       sl0
```

```
Which interface do you want to configure [fa0]: <ENTER>
You want to configure "fa0".  Is this correct [yes]? <ENTER>
Enter the hostname for interface "fa0" []: mysystem-atm <ENTER>
The hostname for interface "fa0" is "mysystem-atm".
Is this correct [yes]? <ENTER>
Enter the Internet Protocol (IP) address for interface "fa0"
in dot notation []: nnn.nnn.nnn.nnn <ENTER>
The IP address for interface "fa0" is "nnn.nnn.nnn.nnn".
Is this correct [yes]? <ENTER>
Subnetworks allow the systems on a local area network to be on different
physical networks.  For the following question, use the default answer
unless the existing local area network is using subnet routing.
If the local area network is using subnet routing, you need to know
the subnet mask.
Enter the subnet mask in dot notation [255.255.255.0]: <ENTER>
The subnet mask for "fa0" is "255.255.255.0".
Is this correct [yes]? <ENTER>
For the following question USE THE DEFAULT ANSWER unless you would like
to add additional flags (found in the ifconfig reference page) to the
ifconfig command.  Normally, you will USE THE DEFAULT ANSWER.
Do you want to use additional ifconfig flags for this interface [no]? <ENTER>
The configuration looks like:
        interface "fa0" hostname: "mysystem-atm"
        ifconfig fa0 nnn.nnn.nnn.nnn netmask 255.255.255.0
Is this correct [yes]? <ENTER>
***** UPDATING /etc/rc.config *****
"fa0" is configured in /etc/rc.config
***** UPDATING /etc/hosts *****
"nnn.nnn.nnn.nnn mysystem-atm" is configured in /etc/hosts
```

After running /usr/sbin/netsetup, it is necessary to reboot for the changes to take effect.

4.1.3.2 Configuring el Interfaces

For el interfaces, it is necessary to edit /etc/rc.config. The following steps outline the procedure for configuring the el0 interface.

1. Using an editor such as vi, open /etc/rc.config. Increase the count of NUM_NETCONFIG by 1.
2. Choose an unused NETDEV_n entry, and set it to el0 (e.g., NETDEV_2="el0").
3. Modify the corresponding IFCONFIG_n entry to contain the IP address and netmask for el0 (e.g., IFCONFIG_2="198.29.100.61 netmask 255.255.255.0").
4. Save the file and reboot.

For example:

Starting with an /etc/rc.config that has Ethernet (tu0) only configured, the typical output appears as follows:

```
[...]
NUM_NETCONFIG="1"
MAX_NETDEVS="24"
NETDEV_0="tu0"
NETDEV_1=
NETDEV_2=
NETDEV_3=
NETDEV_4=
NETDEV_5=
NETDEV_6=
NETDEV_7=
IFCONFIG_0="169.144.32.86 netmask 255.255.255.0"
IFCONFIG_1=
IFCONFIG_2=
[...]
```

In the above list, you would change NUM_NETCONFIG to “2”, set NETDEV_1 to "el0", and set IFCONFIG_1 to "<internet address of el0> netmask <correct netmask for el0>". The resulting list in the file fragment would appear as follows:

```
[...]
NUM_NETCONFIG="2"
MAX_NETDEVS="24"
NETDEV_0="tu0"
NETDEV_1="el0"
NETDEV_2=
NETDEV_3=
NETDEV_4=
NETDEV_5=
NETDEV_6=
NETDEV_7=
IFCONFIG_0="169.144.32.86 netmask 255.255.255.0"
IFCONFIG_1="204.95.89.14 netmask 255.255.255.0"
IFCONFIG_2=
[...]
```

When finished editing, save the file and reboot for the changes to take effect.

4.2 PCA-200E Adapter in an Internet Protocol Network

The PCA-200E device driver supports the TCP/IP protocol suite as well as the ATM API. In order to use your PCA-200E adapter card in an IP network, you must set your workstation in one of two configurations:

1. Multi-homed with a network attachment to both ATM and Ethernet (or other legacy network technology)
2. ATM network only

This chapter assumes a working knowledge of TCP/IP, and, in particular, IP addressing and routing issues.

In the following discussion, two example Class C IP network addresses have been used. The network address aaa.aaa.aaa.XX is the ATM IP network, and the network address eee.eee.eee.XX is the Ethernet network. The network portion of the IP address must be different for the ATM and Ethernet networks.

A FORE Systems ASX switch can be configured to be multi-homed (i.e., both an ATM and Ethernet network attachment), and can be used to route IP traffic between the ATM and Ethernet networks.

NOTE: The addresses used should be specific to your network topology.

To proceed with your network configuration, you need access to the following information:

- IP network number for the ATM network
- IP network addresses and names for each ATM and Ethernet interface. If you are installing the PCA-200E adapter card into a multi-homed environment, your Ethernet interface is probably already installed correctly.

NOTE: This text does not describe the steps required for the use of IP subnets. Consult your system administrator for this information.

4.2.1 Multi-homing on ATM and Ethernet Networks

If you wish to have your workstation reside on both an ATM and Ethernet network, you must assign an IP hostname and address on different networks to each interface. Figure 4.1 illustrates the basic network topology for this type of configuration. In this example, to access the workstations on the ATM or Ethernet side of the network, you need only specify the IP hostname or address of the specific workstation.

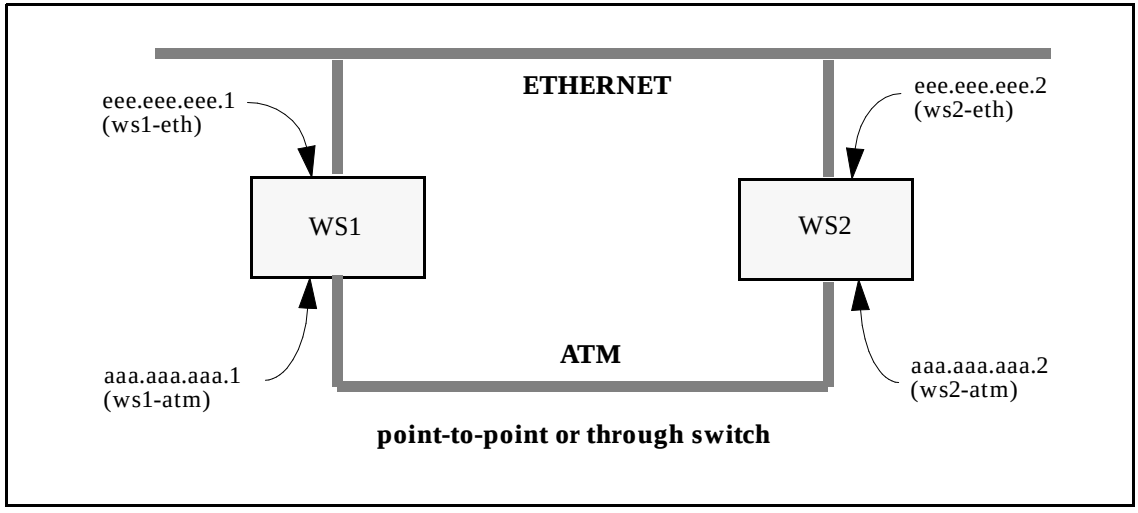


Figure 4.1 - Multi-homing Network Configuration

The following is an example of multi-homing, using the ftp command to transfer a file, using either ATM or Ethernet. In this example, ws2 is the workstation to which you want to connect. To use the ftp command over ATM, type:

```
ftp ws2-atm
```

To use the ftp command over Ethernet, type:

```
ftp ws2-eth
```

4.2.2 Configuring a Workstation as ATM-Only

If you wish to have a workstation on an ATM-only network, but still have access to workstations outside the ATM network, you need to perform additional configuration to your workstation, the ASX ATM switch, and also the external workstation(s). Specifically, you need to configure your workstation to enable it to recognize and reach the external workstation. The external workstation needs the same capabilities. Figure 4.2 below illustrates a basic network topology for this type of configuration.

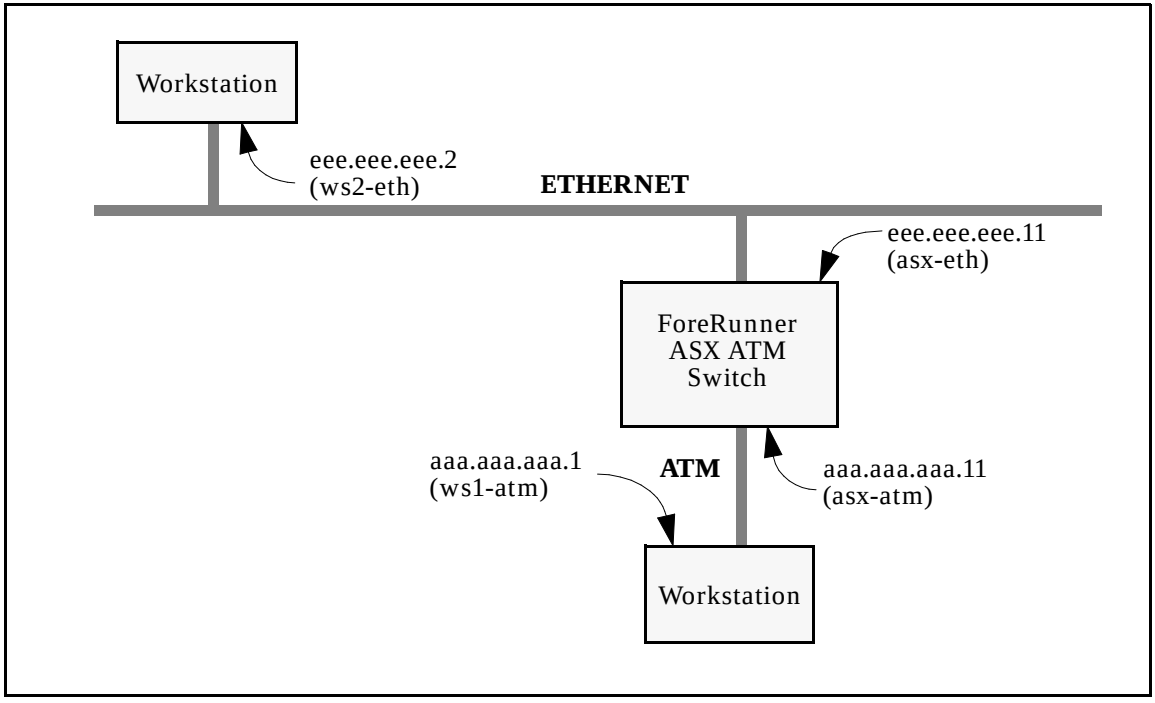


Figure 4.2 - ATM Network with Access to Ethernet

As before, you need to assign an IP address to your ATM interface on the ATM-only workstation. In this topology, the ASX switch is multi-homed and is used to route IP traffic between the ATM and Ethernet networks.

To use the network in this configuration, you must set up the IP routing. There are two ways to handle the IP routing: dynamically and statically. The following section outlines these methods.

4.2.3 Dynamic and Static IP Routing (ATM-Only Network)

4.2.3.1 Dynamic Routing

To use dynamic IP routing, the IP routing daemon (in.routed) must be run on all the workstations in the network that need to reach both the ATM and Ethernet nodes. The routing daemon "listens" for routing information and update its routing tables accordingly.

If the routing daemon is used, the ATM-only workstation should be able to communicate to the Ethernet network nodes as soon as the routing tables are updated (typically every thirty seconds or so).

4.2.3.2 Static Routing

To set up a static route, first disable the routing daemon by preventing it from running. Then establish either a default route or a specific route, on both the ATM-only workstation and the Ethernet workstation.

1. To set up a default route, type the following on the ATM-only workstation:

   route add default asx-atm 1

2. Then type the following on the Ethernet workstation:

   route add default asx-eth 1

To maintain this default route, simply add the default route command into the file . To disable the routing daemon on the next reboot, enter the following command as root:

/sbin/chkconfig routed off

If you do not wish to use a default route, you can also use a specific route to accomplish the correct routing.

1. To do so, type the following on the ATM-only workstation:

   route add net eee.eee.eee asx-atm 1

2. Then type the following on the Ethernet workstation:

   route add net aaa.aaa.aaa asx-eth 1

3. Once a route has been established, you should be able to ftp files from the Ethernet workstation to the ATM-only workstation by typing the following:

   ftp ws2-eth

.

4.2.4 Disabling Signalling

If your PCA-200E adapter is connected to a SPANS-capable device (such as a ForeRunner ASX ATM switch), you may ignore this step in configuring the IP PVC. If your PCA-200E adapter is not connected to another SPANS-capable device, such as a *ForeRunner* ASX ATM Switch, you must disable SPANS signalling in the device driver for that unit. Disabling the signalling informs the device driver that it may send and receive cells without knowing its physical address, which is typically supplied by the SPANS-capable device.

The atmconfig command can enable, disable, or report on the state of signalling (both SPANS and UNI 3.0) for a particular unit. The syntax is as follows:

atmconfig <device>	display current configuration
atmconfig -s on <device>	enable SPANS signalling
atmconfig -s off <device>	disable SPANS signalling
atmconfig -u on <device>	enable UNI 3.0 signalling
atmconfig -u off <device>	disable UNI 3.0 signalling

For example, to disable SPANS signalling on device fa0, the following command should be entered:

atmconfig -s off fa0

The configuration may then be checked by again using atmconfig to display the current configuration:

atmconfig fa0

For more information on the atmconfig command, see Section 4.4.

4.2.5 Configuring an Outgoing IP PVC

The first step in configuring an IP PVC connection is to set up the outgoing link to the destination IP host. The following parameters need to be determined before you configure this part of the connection: outgoing device (typically fa0), destination IP hostname or address, VPI, VCI and AAL type (3/4 or 5). Once these have been determined, the atmarp command is used to configure the outgoing link using the supplied parameters as follows:

atmarp -s destination_ip_hostname device vpi vci aal_type

For example, to set up an outgoing connection from ws1-atm to ws2-atm using the fa0 device, VPI of 0, VCI of 100 and AAL5, you would specify:

atmarp -s ws2-atm fa0 0 100 5

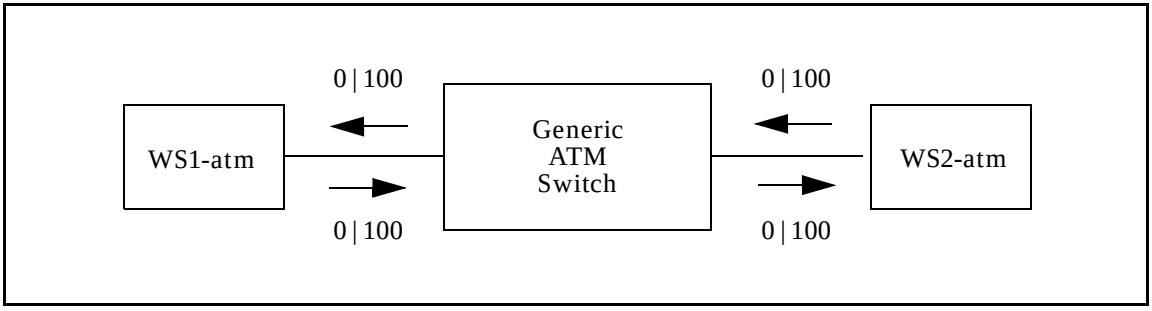


Figure 4.3 - IP Permanent Virtual Circuit

You also need to set up an equivalent outgoing connection from ws2-atm to ws1-atm using the fa0 device. To set up this connection with VPI of 0, VCI of 100 and AAL5, type the following:

atmarp -s ws1-atm fa0 0 100 5

4.2.6 Configuring an Incoming IP PVC

The second step in configuring an IP PVC connection is to link an incoming VPI/VCI to the IP queue (see Figure 4.3). The following parameters should be determined before configuring this part of the connection: incoming device, VPI, VCI, and AAL type (3/4 or 5). Once these have been determined, the atmarp command is used to configure the incoming link using the parameters as follows:

atmarp -l device vpi vci aal_type

For example, to set up an incoming connection to ws1-atm from ws2-atm using the fa0 device, VPI of 0, VCI of 100 and AAL 5, you would enter the following on host ws1:

atmarp -l fa0 0 100 5

This command links cells coming in on device fa0, on VPI/VCI of 0/100 using AAL5 to the IP queue on ws1-atm.

Similarly, to set up the incoming connection to ws2-atm from ws1-atm using the fa0 device, VPI of 0, VCI of 100 and AAL 5, you would enter the following on host ws2:

atmarp -l fa0 0 100 5

This command links cells coming in on device fa0, on VPI/VCI of 0/100 using AAL5 to the IP queue on ws2-atm.

For more information about the atmarp command, see Section 4.3.

4.2.7 Verifying the PVC Configuration

The atmarp command can also be used to view the ARP cache in the device driver. This output can be used to view the ARP cache entry of the newly created PVC for verification. To view the ARP cache, enter:

atmarp -a

The following is displayed:

```
Outgoing connections:
fa0: ws2-atm (198.29.21.74): vpi.vci=0.100 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
```

For a SPANS PVC, the incoming and outgoing connection appears in the output with the "flags" indicating that this entry is a PVC. With a Classical IP PVC, there is only an entry in the "Outgoing" section.

For more information about the atmarp command, see Section 4.3.

4.2.8 IP Multicasting Support

NOTE: The OS must support IP multicasting or have IP multicasting extensions installed. For Digital UNIX, multicasting is enabled by running the /usr/sbin/iprsetup -s command.

Multicasting support per RFC 1112 specification is a standard feature. Multicasting is performed by the switch hardware. Multicasting can be performed over SVCs as well as PVCs. Multicast SVCs are created using the SPANS-UNI and SPANS-NNI protocols. Multicasting is also supported for LAN emulation using the UNI 3.0 protocol.

Applications wishing to use multicast SVCs join and leave multicast groups under their own control can use the standard socket options: IP_ADD_MEMBERSHIP and IP_DROP_MEMBERSHIP.

There are two modes possible for PVCs. In the first case, a PVC is created for every multicast group to which the host wishes to send traffic. In the second case, one PVC is created to transmit traffic for all groups. This PVC can be viewed as the default multicast PVC. That is, if an explicit ATM ARP table entry is not found for a given IP multicast address, traffic is sent on the default multicast PVC if it exists.

If a default multicast PVC does not exist, the host driver will automatically attempt to create a multicast SVC. Extensions to the host adapter management tool atmarp (see Section 4.3) were made to support multicast PVCs.

4.2.9 IP Load Balancing across Multiple Adapters

IP load balancing can make multiple adapters appear to be a single network interface. When load balancing is enabled, all IP traffic traveling over SVCs and destined for an ATM network is automatically balanced (at connection set-up time, based upon the total peak bandwidth of all connections through an interface) across all FORE ATM interfaces attached to that same physical network. Balancing occurs on both incoming and outgoing connections, across different series and speeds of FORE adapters. The -b option in atmconfig(8c) is used to enable and disable IP load balancing. Section 4.4 contains complete information on atmconfig.

IP load balancing can also provide a means of fault tolerance. If an interface is configured down, all IP SVCs currently using that interface are closed and then automatically re-opened and balanced across all interfaces currently alive.

NOTE: For purposes of bandwidth comparison, all Unspecified Bit Rate (UBR) IP connections are assumed to have a peak rate of 50 Mbps. The specific IP addresses assigned to multiple interfaces are not important to the load balancing operation. Each of the interfaces may be configured to be on the same subnet or different subnets.

4.2.10 Driver Support for FORE IP Multicasting in a Routed Environment

NOTE: FORE IP multicasting is only available on platforms with OS support for IP multicast.

All Internet Group Membership Protocol (IGMP) messages are transmitted to all members of an IP multicast group using the connectionless service. This drastically reduces the number of VCs required (in the ATM network) for IP multicast support since a host which is strictly receiving from a group need not have a connection open for transmission to the group.

When a host opens a connection to transmit to an IP multicast group, it automatically adds the address DVMRP.MCAST.NET (224.0.0.4) as a member of that group. Since all IP multicast routers are members of the DVMRP.MCAST.NET group, routers now have the ability to route IP multicast packets from an ATM network to other networks.

4.2.11 Settable Peak Cell Rate for FORE IP SVCs

The peak cell rate for FORE IP SVCs can be set. Traffic over all FORE IP SVCs opened on a given interface is limited to the peak cell rate specified for that interface. The -q option in atmconfig(8c) is used to set the peak cell rate to a specific value, or to turn off peak cell rate control. See Section 4.4 for more information.

4.2.12 MTU Size

An interface's maximum transmission unit (MTU) can be set up to 65535 bytes. Certain operating systems have maximum values for the MTU, which in some cases are much smaller than 65535 bytes (for example, the maximum MTU size for the FORE API under SunOS 4.1.3 is 32763). On these systems an attempt to increase the MTU past the maximum value supported by the operating system results in the MTU being set to the maximum supported value. The default MTU is 9188 bytes for FORE IP interfaces, 9180 bytes for Classical IP interfaces, and 1516 bytes for an emulated LAN interface (el0, el1, el2, etc.). A 65535 byte MTU is supported for AAL types null (0), four (4), and five (5).

CAUTION



Caution should be used when increasing the MTU. A large MTU increases the probability of cell loss, which, therefore, increases the probability of packet loss due to reassembly errors. Cell loss may increase due to buffer overflow in the network and on the adapter cards.

4.3 atmarp(8c)

NAME

atmarp – manipulate Internet to ATM address mappings

SYNOPSIS

atmarp [**-N**] *hostname*

atmarp [**-N**] **–a**

atmarp –d *hostname*

atmarp –f

atmarp –s *hostname device vpi vci aal [encapsulation] [peak]*

atmarp –l *device vpi vci aal [decapsulation]*

atmarp –x *device vpi vci*

atmarp –c *hostname device vpi vci revalidate [peak]*

atmarp –r *hostname*

atmarp –m *device vpi vci aal [encapsulation] [peak]*

atmarp –u

atmarp –n *ATMaddress device*

atmarp –z *device*

atmarp –o *hostname ATMaddress device*

atmarp –p *ATMaddress device*

atmarp –g *device*

atmarp –t *device*

atmarp –v *device*

DESCRIPTION

The **atmarp** program displays and deletes Internet-to-ATM address translation table entries used by the ATM address resolution protocol. It also allows IP traffic to particular destinations to be routed over Permanent Virtual Circuits (PVCs). This functionality is only needed for special applications which may require the use of PVCs for IP traffic. This program does not actually control the creation of the PVCs.

If the single argument *hostname* is given, the ATM ARP entry for *hostname* is displayed. When used with the **–N** flag, the network address is displayed in numerical form. When the **–N** flag is not specified, both the symbolic and numerical forms are displayed.

OPTIONS

–a Display all of the current ATM ARP table entries. When used with **–N** flag, the network address is displayed in numerical form. When **–N** flag is not specified, both the symbolic and numerical forms are displayed.

–d Delete address mapping for specified hostname from the ATM ARP table. If an ATM connection is open to the specified host then the connection is closed.

–f Delete all dynamic address mappings from the ATM ARP table and close all Switched Virtual Channels (SVCs) to all hosts in the table.

–s Set ARP entry for outgoing Permanent Virtual Channel (PVC). All traffic to *hostname* will be encapsulated based on *encapsulation* and sent via the *device* interface on VPI *vpi*, VCI *vci*, using AAL type *aal*. *device* must be one which supports SPANS signaling (e.g. **fa0**). Specifying *peak* will limit all traffic to *hostname to peak* kilobits per second. If *peak* is not specified, no rate control is applied.

–l Attach IP to an incoming PVC. All traffic received on the interface *device* with VPI *vpi*, VCI *vci*, and AAL type *aal* will be decapsulated based upon *decapsulation* and handed over to IP. *device* must be one which supports SPANS signaling (e.g. **fa0**).

–x Detach IP from an incoming SVC or PVC. IP traffic will no longer be accepted on the specified VPI and VCI.

–c Set ARP entry for RFC 1577 (Classical IP) Permanent Virtual Channel (PVC). Also attach IP to this PVC. All traffic to *hostname* will be sent via the *device* interface on VPI *vpi*, VCI *vci*, using AAL type 5. *device* must be one which supports Q.2931 signaling (e.g. **qaa0**). Specifying *peak* will limit all traffic to *hostname to peak* kilobits per second. If *peak* is not specified, no rate control is applied. The entry will be revalidated by sending an InARP request over the PVC at 15 minute intervals if *revalidate* is non-zero. To disable this feature, use 0 for the revalidate parameter.

–r Remove ARP entry for RFC 1577 (Classical IP) Permanent Virtual Channel (PVC). Also detach IP from this PVC. IP traffic will no longer be accepted on VPI/VCI associated with this entry.

–m Set IP multicast default outgoing PVC. All traffic destined for an IP multicast address not found in the ARP table will be encapsulated based on *encapsulation* and sent via the *device* interface on VPI *vpi*, VCI *vci*, using AAL type *aal*. Specifying *peak* will limit all traffic sent on the PVC to *peak* kilobits per second. If *peak* is not specified, no rate control is applied.

–u Remove IP multicast default outgoing PVC. All traffic destined for an IP multicast address not found in the ARP table will be sent over a multicast SVC, if one can be created to the appropriate multicast group.

–n Configure the ATM address for device *device*. The ATM address is specified as 40 hexadecimal characters, with or without a leading 0x and interspersed dots (e.g. 0x0102030405060708090a0b0c0d0e0f1011121314). NOTE: The last two digits will be ignored and qaa0 will get 00, qaa1 will get 01 etc.

–z Display the ATM address for device *device*. *device* must be one which supports Q.2931 signaling (e.g. **qaa0).**

–o Add an ATM–address–to–IP–address mapping to the ARP table. The ATM address is specified as 40 hexadecimal characters, with or without a leading 0x and interspersed dots (e.g. 0x01.0203.04.050607.0809.0a0b.0c0d.0e0f10111213.14). This creates a single ARP entry for *hostname* and is used to connect to hosts which do not support ARP.

–p Set the ARP server's ATM address for the device *device*. The ATM address is specified as 40 hexadecimal characters, with or without a leading 0x and interspersed dots (e.g. 01.0203.04.050607.0809.0a0b.0c0d.0e0f10111213.14).

–g Get the ARP server address that has been configured for the device *device*.

–t Tell whether or not we are the ARP server for *device's* IP subnet.

–v Display ARP Server connection information for the device *device.* This information is useful for debugging. It includes the VPVC over which we are communicating with the ARP Server, the number of times we have unsuccessfully attempted to connect to the ARP Server, whether or not we are in the process of connecting to the ARP Server (meaning we have sent a SETUP but have not yet received a CONNECT or a RELEASE COMPLETE), and the number of Inverse ARP packets we have sent. *device* must be one which supports Q.2931 signaling (e.g. **qaa0).**

RESTRICTIONS

Currently *vpi* must be zero (0) and *vci* must be less than 1024 for all incoming PVCs. *aal* must be one of 3, 4, or 5. *encapsulation* must be one of null (no encapsulation, the default), llc_routed (IEEE LLC encapsulation for routed PDUs), or llc_bridged_8023 (IEEE LLC encapsulation for Ethernet/802.3 bridged PDUs). If *encapsulation* is specified as llc_bridged_8023 the following argument must be the 6-byte colon separated destination MAC address. *decapsulation* must be either null (no decapsulation, the default) or llc (IEEE LLC decapsulation).

The peak rate is based on the 48 byte payload of an ATM cell. The maximum data rate at the ATM Adaptation Layer for 100 Mb TAXI is 87.3 Mb/sec, 122.2 Mb/sec for 140 Mb TAXI, and 135.6 Mb/sec for SONET-OC3. This rate is limited by Physical Layer, ATM Layer, and Adaptation Layer overhead. Rate control is only available on FORE 200-series adapters. Attempts to use this optional parameter with 100-series adapters will result in an error.

EXAMPLE

The following example displays the address mapping for hostname *piranha1*. An ATM address is comprised of the ATM switch identifier and port number. The host may be specified by name or by number, using Internet dot notation.

