PowerHub 7000/8000 Installation and Maintenance Manual

MANU0166-02 - Rev. A - July 27, 1998

Software Version PH_FT 5.0.x

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- EN 50082-1 - "Electromagnetic compatibility - Generic immunity standard Part 1: Residential, commercial, and light industry."

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NOTICE: The Industry Canada label identifies certified equipment. This certification means that the equipment meets certain telecommunications network protective, operational and safety requirements. The Industry Canada label does not guarantee the equipment will operate to the user's satisfaction.

Before installing this equipment, users should ensure that it is permissible to be connected to the facilities of the local telecommunications company. The equipment must also be installed using an acceptable method of connection. In some cases, the company's inside wiring associated with a single line individual service may be extended by means of a certified connector assembly (telephone extension cord). The customer should be aware that compliance with the above conditions may not prevent degradation of service in some situations.

Repairs to certified equipment should be made by an authorized Canadian maintenance facility designated by the supplier. Any repairs or alterations made by the user to this equipment, or equipment malfunctions, may give the telecommunications company cause to request the user to disconnect the equipment.

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Caution: Users should not attempt to make such connections themselves, but should contact the appropriate electric inspection authority, or electrician, as appropriate.

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Preface

The intent of this manual is to supply users of the *PowerHub* 7000/8000 with all the necessary information to successfully install and maintain the PowerHub. If questions or problems with the installation arise, please contact FORE Systems Technical Support.

Chapter Summaries

Chapter 1 - Overview - Provides an overview of the physical characteristics of the PowerHub. The major functional components and the relationships between them are explained.

Chapter 2 - Chassis and Packet Engines - PowerHub chassis options and Packet Engines are discussed. How the Packet Engines process traffic through the *PowerHub* is also explained.

Chapter 3 - Quickstart - Provides basic quickstart information to assist in getting the PowerHub platform installed and operating.

Chapter 4 - Safety and Environmental Requirements - Precautions and environmental concerns when handling PowerHub components are explained. The hazards and problems that can occur are discussed.

Chapter 5 - Installation, Upgrade, and Removal Procedures - This chapter provides procedures to remove and install PowerHub components. The procedures include the removal and installation of components while the PowerHub is operating.

Chapter 6 - Boot PROM Commands - The PowerHub supports a series of boot PROM commands. These commands are available to the user in the event the PowerHub fails initial loading. The section describes these commands.

Chapter 7 - ATM Interfaces - Asynchronous Transfer Mode (ATM) interfaces used in PowerHub systems are discussed. The various types of ATM modules and adapters are explained in detail.

Chapter 8 - Ethernet Interfaces - Ethernet interfaces used in PowerHub systems are discussed. The various types of Ethernet modules and adapters are explained in detail.

Chapter 9 - FDDI Interfaces - Fiber Distributed Data Interface (FDDI) interfaces used in PowerHub systems are discussed. The various types of FDDI modules and adapters are explained in detail.

Appendix A - Pinouts - This appendix provides pinouts of the various interfaces found on the PowerHub, interface modules and media adapters.

Appendix B - Balancing Bandwidth - This appendix discusses how to configure load-balancing in both non-blocking and blocking configurations to improve the packet-forwarding capacity of PowerHub systems.

Acronyms - Lists common networking acronyms and their meanings.

Glossary - Contains descriptions of acronyms and terms used in the networking community and throughout this manual.

Related Documentation

The following manuals are referenced throughout this manual. These manuals, including this manual, comprise the *PowerHub* 7000 / 8000 Reference Manual set.

- *PowerHub 7000/8000 Release Notes*, MANU0254-05, June 1, 1998
- *PowerHub 7000/8000 Software Reference Manual*, MANU0167-02, June 1, 1998
- *PowerHub 7000/8000 Filters Reference Manual*, MANU0168-02, June 1, 1998
- *PowerHub 7000/8000 Protocols Reference Manual*, MANU271-02, June 1, 1998

Technical Support

In the U.S.A., customers can reach FORE Systems' Technical Assistance Center (TAC) using any one of the following methods:

1. Select the "Support" link from FORE's World Wide Web page:

   http://www.fore.com/

2. Send questions, via e-mail, to:

   support@fore.com

3. Telephone questions to "support" at:

   800-671-FORE (3673) or **724-742-6999**

4. FAX questions to "support" at:

   724-742-7900

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+1 724-742-6999

No matter which method is used to reach FORE Support, customers should be ready to provide the following:

- A support contract ID number
- The serial number of each product in question
- All relevant information describing the problem or question.

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 the Enter or Return key is represented as <ENTER>. The following example demonstrates this convention:

cd /usr <ENTER>

Commands or file names that appear within the text of this manual are represented in the following style: “...the fore_install program installs this distribution”

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 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 damage to the operator, 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. 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.

Laser Warning

Class 1 Laser Product:
This product conforms to applicable requirements of 21 CFR 1040 at the date of manufacture.

Class 1 lasers are defined as products which do not permit human access to laser radiation in excess of the accessible limits for Class 1 for applicable wavelengths and durations. These lasers are safe under reasonably foreseeable conditions of operation.

The PowerHub ATM single-mode physical layer ATM Media Modules (AMAs) contain Class 1 lasers.

Safety Agency Compliance

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

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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.

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CAUTION

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WARNING!

FORE Systems products are designed to work with single-phase power systems having a grounded neutral conductor. To reduce the risk of electrical shock, do not plug FORE Systems products into any other type of power system. Contact your facilities manager or a qualified electrician if you are not sure what type of power is supplied to your building.

WARNING!

Your FORE Systems product is shipped with a grounding type (3-wire) power cord. To reduce the risk of electric shock, always plug the cord into a grounded power outlet.

Command Syntax

The following expressions are used in this manual when describing command syntax:

AaBbCcDd A term that is being defined. Example:

IP Helper is an enhancement to the **ip** subsystem that allows a system to be boot from a server separated from the boot client by a gateway.

AaBbCcDd A command name. PowerHub commands are case-sensitive; they should always be issued in lowercase. Example:

```
dir
```

| 1) Separates the full and terse forms of a command or argument:

- The full form is shown on the left of the **|**.
- The terse form is shown on the right of the **|**.

Example:

```
dir | ls
```

When the command or argument is entered, either the full form or terse form may be used. In this example, either **dir** or **ls** can be used.

2) Separates mutually exclusive command arguments. Example:

```
active-ama|aa cset p[rimary]|b[ackup] <slot>|all
```

In this example, the command **active-ama|aa** can accept either **active-ama** or **aa**, but not both.

[ ] Enclose optional command arguments or options. Example:

```
active-ama|aa [show] [linemode|lm] <slot>|all
```

In this example, the **[ ]** enclose optional arguments. The command can be issued without the argument(s) shown in **[ ]**. However, the argument must be one of the two options listed between the **[ ]**.

<*AaBbCcDd***>** Indicates a parameter for which a value is supplied by the operator. When used in command syntax, <*italics*> indicates the value to be supplied. Example:

savecfg <*filename***>**

In this example, <*filename*> is a parameter for which a value must be supplied with the command when issued.

AaBbCcDd Indicates a field or file name.

An example of a field name is when booting the software, the `login:` prompt is displayed.

A file name example is when booting the software, the system looks for a file name `cfg`.

AaBbCcDd or AaBbCcDd — Indicates text displayed by the software or input typed at the command prompt. To distinguish typed input from command output, the typed input is shown in bold typeface. Example:

```
22:PowerHub:system# bootinfo
Thu Aug 7 13:03:38 1997 start
Thu Aug 7 13:03:43 1997 nvram boot order: m
boot device: m
```

In this example, the user enters **`bootinfo`** and the software responds with

```
Thu Aug 7 13:03:38 1997 start
Thu Aug 7 13:03:43 1997 nvram boot order: m
boot device: m.
```

CHAPTER 1 Overview

This chapter provides an overview of the physical characteristics of the *PowerHub* 7000 / 8000, including the use of the terms “slot,” “port,” and “segment” as they apply to the PowerHub. The configuration and management features supported by the PowerHub systems are also introduced. Figure 1.1 shows a 5-slot PowerHub 7000. Refer to Section 1.1 for information on the available chassis sizes and configurations. This chapter provides information on the following subjects:

- PowerHub Chassis
- Chassis Features
- Intelligent Packet Switching
- Chassis Configuration
- Software Features

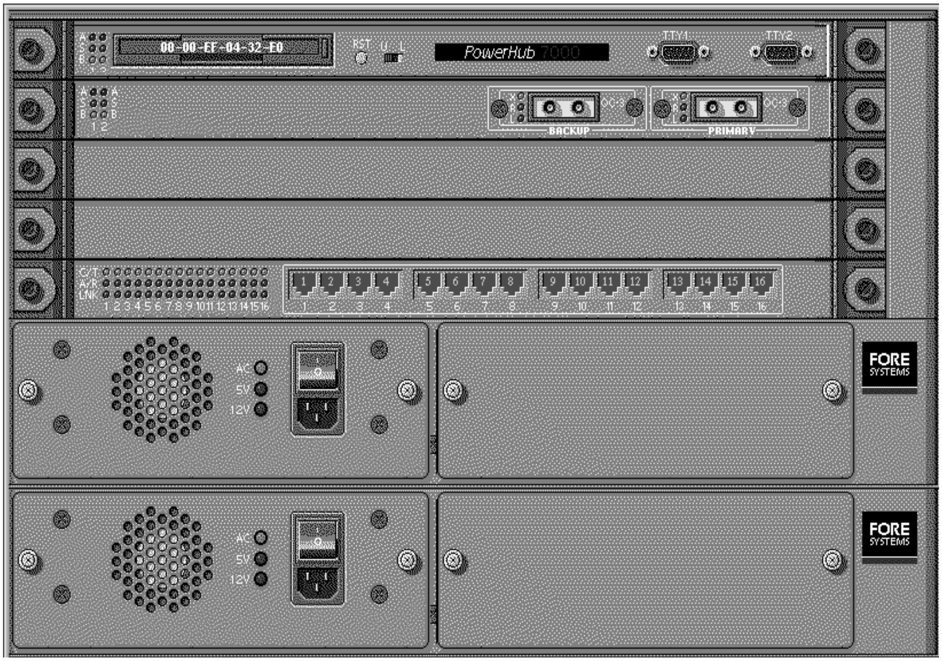


Figure 1.1 - *PowerHub* 7000

1.1 PowerHub Chassis

The PowerHubis available in several chassis sizes and are configurable with power modules and Network Interface Modules(NIMs). The following sections describe the different chassis configurations. Table 1.1 lists the available basic chassis configurations.

Table 1.1 - PowerHub Chassis Configurations

PowerHub System	Slots	Packet Channels	FDDI Concentrator Support
7000	5	2	No
	10	2	Yes
8000	5	2	No
	10	4	Yes
	15	4	Yes

1.1.1 PowerHub 7000

The PowerHub 7000 is available in either a 5-or 10-slot chassis, can contain up to four power modules and contains a two-channel backplane. The heart of the PowerHub 7000 is the Packet Engine 1(PE1). The PE1 supports the two packet-channel backplane in either the 5-or 10-slot chassis. The two-channel backplane supports 800Mb/s bandwidth per channel, providing a total throughput of up to 1.6 Gbp/s. For more information on the Packet-Channel Backplane, refer to Section 1.3.1. For more information on the PE1, refer to Section 1.3.2.

1.1.2 PowerHub 8000

The PowerHub 8000 is available in either a 10- or 15-slot chassis, can accommodate up to four power modules, and contains a four-channel backplane. The heart of the PowerHub 8000 is the Packet Engine 2 (PE2). The PE2 supports the four packet-channel backplane in either the 10- or 15-slot chassis. The four-channel backplane supports 800Mb/s bandwidth per channel providing a total throughput of up to 3.2 Gbp/s. The PowerHub 8000 also supports PE2 redundancy. For more information on the Packet-Channel Backplane, refer to Section 1.3.1. For more information on the PE2, refer to Section 1.3.3.

1.2 Chassis Features

The PowerHub chassis contains card slots in which the packet engine, either PE1 (7000) or PE2 (8000), and Network Interface Modules(NIMs) can be inserted to provide various physical network interfaces. Security features are provided to help protect the PowerHub from unwanted access and tampering. The sections below provide information on the following:

- How ports, slots, and segments are defined and numbered
- Modules (NIMS and media adapters)
- Security

1.2.1 Ports, Slots, and Segments

The term “segment” refers to a single 10 or 100 Mb/s Ethernet collision domain or 100 Mb/s FDDI token-passing domains. For example, each physical network connection on a NIM connects to an individual segment. The term segment also applies when a segment is operating in full-duplex mode. For example, although no collisions occur on an Ethernet segment operating in full-duplex mode, the 10 or 100 Mb/s Ethernet domain is still considered a segment.

Some PowerHub segments are *micro-segmented*; that is, they contain multiple physical connections to the same segment. Each of these connections is called a “port.” All ports on a given segment share the collision or token-passing domain of that segment. For example, the connections on a *micro-segmented* UTP segment are ports which share that segment’s collision domain. The A and B connectors on a single FDDI segment are each ports and provide connection to that segment’s token-passing domain.

The word “port” is also used to refer to the TTY (TTY1/TTY2) ports on the Packet Engine. However, these ports are clearly distinguishable from micro-segmented ports.

Figure 1.2 identifies the ports and segments in a PowerHub 7000 (10-slot, two packet-channel chassis). Note that not all the ports and segments on this chassis are labeled as such.

Virtual segments are created on the PowerCell ATM modules. Virtual segments are created when multiple ATM segments are assigned to a single ATM port. The PowerCell 700 ATM module can support up to 32 virtual segments on a single ATM port. Note that if a second port exists on the PowerCell module, it is a redundant port for failover use only and does not support additional segments or load/connection balancing.

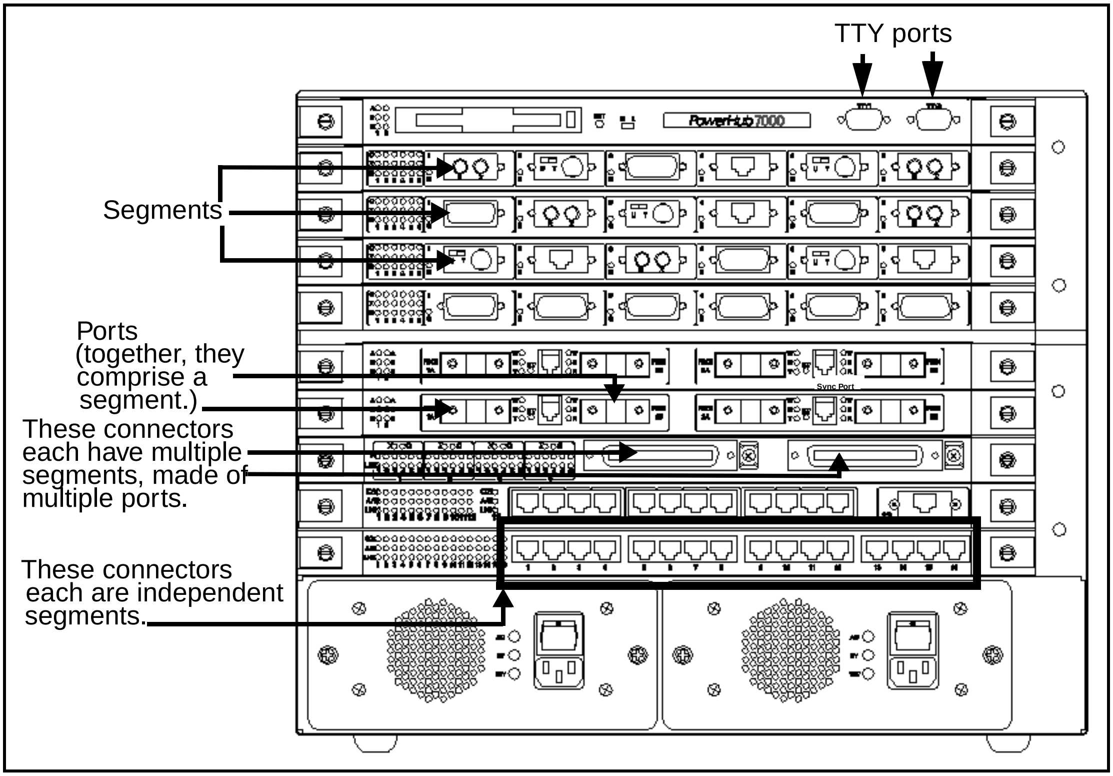


Figure 1.2 - Ports and Segments

As shown in Figure 1.2, some connectors attach to a single segment, some to a single port in a segment, while others attach to multiple segments that are micro-segmented into multiple ports. The connectivity provided by the connection depends upon the type of module or Media Adapter of the connection.

If the connection is an Ethernet or Fast Ethernet Media Adapter (EMA / FEMA), it is a one-segment connection. On a 4x4 Micro-segment Ethernet Module, for instance, there are four segments, each of which are connected to four ports, for a total of 16 ports. On a 4x6 Micro-segment Ethernet Module there are four segments, each of which are connected to six ports. Connections on FDDI modules are for one FDDI port each. Connections on a PowerCell 700 ATM Module are for one physical (PHY) port with up to 32 logical segments.

1.2.2 Card Slots and Segments

The card slots accommodate Network Interface Modules (NIMs). The number of slots in the chassis varies with the size chassis installed. Each slot in the chassis accommodates one module. The placement of the Packet Engine is determined by the PowerHub model and chassis size. Table 1.2 lists the packet engine locations of the PowerHub 7000 and 8000.

Table 1.2 - Packet Engine Location

PowerHub Model	Packet Engine Model	Chassis	Location
7000	PE1	5-slot	5
		10-slot	10
8000	PE2	5-slot	5
		10-slot	5
		15-slot	10

The remaining slots are for the installation of NIMs. The PowerHub can operate with empty NIM slots provided cover plates are installed over unused slots. Slots are numbered sequentially starting with slot 1 at the bottom. For more information on NIMs, refer to Section 1.4.2.

Segments are numbered according to the following rules:

- Segments are counted from the bottom slot up. Counting of segments begins with the first segment encountered by the software. Within a slot, segments are numbered from left to right. The PowerHub 7000 supports 96 segments while the PowerHub 8000 supports 128 segments.
- The chassis can be populated with NIMs that total more than the maximum number of supported segments. However, only the supported number of segments are recognized.
- The last supported segment can be in the “middle” of a module. A segment boundary need not occur on the last segment of a module.
- Filled and blank NIM slots may be combined in any form, but only installed segments are numbered. In other words, NIMs with 0 segments can be installed between slots with more than 0 segments.

NOTE

Placement of FDDI modules can make a difference in performance and in whether FDDI Concentrator modules can be managed. Refer to *Chapter 9, FDDI Interfaces* for more information.

The allocation of segments on each module can be changed with the **`nvram slotsegs[n] set`** command. For example, the allocation of segments on a 16x1 Ethernet NIM can be changed from the default of 16. Refer to the *PowerHub 7000/8000 Software Reference Manual* for detailed information on the **`nvram`** subsystem commands.

1.2.3 Security Features

The PowerHub contains both hardware and software levels of security. At the software level, filters for bridge, TCP, IP, IP RIP, AppleTalk, and IPX RIP and SAP packets can be created. Refer to the *PowerHub 7000/8000 Filters Reference Manual* for more information on applying filters. The following paragraphs describe the hardware level security features.

1.2.3.1 PowerHub 7000 Hardware Security

The PowerHub 7000 has two levels of hardware security. A Lock/Unlock switch, located on the PE1 front panel, and Lock/Unlock jumpers, located on the PE1 circuit board. When the Lock Switch is set to lock (L), a user must enter a valid login ID and password to execute commands that affect configuration settings. The position of the Lock/Unlock jumper setting overrides the front panel switch setting. Refer to *Chapter 2, Chassis and Packet Engines* for more information on the Lock/Unlock Switch and *Chapter 5, Installation, Upgrade, and Removal Procedures* for instructions on changing the Lock/Unlock Jumper.

1.2.3.2 PowerHub 8000

Hardware security on the PowerHub 8000 is available only through the Lock/Unlock switch located on the PE2 front panel. When the Lock Switch is set to lock (L), a user must enter a valid login ID and password to execute commands that affect configuration settings.

1.2.4 Displaying Chassis Configuration and Segment Numbers

Segment numbers can be displayed through the user interface (UI) by issuing the **`config`** command from the **`system`** subsystem (refer to the *PowerHub 7000/8000Software Reference Manual* for information on **`system`** subsystem commands). This command displays basic chassis configuration information, including:

- The amount of installed DRAM (in megabytes).
- Baud rates for the TTY ports (TTY1/TTY2).
- Slot containing the Packet Engine (PE)
- Presence and status of power modules (PMs).
- Number of segments present in each slot, and the medium type in use by each segment.

1.3 Intelligent Packet Switching

The PowerHub utilizes the Packet Engine to process packets traveling on configured segments. The Packet Engine is a centralized packet-processing and forwarding engine. When a packet is received on a segment, the packet is forwarded to the Packet Engine and placed in Shared Memory where it is examined and either dropped or forwarded as applicable.

NOTE

Segments are attached through NIMs. Under certain circumstances Intelligent Network Interface Modules (INIMs) can perform some packet processing that bypass the Packet Engine and enhance packet throughput. Refer to Section 1.4.2.1 for more information on INIMs.

1.3.1 Packet-Channel Backplane

The Packet-Channel Backplane contains either a two-channel backplane in the PowerHub 7000 or a four-channel backplane in the PowerHub 8000. Each channel of the backplane can handle data throughput up to 800Mb/s. The packet channels connect all installed interface modules directly with the packet engine. Refer to *Chapter 2, Chassis and Packet Engines* for detailed information on the Packet Channel Backplane.

1.3.2 Packet Engine 1 (PE1)

The Packet Engine 1(PE1) was the first-generation packet engine. The PE1 contains 2 CPUs that accesses the two-channel packet-channel backplane found in the PowerHub 7000. Refer to *Chapter 2, Chassis and Packet Engines* for detailed information on the PE1.

1.3.3 Packet Engine 2 (PE2)

The Packet Engine 2 (PE2) is the second-generation PowerHub packet engine. The PE2 contains 4 CPUs that access the four-channel backplane found in the PowerHub 8000. Additionally, the use of Remote Monitoring (RMON) tools is enhanced without the usual performance hit caused by the bandwidth requirements of RMON applications. Refer to *Chapter 2, Chassis and Packet Engines* for detailed information on the PE2.

1.3.3.1 PE2 Redundancy

PE2 redundancy is achieved when two PE2 modules are installed in a 10- or 15-slot PowerHub 8000. PE2 redundancy provides the PowerHub 8000 with a secondary packet engine. This secondary packet engine takes over control of the PowerHub in the event of a failure of the primary packet engine. Refer to *Chapter 3, Quickstart* for a more detailed discussion on PE2 redundancy.

1.4 Chassis Configuration

The PowerHub chassis is designed for easy re-configuration in response to networking needs. Upgrades can be performed using a few standard tools (usually ordinary screwdrivers). Network downtime is minimal while performing the upgrades.

The chassis is configured by adding NIMs, power modules, and various other performance-enhancing options. NIMs provide the interfaces to the PowerHub. The NIMs are connected to the PE by the Packet Channel Backplane. Packets and control data sent between the PE and NIMs pass through this backplane. Power modules provide load sharing and redundancy.

1.4.1 PE1 Performance Enhancing Options

Performance of the PowerHub 7000 can be enhanced in several ways. These enhancements can increase the packet-processing speed of the PE1, increase protocol support, and add redundancy to the system in case of component failure. Depending upon network needs, one or more of the performance-enhancing options described below can be added *Chapter 5, Installation, Upgrade, and Removal Procedures* contains complete instructions for adding these hardware options.

NOTE

At this time there are no performance enhancing options available for the PowerHub 8000. The PowerHub 8000 ships with 32MB of DRAM memory and a 10MB Compact Flash Card.

1.4.1.1 Packet Accelerator Upgrade

Adding a Packet Accelerator to the PE1 increases the packets-per-second throughput by adding RISC CPUs to increase the processing power of the PE1. Refer to *Chapter 5, Installation, Upgrade, and Removal Procedures* for instructions for Packet Accelerator Installation.

1.4.1.2 Flash Memory Module Upgrade

The Flash Memory Module is very useful for fast system booting. It allows storing and local file management on the PE1. Refer to *Chapter 5, Installation, Upgrade, and Removal Procedures* for instructions for Flash Memory Module Upgrade.

1.4.2 Network Interface Modules

As connectivity needs change, interfaces can be added or changed by adding or changing NIMs. NIMs can be removed, swapped, and rearranged in the chassis. The basic types of NIMs supported are:

- Intelligent NIMs
- Universal NIMS
- Micro-segmented NIMS

Intelligent NIMs can enhance the overall throughput of the system and are discussed in Section 1.4.2.5. Intelligent NIMs include the PowerCell 700 ATM, FDDI and Fast Ethernet modules. On Universal NIMs, individual segment connectors can be changed by changing Media Adapters. For information about specific Universal NIMs, refer to the following:

- Universal Ethernet Module (UEM), see *Chapter 8, Ethernet Interfaces*.
- 6x1 Universal Fast Ethernet Module (6x1FE), see *Chapter 8, Ethernet Interfaces*.
- Universal FDDI modules, see *Chapter 9, FDDI Interfaces*.

Micro-segmented NIMs add functionality when configurations that do not require a full 10 Mb/s for each half-duplex network connection are desired. Two types of NIMs, the 4x4 and the 4x6, contain repeated UTP (10Base-T) ports. The 4x4 contains four segments, each of which is micro-segmented into four UTP ports. The 4x6 also contains four segments, but are micro-segmented into six ports each.

NOTE Ports are not the same as segments. Refer to Section 1.2.1 for information about how the terms “port” and “segment” are used in the PowerHub.

Each NIM contains physical connectors and on-board electronics to support Ethernet, FDDI, or ATM protocols. Any type of NIM can be installed in the PowerHub chassis, for an arrangement of ATM, Ethernet, Fast Ethernet, micro-segmented Ethernet, and FDDI segments that meet networking needs.

The PowerHub 8000 supports up to a total of 128 independent segments, depending on chassis and configuration. The PowerHub 7000 supports up to a total of 96 independent segments.

The PowerHub can be configured with up to six FDDI segments and any number of Ethernet or logical ATM segments as long as the number does not exceed the total number of supported segments. The system is designed to balance configuration flexibility and packet throughput. NIMs can be installed in any position in the chassis except the slot(s) reserved for the Packet Engine. However, if the chassis contains multiple FDDI or ATM modules, system performance can be optimized by installing them in specific NIM slots. (Refer to *Appendix B, Balancing Bandwidth* for detailed information on optimizing performance.)

The following section provides an overview of the various interface module types available. NIMs can be added, removed, or reconfigured in the chassis when necessary.

1.4.2.1 PowerCell 700 ATM Modules

The PowerCell 700 ATM module contains the ATM physical layer (PHY) and ATM Segmentation and Reassembly (SAR) layers.

The PowerCell 700 module can be installed in any slot except the slot(s) reserved for the Packet Engine. Up to four PowerCell 700 modules can be installed in a PowerHub chassis. Each PowerCell 700 can support up to 32 logical segments.

The PowerCell module contains the following hardware features:

- AAL5 support.
- Support for up to 155 Mb/s.
- Traffic and status LEDs.
- Optional Backup PHY (redundant) connection.
- Choice of DS-3, E-3, or UTP interfaces.
- Choice of single-mode or multimode fiber on the OC-3 interface.

Connections to the ATM network is made by attaching the PowerCell module to an ATM switch, which in turn is connected to the ATM network. The PowerCell module is interoperable with all FORE Systems' ATM switches. The PowerCell module can also be used with other vendors' ATM switches provided those switches conform to the ATM Forum standards that the PowerCell module supports. For example, other vendors' equipment must support the ATM Forum standards for LAN Emulation (LANE) version 1.0 and 2.0 and User-Network Interface (UNI) 3.0 or 3.1 if this equipment is to be used with the FORE Systems PowerCell module in a LANE 1.0 or 2.0 network.

1.4.2.2 FDDI Modules

FDDI modules are "intelligent" modules. Each module contains the FDDI Engine, which has hardware and firmware similar to the Packet Engine's. The FDDI Engine can locally filter packets, as well as make forwarding decisions for bridge, IP, and IPX packets. Moreover, for packets destined from one segment to the other on the same module, the FDDI Engine can locally bridge or route the packets. Table 1.3 provides descriptions of the available FDDI modules.

Table 1.3 - FDDI Modules

FDDI Module	Description
Single FDDI Module	Contains one FDDI segment, providing one A port and one B port for use with multimode fiber-optic cable. (See *Chapter 9, FDDI Interfaces*.)
Dual FDDI Module	Contains two FDDI segments, each providing one A port and one B port for use with multimode fiber-optic cable. (See *Chapter 9, FDDI Interfaces*.)
Universal Single FDDI Module	Contains one FDDI segment, configured for any combination of single-mode and multimode fiber-optic cable. Each port is configured using a FDDI Media Adapter (FMA), which is installed directly on the FDDI module. (See *Chapter 9, FDDI Interfaces*.)
Universal Dual FDDI Module	Contains two FDDI segments, configured for any combination of single-mode or multimode fiber-optic cable. Each port is configured using an FMA. (See *Chapter 9, FDDI Interfaces*.)
6-port Concentrator Module	Contains six MICs for repeating FDDI traffic within a FDDI ring. (See *Chapter 9, FDDI Interfaces*.)
16-port Concentrator Module	Contains 16 Twisted-Pair Physical Medium Dependent (TP-PMD) ports for repeating FDDI traffic within a FDDI ring. (See *Chapter 9, FDDI Interfaces*.)

NOTE

FDDI Concentrator modules can only be placed in slots 3 through 7 in a PowerHub 7000 10-slot chassis and slots 6 through 10 in a PowerHub 8000 10-slot chassis. On a PowerHub 8000 15-slot chassis, FDDI Concentrator modules can be placed in slots 3 through 7 and slots 11 through 15. The 5-slot chassis does not support FDDI Concentrators.

1.4.2.3 Fast Ethernet Modules

Fast Ethernet modules provide connections to high-performance workstations or to upstream hubs. The PowerHub supports Fast Ethernet segments using Fast Ethernet Modules. The PowerHub 7000 and 8000 use the same Fast Ethernet Modules. Table 1.4 provides descriptions of the available Fast Ethernet modules.

Table 1.4 - Fast Ethernet Modules

Fast Ethernet Module	Description
6x1 Universal FEMA	Provides six independent Fast Ethernet segments. The 6x1FE can contain up to six Fast Ethernet Media Adapters (FEMAs), in any combination of 100Base-TX, 100Base-FX, and 10/100 (auto-negotiating and auto-detecting). FEMAs can operate in half- or full-duplex mode.

1.4.2.4 Ethernet Modules

Ethernet NIMs are optional modules that can increase the number of Ethernet segment connections on the hub. Install NIMs in any slots except the slot(s) reserved for the Packet Engine. Table 1.5 provides descriptions of the available Ethernet modules.

Table 1.5 - Ethernet Modules

Ethernet Module	Description
6x1 Universal Ethernet Module (UEM)	Provides six slots for installation of Ethernet Media Adapters (EMAs). EMAs that can be installed on the UEM ar as follows: AUI (10Base-5), 10Base-FL (FOIRL-compatible), 10Base-FB, BNC (10Base-2), MAU (Media Access Unit), and 10Base-T (UTP).
10x1 10Base-FL	Provides 10 independent 10Base-FL segments. The connection for each segment is provided by multimode ST connectors). The segments can operate in half- or full-duplex mode.
13x1 Ethernet Module	Provides 12 independent 10Base-T segments and one 100Base-T segment. The connection for each is provided by an RJ-45 connector. For information on the 100Base connection see *Chapter 8, Ethernet Interfaces*. The segments can operate in half- or full-duplex mode.
16x1 Ethernet Module	Provides 16 independent 10Base-T segments. The connection for each is provided by an RJ-45 connector. The segments can operate in half- or full-duplex mode.

Table 1.5 - Ethernet Modules

Ethernet Module	Description
4x4 Micro-segment Ethernet	Provides four independent 10Base-T segments. Each segment has four repeated ports and connection to each port is provided by an RJ-45 connector.
4x6 Micro-segment Ethernet	Provides four independent 10Base-T segments. Each segment six repeated ports and connection to each port is provided by wires in a 50-pin Champ-style connector—so this means each segment is attached to the network by a Champ-style connector.

1.4.2.5 Intelligent Modules

Some NIMs, including Fast Ethernet, FDDI, and ATM NIMs, contain their own packet processing engines. These *intelligent NIMs* enhance the overall throughput of the system by locally bridging or forwarding traffic that normally travels to the Packet Engine for processing. Figure 1.3 shows an example of how traffic is forwarded in the Dual FDDI Module, one of the intelligent NIMs.

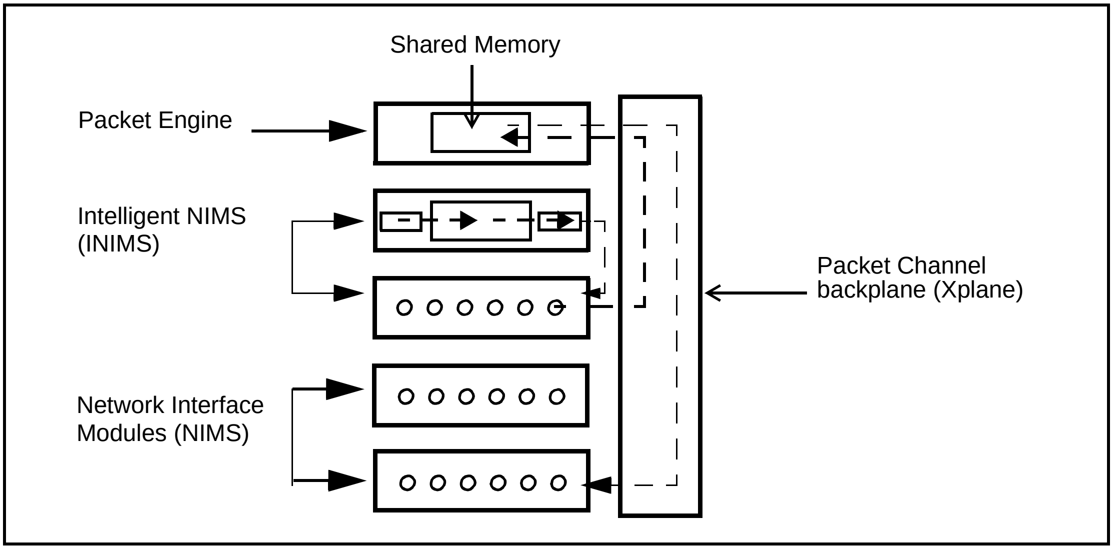


Figure 1.3 - Intelligent NIM Shared Memory Architecture

Figure 1.3 shows how traffic, received on one segment on an intelligent NIM that is bound for another segment on the same NIM, is forwarded directly to that segment, bypassing the Packet Engine. All packet processing takes place locally, on the NIM itself. Even packets destined to other NIMs have some pre-processing done to them in order for the packets to be forwarded more quickly by the Packet Engine. Note that this type of processing applies only to bridge, IP, and IPX traffic from one segment to another segment on the same module. The following modules for the PowerHub are considered intelligent modules:

- PowerCell 700 ATM Module. (See *Chapter 7, ATM Interfaces*.)
- FDDI modules. (See *Chapter 9, FDDI Interfaces*.)
- 6x1 Universal Fast Ethernet Module. (See *Chapter 8, Ethernet Interfaces*.)

1.4.2.6 Full Duplex Capability on Ethernet Segments

The PowerHub connections for 10Base-T, 10Base-FL, 100Base-FX and 100Base-TX segments can be configured to operate in full-duplex mode. Full-duplex mode doubles the maximum bandwidth on these segments. For the 10Base-T and 10Base-FL segments, whose theoretical maximum bandwidth is 10 Mb/s, full-duplex mode increases the maximum bandwidth to 20 Mb/s. For Fast Ethernet segments, full-duplex doubles the maximum bandwidth from 100 Mb/s to 200 Mb/s.

NOTE Ethernet segments running full duplex are not subject to collisions.

1.4.3 Power Sharing and Redundant Power Modules

The PowerHub supports load sharing and redundant power to ensure uninterrupted operation in the event that a power module fails. The PowerHub can be equipped with up to four power modules. The load is shared across the functioning power modules and redistributed if a power module fails. These two features increase the life span of the power modules and reduce the likelihood of power module failure.

Power modules are available in two AC versions (283 Watt and 500 Watt) and a 48-volt DC version. When redundant power modules are installed, NIMs can be “hot swapped,” allowing configuration changes while the system is operating. The 500 Watt power modules are for use in the 10- and 15-slot chassis. Refer to *Chapter 2*, *Chassis and Packet Engines* for more information on power modules.

1.4.4 Status LEDs

Packet Engine or intelligent NIM status information, as well as traffic information and connection status is displayed in LEDs located on each module.

Status LEDs indicate whether the module has experienced a failure, is performing normal runtime tasks, or is loading software. A "sticky" Alarm LED (the Packet Engine status LED remains lit) indicates that a crash has occurred. Refer to *Chapter 2, Chassis and Packet Engines* for further information on the PE status LEDs.

Traffic LEDS on NIMs indicate traffic flow for per segment. One LED per segment shows the link status of that segment. Other LEDs flash to indicate when packets are sent or received on the segment. In addition, collision LEDs on the Ethernet NIMs flash each time the module detects an Ethernet collision when the hub attempts to transmit on that segment.

The traffic LEDs on most of the Ethernet NIMs (except the Universal Ethernet Module), can be configured to show network activity and collisions, or send and receive traffic (but not collisions). For more information on the LEDS, refer to the appropriate NIM chapter.

1.5 Software Features

PowerHub software features are documented in the *PowerHub 7000/8000 Software Reference Manual*, *PowerHub 7000/8000 Protocols Software Reference Manual* and the *PowerHub 7000/8000 Filters Reference Manual***.** The following are short descriptions of some features with references to manuals that contain more complete information.

1.5.1 DOS-Like File Management System

The Floppy Disk (7000 only), Flash Memory Module (7000 only), and Compact Flash Card (8000 only) use a DOS-like file management system. Files created or stored on these devices can be edited using a standard ASCII editor on another device (PC, Macintosh, etc.). Note that the file management system does not support hierarchical directory structures.

1.5.2 Concurrent Command-Line Sessions

Concurrent command line sessions are supported. The primary command-line session is always established through a direct connection between a PC or modem and the RS-232 port labeled TTY1 on the packet engine. A second TTY port (TTY2) can be used to establish a second direct connection.

Additionally, up to two in-band TELNET sessions can be established with the command-line interface. To use TELNET, an IP interface is defined on the segment attaching the PowerHub to the terminal. For more information on command-line sessions, refer to *Chapter 3, Quickstart*.

1.5.3 Multiple Boot Sources

The PowerHub software can be loaded entirely from a floppy disk (7000 only), Flash Memory Module (7000 only), Compact Flash Card (8000 only) or from the network (netbooting). A combination of boot sources can be configured and saved in a **`bootdef`** file. After booting, the PowerHub can be configured using configuration and environment files.

- Compact Flash (8000 only)
- BOOTP / TFTP server

If possible, configure the PowerHub to attempt loading from any two or more of these sources in any order. If one method fails, the PowerHub attempts to load using one of the remaining methods. For example, in an installation containing many PowerHubs, they can be configured to boot over the network, as depicted in Figure 1.4. In such a configuration, all of the PowerHubs download and boot from the same system software, while each PowerHub's unique configuration file is downloaded from the server. The boot order is set using the **`nvram bo`** command. See *PowerHub 7000/8000 Software Reference Manual* for information on the **`nvram bo`** command.

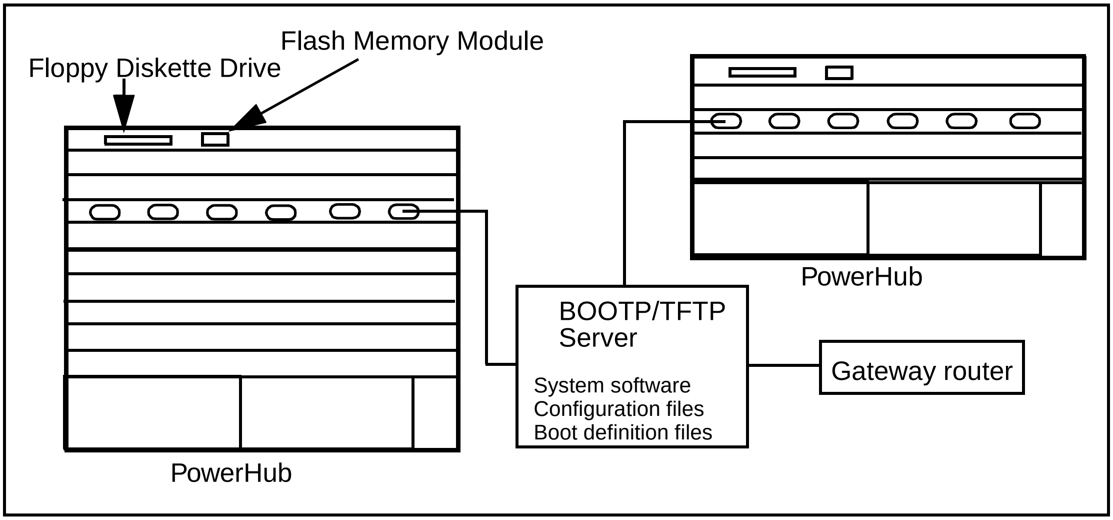


Figure 1.4 - Netbooting Multiple PowerHubs from One Server

Figure 1.4 shows an example of the configuration needed to boot from a BOOTP / TFTP server. In the case where network problems prevent netbooting, the PowerHub attempts booting from the secondary boot source. In this example, the secondary source could be either the Flash Memory Module or a Floppy Diskette in the Floppy Drive.

Notice that the PowerHub 7000 shown in Figure 1.4, is configured to netboot even when the server is separated by a gateway. The PowerHub software contains a feature called *IP Helper* that makes this type of netbooting easy to configure. The *PowerHub Software Reference Manual* contains instructions for configuring the boot source.

1.5.3.1 Configuration and Environment Files

When configuring the PowerHub, parameters such as the name, routing interface definitions, and filters, can be defined. These definitions are not retained across power cycles. They can, however, be saved and re-instated at any time using the appropriate software commands.

The **`system savecfg`** command creates a file called **`cfg`** and saves it on the default-device (floppy disk (**`fd:`**), Flash Memory Module (**`fm:`**) or Compact Flash Card (**`fc:`**)). This file contains ordinary commands, such as might be issued to configure the system. When booting, this **`cfg`** file is read, commands executed, and the system is configured according to its contents. Multiple configurations can be created and loaded as needed. It is recommended that the old configuration file is saved as a back-up before replacing it with the new configuration file.

Parameters for command-line sessions can also be stored and read into the PowerHub. Session parameters are stored in environment files (**`*.env`**). Like configuration files, environment files contain PowerHub commands and can be loaded during login. Unlike configuration files, environment files apply only to the command-line session in which they are loaded.

1.5.4 Easily Accessible Dump Files

The PowerHub is designed for reliable operation under diverse traffic demands. However, in the event the system crashes, an attempt is made to reboot the system. A dump file is written to the default-device. This dump file is named **`fore.dmp`** and contains information that can be used by FORE Systems TAC to help diagnose the cause of the crash.

FORE Systems TAC can also use the contents of the **`dispcfg`** file to diagnose system problems. The **`dispcfg`** file is a configuration file provided with the system software diskettes. When reading the file (by issuing the **`system readcfg dispcfg`**), the software configuration of the system is displayed on the management terminal.

1.5.5 On-Line Hardware Information

At any time during normal operation, commands can be issued to display various hardware information, including the following:

- Chassis configuration
- Power module status
- Module identification and power requirements
- Current temperature of installed modules
- Segment state, status, and statistics
- Termination state of BNC segments (terminated or unterminated)
- Presence of a Packet Accelerator

Hardware information is displayed using commands in the **`system`** subsystem. Information about the segment state, segment status and segment statistics, as well as BNC termination states are available through commands in the **`media`** subsystem. For detailed information about the **`system`** and **`media`** subsystem commands, refer to the *PowerHub 7000/8000 Software Reference Manual*.

1.5.5.1 Automatic Segment State Detection

Using automatic segment-state detection, the PowerHub can detect when the state (up or down) of an attached segment changes. Moreover, when this feature detects a state change, it automatically enables or disables bridging and routing on the changed segment is enabled or disabled, as appropriate and the change is marked in table displays. Refer to the *PowerHub 7000/8000 Software Reference Manual* for information on Automatic Segment State Detection.

1.5.5.2 Port Monitoring

Port Monitoring monitors different types of traffic on any combination of Ethernet segments. The software can be configured to monitor packet traffic received on, forwarded from, or generated by specific segments or between a pair of segments.

To use Port Monitoring, a protocol analyzer (such as a Sniffer, LANalyzer, or Network Pharaoh), can be plugged into a single Ethernet segment. Using software commands, the segments and type of traffic to monitor can be specified. To change what is being monitored, simply change the monitoring configuration. Refer to the *PowerHub Software Reference Manual* for more information on Port Monitoring.

1.5.5.3 Packet Statistics

Packet statistics for any group or range of segments or ports can be displayed. For example, the number of packets received by a particular segment since the system was last booted can be displayed. For most statistics, two separate counters are maintained. For information on displaying statistics for a specific protocol, refer to the *PowerHub 7000/8000 Protocol Reference Manual* section on the respective protocol type.

Statistical tracking begins when the PowerHub is booted and continues until it is powered down or re-booted. This counter always shows the count accumulated since the system was last reset.

Statistical counters can be cleared at any time. When displaying the contents of this counter, the count displayed is the count subsequent to the last time the counter was cleared.

1.5.6 Bridging and Multi-Protocol Routing

Segments can be configured to bridge (as specified in IEEE 802.1d) as well as route packets according to any combination of the following standard protocols:

- IP
- IPX
- AppleTalk
- DECnet

For networks containing both Ethernet and FDDI segments, use IPX encapsulation bridging to bridge frames forwarded between Ethernet and FDDI. In addition, the PowerHub contains an implementation of IP Multicast, which allows multicast routing for bandwidth-intensive applications, such as video conferencing. The same segments can be used to bridge and route packets. In fact, a segment can be configured to not only bridge, but route all four protocols, and perform IP Multicast. For information on configuring segments for bridging and routing, refer to the *PowerHub 7000/8000 Protocols Software Reference* .