```
example% atmarp piranha1
fa0: piranha1 (192.135.217.1): vpi.vci=0.32 aal=5
     switch.port=f1150ab4.6
     flags=() encapsulation=NULL peak rate=10000
```

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), **cport**(8C), **cpath**(8C), **cchan**(8C)

4.4 atmconfig

NAME

atmconfig – Interface / IP / SPANS / Q.2931 / OC3 configuration tool for FORE ATM devices

SYNOPSIS

atmconfig *device*

atmconfig –m *mtu device*

atmconfig [**–s | –u | –p | –l**] [*on* | *off*] *device*

atmconfig –b [*on* | *off*]

atmconfig –f [*sonet* | *sdh*] *device*

atmconfig –i [*idle* | *unassigned*] *device*

atmconfig –t [*external* | *internal*] *device*

atmconfig –q [*peak(Kb/sec)* | *off*] *device*

DESCRIPTION

atmconfig is a tool to display the current configuration of an ATM device. The interface, IP, SPANS, Q.2931 and OC3 configurations may be viewed. It also can be used to enable and disable SPANS, IP load balancing, and IP multicast, as well as to modify the operation of an OC3 interface, where applicable.

If no action is indicated for the specified device, the configuration information for the device is displayed. The interface information includes the MTU. The IP information includes the state of load balancing and multicast. The SPANS information includes the state of the interface and the VPI and VCI values for SPANS signaling and connectionless messages. The Q.2931 information includes the state of the interface and the VPI and VCI values for Q.2931 signaling. If the media type for the ATM device is OC3, the current OC3 configuration is also displayed. For OC3, the current framing used, frame and stream scrambling state, device timing source, and loopback state are displayed.

OPTIONS

–m Set the MTU on the specified interface. The largest MTU permissible is 65535 bytes.

–s Enable / Disable SPANS signaling on the specified device.

–s Enable / Disable Q.2931 signaling on the specified device.

–b Enable / Disable IP load balancing. When load balancing is enabled, all IP traffic traveling over SVCs and destined for an ATM network will automatically be balanced (at connection setup time, based upon the total peak bandwidth of all connections through an interface) across all FORE ATM interfaces attached to that same physical network.

–p Enable / Disable IP multicast on the specified interface.

–l Enable / Disable OC3 internal loopback mode.

–f Set OC3 framing type to either SONET or SDH.

–i Set OC3 module to insert idle cells (ITU-T standard) or unassigned cells (ATM Forum and ANSI standard).

–t Set OC3 timing source to external or internal.

–q Set / Disable IP SVC rate control on the specified device. This option is only applicable to a SPANS interface.

NOTES

Care should be taken when setting large MTUs since large packets increase the probability of packet loss due to reassembly errors from cell loss. Certain operating systems may not support the maximum ATM MTU. On these platforms, the interface MTU will be limited to the maximum allowed value. **atmconfig** cannot be used to dynamically change the interface MTU on Solaris platforms. On these machines, the -m option changes the MTU only for STREAMS traffic (including FORE Systems' API). For Solaris platforms, the interface MTU can be dynamically changed with the "mtu" option to ifconfig(1M), or can be set to "value" at boot time by adding "set fore_atm:fore_mtu=value" at the end of the system configuration file (e.g. /etc/system).

The use of IP SVC rate control limits the peak bandwidth of all IP SVC traffic out the specified interface. If peak rate is modified or disabled, the connection must be torn down (see atmarp (8c)) and re-established for the new rate to take effect.

Modifying OC3 parameters may cause communication problems. The parameters must agree with the parameters chosen at the far end or intermediate switching module.

ERRORS

No such device
This indicates that the specified device is invalid.

RELEASE

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

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

SEE ALSO

atmarp(8c)

CHAPTER 5 Configuring a Classical IP ATM Network

5.1 Introduction

This chapter describes how to design, configure, and maintain a Classical IP ATM network. The term classical indicates that the ATM network has the same properties as existing legacy LANs. That is, even though ATM technology allows for large globally connected networks, for example, it is only used in the LAN environment as a direct replacement of existing LAN technology. The classical model of LANs connected through IP routers is maintained in ATM networks. RFC-1577 provides the standard for Classical IP over ATM.

Classical IP over ATM is different than IP in legacy LANs in that ATM provides a virtual connection environment through the use of PVCs and/or SVCs. SVC management is performed via UNI 3.0 signalling. UNI 3.0 is a broadband signalling protocol designed to establish connections dynamically. UNI 3.0 uses Service Specific Connection Oriented Protocol (SSCOP) as a reliable transport protocol, and all signalling occurs over VPI: 0, VCI: 5. UNI 3.0 connections are bi-directional, with the same VPI/VCI pair used to transmit and receive. Currently, FORE Systems uses a subset of UNI 3.0 signalling as defined by the ATM Forum UNI 3.0 specification.

Once a Classical IP connection has been established, IP datagrams are encapsulated using IEEE 802.2 LLC/SNAP and are segmented into ATM cells using ATM Adaptation Layer type 5 (AAL5). In addition, the default Maximum Transmission Unit (MTU) is 9,180 bytes (the SNAP header adds 8 more bytes) with a maximum packet size of 65,535 bytes. There is currently no support for IP broadcast datagrams or IP multicast datagrams in a Classical IP environment.

5.1.1 Logical IP Subnets

An important concept in Classical IP networks is that of a Logical IP Subnet (LIS). An LIS is a group of hosts configured to be members of the same IP subnet (that is, they have the same IP network and subnetwork numbers). In this sense, one LIS can be equated to one legacy LAN. It is possible to maintain several overlaid LISs on the same physical ATM network. Therefore, in a Classical IP ATM network, placing a host on a specific subnet is a logical choice rather than a physical one. In this type of environment, communication between hosts in different LISs is only permitted by communicating through an IP router which is a member of both LISs (as per RFC-1577).

The number of LISs, and the division of hosts into each LIS, is purely an administrative issue. Limitations of IP addressing, IP packet filtering, and administrative boundaries may guide a manager into establishing several LISs onto a single ATM network. Keep in mind, though, that communication between LISs must occur through IP routers.

5.1.2 Classical IP Interfaces

In order to support routing between multiple LISs, the host adapter software allows a host to be configured as a member of (and a router between) up to four distinct LISs per physical ATM interface. Each LIS membership is through a separate Classical IP virtual network interface. Existing system level IP routing configuration tools are used to control routing through each of the virtual interfaces in the same manner as routing among several physical interfaces. Note that even though each virtual interface associated with a given physical interface uses the same physical hardware, they are each configured separately with their own MTU, IP address, and ATM address.

The name of each of the Classical IP interfaces begins with `qa`. All of the Classical IP interfaces associated with physical unit zero will have `a` as the next letter. All of the Classical IP interfaces associated with physical unit one will have `b` as the next letter, and so forth. Finally, each Classical IP interface has its virtual interface number as a suffix. As an example of the above naming convention, the name of the third Classical IP interface (unit 2) on physical unit one is `qab2`.

5.1.3 SPANS Interface

While each of the qa interfaces for a given physical interface is designed to support Classical IP using UNI 3.0 signalling, there also exists a SPANS interface (usually called fa, but user configurable) for each physical interface. The fa interface supports FORE IP on top of SPANS signalling. FORE IP allows communication using AAL4 or AAL5 with no encapsulation, uses a broadcast ARP for SPANS address resolution, and supports direct communication of all hosts on a physical ATM network without the use of IP routers. Since SPANS and UNI 3.0 signalling use different VCIs, a host can simultaneously support FORE IP over SPANS as well as Classical IP over UNI 3.0 on the same physical interface.

As a result of standard IP routing, all traffic sent out an fa interface will use FORE IP, while all traffic sent out a qa interface will use Classical IP. Each of the fa interfaces should be assigned an IP address on a subnet different than the subnets of any of the qa interfaces. It is permissible to place multiple fa interfaces on the same subnet, and the driver will load balance connections across these interfaces.

It is only necessary to configure the fa and qa interfaces if the specific service provided by that interface is required. A host sending only Classical IP need not configure the fa interfaces. Likewise, a host sending only FORE IP would not need to configure the qa interfaces. Both the fa and qa interfaces may be configured simultaneously, but they must be in separate subnets. Remember that Classical IP specific configuration changes can only be done with the qa devices, while SPANS specific configuration changes can only be done with the fa devices.

5.2 Address Registration and ILMI

Before a host can establish connections over a physical interface, the host must know the ATM address for that interface. The primary purpose of Interim Local Management Interface (ILMI) is to discover and register these ATM addresses dynamically.

5.2.1 ATM Addresses

For private ATM networks, addresses uniquely identify ATM endpoints. The UNI 3.0 address format is modeled after that of an OSI Network Service Access Point.

Three address formats have been specified: DCC, ICD, and E.164. Per the UNI 3.0 specification, all private networks should accept initial call setup messages containing ATM addresses with any of the approved formats and forward the calls as necessary.

An ATM address consists of the following:

- a 13-byte network-side prefix - The prefix is the ATM prefix of the switch to which the host is attached.
- a seven-byte user-side part - This consists of the following:
  - a six-byte End System Identifier (ESI) - The ESI is the unique IEEE MAC address of the interface.
  - a one-byte selector - Although each virtual interface for a given physical interface uses the same prefix and ESI, the selector field is the part that indicates the number of the specific virtual interface. The selector field is 00 for `qaa0`, 01 for `qaa1`, 02 for `qaa2`, and 03 for `qaa3`.

5.2.2 Operating with ILMI Support

FORE Systems switches running *ForeThought* software version 3.0 or greater provide support for ILMI. If ILMI is supported on all of the switches and hosts in a given network, when a switch boots up, ILMI enables the switch to discover all of the hosts attached to it and to send its ATM prefix associated with the port to those hosts dynamically. In return, the host prepends that prefix to its ESI and selector fields, forming a complete ATM address. The host then notifies the switch of its complete ATM address. These registration messages are sent and received over AAL5 using VPI: 0, VCI: 16. Once ILMI registration has been completed, then connection setup can occur.

If a host changes network ports after an ATM address has been registered for its interface, all existing connections will be closed. If the new port is on a different switch, a new ATM address (with a different network address prefix) will be registered. The host can then begin to establish new connections.

5.2.3 Operating without ILMI Support

If ILMI is not supported on a particular switch or host in a given network, then the ATM addresses must be manually configured. If a given switch does not support ILMI, it can not supply an ATM prefix to the hosts. Therefore, the user must assign a unique, valid prefix to the switch. Additionally, the same prefix should be used for all hosts in the LIS.

On the host, `atmarp -n` is used to configure the ATM address for a specific interface. The switch directly attached to this interface is then informed of this ATM address/port combination through commands in AMI. Once the host and network have both been informed of this ATM address/port pair, the host may begin signalling.

Once an interface's ATM address has been set, it is possible to change it by first running `atmarp -n` to set the new address, and then bringing the interface down and back up (`ifconfig qaXX down`; `ifconfig qaXX up`) for the address change to take effect.

5.2.4 Configuration

The choice to use ILMI for address registration is made at software installation time. Since ILMI uses SNMP as its management protocol, the use of ILMI is tied into `snmpd`. The choice can be made to run FORE's SNMP agent and use ILMI (`snmpd`), run FORE's SNMP agent without using ILMI (`snmpd -n`), or just use ILMI (`snmpd -i` or `ilmid -i`). The commands to run the chosen daemon, or to configure a host's ATM address statically when not running ILMI, are placed in .

5.3 ARP and ARP Servers

5.3.1 Theory

In order for a host to establish a connection to another host, it must first determine the other host's ATM address. ATMARP (ATM address resolution protocol) is the procedure used to resolve an IP address into an ATM address. Since the ATM standards do not currently support broadcast on an ATM LAN, address resolution is performed by direct communication with a special ARP server, rather than broadcasting ARP requests as is done in legacy LANs. Each LIS must have only one ARP server configured, but a single ARP server can be the server for several LISs.

Each host in an LIS must be configured with the ATM address of the host providing ARP service for its LIS. On a host ARP server, the ATM address of the ARP server can be obtained by running `atmarp -z` (remember to use the interface associated with the given LIS). The ARP server address is normally configured into each host at installation time, but it may be done at any time by running `atmarp -p`. If the ARP server address is configured , it will be persistent across reboots, but if it is configured using `atmarp -p`, it will not be persistent across reboots.

Since only one ARP server can be functioning at a time in a given LIS, and since the ARP server's address is manually configured into each host, it is not possible to use multiple, redundant ARP servers to improve robustness. If an ARP server becomes nonfunctional, a new ARP server must be configured, and then each host within the LIS must be configured to use the new ARP server. To configure a new ARP server address on a host, run `atmarp -p` to set the new address, then bring the appropriate interface down and back up (`ifconfig qaXX down`; `ifconfig qaXX up`) for the change to take effect.

FORE's ATM switches also have the capability of being an ARP server. This process is described in the next section.

5.3.2 Configuring a FORE Switch to be an ARP Server

To configure a FORE switch as an ARP server, perform the following steps:

1. Using the AMI on the switch, determine the ATM address of the switch with the command:

   configuration atmarp> getnsap