1.5.7 Virtual LANs (VLANs)

To make management of network segments easier, the PowerHub allows creation of Virtual LANs (VLANs). A VLAN is a network that spans two or more physical segments. VLANs make network configuration changes by allowing the creation and changing of LANs logically, as opposed to physically moving segment cables. The PowerHub bridges, rather than routes, packets among segments in a VLAN. Figure 1.5 shows an example of a typical VLAN.

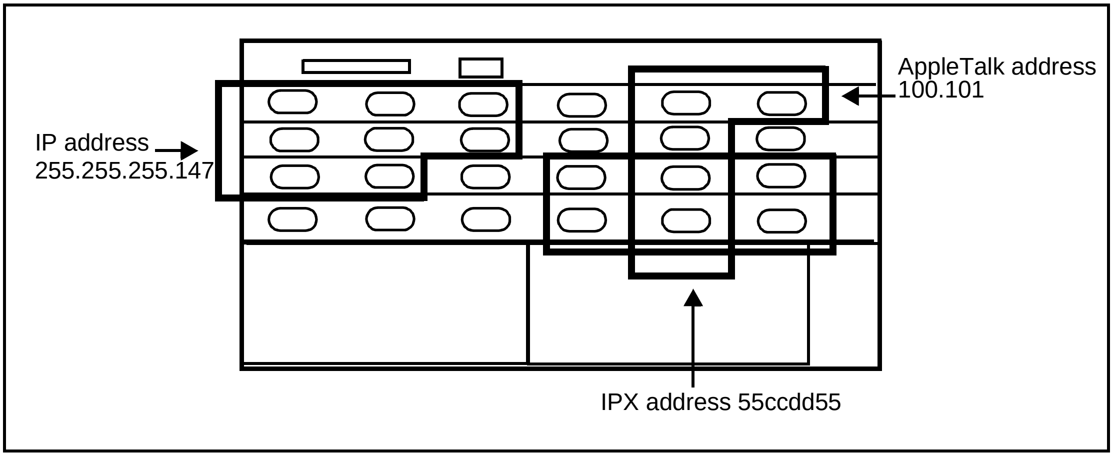


Figure 1.5 - Virtual LAN Examples

As shown in Figure 1.5, a VLAN consists of a group of segments. Each segment in the VLAN has the same interface address. VLANs for IP, IPX, and AppleTalk interfaces can be created. Notice that VLANs can overlap. Refer to the *PowerHub 7000/8000 Protocols Reference Manual* for more information on VLAN configuration.

1.5.8 Security Filters

In addition to the Lock Switch and password protection described in Section 1.2.3, logical filters can be defined to control traffic entering and leaving the PowerHub, or specific segments or interface addresses. Filters can be defined on the following protocols:

- AppleTalk
- Bridge
- TCP and UDP
- IP
- RIP
- IPX RIP and SAP

The PowerHub also contains an implementation of IP security as defined in RFC 1108. For detailed information on filters, refer to the *PowerHub 7000/8000 Filters Reference Manual*.

1.5.9 SNMP and MIB Support

PowerHub commands can be used to define Simple Network Management Protocol (SNMP) managers and communities. Once the system is configured so that it can be managed through SNMP, implementations of the following standard Management Information Bases (MIBs) can be accessed:

- MIB II (RFC 1213)
- AppleTalk MIB (RFC 1243)
- Bridge MIB (RFC 1286)
- Ethernet MIB, Version II (RFC 1398)
- FDDI MIB (RFC 1512)
- OSPF V2 MIB (RFC 1253)
- Mini-RMON MIB (RFC 1757)

In addition, SNMP can be used to access objects in the PowerHub MIB, which is designated as enterprise MIB 390. The PowerHub MIB contains objects not contained in the standard MIBs listed above, as well as objects that display configuration information. This includes objects for displaying the current software installed and various configuration information. Refer to the *PowerHub 7000/8000 Software Reference Manual* for information about configuring SNMP and the standard and PowerHub MIB objects.

CHAPTER 2 Chassis and Packet Engines

The PowerHub is designed to grow with network needs. The PowerHub 7000 and 8000 each contain a modular chassis and is available in a 5-or 10-slot chassis with a two-channel backplane and either two or four Power Module bays, while the 8000 is available in a 5- 10-, or 15 slot chassis with a four-channel backplane (the 5-slot has a two packet-channel backplane) and ships with four Power Module bays. Table 2.1 lists configuration options for the PowerHub 7000 and 8000 chassis.

The PowerHub makes use of a Packet Engine to intelligently process and forward packets. Each model has a unique version of the Packet Engine. This chapter describes the following hardware:

- Chassis (See Section 2.1)
- Packet Channel Backplane (See Section 2.2)
- Packet Engines (See Section 2.3)
- Power Modules (See Section 2.5)
- Fan Module (See Section 2.6)

2.1 Chassis

The PowerHub incorporates a modular chassis design. Most components can be added or removed at any time. Network Interface Modules (NIMs) with different physical interfaces are available to further tailor the PowerHub to suit network requirements. Refer to *Chapter 1, Overview* for NIM options. The following sections provide additional information on chassis options. The PowerHub contains slots, or bays, which accommodate the following modules:

- One Packet Engine 1 (PE1)(PowerHub 7000)
- Up to two Packet Engine 2 (PE2) (PowerHub 8000)
- Up to 9 NIMs (PowerHub 7000)
- Up to 14 NIMs (PowerHub 8000)
- Up to three fan modules
- Up to four power modules

Configuration options for the PowerHub 7000 and 8000 are shown in Table 2.1. The PowerHub 7000, and the 5-slot PowerHub 8000, do not contain the four channel backplane and do not support FDDI Concentrators.

Table 2.1 - PowerHub Configuration Options

PowerHub	Chassis	Power Module Bays	Available NIM Slots*	Packet Channels	Height (inches)
7000	5-slot	2	4	2	8 3/4
	10-slot	4	9	2	17 1/2
8000	5-slot	4	4	2	12 1/4
	10-slot	4	9	4	17 1/2
	15-slot	4	14	4	23 1/4
*After the Packet Engine has been installed.					

Figure 2.1 shows a 10-slot PowerHub 7000 identifying the different components. The NIMs are installed in slots numbered from bottom to top. The PowerHub 8000, with four Packet Channels, takes advantage of the enhanced packet handling capabilities of the PE2 and the four-channel backplane. Refer to Section 2.2 for information on the four-channel backplane and the PE2.

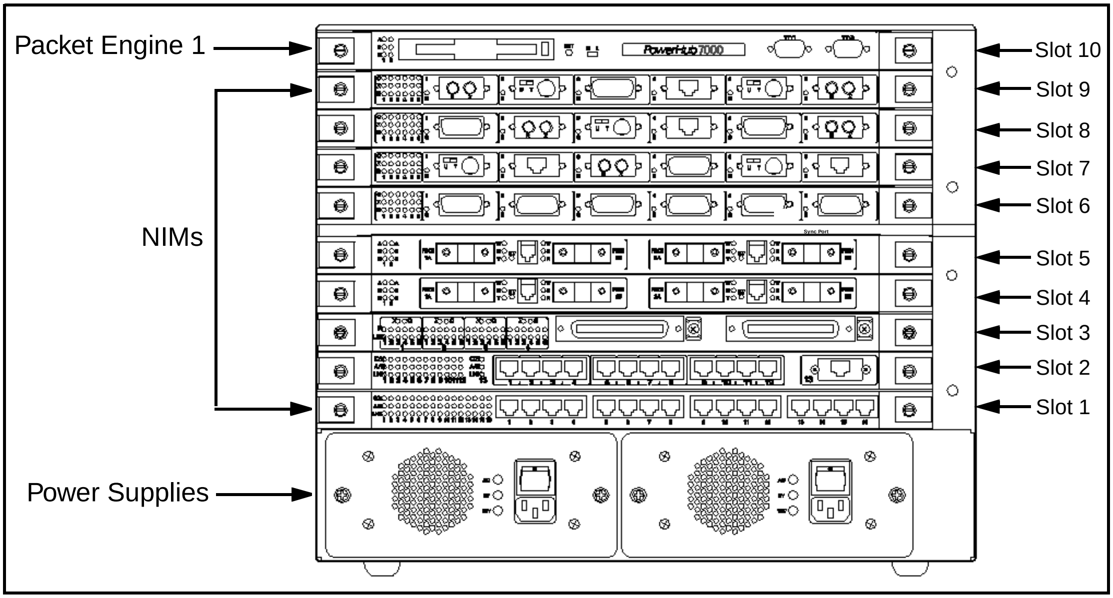


Figure 2.1 - PowerHub 7000 10-Slot Chassis

2.1.1 Packet Engine Placement

The placement of the Packet Engine depends on the PowerHub model installed. Table 2.2 lists the Packet Engine slot placement for each PowerHub 7000/8000 chassis. It is recommended that the Packet Engine be installed in the upper slot of the two slots available. The additional slot, in the case of the PowerHub 8000, is to accommodate Redundant Packet Engines (RPE). Refer to Section 2.2.3 for further information on Redundant Packet Engine use in the PowerHub 8000.

Table 2.2 - Packet Engine Placement

PowerHub	Chassis	Packet Engine Slot
PowerHub 7000	5-slot	5/4
	10-slot	10/9
PowerHub 8000	5-slot	5/4
	10-slot	10/9
	15-slot	10/9

Chassis and Packet Engines

2.1.2 NIM Placement

All other slots accommodate NIMs, configurable modules that provide connections to network segments. In Figure 2.1, a variety of NIMs are shown, but many configurations using other combinations of NIMs are possible. Refer to *Chapter 1, Overview* for information on NIMs.

The bottom of the chassis contains the power module bays. Not shown are the Packet Channel Backplane and the Fan Module. See Section 2.2 for information on the Packet Channel Backplane and Section 2.6 for information on the Fan Module.

2.2 Packet Channel Backplane

The Packet Channel Backplane is the hardware connection between the Packet Engine and any installed NIMs. The Packet Channel Backplane enables packets and control data to be passed to and from the Packet Engine when processing is required.

The Packet-Channel Backplane, whether two or four channel, carries traffic at 800 Mb/s (32 bits @ 25 MHz) per channel. There are two types of Packet Channel backplanes supported in the PowerHub:

- Two channel backplane (5-slot chassis only)
- Four-channel backplane (10- and 15-slot chassis)

NOTE

The PE1 supports the two packet-channel backplane while the PE2 only supports the four-channel backplane. Do not attempt to install the PE1 in a four-channel backplane chassis or a PE2 in a two-channel backplane chassis.

2.2.1 BUS Control Module

The Bus Control Module (BCM) contains clock distribution and bus termination circuits for the Packet Channels. It provides the physical interface to allow the Packet Channels to interface with the Packet Engine. The PowerHub is shipped with the correct BCM attached, so no maintenance is required.

2.2.2 PowerHub 7000

The PowerHub 7000 is available in a 5- or 10-slot chassis. Slots are numbered from 1 through 5 (or 10), bottom to top. The PE1 is installed in the uppermost slot of either chassis. Network Interface Modules (NIMs) can be installed in any of the other available slots. Figure 2.2 illustrates the relationship between the Packet Channel Backplane, Shared Memory, and the NIMs in both a 5- and 10-slot PowerHub 7000.

NOTE The 5-slot chassis does not support FDDI Concentrators. The 10-or 15-slot chassis is required if installing FDDI Concentrators.

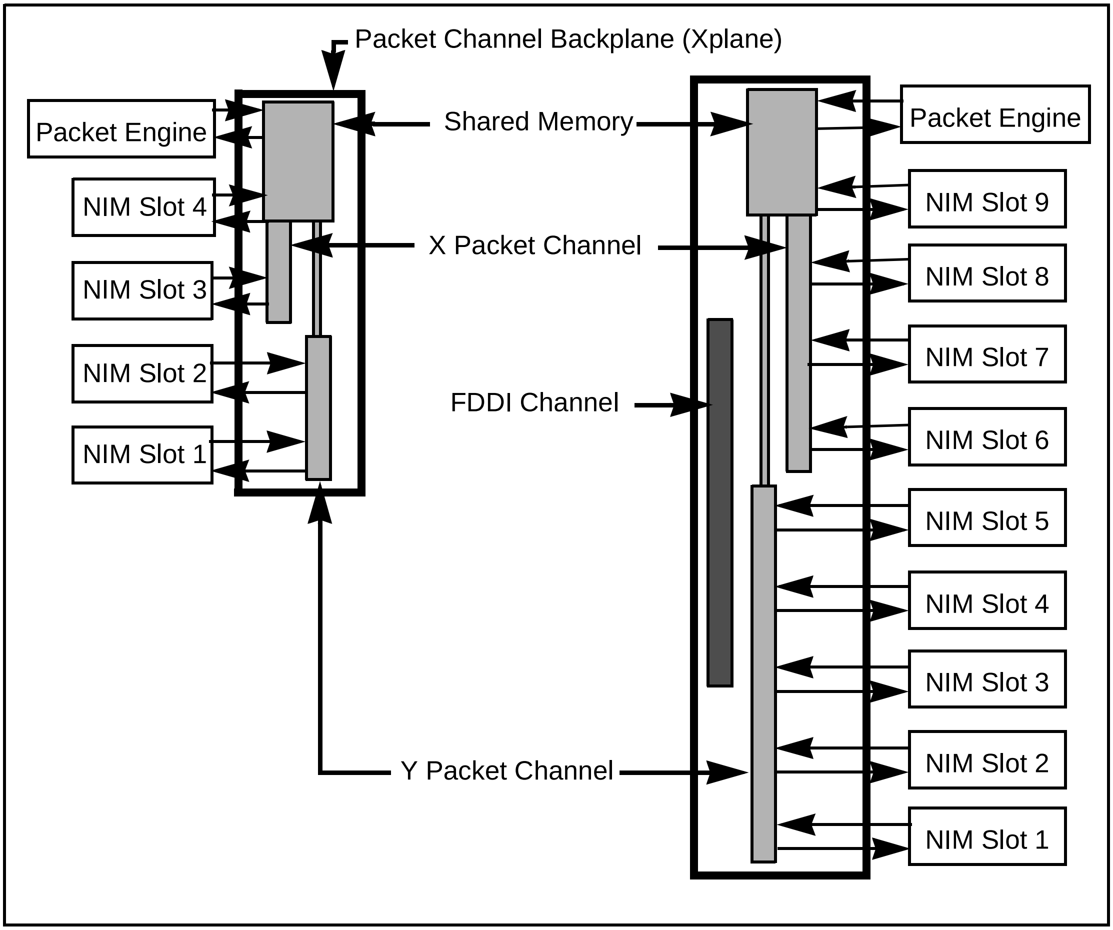


Figure 2.2 - PowerHub 7000 Packet Channel Backplane (5- and 10-slot)

The Packet Channel Backplane joins the slots in the chassis together, carrying information between the PE1 and installed NIMs using the Packet Channels. As shown in Figure 2.2, different chassis configurations distribute the packet channels across different slots:

- In a 5-slot chassis, slots 1 and 2 are served by the Y Packet Channel and 3 and 4 by the X Packet Channel.
- In a 10-slot chassis, slots 1-5 are served by the Y Packet Channel and 6-9 by the X Packet Channel.
- The FDDI Channel serves slots 3-7, in the 10-slot chassis only.

Information is exchanged between the Packet Engine and NIMs across the Packet Channels at speeds up to 800 Mb/s per channel (32 bits at 25 MHz) for a total of 1.6 Gbps, fast enough to support non-blocking operation of a fully-loaded system.

Each Packet Channel can forward wire-speed traffic from up to 40 dedicated 10-Mb/s segments or up to four 100-Mb/s FDDI rings. Any combination of NIMs can be installed on a Packet Channel. However, if ATM, FDDI, or Fast Ethernet modules are installed, optimal traffic throughput can be ensured by balancing the expected loads on the modules evenly across the Packet Channels. (Refer to *Appendix B, Balancing Bandwidth* for information about balancing bandwidth.)

2.2.2.1 FDDI Channel

In addition to the Packet Channels, the Packet Channel backplane in the 10-slot chassis also contains a separate channel for FDDI concentrator traffic. On a 15-slot chassis, the Packet Channel backplane contains two separate FDDI channels. The FDDI Channel is used to directly connect a DAS connection on an FDDI module to M-type FDDI ports on PowerHub FDDI Concentrator Modules. The location of the channels are shown in Table 2.3.

Using PowerHub FDDI Concentrator modules, the FDDI backbone can be collapsed into one easily managed location. FDDI traffic is repeated by the FDDI module to all M ports on the Concentrator modules, without adding any load to the Packet Engine. See *Chapter 9, FDDI Interfaces* for information about the FDDI Concentrators.

2.2.3 PowerHub 8000

The PowerHub 8000 is available in either a 5-, 10- or 15-slot chassis. The slots are numbered from 1 through 5, 10 or 15 depending on chassis, from the bottom to the top. The PE2 is installed in slot 5 of the five slot and slot 10 of the 10- or 15-slot chassis. Network Interface Modules (NIMs) can be installed in any of the other available slots. Figure 2.3 illustrates the relationship between the four-channel Packet Channel backplane, Shared Memory, and the NIMs in both a 10- and 15-slot PowerHub 8000.

NOTE

The PowerHub 8000 5-slot chassis only supports a two-channel backplane and the slot relationships are the same as for the PowerHub 7000 5-slot chassis. The advantages of a 5-slot PowerHub 8000 over a 5-slot PowerHub 7000 is the added processor capabilities of the PE2.

Information between the PE2 and installed NIMs is exchanged across the Packet Channel backplane at a speed of up to 800 Mb/s per channel (32 bits @ 25 MHz), for an aggregate bandwidth of 3.2 Gbp/s, fast enough to support non-blocking operation of a fully-loaded PowerHub at Ethernet, ATM, or FDDI wire speeds.

Each Packet Channel backplane can forward wire-speed traffic from up to 40 dedicated 10-Mb/s segments or up to four 100-Mb/s FDDI rings. Any combination of NIMs can be installed on the Packet Channel backplane. However, if ATM, FDDI, or Fast Ethernet modules are installed, optimal traffic throughput can be ensured by balancing the expected loads on the modules evenly across the Packet Channel backplane. Figure 2.3 shows the packet channel slot distribution. (Refer to *Appendix B, Balancing Bandwidth* for information on balancing bandwidth.)

As shown in Figure 2.3, different chassis configurations distribute the packet channels across different slots.

- In a four-channel, 10-slot chassis, slots 1 and 2 are served by the Y Packet Channel; 3 and 4 by the X Packet Channel; 6, 7, and 8 by the Z channel; and 9 and 10 by the W channel.
- In a 15-slot chassis, slots 1-5 are served by the Y Packet Channel; slots 6-9 by the X Packet Channel; 11, 12, and 13 by the Z channel; and 14 and 15 by the W channel.

All four Packet Channels connect directly to the Packet Engine.

Table 2.3 - FDDI Channel Locations

Chassis	Slots	FDDI Channels	FDDI Channel location
7000	5	None	None
	10	1	Slots 3-7
8000	5	None	None
	10	1	Slots 6-8
	15	2	Slots 3-7 and 11-13

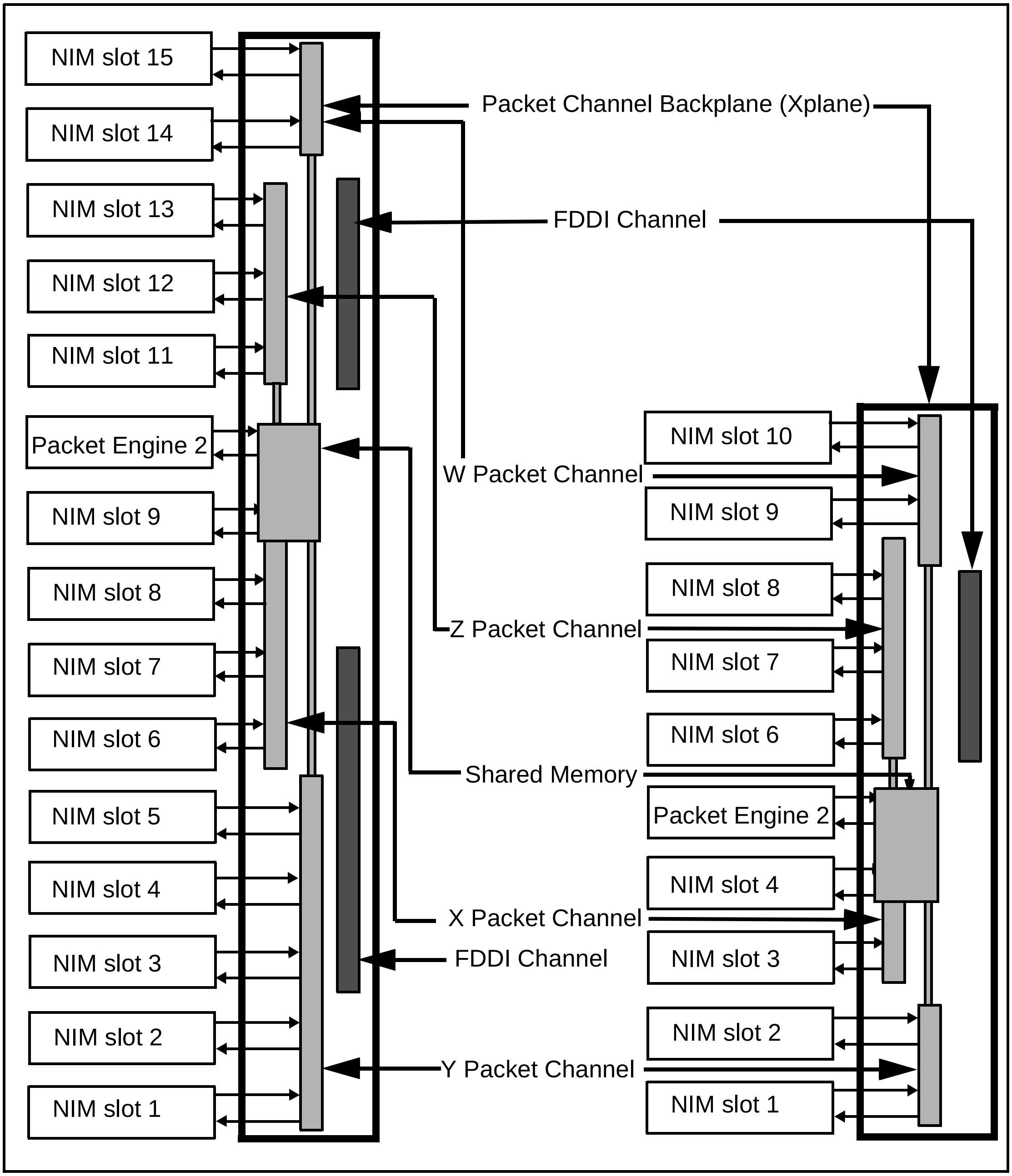


Figure 2.3 - PowerHub 8000 Packet Channel Backplane (10- and 15-slot)

2.3 Packet Engines

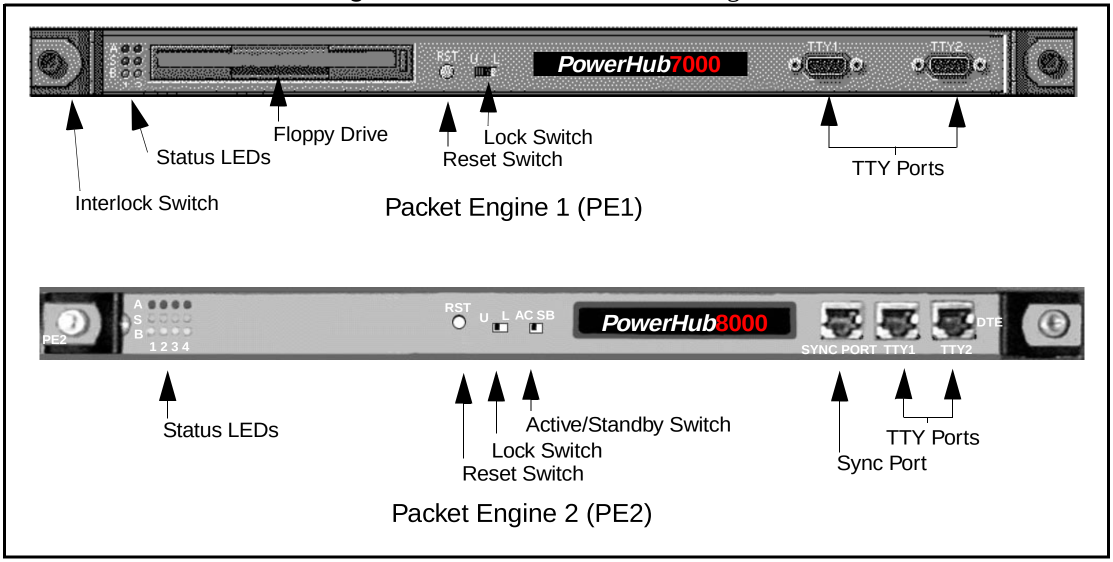
Each PowerHub requires a Packet Engine, the centralized packet processing and forwarding engine. The Packet Engine is installed in a specific slot in the chassis. The slot in which the Packet Engine is installed is dependent on the type of backplane and chassis size.