```
qaa0 NSAP address: 47000580ffe1000000f21510a00020481510a000
```

   The response from this command also shows the interface name to which the ATM address is attached.

2. Set the ATM address of the ARP server for the interface name (from step 1) to be the ATM address of that interface with the AMI command:

configuration atmarp arpserver> set <NSAPaddress> <interface>

For example:

configuration atmarp arpserver>
set 0x47.0005.80.ffe100.0000.f215.10a.00020481510a0.00 qaa0

NOTE: This example shows the Classical IP interface name of `qaa0` used as the ARP server interface name. Any of the Classical IP interface names (`qaa0` through `qaa3`) could be used as the ARP server name.

5.3.3 Configuring a Host to be an ARP Server

Typically, you would define a host as an ARP server during the initial system installation and configuration. This is fully explained in Chapter 3.

5.3.4 Classical IP Operation

Once a host knows its own ATM address and the ATM address of its ARP server it will attempt to establish a connection to the ARP server, which will be used to send ARP requests and receive ARP replies. When the connection to the ARP server has been established, the ARP server sends an inverse ARP (InARP) request on the new VC to learn the host's IP address. When an InARP reply is received, the ARP server places that host's IP address to ATM address mapping in its ARP cache. Therefore, over time, the ARP server dynamically learns the IP to ATM address mappings of all the hosts in its LIS. It can then respond to ARP requests directed toward it for hosts in its LIS.

NOTE: In order for a host to communicate with an ARP server, it must have learned its own ATM address and have been configured with the ATM address of the ARP server.

A host will not be able to resolve the ATM addresses of hosts in its LIS unless it can communicate with its ARP server.

Since there is no mechanism for ARP servers to exchange mapping information with each other, it is imperative that each LIS be configured with only one ARP server.

When a host wants to communicate with another host in its LIS, it first sends an ARP request to the ARP server containing the IP address to be resolved. When an ARP reply is received from the ARP server, the host creates an entry in its ARP cache for the given IP address and stores the IP to ATM address mapping. This ARP cache entry will be marked as complete. To ensure that all of the IP to ATM address mappings known by a certain host are up-to-date, hosts are required to age their ARP entries. Every 15 minutes (20 minutes on the ARP server), a host must validate its ARP entries. Any ARP entries not associated with open connections are immediately removed.

A host validates its SVCs by sending an ARP request to the ARP server. A host validates its PVCs, and an ARP server validates its SVCs, by sending an InARP request on the VC. If a reply is not received, the ARP entry is marked invalid. Once an ARP entry is marked invalid, an attempt is made to revalidate it before transmitting. Transmission will proceed only when validation succeeds. If a VC associated with an invalid ARP entry is closed, the entry is removed.

5.3.5 Operational Issues

Certain hosts in an LIS may not support Classical ARP. It is still possible to communicate with these hosts (and for these hosts to communicate themselves) by using static ARP entries. If a host does not support Classical ARP, its IP to ATM address mapping should be placed in its ARP server's cache as a static entry. This allows other hosts that do support Classical ARP to contact their ARP server as usual and obtain the correct address mapping. If a host that does not support Classical ARP wants to initiate connections, the IP to ATM address mappings of the destination hosts should be put in its ARP cache, again as static entries. By using static ARP entries in the above fashion, the ability for all hosts to communicate can be maintained.

There are some restrictions on the number of hosts that can be maintained dynamically. They are as follows:

- In the default configuration, a host can only have approximately 250 virtual connections open simultaneously. This means that an ARP server can only serve 250 clients, since each client must maintain a connection with its ARP server. This may be a limitation if the ARP server is servicing multiple LISs.
- It is possible to increase the number of connections allowed by using the AMI program (see the *ForeRunner ATM Switch Configuration Manual*).
- Hosts support a maximum of 1,024 connections per adapter.

5.4 Classical IP PVCs

5.4.1 Theory and Configuration

Normally, ATM connections in a Classical IP environment are established dynamically using UNI 3.0. ARP, ILMI, and UNI 3.0 all work together as described previously to set up an SVC. If a host from another vendor does not support Classical ARP or ILMI, it is still possible to setup an SVC using work-arounds. If a host or switch in an LIS does not support UNI 3.0, however, it is not possible to establish an SVC. In this case, a Classical IP PVC can be used for communication.

On each of the hosts, `atmarp -c` is used to establish the PVC. An unused VPI/VCI pair must be chosen for each host. PVCs using the chosen VPI/VCI pairs must also be setup from each of the hosts to their connecting switch, and then on all of the switches between the two connecting switches.

NOTE: Both the incoming and outgoing connections are set up simultaneously on the host, but they must be set up individually on the switches. The same VPI/VCI pair is used by a host to send on the PVC as well as receive on the PVC. The IP datagrams are sent over the PVC using AAL5 with LLC/SNAP encapsulation.

5.4.2 Revalidation and Removal

Normally, the device driver periodically checks that its PVCs are still established and functioning. A host revalidates a PVC every 15 minutes by sending InARP requests over the PVC, if the user specifies that revalidation should occur by choosing 1 as the revalidate option to `atmarp -c`. If non-FORE equipment supports revalidation, the same command, `atmarp -c` and the revalidate option of 1 must be used. If an InARP reply is not received, the revalidation fails, the PVC is marked invalid (as shown through `atmarp -a`), and communication over the PVC is no longer possible.

Once a PVC is marked invalid, an attempt is made to validate the PVC before transmitting. Transmission will proceed only when validation succeeds. It is possible to disable this revalidation feature by specifying 0 as the revalidate option to `atmarp -c`. This is often desirable when the remote end of the PVC (such as a video camera) does not support InARP.

A Classical IP PVC is removed on the host side using `atmarp -r`. Both the incoming and outgoing connections are removed simultaneously. The PVC must then be removed from each of the network switches involved.

5.5 Debugging

The atmarp utility on the host provides a number of useful options to aid communication debugging. Some of this information can also be displayed on the switch using various AMI commands. If an equivalent AMI command is available, it will be listed here.

- On the host, atmarp -a shows the IP address of the entry, the associated ATM address if the mapping is known, the VPI/VCI pair for an established connection, and various flags. The "Classical IP" flag indicates connections using Classical IP over UNI 3.0. Two other flags are especially important for connection state: "incomplete" indicates that the IP to ATM address mapping is not yet known for the given IP address; "pending" indicates that a connection has not yet been established. On the switch, AMI command configuration atmarp show provides the same information.
- On the host, atmarp -z displays the ATM address of the given interface. If the host is using ILMI for address registration, the ATM address will be displayed as nonzero when the host has successfully registered its address with the network. On the switch, AMI command configuration atmarp getnsap interface provides the same information.
- On the host, atmarp -g displays the ATM address of the current ARP server for the LIS associated with the given interface. On the switch, AMI command configuration atmarp arpserver show interface provides the same information.
- On the host, atmarp -t indicates whether this host is the ARP server for the LIS associated with the given virtual interface. On the switch, AMI command configuration atmarp arpserver show interface provides the same information.
- On the host, atmarp -v displays the status of the ARP server connection. One of the first things to check in a trouble state is that a connection to the ARP server is fully established. If the ARP server connection is established, the ARP VPI/VCI will be nonzero. The CALLING_SERVER flag indicates whether or not an attempt is currently being made to connect to the ARP server. The retry count indicates the number of attempts to connect to the ARP server which have been unsuccessful since the last successful attempt. The InARP count indicates the number of InARP requests that have been sent on the ARP server connection without a response.

5.6 Configuring the Network

In an ATM network, before any connections can be made, the two parties must know each other's ATM address in order to set up that connection.

To allow those connections to work, the ideal scenario is for all hosts and switches in the network to have support for both ILMI and for RFC-1577 (Classical IP over ATM). However, when using non-FORE equipment, this may not be the case. This section will describe how to configure a network with the following scenarios:

- Configuring a third-party host that has no ILMI or RFC-1577 support
- Configuring a third-party switch that has ILMI support
- Configuring a third-party switch that has no ILMI support, but has RFC-1577 support

5.6.1 Third-Party Host with No ILMI and No RFC-1577 Support

In establishing this configuration, the third party equipment must support UNI 3.0 and have LLC/SNAP encapsulation. To configure a network with a third-party vendor's host (or an edge device) that does not support ILMI or RFC-1577 (as shown in Figure 5.1), perform the following steps:

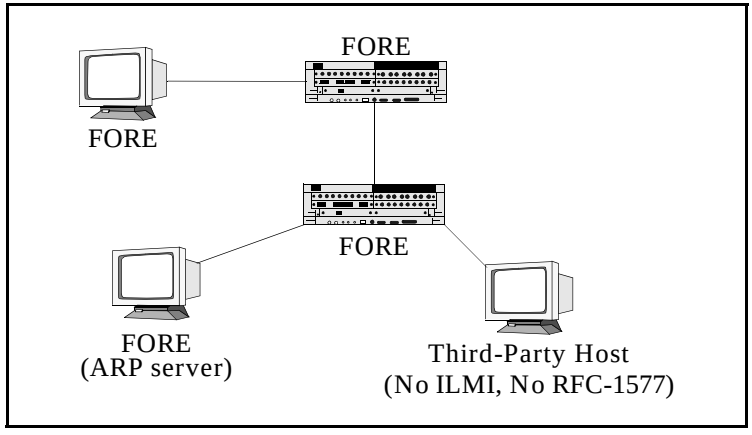


Figure 5.1 - Configuring a Third-Party Host with No ILMI and No RFC-1577 Support

1. Before you begin this process, you must have already installed software on the FORE host which is the ARP server. FORE software must also be installed and running on the other FORE equipment.
2. Using the configuration software of the third-party host, assign an ATM address with the same prefix as its switch.
3. Configure the switch so that it has a static route to the third-party host using the following AMI command:

configuration nsap route new <NSAP> <mask> -port <port> -vpi <vpi>

   Be sure to use a mask value of 152.

4. Configure the ARP server with a static IP to ATM mapping for the third-party host.

5.6.2 Third-Party Switch with ILMI Support

To configure a network with a third-party vendor's switch that supports ILMI, (as shown in Figure 5.2), perform the following steps:

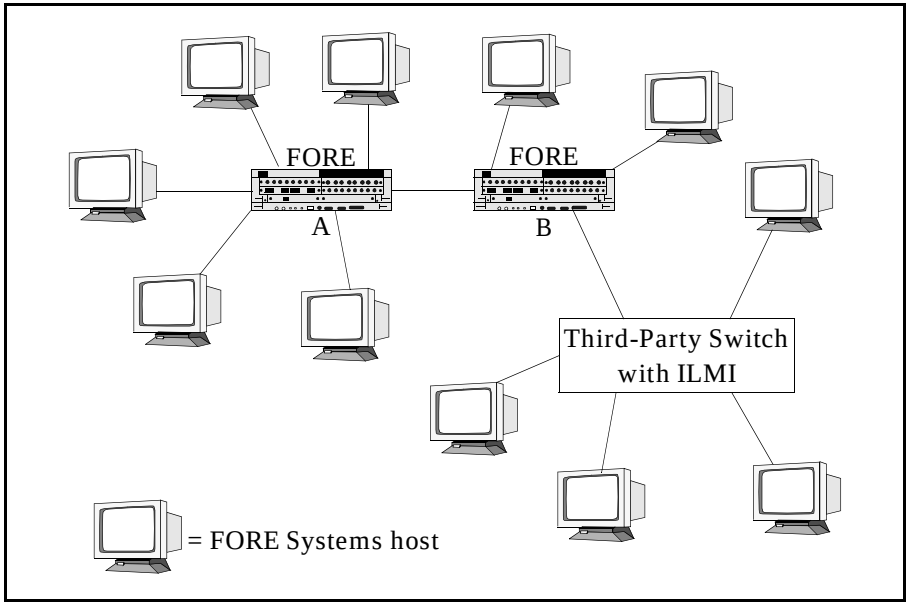


Figure 5.2 - Configuring a Third-Party Switch with ILMI Support

1. This process assumes that FORE software has been installed on all hosts and that ILMI was set in the installation process. ILMI dynamically performs address registration for all of the hosts.
2. Refer to the *ForeRunner* ATM Switch Configuration manual for procedures to configure the following:
    a. Configure a static ATM route on FORE switch "B" to the third-party switch.
    b. Configure IISP on FORE switch "B."

    Be sure to use a mask value of 104.
3. 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.

5.6.3 Third-Party Switch with RFC-1577 and No ILMI Support

To configure a network with a third-party vendor's switch that does not support ILMI, but does support RFC-1577 (as shown in Figure 5.3), perform the following steps:

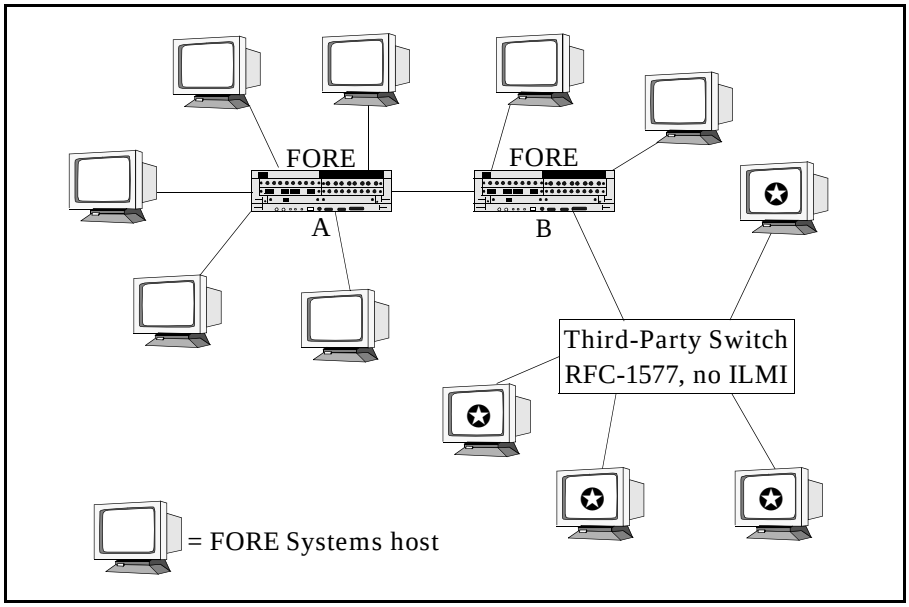


Figure 5.3 - Configuring a Third-Party Switch with RFC-1577 and No ILMI Support

1. This process assumes that FORE software has been installed on all hosts and that ILMI was set in the installation process. ILMI dynamically performs address registration for all of the FORE hosts and switches.
2. Statically configure the ✪ hosts with ATM addresses, using the same switch prefix for all of the hosts.
3. Configure a static ATM route on FORE switch "B" to the third-party switch using the following AMI command:

configuration nsap route new <NSAP> <mask> -port <port> -vpi <vpi>

Be sure to use a mask value of 104. Also, be sure to use the same prefix that was used to configure the hosts.

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.

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.

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 4.0.2* 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.

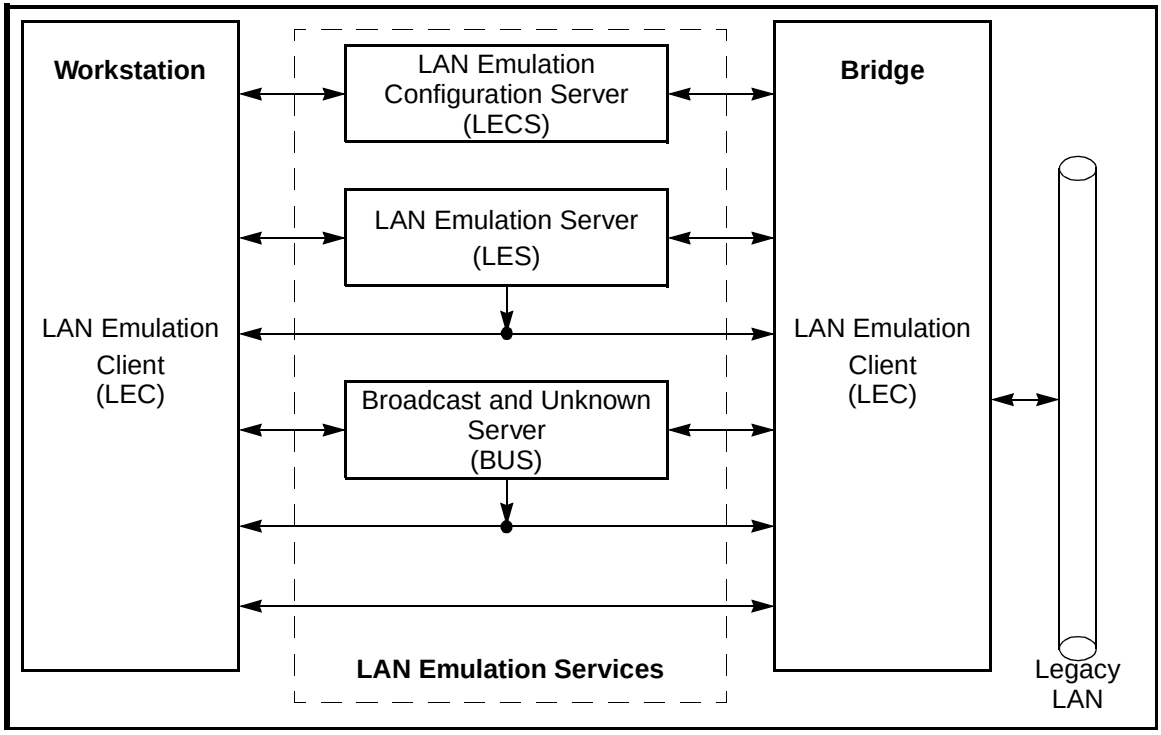


Figure 6.1 - Basic Emulated LAN Interconnections

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 4.0.2* 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 4.0.2*, 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 4.0.2* also supports the use of "intelligent" BUSs that allow the BUS to use the LES's registration table to direct unicast traffic.

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.

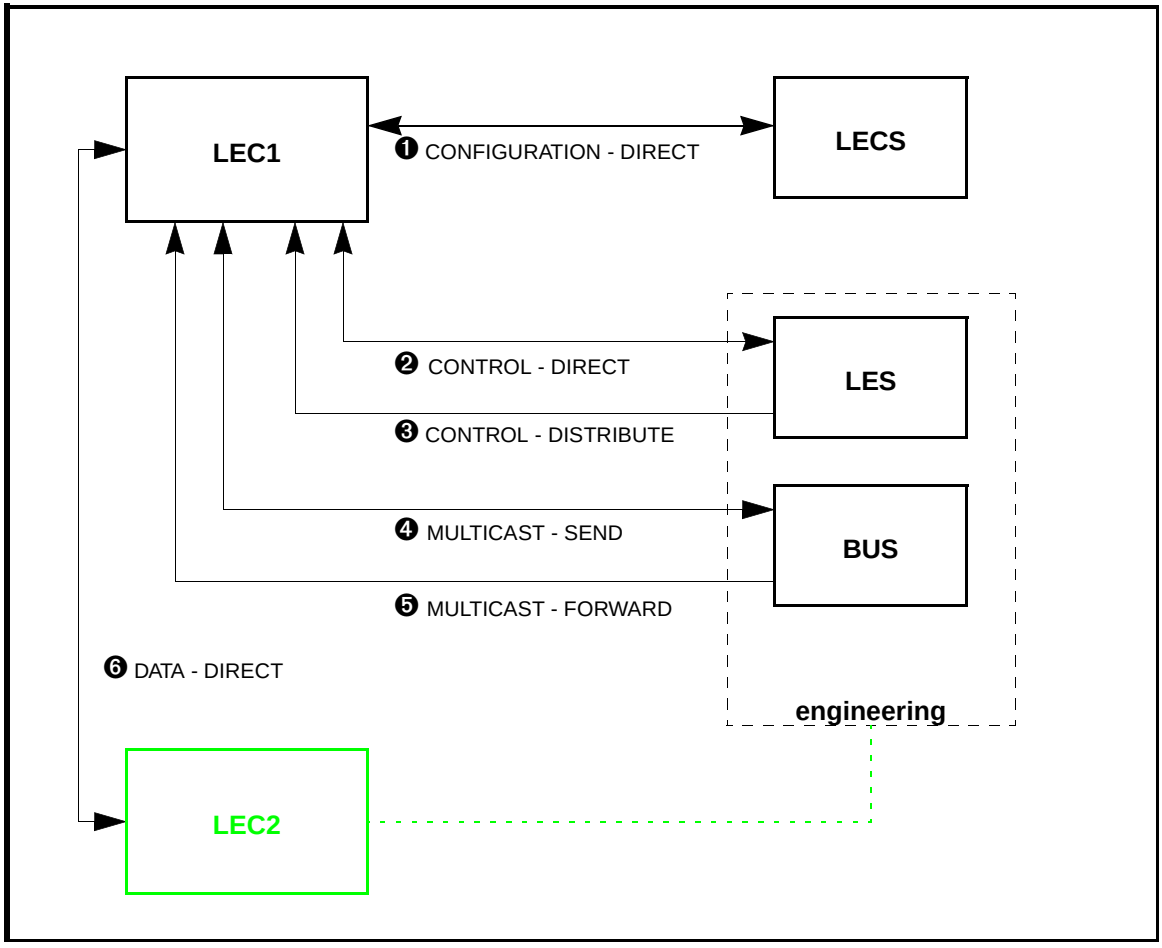


Figure 6.2 - ELAN Operation

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.

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.

6.4 Configuring a LEC

Currently, only local LAN Emulation Clients may be configured on hosts running under Digital UNIX. 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

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.

Execute the configure_lanem script as follows:

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

   /usr/fore/etc/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.