The Packet Engine examines packet headers for bridging and routing then modifies them as required for routing. When a segment connector receives a packet, the connector transfers the packet directly to Shared Memory on the Packet Engine. Bridging and routing engines in the Packet Engine store all packets and related data structures in Shared Memory. This contributes to high packet throughput because all packet-related data is stored in one place.

The Packet Engine contains the following components (all items listed are common unless otherwise stated):

- Status LEDs (See Section 2.3.1.1 and Section 2.3.2.1)
- Floppy drive (PE1 only) (See Section 2.3.1.2)
- Reset switch (See Section 2.3.3)
- Lock switch (See Section 2.3.4)
- Active/Standby Switch (PE2 only) (See Section 2.3.2.5)
- Sync Port (PE2 only) (See Section 2.3.2.6)
- RS-232 ports (See Section 2.3.4.1)
- Flash Memory module (PE1 only) (See Section 2.3.1.3)
- Compact Flash memory module (PE2 only) (See Section 2.3.2.2)
- Temperature sensor (See Section 2.3.5)
- Main memory (See Section 2.3.6)
- Shared memory (See Section 2.3.7)
- Fast-path memory (See Section 2.3.8)
- Boot PROM (See Section 2.3.9)
- ID PROM (See Section 2.3.10)
- Non-Volatile RAM (NVRAM) and Clock (See Section 2.3.11)
- Proprietary Bus Memory Interface ASICs (See Section 2.3.1.4 and Section 2.3.2.3)
- Central Processing Units (CPUs) (See Section 2.3.1.5 and Section 2.3.2.4)

Figure 2.4 - PowerHub Packet Engines



2.3.1 Packet Engine 1

The Packet Engine 1 (PE1) contains 3 CPUs, when a Packet Accelerator is installed, and only supports the two-channel backplane. The PE1 is shown in Figure 2.4.

2.3.1.1 Packet Engine 1 (PE1) Status LEDs

A series of Status LEDs provide visual status of what is happening within the Packet Engine. Table 2.5 describes the function of the status LEDs.

The PE1 has two columns of LEDs. Each column provides status information for one of the two RISC processors.

Table 2.4 - Packet Engine LEDs

Label	Color	Indicates this condition.
A	Red	**Alarm**. Indicates that a system crash has occurred. One or all LEDs remain lit until the system is reset. To reset the system, press the reset (RST) switch or switch the power supplies off and then on.
S	Green	**Status**. Indicates CPUs are functioning normally. If the left LED goes out during normal operation, there might be a problem in the Packet Engine.
B	Amber	**Boot**. Indicates the system is booting. These LEDs are lit only during the booting process and go out as soon as booting is complete.

2.3.1.2 Floppy Disk Drive

The floppy disk drive is a 3-1/2” high density (HD) drive available only on the PowerHub 7000. The floppy disk drive accepts 1.4 MB MS-DOS formatted diskettes. Various file management tasks including displaying, copying, renaming, and removing files can be performed using the floppy disk drive as a source or destination of the file. However, the PowerHub file system does not support hierarchical directory structures.

Generally, the floppy drive is only used to perform software upgrades, save changes to, read configuration or environment files, or to boot the system. The floppy drive is not used during normal, unattended operation. However, if the system is configured to boot from a floppy diskette, the proper image(s) are on the diskette. If the system is loaded from floppy diskette, the floppy disk must be inserted in the floppy disk drive at all times.

The PowerHub 7000 supports two alternatives to booting from floppy disk: (1) netbooting over the network from a TFTP server, or (2) from the Flash Memory Module (PE1). See Section 2.3.1.3.

NOTE

If more than one intelligent NIM is installed, or the one intelligent NIM installed is an ATM NIM, the software image is too large to fit on one floppy diskette, and the system must be loaded from the Flash Memory Module, or a TFTP server.

2.3.1.3 Flash Memory Module

The PE1 in an PowerHub 7000 ships with a 4MB Flash Memory Module. The Flash Memory Module stores configuration settings and boot information and is required if the PowerHub is not booted over the network. Software can be loaded into the Flash Memory Module through a tftp session or by copying the files from a floppy diskette. Use of the Flash Memory Module allows for fast system booting. See *Chapter 5, Installation, Upgrade, and Removal Procedures* for information about installation and removal of the Flash Memory Module.

2.3.1.4 Proprietary Bus-Memory Interface ASICs on PE1

FORE Systems' proprietary BMW (Bus Memory Wide) ASICs and Bus-Memory Interface (BMI) ASICs provide multiple ports for Packet Channels and CPUs to access Shared Memory. The Packet Engine 1 (PE1) contains four BMI ASICs which support two Packet Channel ports (X and Y), each providing 800Mb/s of peak bandwidth and two CPU ports (CPU1 and CPU2), connecting to the MCPU and IOP CPUs. Access to Shared Memory ports is prioritized. The CPU ports have the highest priority, followed by the Packet Channel ports.

2.3.1.5 PE 1 Central Processing Units

The Packet Engine contains CPUs that perform different functions depending on the Packet engine. The PE1 contains two RISC CPUs, each with specialized functions.

2.3.1.5.1 Input/Output Processor (IOP)

The IOP CPU handles real-time processing for network interface chips, including initialization, error handling, packet reception, packet transmission, and buffer management.

2.3.1.5.2 Main CPU (MCPU)

The MCPU runs packet forwarding algorithms, used for MAC-layer bridging and multiprotocol routing. In addition, this CPU runs management software, including an SNMP agent. When a Packet Accelerator is used, a second MCPU and a second IOP are added to the Packet Engine, and the Packet Engine functions similarly to the PE2.

2.3.2 Packet Engine 2

The Packet Engine 2 (PE2) contains 4 RISC VPUs and supports both the two and four-channel backplanes. The utilization of four CPUs and a four-channel backplane doubles the packet-processing power of the PowerHub 8000 compared to the PowerHub 7000. The PE2 is shown in Figure 2.4.

2.3.2.1 Packet Engine 2 (PE2) Status LEDs

The PE2 has four columns of LEDs. Each column provides status information for one of the four RISC processors on the PE2. The left most LEDs monitor the status of the main CPU (MCPU). For information on the RISC processors on the PE2, see Section 2.3.2.3 and Section 2.3.2.4. Table 2.5 shows the Packet Engine LEDs.

2.3.2.2 Compact Flash Card

The PE2 contains a 10MB Compact Flash Card. The Compact Flash Card is much like a small IDE disk drive. It is used to store boot and runtime information and has several advantages over the Flash Memory Module of the PE1. The Compact Flash Card can:

- Be removed and programmed on a PC or laptop using a Compact Flash docking port if a docking port is installed on the PC or laptop.
- Be seen on the PC or laptop system as a 10MB IDE hard drive.
- Is less susceptible to damage than the Flash Memory module.

The Compact Flash Card is the primary boot source in the PowerHub 8000. The PowerHub runtime software, configuration files, and Intelligent NIM runtime information can all be stored on the Compact Flash Card. If a netboot is performed, and the netboot fails, the PowerHub attempts to boot from the Compact Flash Card.

2.3.2.3 Proprietary Bus-Memory Interface ASICs on PE2

FORE Systems' proprietary BMW (Bus Memory Wide) ASICs and Bus-Memory Interface (BMI) ASICs provide multiple ports for Packet Channels and CPUs to access Shared Memory. The Packet Engine 2 (PE2) contains 4 RISC CPUs and supports both the two- and four-channel backplanes. The utilization of four CPUs and a four-channel backplane gives the PowerHub 8000 double the packet-processing power of the PowerHub 7000.

Four Packet Channels (X, Y, W, and Z), each providing 800 Mb/s of peak bandwidth. Two CPU ports (CPU1 and CPU2). Two Input/Output Processors (IOP), one for the incoming and one for the outgoing.

Four pairs of BMWs on the PE2, one that interfaces with the two MCPUs, one that interfaces with the IOPs, and two that interface with the Packet Channels.

Packet descriptor memory enhances performance by allowing the BMW ASICs to route packet description requests to Packet Descriptor memory, eliminating the need to access a packet from Packet Memory. Because Packet descriptions are shorter than packets, the request is processed in a fraction of the time it would take to access the packet for the same information.

2.3.2.4 PE 2 Central Processing Units

The Packet Engine contains CPUs that perform different functions depending on the Packet engine. The PE2 contains four RISC CPUs, each with specialized functions:

2.3.2.4.1 Input/Output Processor (IOP).

The PE2 utilizes one CPU for input and one for output. The IOP CPUs handle real-time processing for network interface chips, including initialization, error handling, packet reception, packet transmission, and buffer management. The input IOP receives and queues all packets and sends them to one of the two Main CPUs. The CPU receiving the packet is determined by Multiprocesser Optimization, which determines whether the packet is for a background task, in which case it is sent to the slow-path CPU. All other traffic is sent to the fast-path CPU for processing. The output IOP receives and queues all packets for transmission on the appropriate destination ports.

2.3.2.4.2 Main CPU (MCPU).

The MCPUs run packet forwarding algorithms, used for MAC-layer bridging and multiprotocol routing. The primary MCPU handles all fast path packet forwarding. The secondary MCPU runs management software, including an SNMP agent. This enables the PowerHub to run RMON and SNMP functions without significant reduction in network performance.

2.3.2.5 Active/Standby Switch

The PE2 supports redundant PE2s through the use of a second PE2. When a second PE2 is installed, the primary PE2 is set as active, and the secondary is set as standby using the Active/Standby switch on the front panel. The PE2s can then be connected through the Sync Port on the Packet Engine face plate using a standard CAT-5 crossover cable. The Active/Standby Switch is not implemented in this release and is intended for future development.

2.3.2.6 Sync Port

Two PE2s can be installed in a PowerHub 8000. When a second PE2 is installed, it serves as a backup to the active PE2. The standby (backup) PE2 does no packet processing unless the active (primary) PE2 fails. If the primary PE2 fails, the backup PE2 assumes the primary role and the PE2 tasks switch over to the secondary Packet Engine. When configuring the PE2s for redundancy, the PE2s must be connected through the Sync Port using a standard CAT-5 crossover UTP cable. The Sync Port is not implemented in this release and is intended for future development.

NOTE

The Sync Port on the PE2 cannot be used for regular Ethernet Traffic. It is to connect the active and standby PE2 only.

2.3.3 Reset Switch

The reset switch can be used to reboot the system. When the reset switch is pressed, the Packet Engine performs a “cold” restart. During a cold restart, the Packet Engine conducts a power-on self-test to check various hardware components. The reset switch is located in the center of the Packet Engine, to the left of the Lock Switch.

When the Reset Switch is pressed and the system reboots, it boots according to the boot preference(s) specified. The Packet Engine uses files in the Flash Memory Module, Compact Flash, Floppy Disk Drive, or via a TFTP server (network booting) to configure the system for runtime operation. When shipped from the factory, the system software is configured to boot from the Flash Memory Module/Compact Flash Card. Refer to the *PowerHub 7000/8000 Software Reference Manual* for information on changing the boot source.

2.3.4 Lock Switch

The Packet Engine features a Lock Switch, located on the front panel of the Packet Engine to the right of the reset (RST) button. The Lock Switch, when set to L (Locked) locks the user interface so that a login ID and password are required before a user can access the command-line interface. The switch is disabled or set to Unlocked (U) at the factory, which allows anyone to establish a connection to the PowerHub and access the user interface.

The PE1 contains a Lock Switch Jumper which can be used to override the Lock Switch. Refer to *Chapter 5, Installation, Upgrade, and Removal Procedures,* for procedures on changing or setting the Lock Switch and Lock Switch Jumper.

NOTE The PE2 contains a Lock Switch, but does not contain the Lock Switch Jumper.

When the Lock Switch (or Lock Switch jumper) is set to Locked, a password is required to obtain management capability. Management capability can be monitor or root: Refer to *Chapter 6, Boot PROM Commands* for procedures on changing or setting passwords.

- **Monitor -** Allows displaying of information, but does not allow statistics to be cleared or configuration settings to be changed.
- **Root -** Allows unrestricted access to the system, including issuing commands that clear statistics and change the configuration.

2.3.4.1 RS-232 Ports

The Packet Engine supports two TTY ports, labeled TTY1 and TTY2. Each port provides an RS-232 connection to the PowerHub. These ports are used to attach management terminals or modems to the PowerHub. Each port supports the following asynchronous modem-control lines: RXD, TXD, DCD, DTR, RTS, and CTS., and baud rates of 1200, 2400, 4800, 9600, or 19200.

To ensure session security, the TTY ports use data carrier detect (DCD). If the terminal or modem connected to the TTY port is supplying the DCD signal, the PowerHub monitors that signal. If DCD is dropped, the software logs the user out of the session. This prevents other terminals or modems from connecting to the session.

If the terminal or modem does not supply a DCD signal, the TTY port can still be used. The Packet Engine has “weak pull-up” resistors that supply the DCD signal internally. (However, if the cable contains another signal where the DCD signal is supposed to be, the cable might prevent proper operation of the TTY port. Refer to *Appendix A, Pinouts* for the pinouts of the TTY1 and TTY2 ports.)

When the system boots, it automatically begins a command-line session on the terminal or modem connected to the TTY1 port. Note that the first time logging on, the modem or management terminal attached to TTY1 must be set to 9600 baud.

NOTE

On the PowerHub 8000, the TTY1 port uses an RJ-45 connector. This connector looks like a UTP Ethernet connector, but cannot be used for an Ethernet connection. Do not attempt to use the TTY1 or TTY2 ports as Ethernet segments.

See *Chapter 3, Quickstart* for instructions on attaching the management terminal or modem to the TTY ports. This section also describes how to assemble an RS-232 cable to connect to the TTY ports.

2.3.5 Temperature Sensor

A temperature sensor is available on each module installed in the chassis. The temperature sensor reads the temperature of the module, within an accuracy of plus or minus 0.5° C. The **`system temperature|temp`** command can be issued at any time to read the current operating temperature of a particular module or all installed modules. (Refer to the *PowerHub 7000/8000 Software Reference Manual* for more information on displaying the temperature.)

2.3.6 Main Memory

Each Packet Engine ships with 32MB of main memory in the form of dynamic random access memory (DRAM). This standard memory configuration is sufficient to support Bridging, IP routing, IP Multicast, IPX, AppleTalk, DECnet, and the Bridge MIB.

2.3.7 Shared Memory

The Packet Engine contains Shared Memory that provides 800Mb/s of bandwidth, more than enough to support a fully-loaded PowerHub. The PowerHub 7000 is equipped with 2MB Shared Memory, while the PowerHub 8000 comes with 8MB Shared Memory.

The RISC CPUs and Packet Channels use the Shared Memory to store packets and related data structures. Because all packet-related data is stored in one place, the system can maintain a high packets-per-second throughput.

2.3.8 Fast Path Memory

In addition to their own on-chip caches, each CPU can access private “fast-path” memory that stores the most performance-critical code and data. Additional resources that can be accessed by both CPUs are described in the following sections. These additional resources are used mostly by the MCPU.

2.3.9 Boot Programmable Read-Only Memory

The Packet Engine also contains a Boot Programmable Read-Only Memory (Boot PROM) that contains software used by the Packet Engine when booting the system. Software commands can be issued to the Boot PROM to perform configuration tasks such as specifying a boot source and installing software upgrades. Refer to *Chapter 6, Boot PROM Commands* for a description of the Boot PROM commands. The command prompt for the boot PROM is shown `<PROM-7pe>`, while in the PE2 it is shown as `<PROM-8pe>`.

2.3.10 ID PROM

The Packet Engine and all NIMs contain an ID PROM located in a reserved area in the Boot PROM that contains identification information of the module and lists the maximum amount of current required to power the module. The ID PROM lists the module’s serial number, model number, hardware revision, and other factory-issued information. To display the contents of the ID PROM use the **`system idprom`** command. (Refer to the *PowerHub 7000/8000 Software Reference Manual* for more information on the ID PROM.)

2.3.11 Non-Volatile RAM (NVRAM) and Clock

The Non-volatile RAM (NVRAM) contains a battery-operated 8K CMOS RAM and time-of-day clock. NVRAM maintains the system time and date and contains configuration information such as the TTY port baud rates, the system name, and boot source.

NVRAM can be configured to contain additional configuration information used in some implementations of network booting. Refer to the *PowerHub 7000/8000 Software Reference Manual* for information on NVRAM commands.

NVRAM can be accessed from either the Boot PROM command prompt or the run-time command prompt. Refer to *Chapter 6, Boot PROM Commands* for information about the Boot PROM commands used to configure NVRAM.

2.4 PE2 Redundancy

Redundant Packet Engine (RPE) is supported on PowerHub 8000s with a four-channel back plane. RPE is a fail-over mechanism, where a secondary PE2 monitors the primary PE2 for a heartbeat signal over the dedicated Sync Port. Refer to *Chapter 3, Quickstart* for procedures on configuring RPE.

2.5 Power Modules

The PowerHub 8000 supports two AC and one DC Power Module. The PowerHub 7000/8000 can also be configured to support redundant power modules and load sharing. Load sharing reduces wear on the power modules and results in longer power module life. The AC power module plugs into a standard grounded three-prong outlet. The power backplane connects the power modules to the rest of the system. The power modules are supplied with an internal fan to provide cooling for the power module components. For more information on working with the power modules, refer to *Chapter 5, Installation, Upgrade, and Removal Procedures*. The following sections discuss the power modules.

2.5.1 Load Sharing

Many configurations require only a single power module to run, but can use a secondary power module for redundancy (backup) and load sharing. When power modules load share, they participate equally in providing power. Load sharing improves the reliability of each power module participating in load sharing. In addition, if one power module ever fails, the entire load is immediately assumed by the remaining power module. As long as the remaining power module is providing sufficient current, it continues to operate without interruption.

When redundant power modules are installed, either power module can be removed without interfering with the operation of the system. As long as the chassis contains the minimum number of power modules required to support the configuration, it continues operating normally.

When a single power module is used, it must always be installed in the left or upper left power module bay. A protective coverplate must be installed in the unused bay(s). (Operating the system with an uncovered power module bay affects internal cooling and can void the warranty.) In the event of a short circuit or other overload condition, all power modules automatically shut down to protect the PowerHub from damage.

2.5.2 Live Insertion

In addition to removing a redundant or failed power module, a new power module can be inserted while the chassis is operating. This is known as live insertion. As soon as AC current is applied to the inserted power module, it begins to load share with the power modules in the chassis. Refer to *Chapter 5, Installation, Upgrade, and Removal Procedures* for instructions on inserting a power module.

2.5.3 AC Power Modules

The PowerHub 8000 supports two AC power modules: a 283 Watt (Figure 2.5) and a 530 Watt (Figure 2.6). The PowerHub 7000 only supports the 283 Watt AC power module. These power modules are interchangeable, interoperable and backwards compatible. A 530 Watt power module can be used in an older chassis, and a 283 Watt power module can be used in a new chassis. The high current power modules were designed to provide a higher degree of reliability for PowerHub 8000 configurations that draw more power. The new power modules achieve this by:

- Improving the cooling capacity.
- Reducing the component count by increasing current.
- Maintaining full load sharing between standard and high capacity power modules.

The power required is dependent on the number of NIMs installed and the current that each NIM draws. Both types of AC power modules can be used in the same PowerHub at the same time, though FORE Systems does not recommend using the standard power modules to backup high current power modules without a careful system analysis to ensure that the standard power modules are sufficient to support the load if the high current power modules fail.

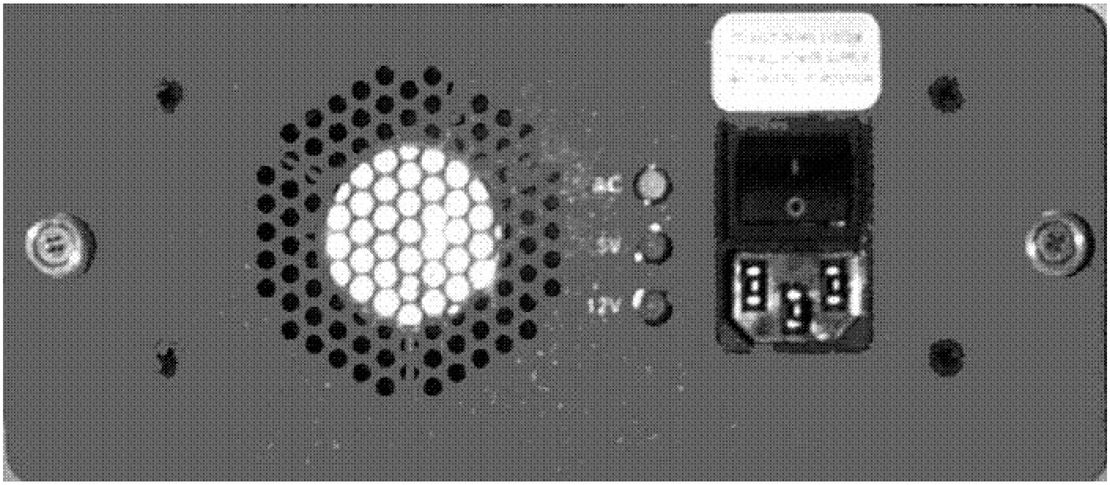


Figure 2.5 - 283 Watt Power Module

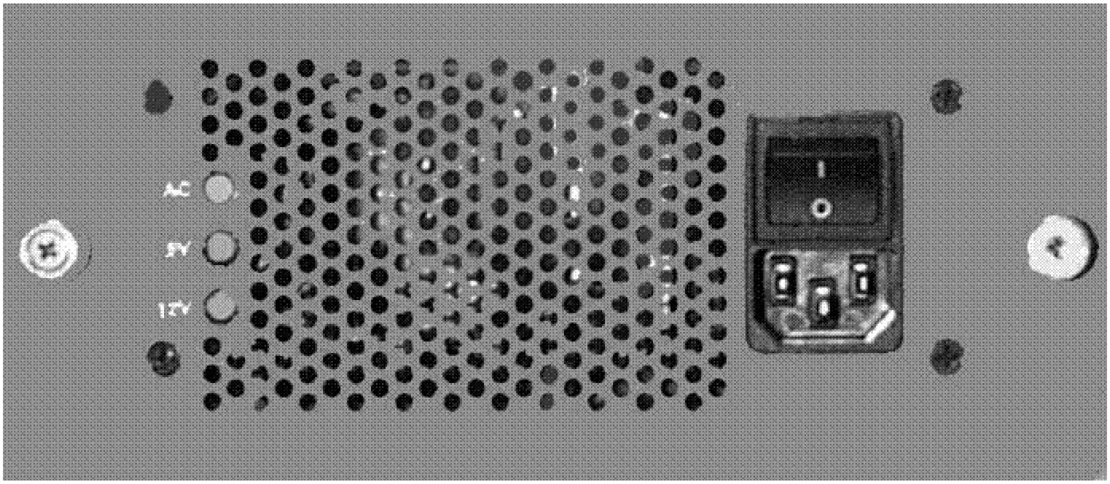


Figure 2.6 - 500 Watt Power Module

The AC power module transforms AC current into the +5- and +12-volt DC current. Each power module requires an input voltage of 85–132 volts AC (or 180–264 volts AC when used in countries using 220-volt AC standard) at 47–60 Hz.

The AC power module runs on a standard 110-volt AC or 220-volt AC power source. The power module automatically detects the input voltage, so no jumpers or switches are needed when setting up for an alternative power source. The power module is shipped with a three-wire power cable that matches the power receptacle used in the destination country. The wiring used to connect to the power source should be capable of carrying at least 10 amperes.

The AC power cord plugs into a receptacle on the front of the power supply. When more than one power module is installed, each requires its own power cable.

A power module must be installed in the primary Power Module bay before booting. In a system with four Power Module bays, the top left bay houses the primary supply. In a system with two Power Module bays, the left bay houses the primary module. The other bays house secondary power modules. The minimum number of power modules required depends upon the configuration. For information about power requirements, refer to *Chapter 4, Safety and Environmental Requirements*. Figure 2.1 shows a 10-slot PowerHub 8000 with four power modules installed.

In a 5-slot chassis, containing four Universal Ethernet Modules (UEMs) but no FDDI modules, one power module is sufficient to power the PowerHub; a second power module can be used for load sharing and redundancy. However, if the chassis is fully loaded with FDDI or ATM modules, or it is a 10-slot chassis with several NIMs, a minimum of two power modules is required to power the chassis.

Not shown in Figure 2.1 is the power backplane. The power backplane connects the power modules to the system. The AC and DC power modules each have three LEDs. Table 2.5 lists the LEDs on the AC and the DC power modules.

Table 2.5 - Power Supply LEDs

Label	Color	Indicates the following condition.
AC (DC on the DC Power Supply)	Amber	Power module is receiving current from the power source. If this light is on, but the following two lights are off, a short circuit or other overload condition has occurred. Refer to *Chapter 4, Safety and Environmental Requirements* for information on resetting the module(s) following an overload condition.
5V	Green	Power supply is supplying +5-volt power.
12V	Green	Power supply is supplying +12-volt power.

2.5.4 DC Power Module

The DC power module transforms DC current into the +5-volt and +12-volt DC current. Each power module requires an input voltage of 40–60 volts DC. The maximum output current of the power module is 35A at +5 volts DC and 9A at +12 volts DC.

The DC power cable consists of six wires: two black (+48V), two red (-48V), and two green (safety ground). In a normal telephone system, the +48-volt battery terminal is connected to an earth or safety ground, while the -48-volt battery terminal is floating.

When shipped from the factory, one end of the cable contains a keyed connector that plugs into the DC power module. The other end of the cable has no connector. Connect the wires to the DC power source. The ends of the wires are stripped to simplify the installation.

The power switch on the DC power module is actually a circuit breaker. When the switch is set to the ON position (marked **|**), the circuit is closed. When the switch is set to the OFF position (**O**), the circuit is open.

Figure 2.7 shows the control panel of the DC power module. Notice that the LEDs are labeled differently from the AC power module, and the connector for the power cable is different.

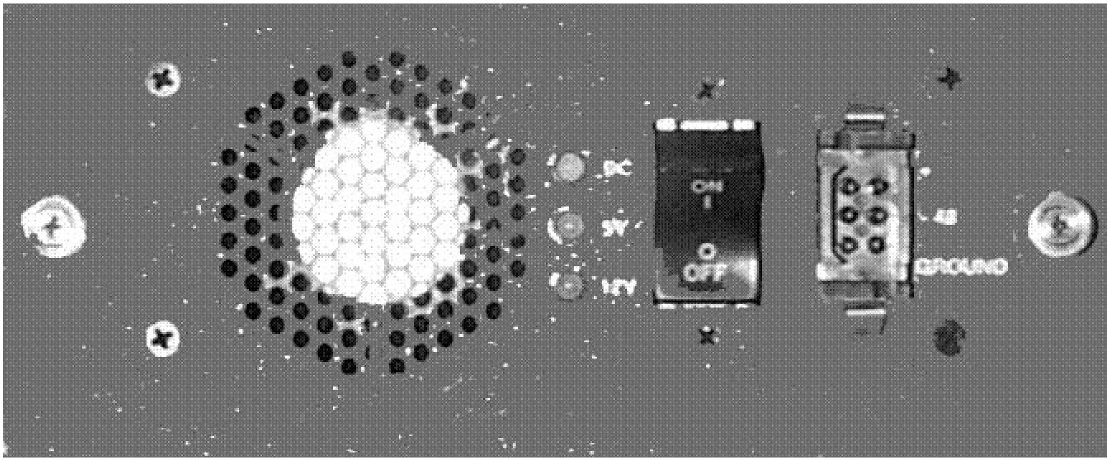


Figure 2.7 - -48Volt DC Power Supply

NOTE

The DC power module can be used to power the four-channel PowerHub 8000 chassis as long as the power requirements of the chassis, Packet Engine, and NIMs are met.

2.6 Fan Module

Fan modules are provided to help dissipate heat and keep the NIMs and Packet Engine at optimal operating temperatures. Each PowerHub contains one fan module for every five slots of chassis. The fan module contains three fans providing a steady flow of air to the Packet Engine and NIMs. In the event that one fan in a module fails, the remaining two fans can provide adequate cooling.

CHAPTER 3 Quickstart

This chapter provides quickstart information to assist in getting the PowerHub 7000/8000 up and running. Detailed configuration information is not provided in this chapter. Refer to the *PowerHub 7000/8000 Software Reference Manual*, *PowerHub 7000/8000 Protocols Reference Manual*, and *PowerHub 7000/8000 Filters Reference Manual* for detailed configuration information. Some of the things discussed in this chapter include:

- Installing the chassis.
- Connecting the management terminal or modem.
- Booting the system
- Allocating segments
- Configuration files
- Configuring Redundant Packet Engines

Quickstart

3.1 Installing the Chassis

This section describes how to install the PowerHub chassis. Table 3.1 shows specifications of the PowerHub chassis configurations. The weights listed are approximate and include the maximum number of power supplies and Network Interface Modules (NIMs) in every slot. The actual weight may vary.

Table 3.1 - PowerHub Specifications

Number of Power Module	Number of Slots	Height	Weight
2	5	8 3/4”	~65 lbs
4	10	17 1/2”	~100 lbs
4	15	23 1/2”	~130 lbs

The chassis listed above are 17” deep and approximately 17” wide without the rack-mounting ears installed.

NOTE

Before beginning to work with the chassis, read the safety and environmental requirements detailed in *Chapter 4, Safety and Environmental Requirements*.

The chassis can be installed in any of the following ways:

- On a tabletop.
- In a standard 19” equipment rack using one of the following:
  - Front-mount (closed computer rack) brackets.
  - Center-mount (open telecom rack) brackets.

CAUTION

If the chassis is to be front-mounted in a closed rack, it is recommend that a metal strip or tray be installed to support the rear of the chassis. If the rear of the chassis is not supported, the chassis weight could break the bolts securing the mounting brackets to the rack.

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The PowerHub is shipped with the Packet Engine, NIMs, and power modules installed. The fully-configured chassis is heavy. If the chassis is to be installed in a rack, it is recommended that the procedures in *Chapter 5, Installation, Upgrade, and Removal Procedures* be followed to temporarily remove the Packet Engine, NIMs, and power modules.

3.1.1 Installing the Chassis on a Tabletop

To install the chassis on a tabletop, prepare the tabletop to allow at least 3” of open space around the sides and in front of the chassis, then place the chassis in the space prepared. If any NIMs or the Packet Engine were removed, replace them using the procedures outlined in *Chapter 5, Installation, Upgrade, and Removal Procedures* before powering on the PowerHub.

3.1.2 Cable Organizer

The chassis can be outfitted with a cable organizer. To install the cable organizer, align it over the two empty screw holes on the right side of the front of the chassis and attach it with the two screws provided.

3.1.3 Rack Mounting the Chassis

The chassis can be mounted in a standard 19” closed-frame rack using the angle brackets supplied. For safety reasons, install a supporting shelf below the chassis. For this type of installation, the following are needed:

- Two closed-rack mounting brackets.These mounting brackets are smaller than the open-frame brackets and each have twelve screw holes for the chassis and four screw holes for the rack.
- Eight pan-head screws, four for each bracket.
- A #2 Phillips-head screwdriver.
- A flat-head screwdriver.

NOTE

Before installing the chassis in a closed-frame rack, remove the Packet Engine, NIMs, and power modules from the chassis using the procedures in *Chapter 5, Installation, Upgrade, and Removal Procedures*.

To install the chassis in a closed-frame rack:

1. Place the chassis on its side to access the four rubber feet on the bottom.
2. Remove the rubber feet.
3. Remove the screws from one side of the front of the chassis that align with the associated screw holes in the appropriate bracket(s).
4. Align one of the closed-frame brackets over the screw holes. Ensure that the flange that connects to the rack is facing toward the front of the chassis. When the bracket is correctly positioned, the flange is flush with the front of the chassis.
5. Insert the screws removed in Step 3. Do not over-tighten the screws; they should be hand tight.
6. Repeat steps 3–5 on the other side of the chassis for the other bracket.
7. When both brackets are installed, carefully lift the chassis into the rack, align the screw guides over the holes in the rack, then use the flat-head screwdriver to insert the eight screws provided. The screws go into the mounting holes in the brackets.
8. Reinstall any modules that were removed before installing the chassis, using the appropriate procedures in *Chapter 5, Installation, Upgrade, and Removal Procedures.*

3.2 Connecting a Management Terminal or Modem

The PowerHub 7000 is shipped with an RS-232 cable assembly kit, which contains parts to assemble the cable. Like most RS-232 connections, the TTY ports are wired as DTE (Data Terminal Equipment). Refer to Figure 3.1 for an illustration of how to assemble the necessary management terminal or modem cable assembly.

NOTE

If the management terminal requires a DTE connection, a null modem or other means to swap the signal pairs cable may be required.

PowerHub 8000

The TTY connectors are RJ-45 connectors. Figure 3.1 shows the cable assembly that must be used to connect to the TTY ports.

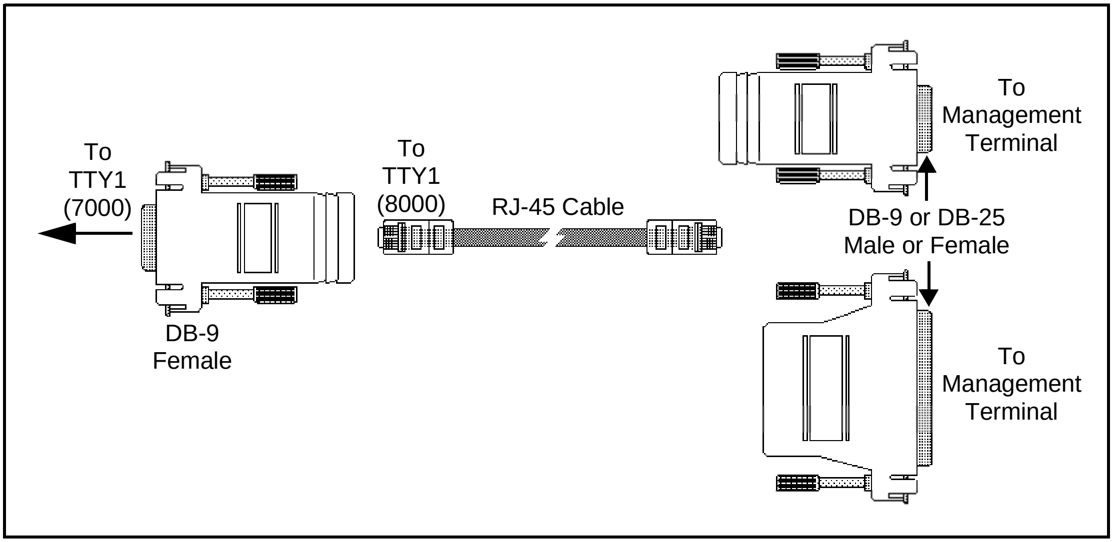

Figure 3.1 - TTY Port Cable Assemblies

The initial login requires that the modem or management terminal attached to TTY1 must be set to 9600 baud

NOTE

To use the TTY2 port, in addition to TTY1, an additional cable is required. Contact FORE Systems TAC about ordering an additional adapter kit for the TTY2 cable.

1. To connect a management terminal or modem, determine the type of connector needed for the management terminal or modem side of the connection. E.g, a terminal whose serial port is a female DB-9 needs a male DB-9 connector. If the management terminal or modem port is wired as DTE, use a null modem or some other means to swap the RS-232 signal pairs as indicated in Figure 3.2.

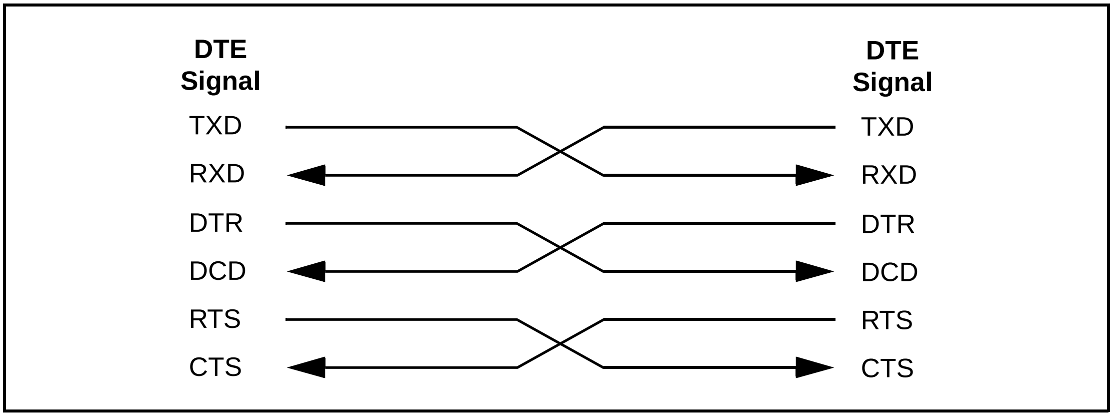

Figure 3.2 - DTE Null Modem Connections

NOTE

One way to swap the signal pairs is to wire the connector or management terminal as DCE.

2. Select the RJ-45 cable and/or DB-9 or DB-25 connector shell that fits the terminal or modem serial port from the assembly kit.
3. Using Table 3.2, assemble the connector. For example, if a DB-9 connection to a PC DTE is needed, and a null-modem function is to be incorporated in the cable, use the DB-9 column on the Modem Signal (DCE) side of Table 3.2.
4. Set the serial port on the modem or management terminal to 9600 baud.
5. Plug the RJ-45 connector into the management terminal or modem connector just assembled.

6. Plug the management terminal or modem connector into the management terminal or modem.
7. Plug the female DB-9 connector into the TTY1 port and the RJ-45 connector into the DB-9 in the TTY1 port.

Table 3.2 - RS-232 (TTY) Pinout Reference

RJ-45*	Terminal (DTE)	DB-25	DB-9	Modem (DCE)	DB-25	DB-9
6 (Yellow)	TXD	3	2	TXD	2	3
3 (Black)	RXD	2	3	RXD	3	2
4 (Red)	GND	7	5	GND	7	5
7 (Brown)	DTR	6	6	DTR	20	4
5 (Green)	DCD	20	4	DCD	8	1
8 (White)	RTS	5	8	RTS	4	7
1 (Blue)	CTS	4	7	CTS	5	8
2 (Orange)	n/a	n/a	n/a	DSR	6	6

* The colors refer to the wires inside the connector shells, not the wires in the cable itself.

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3.3 Booting the System

There are four different ways to boot the PowerHub software. The software can be loaded by:

- Turning on the power supplies.
- Pressing the Reset Switch (RST) on the Packet Engine.
- Issuing the **`boot|b`** command from the Boot PROM (<PE1> or <PE2>) prompt (refer to *Chapter 6, Boot PROM Commands* for more information on the **`boot|b`** command).
- Issuing the **`reboot`** command from the system (`PowerHub:system#`) prompt (refer to the *PowerHub 7000/8000 Software Reference Manual* for more information on the **`reboot`** command).

CAUTION

Ensure that the chassis contains at least the minimum number of power modules to support the configuration. If not sure, refer to *Chapter 4, Safety and Environmental Requirements*. Also, make sure a power module is installed in the primary power module bay. The primary module bay is the upper-left bay.

The first two options are physically performed by either turning the power modules on or pressing the reset (RST) switch on the Packet Engine (PE). To power on the PowerHub, do the following:

1. Ensure that all unused slots and bays in the chassis are covered with the proper cover plates. Operating the system without cover plates installed over unused bays or slots is unsafe, potentially damaging, and can void the warranty.
2. Plug the power module cables into the power modules, then into a grounded circuit(s) capable of supplying the required amount of AC or DC current.
3. Switch on all power modules at the same time (or at least the minimum number of modules required for the configuration). If the minimum number of power modules required are not powered on, the power modules powered on may become overloaded and shut down. To simplify this step, plug all of the power modules into a power strip or into the same circuit, then apply power to the strip or circuit to simultaneously apply power to all modules.

NOTE

If a power module becomes overloaded and shuts down, switch all the power modules off to reset the ones that are overloaded, then simultaneously switch all the power modules on again.

When enough power modules are powered on to meet the configuration's power needs, the PE will conduct a power-on self-test as part of the booting procedure. When the PE boots, the Boot (B) LED flashes to indicate that the module is booting. As soon as the PE finishes booting, the Boot LED becomes dark and one of the Status (S) LEDs on the left end of the PE glows steadily, indicating that the system is ready for operation.

Messages, similar to the following, are displayed on the management terminal during the boot process (PowerHub 7000 shown).

```
FORE Systems PowerHub 7000 Packet Engine
Prom version: PE1-3.0.0 (7887) 1998 05.06 13:01
I-cache 16KB OK
Entering cached code
I-cache execution OK
D-cache 4KB OK
SRAM 128KB OKDRAM 24MB OK
Shared Memory 4MB OK
Entering Monitor
FlashInit: found 2MB Flash Memory Module
Board Type: 7PE ,  CpuType: MCPU,  Instance: 1
Ethernet address: 00-00-ef-03-9a-b0
(normal start)
Hit any key now to abort boot [4]:
```

If the system does not boot when power is applied, check the LEDs on the power modules and PE. If no LEDs are glowing, there may be an overload in the power circuit or the system may not contain enough power modules. First check the power circuit to ensure that there is sufficient power going to the modules, then ensure that there are sufficient power modules for the configuration. For information on power requirements for different configurations, refer to *Chapter 4, Safety and Environmental Requirements.*

When the system is finished booting, the runtime command prompt is displayed. However, if the boot process is aborted, the prompt for the PE boot PROM is displayed. To resume the boot process, issue the following command at the <PROM-7PE> or <PROM-8PE> prompt:

b [n|f|m]

where: **n**
Boot from the network. (The system must be configured for netbooting.)

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f
Boot from the Floppy Diskette.

m
Boot from the Flash Memory Module (PowerHub 7000)

NOTE

If a boot source is not specified, the boot order configured in NVRAM is used. If a boot order has not been configured, the system attempts to boot first from the Flash memory Module (PowerHub 7000) or Compact Flash Card (PowerHub 8000), then from the network.

3.3.1 Specifying the Boot Source

The system can be configured to boot from Floppy Diskette, Flash Memory Module (PowerHub 7000), Compact Flash Card (PowerHub 8000) or from a TFTP server (network booting). The system can be configured to use one method exclusively or to try one method first, then try one or both of the other methods.

NOTE

If the system boots from Floppy Diskette or the Flash Memory Module (7000) or Compact Flash Card (8000), no connection to the network is required. However, to boot from a TFTP server, the system must be attached to the tftp boot server using a segment cable.

To specify the boot source:

1. Power on the PowerHub. A command prompt similar to the following is displayed.

   <PROM-7PE>

2. Enter the following command at the runtime command prompt or the Boot PROM command prompt, then press Enter:

   nvram set bo *<value>*

where:

<value> Specifies the boot source(s). Valid boot sources are:

- **f** Floppy diskette (7000)
- **m** Flash Memory Module (7000)
- **n** Network
- **c** Compact Flash Card (8000)

If more than one boot source is specified, the system attempts them in the order specified. (Ex: if **fmn** is entered, the Floppy Diskette is the first boot source option, then the Flash Memory Module (7000) or Compact Flash Card (8000) and then the network.)

NOTE A valid configuration file must be present on the designated netboot device before booting off the network device can occur.

3.3.1.1 Configuring the System for Network Booting

The manner in which the system boots depends on whether the system is on the same subnet as the boot server.

- If the PowerHub and the boot server are on the same subnet, use the procedure in Section 3.3.1.1.1 to implement point-to-point netbooting.
- If the PowerHub and the boot server are on different subnets, use both the procedure in Section 3.3.1.1.2 to implement cross-gateway netbooting.
  If **n** (network) was specified as the boot source in the procedure in Section 3.3.1, one or both of the procedures in the following sections must be performed.

NOTE The following procedures recommend specific path names for storing the system software, boot definition, and configuration files. Use path names that are legal on the TFTP server, but ensure the path names are used consistently. For example, copy the bootdef (boot definition) file onto the TFTP server and specify the path names in the bootdef file. The path names in the bootdef file must match those specified on the server. Alternatively, all the files can be installed in the TFTP home directory.

3.3.1.1.1 Point-to-Point Booting

This section describes the steps that must be performed to configure the PowerHub for point-to-point booting. Cross-references to the section documenting the referenced commands are provided. File and path names included in these steps are for illustrative purposes only, the path and file names may be different. To configure the PowerHub and the boot server for net-booting:

1. Configure the TFTP server:
   - Copy the system software image file, pe1 (7000) or pe2 (8000), and boot definition file (bootdef) onto the server. If installing them to the TFTP home directory, skip the next bulleted item.
   - If separate TFTP sub-directories for the software image file, boot definition file, and configuration file are to be set up, create the following sub-directories:

     `fore/ph/images/<software version>`

     `fore/ph/configs`

     Copy the image file into the <*software version*> sub-directory and the boot definition file (bootdef) and the configuration files into the configs subdirectory. (Section 3.5 describes how to create a configuration file and save it to the TFTP server.)