```
=========================================================================
                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 appears if you have configured LECs.

```
=========================================================================
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 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).

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 does not appear if you answer n.

```
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 are then 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
======================================================================

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.

6.4.1.2 Administering LECs using the elconfig Command

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).

NOTE: Due to system limitations, the elconfig add command may be issued no more than 200 times per boot lifetime. Exceeding this limit will produce the following message:
elconfig: Number of allowable ELAN/ interface adds exceeded.

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 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.

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.

LEC Failover

An added feature of *ForeThought 4.0.2* 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 , 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.

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.

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*>

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.

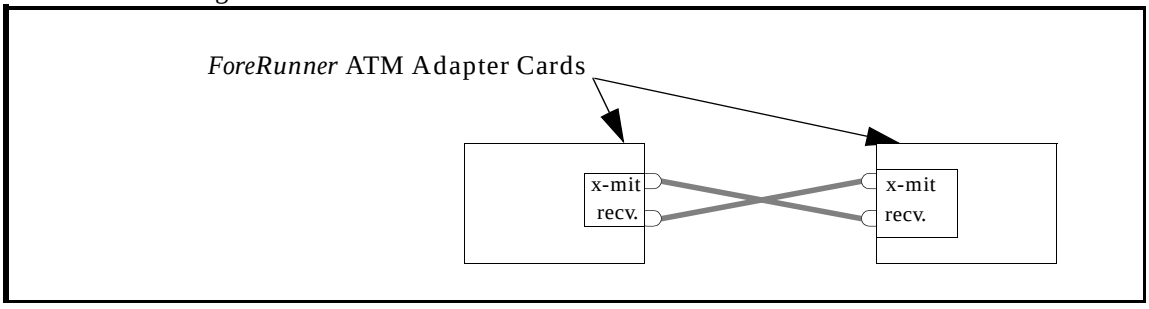


Figure 7.1 - Back-to-Back Configuration with SPANS Signalling

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.