- Edit the boot definition file (bootdef) copied onto the server to contain parser version 1, the pathname and file name of the configuration file, and the pathname and file name of the boot image file. (Ensure that the boot definition file used for netbooting contain %vstart 1 and %vend 1 lines.) Here is an example of a bootdef file altered for point-to-point netbooting.

```
%vstart 1
fore/ph/configs/0000EF014A00.cfg          c
fore/ph/images/<software version>/pe1 m
%vend 1
```

In this example, the MAC-layer hardware address is used for <*file-name*> in the configuration file name. Note that each MAC-layer hardware address is unique. (See the label on the front of the chassis.) The procedures in Section 3.5 describe how to save the configuration. When the configuration file is saved to the TFTP server, ensure that the filename is the same as the filename specified in the boot definition file.

2. Configure the BOOTP server or the Packet Engine's NVRAM to contain the following information. If only one system is being configured, configure these values into NVRAM. By doing so, the need to configure a BOOTP server can be avoided. However, if multiple systems are going to be configured for netbooting, configure these values on the BOOTP server instead.
   - Client IP address.
   - Client subnet mask.
   - Gateway IP address (if the client and server are on different subnets).
   - TFTP server IP address.
   - Name of the boot definition file (often called bootdef) to be used to boot the client. Install this file on the TFTP server, but specify the name on the BOOTP server or in NVRAM. Note that the boot definition file is not the image file (8pe) and is not a configuration file (such as cfg).

To configure these values on the BOOTP server, see the BOOTP server documentation.

To configure these values in NVRAM, issue the following commands. These commands can be issued from the Boot PROM or runtime prompt:

nvram set myip *<value>*

where:

<value> The IP address of the PowerHub. Specify the address in dotted decimal notation (ex: 147.128.16.1).

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nvram set mysm *<value>*

where:

<value> The IP subnet mask of the PowerHub. Specify the mask in dotted decimal notation (ex: 255.255.255.0).

nvram set gwip *<value>*

where:

<value> The gateway router IP address of the PowerHub. Specify the address in dotted decimal notation (ex: 147.128.16.2).

nvram set fsip *<value>*

where:

<value> Is the TFTP server's IP address. Specify the address in dotted decimal notation (ex: 147.128.16.3).

nvram set netbdfile *<value>*

where:

<value> The name of the boot definition file on the TFTP server. Specify a name that is meaningful to the TFTP program on the server. For example, if the server contains a subdirectory called `fore` and this directory is specified as the TFTP home directory, do not specify `fore` as part of the file name.

3. Connect the PowerHub to the boot server (or intervening gateway) by attaching a network cable from the server to a segment on the PowerHub.
4. If the chassis contains BNC segments, make sure they are properly terminated. To terminate a BNC segment, set the switch on the segment to the terminated (T) position.

3.3.1.1.2 Cross-Gateway Booting

Cross-gateway netbooting refers to a netbooting configuration in which the PowerHub (boot client) and the boot server are separated by a gateway router. The configuration steps for cross-gateway netbooting include the steps for point-to-point netbooting. In addition, configuring for cross-gateway netbooting requires one of the following steps:

- If the gateway has a boot helper service, configure the gateway to help BOOTP packets sent by the client PowerHub to reach the BOOTP server.[1] If the gateway is another PowerHub, use the **`ip helper add`** command to configure a helper address (refer to the *PowerHub 7000/8000 Protocols Reference Manual* for details on the **`ip helper add`** command).
- If the gateway does not contain a boot helper service, configure the following values in the client PowerHub NVRAM:
  - Client IP address.
  - Client IP subnet mask.
  - Gateway IP address.
  - TFTP server's IP address.
  - Name of the boot definition file.

The commands for configuring these values are described in Step 2 in the procedure in Section 3.3.1.1.1. To configure for cross-gateway netbooting:

1. Perform the steps in Section 3.3.1.1.1.
2. If the gateway that separates the PowerHub from the TFTP server is another PowerHub, make sure the segment on the gateway PowerHub is configured as an IP interface. If the gateway segment does not have an IP interface, configure one using the **`ip interface add`** command on the gateway (refer to the *PowerHub 7000/8000 Protocols Reference Manual* for details on the **`ip interface add`** command):
3. Create an ip helper using the **`ip helper add`** command (refer to the *PowerHub 7000/8000 Protocols Reference Manual* for details on the **`ip helper add`** command).

[1] Boot helper services are sometimes called IP helper services or UDP helper services. The PowerHub contains a feature called *IP Helper* that provides boot helper services.

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3.4 Allocating Segments

When shipped, the PowerHub is configured to recognize the maximum allowable segments per NIM in the chassis. If the chassis does not contain modules whose total segment count exceed the maximum allowable segments, 96 for the PowerHub 7000 and 128 for the PowerHub 8000, the default segment allocations work for this system. However, if the chassis contains modules that exceed the allowable segment count, segments on some NIMs must be explicitly allocated or the additional segments are ignored. Refer to *Chapter 6, Boot PROM Commands* for information on allocating segments from the Boot PROM (`<PROM-7PE>`) prompt or the *PowerHub 7000/8000 Software Manual* on allocating segments from a runtime (`:PowerHub:nvram#`) prompt. Enter the maximum, or desired number up to the maximum, for the type of NIM installed, as listed in Table 3.3.

NOTE

Installing Intelligent NIMs above the allowable segment count for the specific chassis causes an error condition to occur. It is advisable to remove any unused NIMs installed above the maximum allowable segment count.

Table 3.3 - Maximum Segments per NIM

NIM Type	Maximum Number of Segments
ATM PowerCell	32
6x1 Fast Ethernet	6
10x1 10Base-FL Ethernet	10
Dual FDDI	2
Single FDDI	1
Universal Dual FDDI	2
Universal Single FDDI	1
1x6 FDDI Concentrator Module	1
1x16 TP-PMD Concentrator Module	1
Universal Ethernet	6
4x4 Ethernet Microsegment	4
4x6 Ethernet Microsegment	4

Table 3.3 - Maximum Segments per NIM

NIM Type	Maximum Number of Segments
13x1 Ethernet	13
16x1 Ethernet	16

NOTE It is recommended that segments for all NIMs be explicitly allocated, to eliminate "empty" segments.

Segment allocations are stored in NVRAM on the Packet Engine. If the Packet Engine is changed for any reason, the segments need to be re-allocated and the values stored in NVRAM in the new Packet Engine.

3.4.1 Verifying Segment Allocations

To display the current segment allocations to a particular NIM slot or all installed NIMs, issue the following command:

```
slotsegs[<n>] [show]
```

where:

[<n>] Specifies the slot number. This argument is optional. If the slot number is not specified, segment allocations for all slots are displayed.

NOTE If this command is used with the slot argument, the brackets around the slot number must be included.

3.4.2 Attaching Network Segments

To attach network segments, simply plug the segment cables into the appropriate segment connectors. Make sure to set the termination switch on any BNC EMAs to T (terminated) or U (unterminated) as required Also, if the chassis contains MAU EMAs, make sure the hardware jumpers are set for the correct operating mode. See *Chapter 5, Installation, Upgrade, and Removal Procedures* for information.

3.4.3 Enabling Automatic Segment-State Detection

Automatic-segment state detection enables the software to note changes in the state of segments (whether they go up or come down). This software automatically enables bridging and routing on segments that are active and marks the changes in corresponding table displays. (See *PowerHub 7000/8000 Software Reference Manual* for more information about Automatic segment-state detection.

3.5 Saving the Configuration

When the system boots, the software looks for a configuration file on the device specified as the boot source. When the configuration file is read, the configuration changes saved in the file are reinstated. A configuration file name can be specified in the boot definition file:

- If the system boots from the Flash Memory Module or Compact Flash Card, the `bootdef` file identifies a configuration file. By default, the bootdef file identifies the name cfg. (The default configuration name in the boot definition file can be changed by editing the file.)
- If the system boots from a BOOTP / TFTP server, the boot definition file identifies a file named <*file-name*>.cfg, where <*file-name*> identifies the system. Depending on how netbooting is configured, a descriptive string or the MAC-layer hardware address may be specified.

NOTE If more than one boot source is to be used, it is recommended that the same configuration be saved to each boot source. These procedures are described below. To avoid potential problems, ensure that the configuration files on all boot sources match.

3.5.1 Saving the Configuration File

Configuration files can be saved to the Flash Memory Module or Compact Flash Card on the Packet Engine to allow faster booting. The 4MB Flash Memory Module is standard on a PE1 and the 10MB Compact Flash Card is standard on the PE2. To save the current configuration to the Flash Memory Module or Compact Flash Card:

1. Boot the software. Following the boot messages, a command prompt is displayed.

NOTE The software must be successfully loaded before saving the configuration. The configuration cannot be saved from a Boot PROM prompt.

2. Type the following command at the system prompt, then press Enter:

```
savecfg cfg
```

The **savecfg cfg** command saves the configuration to a file named **cfg** in the Flash Memory Module or to the Compact Flash Card. Any DOS-like filename can be specified. If the filename does not match the name in the bootdef file (`cfg`), the configuration must be loaded manually each time the software is loaded by using the **system readcfg** command. (See the *PowerHub 7000/8000 Software Reference Manual* for more information on **system** commands.)

3.5.2 Saving the Configuration to a TFTP Server

To save the configuration file to a TFTP server, define an IP interface on a segment attached to the TFTP server, then use the TFTP software to save the configuration into a file on the server.

1. Boot the system. Following the boot messages the system prompt is displayed.

NOTE The software must be successfully loaded before saving the configuration. The configuration cannot be saved from a Boot PROM prompt.

2. Attach a segment cable from the system to the TFTP server.
3. Define a Virtual Local Area Network (VLAN) and an IP interface on the segment:

```
ip vlan add <vlanid> <seglist>
```

where

<vlanid> Specifies a vlan name. The <vlanid> can be up to 20 characters long.

<seglist> Specifies the segment, or segments, that comprise this vlan.

```
ip interface|it add <vlanid> <ipaddr>[/<prefixlen>|<mask>]
                    [br[oadcast] 0|1]
                    [met[ric] <metric>]
```

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where:

<vlanid> Specifies the <vlanid> specified above.

<ipaddr> Specifies the IP address assigned to the specified segment(s) in dotted-decimal notation.

[/<prefixlen>|<mask>] Specifies an optional subnet mask. If a particular network uses IP subnet addressing, then the subnet mask should be specified here using dotted-decimal notation. Otherwise, the system uses a default subnet mask equal to the “natural” subnet mask for the particular class of address.

[br[roadcast] 0|1] Specifies the style of broadcast address on a segment-by-segment basis:

When specifying br0, an “all-0s” broadcast is sent. This means all bits in the host segment of the address are 0s.

When specifying br1, a standard “all-1s” broadcast is sent. This means all bits in the host segment of the address are 1s. The default is br1.

[met[ric] <metric>] Specifies an optional metric. This is the number of extra hops to the destination. The range is **1** through **14**. (The switch decrements an IP packet’s time-to-live field at each hop.) The default is zero. If the subnet is using RIP, the additional cost to the reported metric is added.

4. Enable IP forwarding:

```
ip fps enable
```

5. Save the configuration to the tftp boot server:

```
tftp savecfg|svcfg [-h <host>] <remote-file>
```

where:

[-h <host>] Specifies the IP address of the TFTP server. Unless already specified a default TFTP server using the **`tftp set server`** command, include this argument. For information on the **`tftp set server`** command, refer to the *PowerHub 7000/8000 Software Reference Manual*.

<remote-file> Specifies the configuration file name present on the TFTP server to which the configuration is being saved. Specify a name that is meaningful to the TFTP program on the server. For example, if the server contains a subdirectory called `fore` and this directory is specified as the TFTP home directory, do not specify `fore` as part of the file name.

The **`tftp savecfg`** command saves the configuration file to the tftpboot server on the IP interface defined in Step 3. Note that some TFTP servers require that the remote filename exist on the server before writing to that file name. If the server requires that the filename already exist, create a short file on the server, then specify that file name for *<remote-file>*. On some TFTP servers, including servers running Sun / OS 4.x, files overwritten on the server are not properly truncated. When overwriting an existing file on the TFTP server, if the older version of the file is longer than the new file, the older version is not truncated properly by the server. As a result, the new version of the file contains part of the older version of the file.

If the configuration filename specified in the boot definition file on the server is longer than eight characters, copy the file to the server using a DOS-like name, then rename the file on the server to match the file name specified in the boot definition file.

3.6 Redundant Packet Engine (RPE)

Redundant Packet Engines (RPE) are supported with the Packet Engine 2 (PE2) in the PowerHub 8000 10- and 15- slot chassis.

3.6.1 Configuring

To configure RPE, the following equipment and software is required:

- Two PE2s containing firmware version 2.0.0
- Packet Engine 2 PROM Programming Utility (PPU-pe2)
- Supplied 10Base-T cross-over cable

1. In a 10-slot configuration, the active (AC) and stand-by (SB) PE2s are installed in slots 5 and 4, respectively. In the 15-slot configuration, in slots 10 and 9, respectively.
2. To begin configuring RPE support, insert one PE2 into slot 5 or 10, depending on the chassis being used, and then install the remaining NIMs for the configuration. Once all the necessary NIMs and PE2 are installed, boot the system. Note that the SB PE2 has not yet been installed.
3. Make sure NVRAM slot segments are unset. To unset slot segments, use the following command:

```
nvram slotsegs[n] unset
```

4. Once the system has completed the boot process, configure the unit as desired and save the configuration (**system savecfg cfg**). Save the configuration file to another place in the network as it is required in a later step.
5. Power the system down and remove the AC PE2, from slot 5 or 10, depending on the chassis being used.
6. Install the SB PE2 into slot 4 or 9, depending on the chassis being used, and power the system on.
7. Repeat steps 3 through 5 on the SB PE2.
8. Next, continue the SB PE2 boot sequence. Once the unit is booted with the SB PE2, configure simple IP connectivity to the unit.

ip vlan add <vlanid> <segment>
ip it add <vlanid> <ipaddr>

9. TFTP the cfg file saved in steps above back to the PE2 currently installed.

get cfg

10. TFTP the PROM Programming Utility 8PE (ppu-8pe) to the SB PE2.
11. Once the TFTP transfers are complete, each PE2 (AC and SB) should contain the same NVRAM information and configuration (cfg) file and the SB PE2 should also contain ppu-8pe.

NOTE

The following steps are used to change the Ethernet MAC Address of the SB PE2 to match the Ethernet MAC Address of the AC PE2. Setting these addresses to the same address can reduce the downtime experienced in the event of a fail-over.

CAUTION

Mark the PE2 that is designated as the Standby PE2 to prevent inserting this Packet Engine into another PowerHub 8000 as a sole Packet Engine. It must also be noted that the Ethernet Mac Address must be changed to reflect the Ethernet MAC Address shown on the faceplate of the Packet Engine if used in other than a redundant configuration in this PowerHub 8000.

12. Reboot the system.

system reboot

13. Stop the booting process at the five second interval.
14. From the Boot PROM prompt load ppu-pe2.

```
load ppu-pe2
go
```

15. From the displayed PPU menu, select option 2, Change MAC Address.
16. At the prompts, enter the same Ethernet Address found on the faceplate of the AC PE2.
17. Select option 3, to Reboot.
18. When the system has completed booting, verify the Ethernet Address.

```
system ethaddr
```

19. The address displayed on the console should match that shown on the faceplate of the AC PE2.
20. Power down the system.
21. Insert the AC PE2 in slot 5 or 10, as appropriate.
22. Connect the two PE2s with the supplied 10BaseT Ethernet cross-over cable. This cable plugs into the SYNC port on each PE2. The SYNC port is a 10Mb/s port dedicated for use by the RPE heartbeat protocol.

NOTE This port is not a data port and can not be used for anything other than the RPE heartbeat connection.

23. Disregard the AC-SB switch on the PE2 front panel. This was originally going to be used for static configuration of which PE2. In the current implementation, they arbitrate for it, and this switch is not used.
24. Power the system up and allow the PowerHub to boot in an RPE configuration.

3.6.2 Booting the System

When the system is powered on, internal self tests are run, the hardware is configured, and then (depending on NVRAM settings) either the main code is loaded or, if the system can't locate the main code, the system stops at the Boot PROM prompt.

In the PowerHub 8000, with redundant PE2s installed, except after configuring the hardware, the standby PE2 encountered waits a fixed amount of time for the active PE2 to start. The standby PE2 then checks if the active PE2 has grabbed the data bus. If not, the standby PE2 grabs the data bus and continues with the boot process.

If the bus has been grabbed by the active PE2, the standby PE2 starts looking for a heartbeat message on the `SYNC PORT`. The standby PE2 waits for up to 1 minute for the first heartbeat and then up to 8 seconds for each heartbeat thereafter. As long as the standby PE2 is receiving heartbeats, it goes no further in the boot process. When the standby PE2 fails to receive a heartbeat, it assumes a failure of the primary PE2 and grabs the bus and continues with the boot process.

Once the active PE2 if fully booted, the unit operates normally while sending the heartbeat. If at any time, the active PE2 enters a hung state, crashes, panics or reboots, the standby PE2 stops receiving the heartbeat message, takes control of the bus, and finishes the boot sequence.

The length of downtime, following the active PE2 failure, depends on the system configuration. When the standby PE2 takes over and becomes the active PE2, it is actually recapturing the bus. This requires each slot to be re-initialized, and as a result each GINIM to release their runtime software from the now active PE2.

Downtime is defined as:

downtime = (time to detect loss of heartbeat) + (boot time)

where:

time to HB detect	< 8 seconds
boot time	a factor of number the of GINIMs (to boot their runtime software)

In this implementation, it is the operator's responsibility to ensure that the standby PE2 is equipped and configured to handle the PowerHub following a fail-over. There are no automatic mechanisms to provide for software and configuration information to be sent from the active PE2 to the standby PE2. Only heartbeat messages are passed across the `SYNC PORT`. Any configuration changes to the active PE2, must be saved and the standby PE2 must be re-configured.

Once the active PE2 fails, and the standby PE2 takes over, all local forwarding in data and caches on the GINIMs is flushed, given that the software is reloaded, and all forwarding, routing, table and cache data is lost on the PE2. The newly active PE has to relearn and converge when booting is complete.

CHAPTER 4 Safety and Environmental Requirements

This chapter provides a summary of the safety and handling precautions for handling the PowerHub and its components. The following safety and handling guidelines are discussed:

- Electro-Static Discharge (ESD)
- Avoiding personal injury
- Guarding against damage
- Preventing damage to connector pins
- Securing thumbscrews
- Care of fiber-optic systems and cables

Additionally, this chapter discusses environmental and power requirements for the proper use of the PowerHub.

4.1 Safety Requirements

4.1.1 Electro-Static Discharge

Electronic components can be damaged through improper handling. One of the most common, although unintentional, types of mishandling is Electro-Static discharge (ESD). ESD can permanently damage electronic components. ESD straps should be worn when performing the hardware procedures explained in this chapter. Carefully read all of Section 4.1.3 for details. ESD can occur when the equipment being handled and the individual handling the equipment are at different voltage potentials. When coming into contact with the equipment, the difference in potential can cause energy to be passed from the individual to the component, delivering a shock.

The human body is a good conductor of electricity and can deliver shocks containing thousands of volts. In fact, most people perceive a static shock only when the voltage of the shock is at least 6,000 volts. However, many electronic components can be damaged by shocks as low as 2,000 volts.

4.1.2 Avoiding Personal Injury

Use care and common sense when handling modules. Improper handling of modules can result in damage to the components or personal injury. To avoid personal injury:

- Do not immerse components in water.
- Do not stand on a wet surface while inserting or removing modules.
- Always cover unused slots or bays with the supplied cover plates. Never place tools, or any body part inside empty power module bays or module slots.

4.1.3 Guarding Against Damage

After the chassis, the work surface, and any loose components are grounded, touch the chassis or the work surface containing the components before touching the components themselves. To guard against damaging modules, always take the following precautions:

- Wear an anti-static wrist guard. Make sure the wrist guard directly touches the skin. To insure against ground faults, use a wrist guard that has a 1MΩ (one megohm) resistor.
- Always store modules in their original packaging.
- Never operate the system with exposed power module bays or NIM slots. Operating the unit without cover plates installed over unused bays or slots voids the warranty.
- Handle the modules only by their edges. Never directly touch components on the modules.
- Never remove a module from its protective packaging or from a chassis until the chassis and the work surface are properly grounded. If the work surface is metallic, ground it by attaching a wire from the surface to the electric ground in the building. If the work surface is not metallic, use a ground-conductive rubber mat as the work surface.

NOTE Low humidity levels can increase the danger of ESD. Use extra caution if the PowerHub is in a low-humidity environment.

- After the chassis and any loose components are grounded, touch the chassis or work surface containing the component, before touching the component itself. In this way, any charge is neutralized before it can damage the component. Note that the chassis or other surface must be grounded for this to be effective.

4.1.4 Preventing Pin Damage

Use care when handling modules that have connector pins. Modules such as the Packet Channel Backplane and the power backplane contain many small pins that plug into headers in other modules. These pins can be bent if the modules are mishandled, or if excessive force is used to seat the modules' pins in a header.

Pin damage caused by mishandling is not covered by warranty. If a pin is accidentally bent, to prevent the pin from becoming broken, carefully bend it back into position before attempting to seat the module.

4.1.5 Tightening Thumbscrews

Always use the appropriate screwdriver to tighten thumbscrews on the modules. If a screwdriver is not used to tighten the thumbscrews, the modules can come loose through ordinary vibration, such as when installing cables or moving adjacent modules and cover plates. The thumbscrews on the Packet Engine and NIMs require a regular flat-head screwdriver. The power modules require a #2 Phillips-head screwdriver.

4.1.6 Care of Fiber-Optic Systems and Cables

In addition to the general precautions discussed above, fiber-optic systems require additional precautions.

Always use care when connecting fiber optic cables. Although they look like standard copper cables, they are delicate. Avoid repeated sharp bending of fiber optic cables since it can cause micro-cracking of the glass fiber. Be particularly careful of the open ends of the uncovered connectors. Make sure that the connector surfaces are not dragged along the floor or dropped onto hard or abrasive surfaces. The best practice is to keep the factory supplied dust covers on all unused fiber connectors and optical components.

4.2 Environment Requirements

The system is designed to operate within a temperature range of 0° to 40° C (32° to 104° F) and at 10 to 90 percent relative humidity, non-condensing. The corresponding storage requirements are –20° to 55° C (–4° to 131° F) and 90 percent maximum relative humidity, non-condensing.

To ensure adequate air flow for cooling, maintain at least a 3" clearance on either side and the front. Operating the system without adequate clearance for cooling voids the warranty.

4.2.1 Acoustic Noise Levels

Table 4.1 lists the acoustic noise levels for a fully-loaded system including the fan modules.

Table 4.1 - Acoustic Noise Levels

Chassis	Noise Level
5-slot chassis with two active power modules	~40 dbA at one meter
10-slot chassis with four active power modules	~60 dbA at one meter
15-slot chassis with four active power modules	~60 dbA at one meter

The measured noise may vary by plus or minus 3 dbA from these levels for any particular system.

4.3 Power Requirements

The power requirements are determined by the number of populated slots. A fully populated PowerHub 8000 can support up to 14 NIMs, ten of which can be Intelligent NIMs (INIMs), and up to four power modules. The following sections identify the power requirements so that the power produced by the power modules is sufficient. The following sections specify the power requirements and the power produced by the power modules.

The number of power modules needed by a specific chassis depends upon its configuration—both the number and types of installed modules and whether redundant power operation is desired. In any case, the first step in determining the number of power modules needed is to determine the total power requirements of the modules in the configuration.