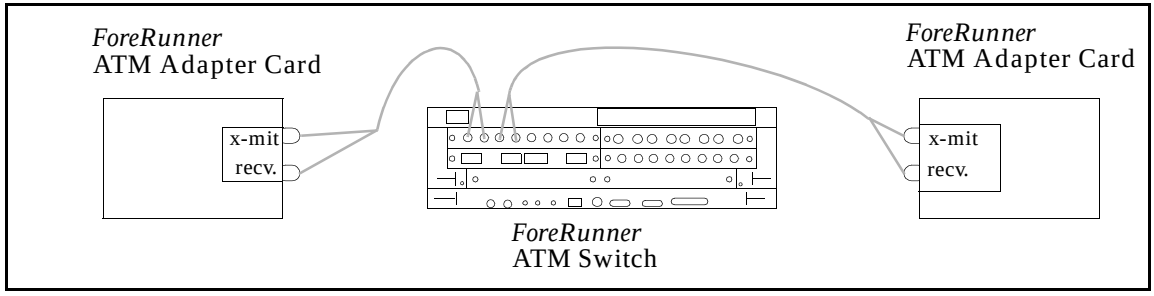


Figure 7.2 - Minimum Configuration with UNI 3.0 Signalling

7.3 Adapter-to-Other Vendor's Equipment 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.

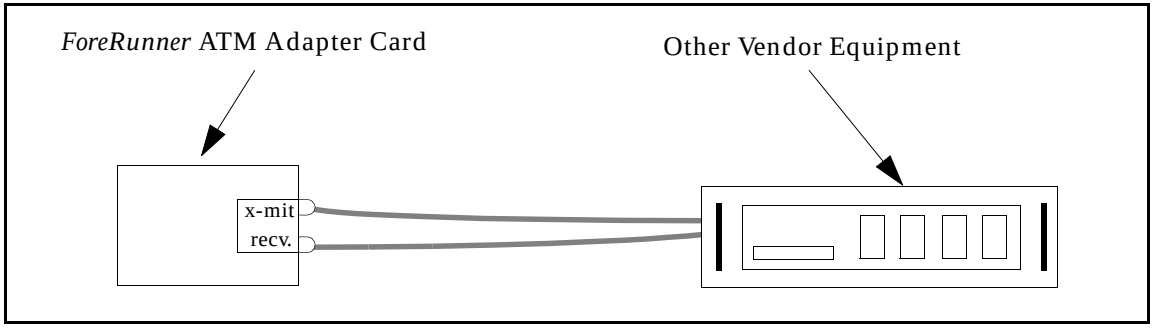


Figure 7.3 - Adapter-to-Other Vendor Configuration

CHAPTER 8 Additional Administration Information

8.1 Additional Software and Manual Pages

This *ForeRunner* PCA-200E 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 /usr/fore/etc directory to the PATH environment variable, the /usr/fore/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.

8.2 PCA-200E Administrative Programs

The following *ForeRunner* PCA-200E 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 PCA-200E 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 PCA-200E 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 PCA-200E.

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).

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.

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:

Release Date:

SEE ALSO

arp(8C)

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.

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:

Release Date:

SEE ALSO

ifconfig(8C)

CHAPTER 9 Software Interfaces

9.1 Berkeley Socket Interface

The PCA-200E 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.

9.2 Application Programming Interface

The PCA-200E device driver also supports FORE Systems' user-level ATM API (Application Programming Interface). The API 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 man page. Consult the ATM API man pages located in Section 4 of the on-line manual for more information.

9.2.1 Concurrent Server Model for the API

FORE's ATM API supports both the concurrent server model and 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 listening file descriptor and the accepting file descriptor arguments to atm_accept may, but need not, be different. To implement a concurrent server, once a call to atm_listen returns, the server should obtain a new file descriptor from atm_open to use 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 and atm_send family of functions within the new process should use the new accepting descriptor.

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 19. 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).

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.

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.

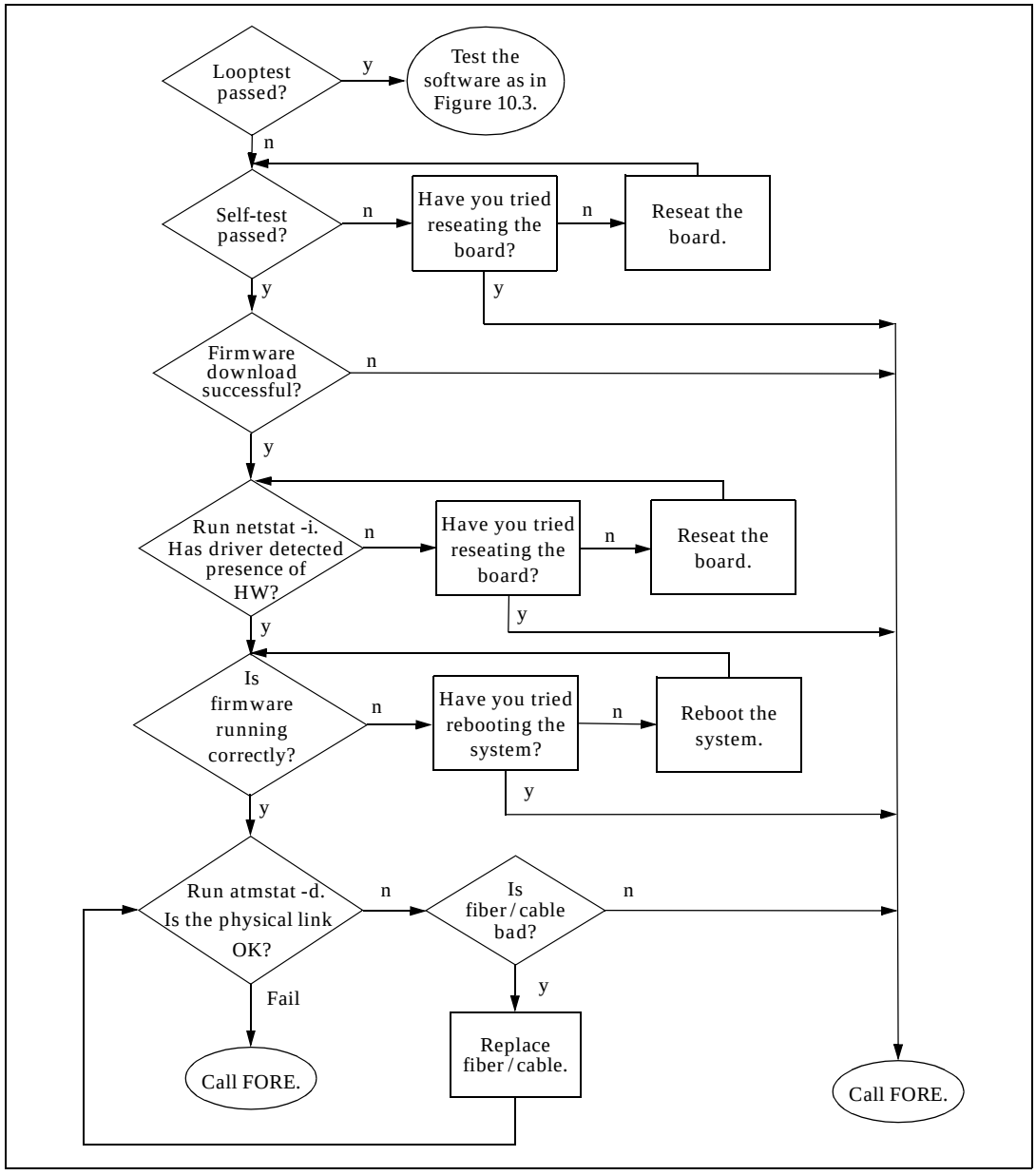


Figure 10.1 - Adapter Hardware Troubleshooting Flowchart

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.

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.

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.

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.

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.

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.

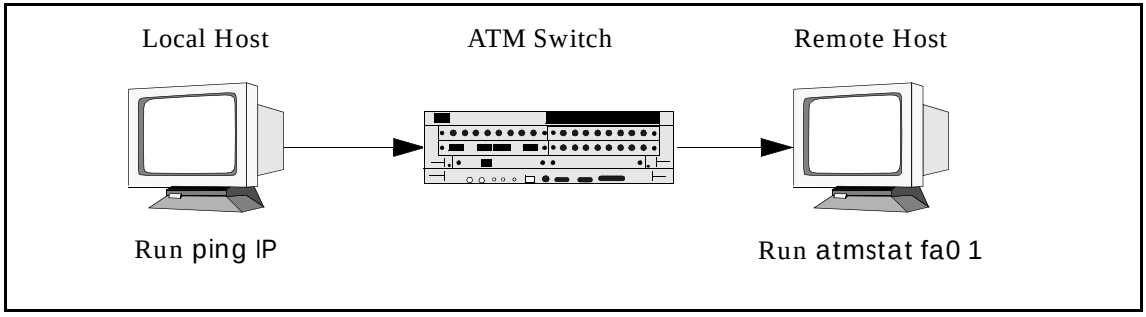


Figure 10.2 - Hardware Configuration for Checking PVCs

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.

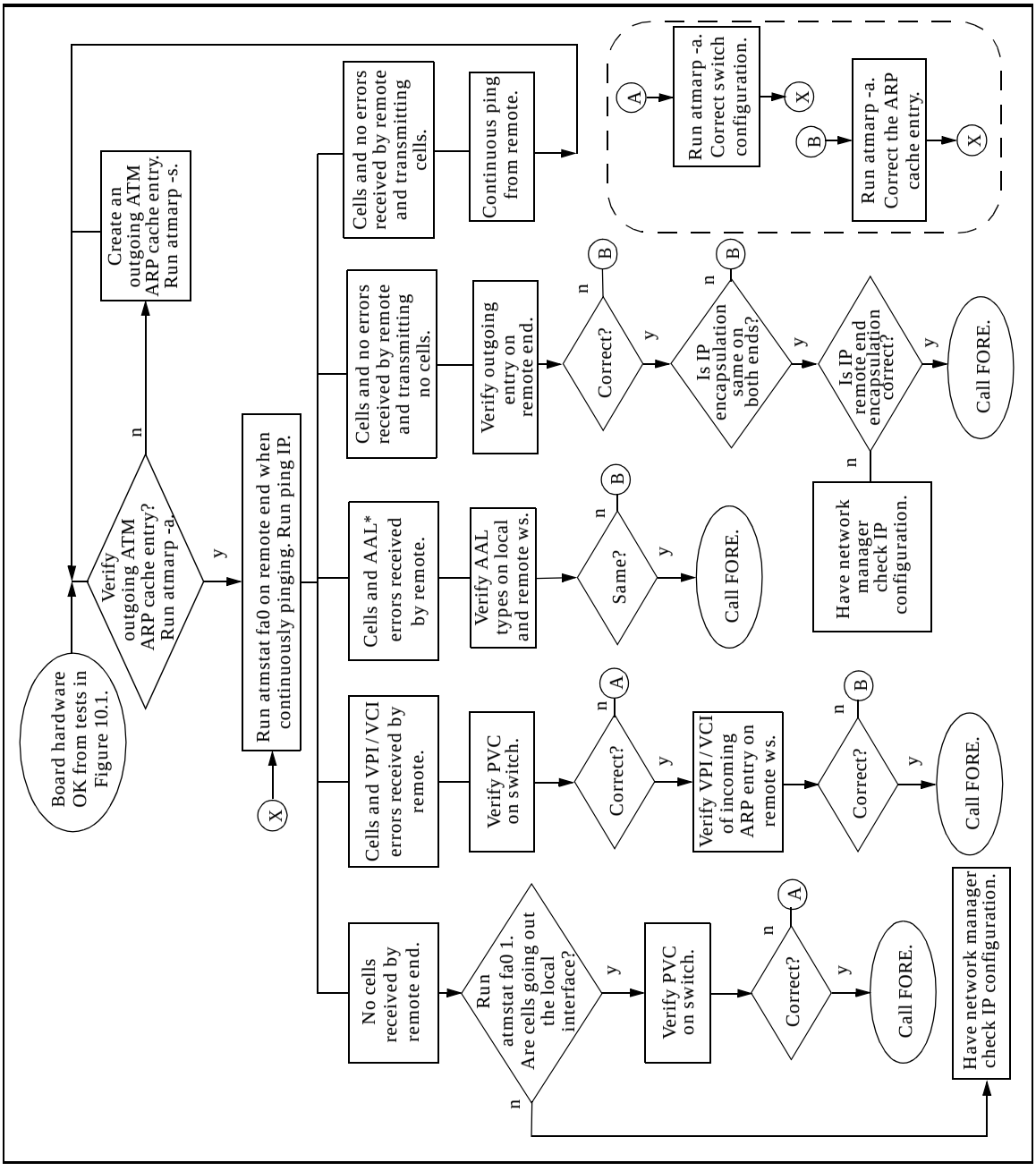


Figure 10.3 - Networking Connectivity Using PVCs

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 *ForeRunner* ATM 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>

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.

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.

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.

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.

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

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 the syslog file to see if ILMI has registered the ATM address with the switch)
   - If not running, reinstall the software OR call FORE Technical Support.
2. Enter the command `atmstat fa0` and observe the 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.

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

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

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

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

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

4. If services are UP, check the 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 the 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 the elconfig output. Make sure that the LES is running if vpi.vci is not assigned.

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

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

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

   Make sure that the 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.

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.

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

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
```

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_4.0.2
fa0: pca-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
```

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

On the switch, log in to the ATM Management Interface (AMI) 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
```

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
```

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  State Type   CDVT  Action RemoteAddress
1C1     0  down  uni     250  tag
1C2     0  down  uni     250  tag
1C3     0  down  uni     250  tag
1C4     0  up    uni     250  tag    169.144.60.108
1D1     0  down  uni     250  tag
1D2     0  down  uni     250  tag
1D3     0  down  uni     250  tag
1D4     0  down  uni     250  tag
1CTL    0  up    uni       0  tag    10.10.10.48
```

configuration spans show advanced

```
Port  VPI SigVCI CLSVCI AAL MinVCI MaxVCI SigBW CLSUPC
1C1     0     15     14   4     32    511     0      0
1C2     0     15     14   4     32    511     0      0
1C3     0     15     14   4     32    511     0      0
1C4     0     15     14   4     32    511     0      0
1D1     0     15     14   4     32    511     0      0
1D2     0     15     14   4     32    511     0      0
1D3     0     15     14   4     32    511     0      0
1D4     0     15     14   4     32    511     0      0
1CTL    0     15     14   4     32    511     0      0
```

configuration port show

```
Port Carrier   Mb/s iVPs iVCs    iBW oVPs oVCs    oBw Model
1C1  no       155.0    1    4  155.0    1    4  155.0 OC3
1C2  no       155.0    1    4  155.0    1    4  155.0 OC3
1C3  no       155.0    1    4  155.0    1    4  155.0 OC3
1C4  yes      155.0    1    4  155.0    1    4  155.0 OC3
1D1  no       155.0    1    2  155.0    1    3    0.0 OC3
1D2  no       155.0    1    5  155.0    1    4  155.0 OC3
1D3  no       155.0    1    4  155.0    1    4  155.0 OC3
1D4  no       155.0    1    4  155.0    1    4  155.0 OC3
1CTL yes       80.0    1   28    0.0    1   36    0.0 ASX
```

configuration port show advanced

```
Port   CDVT  Policing VBROB BuffOB
1C1     250  enabled    100    100
1C2     250  enabled    100    100
1C3     250  enabled    100    100
1C4     250  enabled    100    100
1D1     250  enabled    100    100
1D2     250  enabled    100    100
1D3     250  enabled    100    100
1D4     250  enabled    100    100
1CTL   5000  enabled    100    100
```

configuration uni30 show

```
Port  VPI  State ILMI   UNIside  Type  OperType   RemoteAddress
1C1     0  down  down   network  auto  privateUNI
1C2     0  down  down   network  auto  privateUNI
1C3     0  down  down   network  auto  privateUNI
1C4     0  down  up     network  auto  privateUNI 169.144.64.108
1D2     0  down  down   network  auto  privateUNI
1D3     0  down  down   network  auto  privateUNI
1D4     0  down  down   network  auto  privateUNI
1CTL    0  up    down   network  auto  privateUNI
```

configuration uni30 show advanced

```
Port  VPI SigVCI ILMIVCI SigAAL MinVCI MaxVCI SigBW ILMIBW
1C1     0      5      16      5     32    511     0      0
1C2     0      5      16      5     32    511     0      0
1C3     0      5      16      5     32    511     0      0
1C4     0      5      16      5     32    511     0      0
1D2     0      5      16      5     32    511     0      0
1D3     0      5      16      5     32    511     0      0
1D4     0      5      16      5     32    511     0      0
1CTL    0      5      16      5     32    511     0      0
```

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         8192  C       none       NM-C-TAXI-100-ST-128KB-6PT
1A2  no         down       8192  C       none       NM-C-TAXI-100-ST-128KB-6PT
1A3  no         down       8192  C       none       NM-C-TAXI-100-ST-128KB-6PT
1A4  no         down       8192  C       none       NM-C-TAXI-100-ST-128KB-6PT
1A5  no         down       8192  C       none       NM-C-TAXI-100-ST-128KB-6PT
1A6  yes        up         8192  C       none       NM-C-TAXI-100-ST-128KB-6PT
```

configuration port ds3 show

```
Port Carrier Status Mode Framing Loopback ClockSrc Scrambling IdleCells Length
1A1  no      0x80   hcs  cbit    diag     internal off        unassigned Gt225
1A2  no      0x24   plcp cbit    none     internal off        unassigned Gt225
```

configuration port ds1 show

```
Port Carrier Status Mode  Framing  Loopback ClockSource  LineLength IdleCells
1C1  yes     0x1    plcp  ESF      none     internal     Lt110      unassigned
1C2  yes     0x1    plcp  ESF      none     internal     Lt110      unassigned
1C3  no      0x60   hcs   ESF      none     internal     Lt110      unassigned
1C4  no      0x60   hcs   ESF      none     internal     Lt110      unassigned
1C5  no      0x60   hcs   ESF      none     internal     Lt110      unassigned
1C6  no      0x60   hcs   ESF      none     internal     Lt110      unassigned
```

configuration port e1 show

```
Port Carrier Status  Mode  LineType Loopback ClockSource  LineLength IdleCells
1D1  yes     0x100   hcs   CRC      none     internal     Lt110      idle
1D2  yes     0x100   hcs   CRC      none     internal     Lt110      idle
```

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
1D3  no      0x88   hcs  none     internal     off        unassigned
1D4  no      0x88   hcs  none     internal     off        unassigned
```

configuration port sonet show

```
Port Width  Carrier Status Line Mode  Loopback ClockSource  Scramb. IdleCells
1A1  sts3c  no      0x2    SMM  sonet none     internal     on      unassigned
1A2  sts3c  no      0x2    SMM  sonet none     internal     on      unassigned
1A3  sts3c  yes     0x1    SMM  sonet none     internal     on      unassigned
1A4  sts3c  no      0x2    SMM  sonet none     internal     on      unassigned
```

configuration port tp25 show

```
Port Carrier Media Loopback RxTiming
1A1  no      UTP   none     Yes
1A2  no      UTP   none     Yes
1A3  no      UTP   none     Yes
1A4  no      UTP   none     Yes
1A5  no      UTP   none     Yes
1A6  no      UTP   none     Yes
1B1  yes     UTP   none     Yes
1B2  yes     UTP   none     Yes
1B3  no      UTP   none     Yes
1B4  yes     UTP   none     Yes
1B5  no      UTP   none     Yes
1B6  yes     UTP   none     Yes
```

configuration port j2 show

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

APPENDIX A PMD LED Indicators

This appendix shows the location of and gives a description of the PMD module LED indicators.

A.1 LED Location

The figures below show the appearance of the face plate.

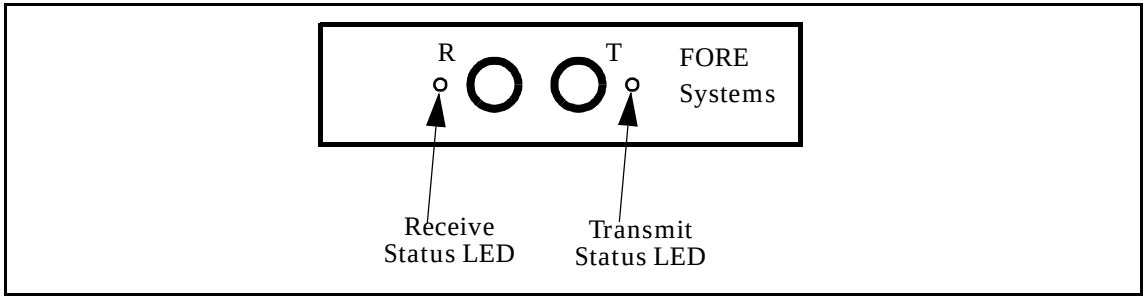


Figure A.1 - ST Connector Face Plate Configuration

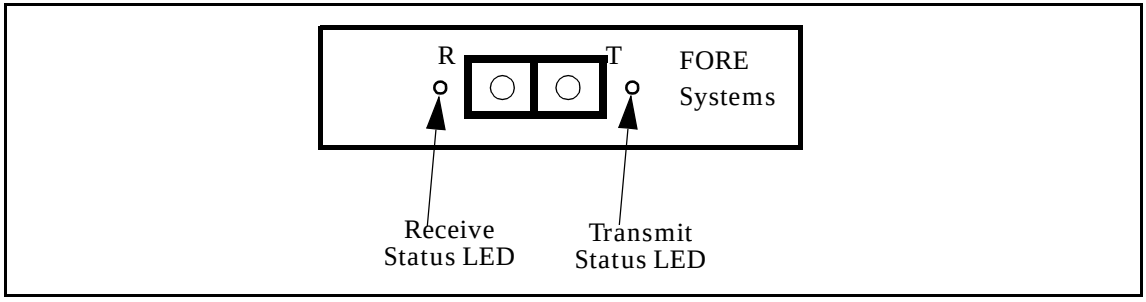


Figure A.2 - SC Connector Face Plate Configuration

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.2 - Receive LED

LED Color	Meaning
green	Receiving data
off	Idle
red	No carrier

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.

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.

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.

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.

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.

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.

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.

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.

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.

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.

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.

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).

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.

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.

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.

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.

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.

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.

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.

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.

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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