Modules may consume power at two different voltages, +5-volts and +12-volts. Power needs are determined based on the greater of the +5-volt and +12-volt power requirements. The requirements are identical regardless of whether the current is being supplied by AC or DC power modules.

4.3.1 +5-Volt Current Requirements

Power requirements are calculated by adding the current requirements of all the modules in the system. Technically, the actual power requirement in watts is the supply voltage times the current requirement in amperes; generally, this distinction is only relevant to electrical engineers.

Table 4.2 lists the current requirements, in amperes (A), required from the +5-volt power system by each module. The total +5-volt current required by a particular configuration is determined by adding the +5-volt current requirements of all installed modules, being careful to account for multiple instances of each module type.

Table 4.2 - PowerHub +5-Volt Requirements

Module Type	+5V
Packet Engine	10.0A
UEM + AUI, BNC or MAU	2.0A
UEM + 10Base-T, 10Base-FL, or 10Base-FB EMAs	2.5A
PowerCell 700 ATM Module with 1 PHY (AMA)	7.5A
PowerCell 700 ATM Module with 2 PHYs (AMAs)	8.0A
6x1 Fast Ethernet Module + six FEMAs	9.0A
Single FDDI Module	8.0A

Table 4.2 - PowerHub +5-Volt Requirements

Module Type	+5V
Universal Single FDDI Module	9.0A
Dual FDDI Module	10.0A
Universal Dual FDDI Module	11.0A
4x4 Microsegment Ethernet Module	4.0A
4x6 Microsegment Ethernet Module	4.5A
13x1 Ethernet Module with FEMA	5.0A
16x1 Ethernet Module	5.0A
6 port FDDI Concentrator Module	5.0A
16 port FDDI Concentrator Module	8.0A

If a UEM has multiple types of EMAs (in Table 4.3, 10Base-FL and AUI), use the worst-case +5-volt number (2.5A). Thus, if two UEMs (each containing at least one 10Base-FL EMA) and two 16x1 UEMs are installed, the total +5-volt current requirement is calculated as shown in Table 4.3.:

Table 4.3 - +5 Volt Current Calculation

Packet Engine	10.0A	=	10.0A
UEMs with 10Base-FL EMAs	2 x 2.5A	=	5.0A
16x1 Ethernet Modules	2 x 5.0A	=	10.0A
Total		=	25.0A

4.3.2 +12-Volt Current Requirements

The total +12-volt current required by a particular configuration is determined by adding the +12-volt current requirements of all installed modules. However, besides the fan module (one for each 5-slot shelf), only the AUI Media Cables and BNC EMAs on the UEM actually use +12-volt current, so these calculations are not needed if these are not installed.

Table 4.4 - PowerHub +12-Volt Requirements

Module Type	+12V
Fan module	1.0A
BNC EMA	0.3A
AUI Media Cable	0.5A

Each AUI Media Cable requires an amount of +12-volt current dependent upon the type of external Medium Access Unit (MAU) attached to it. The IEEE 802.3 standard specifies a maximum requirement of 0.5A, but most modern MAUs use less current than this (typically 0.2–0.3A). A lower number can be used if the MAUs require less current.

In Table 4.5, suppose the two UEMs have two 10Base-FL EMAs, four AUI Media Cables, and six BNC EMAs. The total +12-volt current requirement is determined as shown in Table 4.5.

Table 4.5 - +12 Volt Current Calculation

			+12-volt	+5-volt
Packet Engine 2	9.0A	=		9.0A
Fan Module	1.0A	=	1.0A	
Universal Ethernet Modules with10Base-FL EMAs	2 x 2.5A	=		5.0A
AUI Media Cables (with worst-case MAUs)	4 x 0.5A	=	2.0A	
BNC EMAs	6 x 0.3A	=	1.8A	
16x1 Ethernet Modules	2 x 5.0 A	=		10.0A
Total		=	4.8A	24.0A

4.3.3 Nonredundant and Redundant Power Configurations

The system can be configured to provide, or not provide, redundant power. FORE Systems recommends power redundancy, which provides for backup power if one power module fails. FORE Systems' redundant power design allows the system to continue running without interruption if a single power module fails or is removed. In addition, live insertion of modules requires that a redundant power module is present.

If the system does not have a redundant power module and a power module fails, remaining power modules may become overloaded and shut down to protect themselves from damage. If this happens, perform the following:

- Disconnect the power.
- Determine which power module is bad.
- Replace the bad power module.
- Reapply power to the system.

By installing a redundant power module, this type of problem is avoided. A redundant power module ensures that if a power module fails, the system continues to operate normally. Since the system continues operating, unlit LEDs on a bad power module identify where the problem is so that it can be easily corrected.

4.3.4 Determining the Number of Nonredundant Power Modules

The PowerHub supports three different power modules. Two AC modules, which produces 283 Watts and 500 Watts, respectively, and one 48-Volt DC module which produces the same current as the 283 Watt power supply.

The 283 Watt AC and 48 Volt DC power modules are rated to continuously deliver 35A @ +5-volt and 9A @ +12-volt. The 500 Watt AC modules are rated to continuously deliver 70A @ +5-volt and 14A @ +12-volt. However, for conservative operation in nonredundant configurations, FORE Systems recommends that the modules be de-rated to approximately 90% of full capacity when calculating current usage. De-rating the power usage reduces long-term stress on the modules and improves reliability.

Table 4.6 shows the capacity of the 283 Watt power modules, and Table 4.7 the 500 Watt power modules. To determine the power requirements, add the amount of current the installed modules draw and divide the number by the current capacity of the power module to get the number of power modules needed. For example, in Table 4.6, the total +5-volt current requirement is 25A. The total +12-volt current requirement is 4.8A. The number of power modules required for a nonredundant configuration for either 25.0A at +5-volts or 4.8A at +12-volts is 1 (25A / 35A < 1 and 4.8 / 9 < 1).

Table 4.6 - 283 Watt Power Module Requirements

+5V Current (in Amps)	+12V Current (in Amps)	Nonredundant	Redundant
0 - 35	0 - 9	1	2
35.1 - 70	9.1 - 18	2	3
70.1 - 105	18.1 - 27	3	4
105.1 - 140	27.1 - 36	4	4

Table 4.7 - 500 Watt Power Module Requirements

+5V Current (in Amps)	+12V Current (in Amps)	Nonredundant	Redundant
0 - 70	0 - 14	1	2
70.1 - 140	14.1 - 28	2	3
140.1 - 210	28.1 - 42	3	4
210.1 - 280	42.1 -56	4	n/a[1]

1. At these currents, four modules are required for normal nonredundant operation.

The number of modules required is the maximum of the numbers determined using Table 4.6 or Table 4.7. In Table 4.7, if the total +5-volt current requirement was 33A instead of 25A, the number of modules required for a conservative nonredundant configuration would become 2 instead of 1 if the 283 Watt modules are used. The number of modules required to satisfy the +5-volt requirement is now 2, so use 2 modules even though the +12-volt requirement is still satisfied by just 1 module.

4.3.4.1 Determining the Number of Redundant Power Modules

The fourth column of Table 4.6 and Table 4.7 shows the number of modules required in a redundant configuration as a function of the +5-volt and +12-volt current requirements.

In Table 4.7, the total +12-volt current requirement is 4.8A, and the total +5-volt current requirement is 25.0A. Using the fourth column in Table 4.6 or Table 4.7, the number of power modules required to satisfy the current requirement at either voltage in a redundant configuration is 2.

During normal operation of a redundant configuration, each module operates well below its maximum capacity. This is true because the power system provides load-sharing, so that each installed module handles an equal share of the total load presented to the power system.

In a redundant configuration, if one module fails or is otherwise not operating, the remaining modules take up the load. This allows for the hot-swapping and replacement of failed power modules while the system is operating. When a new power module is added, the system immediately begins to load share between all installed power modules.

If a power module in a redundant configuration should fail, increasing the load on the remaining power supplies to the threshold of their capacities, it is important to repair or replace the failed module quickly. This is necessary not only to reinstate redundancy, but also to return the power system to a more conservative operation, further improving its reliability.

CAUTION

If only one module is to be installed, always install the module in the primary power-module bay. Otherwise, during live insertion of a module, transients may cause the entire switch to reset. The primary power-module bay is designed to prevent this from occurring. The primary power module bay is the upper-left bay.

CHAPTER 5 Installation, Upgrade, and Removal Procedures

This chapter provides procedures for installation, upgrade, and removal of the Packet Engine (PE1 or PE2), PE1 components, Network Interface Modules (NIMs), Media Adapters and power modules. Individual sections within this chapter may contain cross-references to other chapters in this manual. The chapters referred to provide detailed information on the specific components as listed below:

- Chassis and Packet Engine (*Chapter 2, Chassis and Packet Engines*)
- ATM Interfaces (*Chapter 7, ATM Interfaces*)
- Ethernet Interfaces (*Chapter 8, Ethernet Interfaces*)
- FDDI Interfaces (*Chapter 9, FDDI Interfaces*)

5.1 Packet Engine and NIMs

The following sections provide procedures on the removal and installation of the Packet Engine and NIMs (hereinafter referred to as module). The tools required for this procedure are:

- ESD wrist strap
- Medium flat-blade screwdriver
- #2 Phillips screwdriver
- Grounded work surface, such as a grounded metal table or a table covered with a grounded, rubberized mat.

5.1.1 Installing a Packet Engine or NIM

CAUTION

Static electricity can damage the electronic components. Refer to *Chapter 4, Safety and Environmental Requirements* for the appropriate precautions to be taken when handling components.

1. If the slot in which the module is to be installed is not covered with a cover plate, go to step 2. If the slot has a cover plate, use the Phillips screwdriver to remove the two screws securing the cover in place.

WARNING!

Always power off the PowerHub if installing a Packet Engine.

NOTE

If installing a NIM in an empty slot or installing a NIM that is of a different type than the one currently installed, power off the PowerHub before installing the NIM.

2. If installing the NIM in an empty slot, go to the step 3. If the slot is not empty, remove the NIM from the slot before installing the new NIM. Refer to Section 5.1.2 for procedures to remove a module.
3. Holding the module by its plated edges, align the rear corners of the module in the grooves on either side of the slot. The groove is just below the screw holes for the thumbscrews, as shown in Figure 5.1.

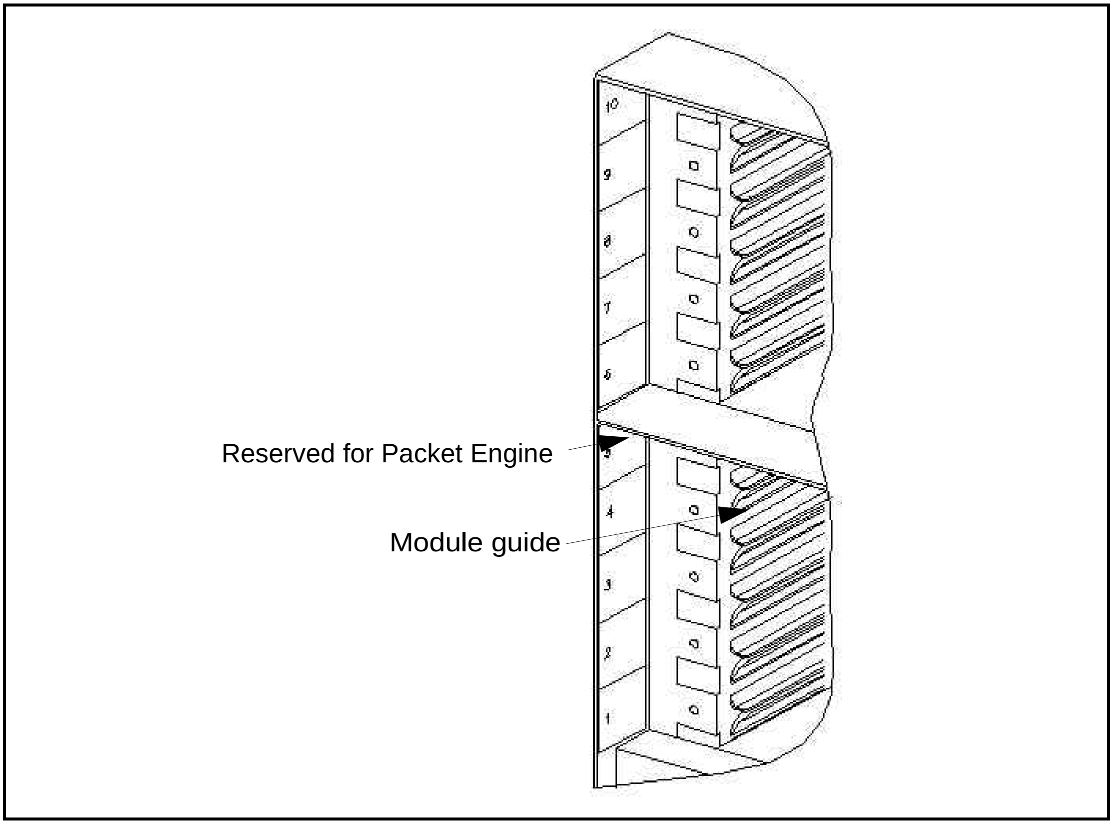


Figure 5.1 - Module Card Guides

CAUTION

Do not touch the components on the module. The Packet Engine installs in slot 5 in a 10-slot chassis and slot 10 in a 15-slot chassis.

4. Slide the module at least two-thirds of the way into the slot. Do not force the module. If it does not slide easily, remove it and try again.

5. Grasp the ejector handles on each end of the module, making sure the handles point back away from the chassis, and push the module the rest of the way into the slot. When the module is in place, the front panel is flush with the other modules or cover plates in the chassis.

CAUTION

Some modules have an activation switch, located behind the ejector handle on the left side of the module. If an activation switch is present on the module, the ejector handle must be pressing on the activation switch for the module to operate. When installing the module, make sure the ejector handles are pressed firmly into place.

6. Secure the module in place by pressing the ejector handles against the front panel.
7. Use the flat-head screwdriver to tighten the thumbscrews.

CAUTION

The thumbscrews must be tightened to prevent the module from coming loose through ordinary vibration. If the module becomes loose, the activation switch becomes disengaged. When this happens, the module automatically shuts down.

8. If the **`card-swap disable`** command was used to remove a NIM from this slot and the same type of NIM is being installed, use the **`card-swap enable`** command from the **`system`** runtime command prompt to notify the system that the NIM has been replaced.

```
enable card-swap|cs <slot>
```

where: <*slot*> is the number of the slot in which the NIM is installed.

9. Attach / reattach network segments to the NIMs or the management terminal to the Packet Engine.

5.1.2 Removing a Packet Engine or NIM

CAUTION

Static electricity can damage the electronic components. Refer to *Chapter 4, Safety and Environmental Requirements* for the appropriate precautions to be taken when handling components.

1. Disconnect all management and/or network cables from the module being removed.
2. Perform one of the following:
   - If removing a Packet Engine, power off the PowerHub.
   - If removing a NIM and replacing it with a NIM of a different type, power off the PowerHub.
   - If removing a NIM, and replacing it with a NIM of the same type, from the **`system`** subsystem, issue the **card-swap** command. To remove a NIM, issue:

     ```
     card-swap disable <slot>
     ```

     where: *<slot>* is the number of the slot in which the NIM is installed.
3. Using the flat blade screwdriver, loosen the thumbscrews securing the module in the chassis.
4. Lift the ejector handles by carefully pulling them away from the module.
5. Grasp the ejector handles and pull the module out until it is about one half of the way out of the chassis.
6. Holding the module by its plated edges, remove it from the chassis and set it on a grounded work surface or anti-static bag.

5.1.3 Live Insertion of Modules

Modules can be inserted, or “hot swapped,” while the PowerHubis powered up if the modules are of the same type, e.g. a FDDI module is replaced with another FDDI module. If you are replacing one module with a different type of module, the PowerHub needs to be powered down first. Live insertion requires power redundancy. In addition, it may be necessary to calculate the power supply needed to support the present modules during a live insertion as the module inserted will initially draw excess power away form existing modules. For specific direction for calculating power supply needs, see the Configuration Guide accessible on the Product Marketing web site.

To do a card swap, use the card swap **`card-swap|cs enable|disable <slot>`** command in the system subsystem.

5.2 Packet Engine 1 (PE1) Components

NOTE There are no replaceable components on the PE2.

The PE1 contains several replaceable components. These include:

- Flash Memory Module
- Packet Accelerator

The following paragraphs provide procedures for the installation and removal of these components. Refer to Figure 5.2 when performing these procedures for the physical location of these components.

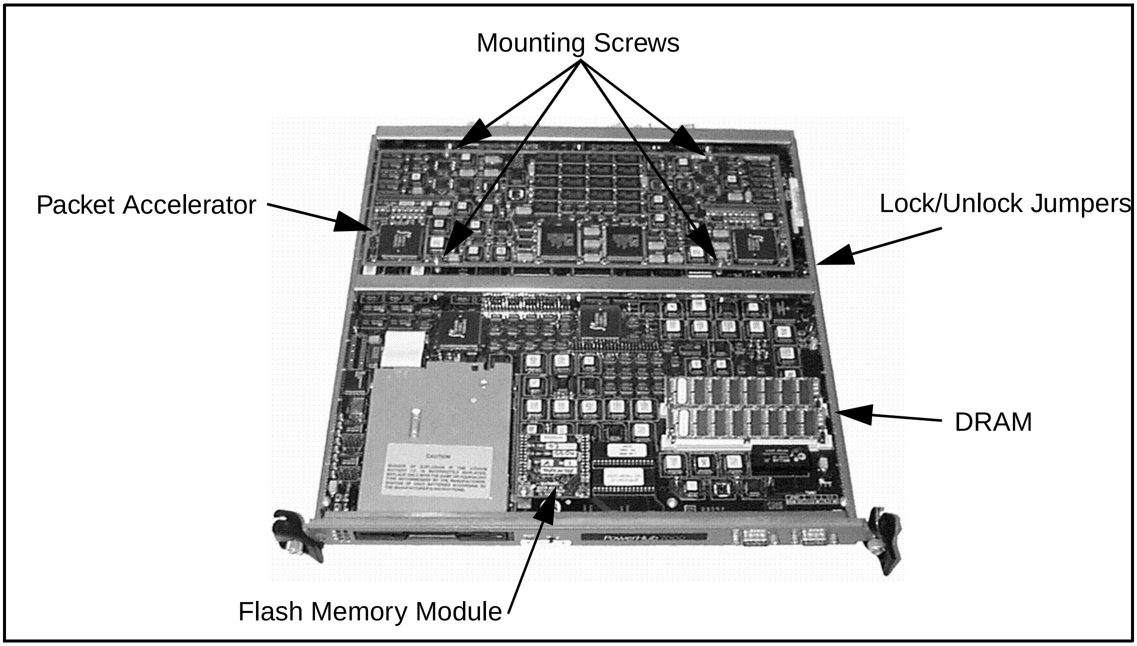


Figure 5.2 - Packet Engine 1 (PE1)

5.2.1 Installing, Upgrading, and Removing Flash Memory

The following procedures describe how to install or remove the Flash Memory Module on a Packet Engine 1 (PE1). A #2 Phillips screwdriver is the only tool required to perform this procedure. Figure 5.2 shows the location of the Flash Memory Module. Figure 5.4 shows the screw that secures it to the PE1. Refer to this figure while performing this procedure. This procedure applies only to the PowerHub 7000.

CAUTION

Static electricity can damage the electronic components. Refer to *Chapter 4, Safety and Environmental Requirements* for the appropriate precautions to be taken when handling components.

5.2.1.1 Upgrading the Flash Memory Module

The following kit is required to perform this upgrade:

- Flash Memory Module Upgrade Kit 7160-02-7

1. Verify if the Packet Engine currently contains a Flash Memory Module by issuing the **system dir fm:**, or **mgmt dir fm:**, command, as shown below.

```
1:PowerHub:system# dir fm:

Volume in device is 4MB FLASH
7PE              1443561    4-27-1998   8:16a
7ATM              598578    4-27-1998   8:16a
7FDDI             149856    4-27-1998   8:17a
7FETH              75770    4-27-1998   8:17a
CFG                28622    4-08-1998   7:51a

5 File(s)    1766912 bytes free

2:PowerHub:system#
```

2. If a Flash Memory Module is currently installed, the first line of the display describes the logical size of the module. If the volume states `4MB FLASH` an upgrade is not required.
3. If the volume states less than 4MB, or an error message stating that a device driver is not present, goto step 4.
4. Power off the system.
5. Remove the Packet Engine from the chassis.
6. If a Flash Memory Module is installed, remove it by removing the mounting screw and lifting the module free, then go to step 8.
7. If no Flash Memory Module is installed go to step 8.
8. Remove the Flash Memory Module from its protective packaging.
9. Orient the Flash Memory Module so that the mounting stud is visible through the corresponding mounting hole in the module.
10. Gently press down on the module when the headers are properly aligned over the pins on the PE1.
11. When the module is completely seated on the pins, insert the supplied screw into the stand-off and tighten.

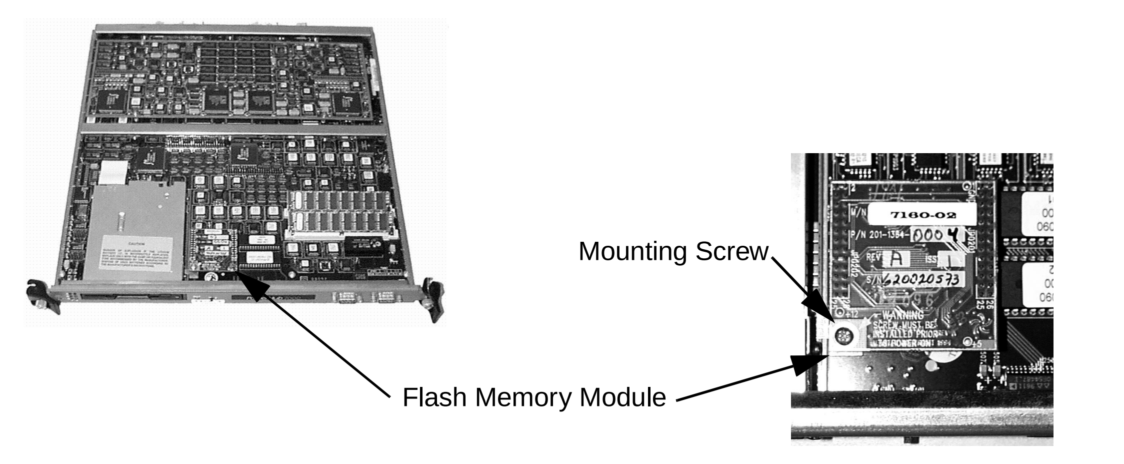


Figure 5.3 - Packet Engine 1 (PE1) Components

12. Reinsert the Packet Engine in the chassis.
13. Power on the system.

NOTE

If file management commands consistently return an error message, such as, <*command*>: -65, where <*command*> is the command attempted, it is necessary to format the Flash Memory module. To format the module, issue the **`format fm:`** command (refer to the *PowerHub 7000/8000Software Reference Manual*).

5.2.1.2 Upgrading Packet Engine 1 Memory

One of the following kits are required to perform this upgrade:

- Memory Upgrade Kit 2700-16 (for 7101-02), or
- Memory Upgrade Kit 2700-32 (for 7101-01)

1. Verify the amount of memory currently installed on the Packet Engine by using the **`system config`**, or **`mgmt scf`**, command.

```
1:PowerHub0:system# config
Accelerator board is present. Accelerator IOP is being used.
Installed DRAM Size: 24 MB
```

2. If less than 32MB is reported, go to step 4.
3. If 32MB, or greater, is reported no memory upgrade is required.
4. Power off the chassis.
5. Remove the Packet Engine from the chassis.
6. Compare the illustrations in Figure 5.2 to the removed Packet Engine and locate the appropriate SIMM socket(s).
7. If the Packet Engine is a 7101-01, go to step 9.
8. If the Packet Engine is a 7101-02, go to step 12.

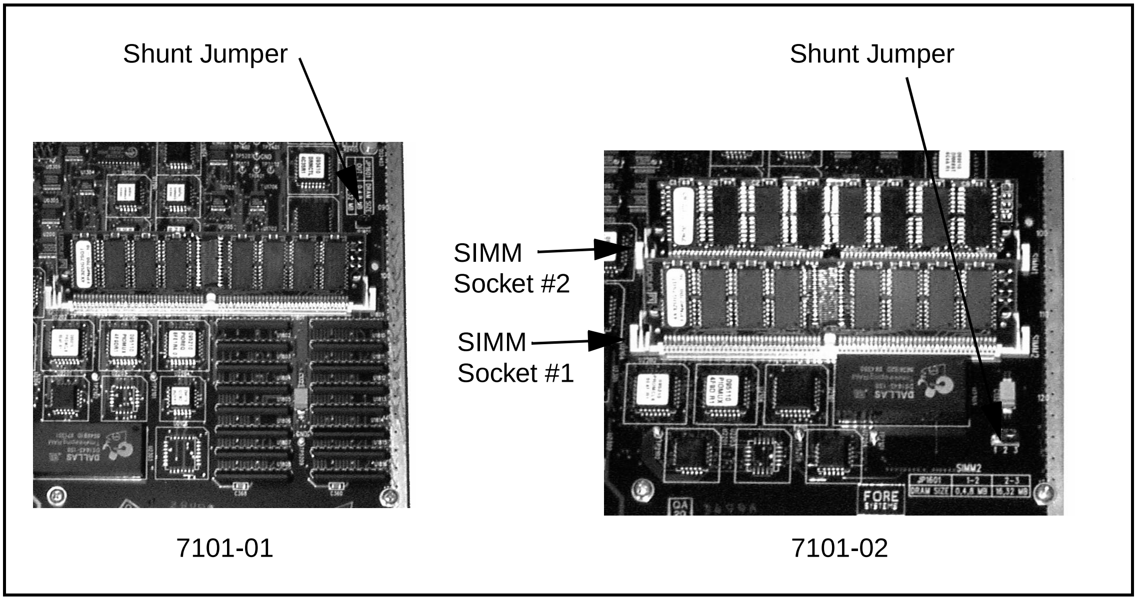


Figure 5.4 - Packet Engine Memory Locations

9. If 8MB was reported in step 1 and no SIMM is present in the SIMM socket, install the SIMM in Memory Upgrade Kit 2700-32, otherwise go to step 10.
10. If 16MB was reported in step 1, remove the SIMM that is installed and replace it with the SIMM from Memory upgrade Kit 2700-32.
11. Verify, or install if missing, a shunt jumper is installed across the pins of JP1601 (see Figure 5.2).
12. If 16MB was reported in step 1 and only one SIMM is installed in SIMM socket 1, install the SIMM from Memory Upgrade Kit 2700-16 in SIMM Socket #2.
13. If <32MB was reported in step 1 and there are two SIMMs installed, remove the SIMM in SIMM Socket #2 and replace it with the SIMM from Memory Upgrade Kit 2700-16.
14. Verify, or install if missing, that a shunt jumper is installed across pins 2 and 3 of JP1601 (see Figure 5.2).
15. Reinsert the Packet Engine into the chassis.
16. Power-on the chassis.

Repeat step 1 when the system has completed loading to verify the amount of DRAM installed.

5.2.2 Installing or Removing a Packet Accelerator

CAUTION

Static electricity can damage the electronic components. Refer to *Chapter 4, Safety and Environmental Requirements* for the appropriate precautions to be taken when handling components.

The following procedures describe how to install, upgrade, and remove the Packet Accelerator on a Packet Engine 1 (PE1). A #2 Phillips screwdriver is the only tool required to perform these procedures. Figure 5.2 shows the location of the Packet Accelerator and the screws that secure it to the PE1. Refer to this figure while performing this procedure.

5.2.2.1 Installing a Packet Accelerator

The following procedures describe how to install a Packet Accelerator. Refer to Figure 5.2 for the location of the Packet Accelerator and mounting screws.

1. Follow the procedure in Section 5.1.2 to remove the PE1 from the chassis.
2. Remove the Packet Accelerator from its protective packaging.
3. Holding the Packet Accelerator by its edges, align the two connector receptacles over the corresponding sockets on the Packet Engine. Verify that the alignment is correct by sighting the four standoffs on the Packet Engine through the corresponding holes in the Packet Accelerator.
4. Make sure the Packet Accelerator is oriented correctly. It is oriented correctly when the serial number and version information are right-side up with respect to the front of the chassis, and the screw holes are aligned as described in step 3.
5. Gently press down on the rear of the Packet Accelerator when the headers are properly aligned over the pins on the PE1.
6. When the Packet Accelerator is completely seated on the pins, insert the supplied screws into the stand-offs and tighten.
7. Check the model number of the Packet Engine. The model number is located in the upper right corner of the Packet Engine.
8. If the Packet Engine model number is 7101-01 or 7101-02, insert the Packet Accelerator shunt jumper (JP1801) by removing the jumper from the single pin it covers and place it over both pins. See Figure 5.5 for the position of the shunt jumper

.

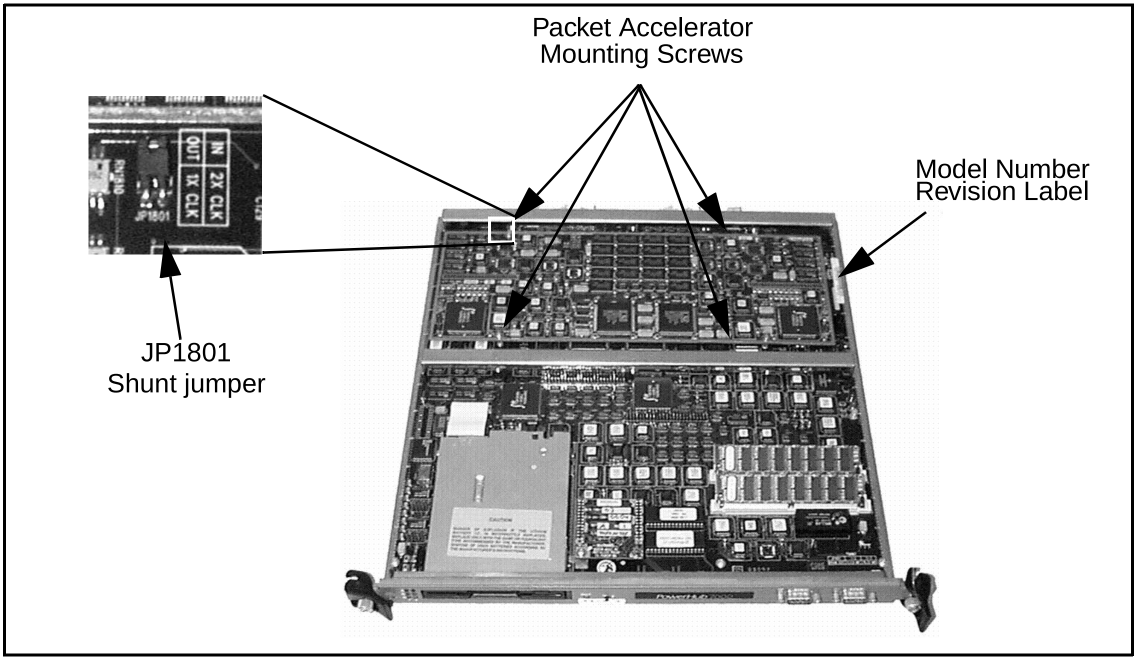


Figure 5.5 - Packet Engine 1 (PE1) Components

9. Install the PE1 into the chassis following the procedure in Section 5.1.1.
10. When the PE1 and any other removed NIMs have been installed, power on the unit and watch the boot messages for a line similar to the one shown below in bold type. If this line is present and shows the Packet Accelerator was installed, the installation was successful.

```
Looking for packet accelerator card
1 2
Found packet accelerator - will use 4MB shared memory
Packet accelerator IOPs will be used
```

5.2.2.2 Removing a Packet Accelerator

The following procedure describes how to remove a Packet Accelerator from the PE1. Refer to Figure 5.2 for the location of the Packet Accelerator and the screws securing it to the PE1.

1. Follow the procedure in Section 5.1.2 to remove the PE1 from the chassis.
2. Remove the mounting screws securing the Packet Accelerator to the PE1 as shown in Figure 5.2.

3. Gently pull up on the Packet Accelerator to free the pin headers from the pin sockets on the PE1. If the module does not lift freely, gently rock it from side-to-side to loosen the pins.
4. Place the Packet Accelerator in its protective packaging.
5. If not reinstalling a Packet Accelerator, follow the procedure in Section 5.1.1 to reinstall the PE1.

5.2.3 Media Adapters

This section provides procedures to install or remove media adapters supported by the Universal Ethernet Module (UEM), Universal FDDI Module or PowerCell 700 ATM Module. The supported media adapters include:

- ATM Media Adapters (AMAs). Refer to *Chapter 7, ATM Interfaces*, for more information on AMAs.
- Ethernet Media Adapters (EMAs) and Fast Ethernet Media Adapters (FEMAs). Refer to *Chapter 8, Ethernet Interfaces*, for more information on EMAs and FEMAs.
- FDDI Media Adapters (FMAs). Refer to *Chapter 9, FDDI Interfaces*, for more information on FMAs.

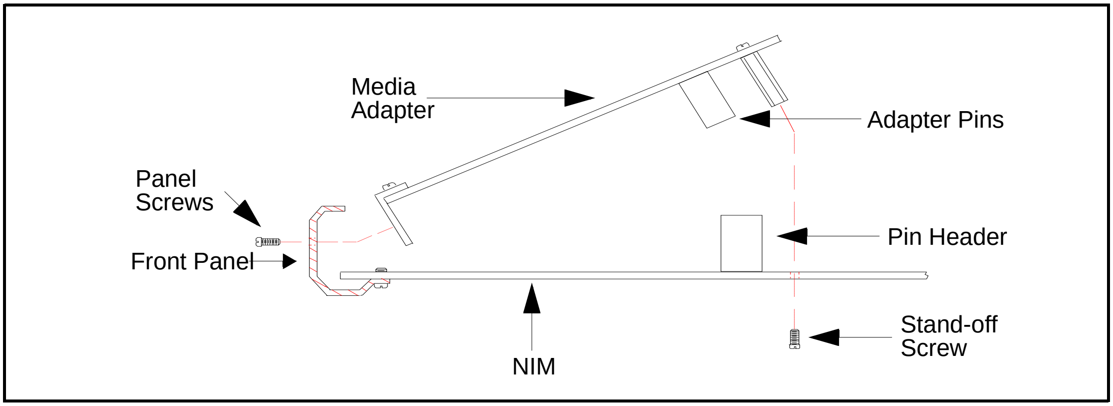


Figure 5.6 - Removing/Installing a Media Adapter

The following media adapters are supported on the modules listed.

Table 5.1 - Media Adapters

UEM (Universal Ethernet Module)	
	AUI

Table 5.1 - Media Adapters

	10Base-FL (FOIRL-compatible)
	10Base-FB
	BNC (10Base2)
	MAU
	UTP (10Base-T)
Universal FDDI Module	
	Single FDDI
	Dual FDDI
PowerCell 700 ATM Module	
	OC-3 (single- or multimode) AMA
	OC-3 UTP

5.2.3.1 Installing a Media Adapter

CAUTION

Static electricity can damage the electronic components. Refer to *Chapter 4, Safety and Environmental Requirements* for the appropriate precautions to be taken when handling components.

The following procedure describes how to install a media adapter. The pin sockets on some NIMs contain a plastic border around the pins. This border creates a tight fit for the media adapters when installing them.

NOTE

When installing the adapters, do not plug any cables into the adapters until the system has completed the booting process.

This procedure does not apply to AUI Media Cables. To install an AUI Media Cable, use the procedure in Section 5.2.4.1. The following tools are required to install a media adapter:

- #2 Phillips screwdriver
- Medium flat-head screwdriver
- 3/16” hex nutdriver

- A grounded work surface, such as a grounded metal table or a table covered with a grounded, rubberized mat is required if components are to be removed or installed.

1. Remove the two screws securing the blank faceplate covering the empty adapter bay to the front of the NIM. Retain the blank faceplate and screws in the event the adapter is later removed.

NOTE

If removing a MAU EMA, use the hex nutdriver to remove the hex mounting studs securing the blank faceplate to the front of the NIM.

2. While holding the rear of the adapter, gently insert the segment / port connector of the adapter through the opening on the NIM front panel as shown in Figure 5.6. Notice that adapter is installed component-side down.
3. Ensure that the segment / port connector is fully forward by pushing on it until it is firmly in place. The front of the adapter must be flush with the back of the front panel.
4. Align the adapter pins directly over the pin socket on the NIM.

CAUTION

Visually ensure that the standoffs and their corresponding screw holes, and the connector pins and their corresponding pin sockets are properly aligned. If the pins and sockets are not aligned properly, the pins can break and the NIM and / or adapter can be damaged.

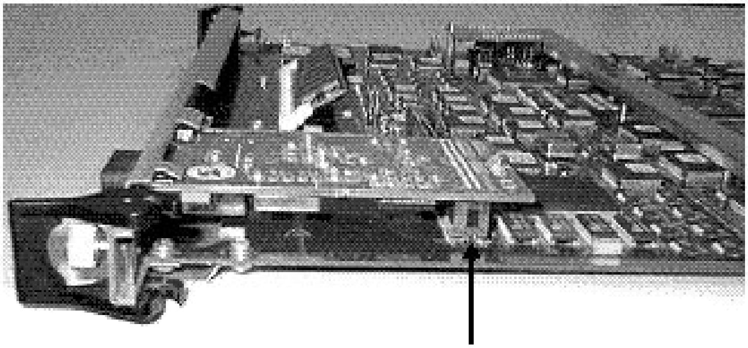
5. When the pins are properly aligned over the socket, firmly and evenly press the backside of the adapter down to push the pins into the socket. While pushing down on the adapter, it may be necessary to gently rock it side-to-side to help seat the pins into the socket.

CAUTION

When seating the adapter, check the sides of the pin socket for pins that are protruding. If increased resistance is felt when seating the adapter or if pins are protruding from the side of the pin socket, stop seating the adapter, and remove it.

Repeat step 5 to attempt to seat the adapter. If the module still does not seat properly, call FORE Systems TAC.

When the adapter is properly seated, it should appear as shown in Figure 5.7.



Ensure that all pins are correctly aligned and seated in the pin socket.

Figure 5.7 - Media Adapter Alignment

6. To secure the adapter to the NIM, insert and tighten the screw on the underside of the NIM.

NOTE

If installing a FEMA, insert and tighten the other supplied screw through the screw hole on the adapter into the top of the standoff. Remember that adapters are installed component-side down.

CAUTION

Be sure to use the screws provided with the adapter. Use of screws other than those provided may result in damage to the adapter or the NIM.

7. Re- insert the NIM into the PowerHub, securing the thumbscrews.

8. If no more adapters are to be removed from this NIM, use the procedure in Section 5.1.1 to reinstall the NIM.
9. Reboot the system to activate the changed system configuration.

5.2.3.2 Removing a Media Adapter

CAUTION

Static electricity can damage the electronic components. Refer to *Chapter 4, Safety and Environmental Requirements* for the appropriate precautions to be taken when handling components.

The following procedure describes how to remove a media adapter from a PowerHub NIM. The pin sockets on some NIMs contain a plastic border around the pins. This border creates a tight fit for the media adapters when removing them. The following tools are required to remove a media adapter:

This procedure does not apply to the removal of AUI Media Cables. To remove an AUI Media Cable, use the procedure in Section 5.2.4.2. The following tools are required to remove a media adapter:

- #2 Phillips screwdriver
- Medium flat-head screwdriver
- 3/16” hex nutdriver
- Regular flat-head screwdriver
- ESD wrist-strap
- A grounded work surface, such as a grounded metal table or a table covered with a grounded, rubberized mat is required if components are to be removed or installed.
- If the removed Media Adapter is not to be replaced, replace the appropriate cover plate.

Figure 5.6 shows how a Media Adapter is removed from a module.

1. Use the procedures in Section 5.1.2 to remove the NIM containing the media adapter to be removed from the chassis.

CAUTION

Never attempt to add, remove, or modify components on a Packet Engine or NIM when the module is still in the chassis. Components can break or be damaged by electrostatic discharge, or the module itself may crack as a result of improper handling.

2. Remove the screw and washer securing the adapter to the NIM. These are located on the underside of the NIM. Do not remove the standoff on the adapter itself.
3. Remove the two pan-head screws securing the adapter to the NIM front panel. (This does not apply to the MAU EMA.)

NOTE

If removing a MAU EMA, use the hex-head nutdriver to remove the two mounting studs that secure the EMA to the UEM front panel.

4. Grasp the rear of the adapter, making sure not to grab the pin connections. (These can become bent and damage the adapter.)
5. Gently pull up on the rear of the adapter to loosen the pins from the socket on the NIM. If the pins do not come loose, gently rock the rear of the adapter from side to side while pulling up. Stop pulling as soon as the pins come loose to prevent damaging the adapter.
6. When the adapter pins are free from the socket on the NIM, gently pull the adapter straight out of the NIM front panel. If the adapter gets caught, gently jiggle it free. Do not force the adapter to come free to prevent damaging components.
7. When the adapter is completely free of the NIM, either place it in its protective container for storage or, if planning on installing it in another NIM, place it on a grounded table.
8. If the adapter is not to be replaced with another adapter, install the appropriate cover plate over the unused adapter position.
9. If no more adapters are to be removed from this NIM, use the procedure in Section 5.1.1 to reinstall the NIM.
10. Reboot the system to activate the changed system configuration.

5.2.4 Replacing an AUI Media Cable

This section describes the procedures required to remove or install an AUI Media Cable. When performing these procedures, refer to Figure 5.8 for a depiction of how the AUI Media Cable is attached.

.

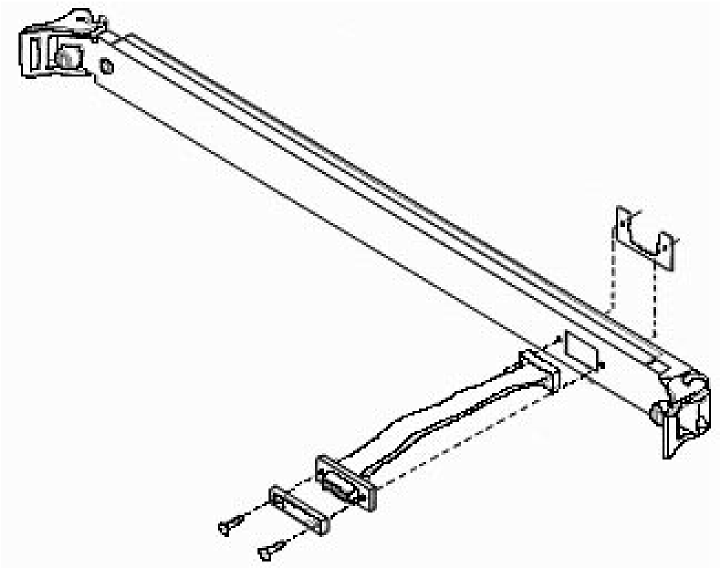


Figure 5.8 - Attaching An AUI Media Cable

5.2.4.1 Installing an AUI Media Cable

The procedure for installing an AUI Media Cable differs from the procedure for installing a Media Adapter. This procedure applies only to AUI Media Cables. To install a Media Adapter, use the procedure in Section 5.2.3.1.

CAUTION

Static electricity can damage the electronic components. Refer to *Chapter 4, Safety and Environmental Requirements* for the appropriate precautions to be taken when handling PowerHub components.

For this procedure, the following parts and tools are required:

- AUI Media Cable and supplied mounting hardware
- A small flat-head screwdriver.

Figure 5.8 shows how an AUI Media Cable is attached to a UEM and should be referred to while performing this procedure.

To install an AUI Media Cable:

1. If not already done so, use the procedure in Section 5.1.2 to remove the UEM from the PowerHub chassis.

CAUTION

Never attempt to add, remove, or modify components on a Packet Engine or NIM when the module is still in the chassis. Components can break or be damaged by electrostatic discharge, or the module itself can crack as a result of improper handling.

2. Remove the coverplate from the UEM position where the AUI Media Cable is to be installed.
3. From the rear of the UEM front panel, insert the segment connector on the AUI Media Cable into the front panel.
4. Align the connector pins at the rear of the cable directly over the header on the UEM. The AUI header is the one closest to the rear of the UEM.
5. When the connector pins are aligned, gently press them all the way down into the UEM header.
6. Insert the fastener directly behind the segment connector on the rear of the front panel. The two screw holes in the fastener must line up with the screw holes in the front panel.
7. Use the flat-head screwdriver to start (but do not screw all the way in) the supplied screws in the front of the AUI connector. The screws must screw into the fastener behind the UEM front panel.

8. Place the slide latch over the screws and onto the segment connector. Make sure the round screw holes on the slide latch face outward.
9. Use the flat-head screwdriver to fasten the screws firmly into place, securing the segment connector firmly to the face plate. Do not over-tighten the screws; the slide latch must be able to switch left and right.
10. Repeat this procedure for each AUI Media Cable. When finished, use the procedure in Section 5.1.1 to reinstall the UEM.

5.2.4.2 Removing an AUI Media Cable

The procedure for removing an AUI Media Cable applies only to the AUI Media Cable and differs from the procedure for removing a Media Adapter. To remove a Media Adapter, use the procedure in Section 5.2.3.2.

CAUTION

Static electricity can damage the electronic components. Refer to *Chapter 4, Safety and Environmental Requirements* for the appropriate precautions to be taken when handling PowerHub components.

A small flat-head screwdriver is required to perform this procedure. Refer to Figure 5.8 to see how an AUI Media Cable is attached while performing this procedure.

To remove an AUI Media Cable:

1. Refer to Section 5.1.2 for the procedures to remove the UEM.

CAUTION

Never attempt to add, remove, or modify components on a Packet Engine or NIM when the module is in the chassis. Components can break or be damaged by electrostatic discharge, or the module itself may crack as a result of improper handling.

2. Use the flat-head screwdriver to remove the two screws that fasten the AUI connector and slide latch to the UEM front panel. When the screws are removed, the slide latch and fastener that secures the connection from the rear of the front panel (see Figure 5.8) are freed.

3. Collect the two screws, the slide latch, and the fastener and place them in a container for storage. These may be necessary if the AUI Media Cable is to be installed at a later time.
4. Pull the AUI Media Cable's pin connector loose from the socket on the UEM. If the connector does not come off easily, gently rock the connector from side to side to free it from the pins.
5. From the rear, pull the connector out of the UEM front panel.
6. Unless the AUI Media Cable is to be installed on the same or another UEM, place the removed media cable in the storage container with the screws, slide latch, and fastener.
7. If a Media Adapter is to be installed in place of the removed AUI Media Cable, use the procedure in Section 5.2.3.1. If the segment position is to be left unoccupied, install the appropriate cover plate.

NOTE

Install the appropriate cover plates over all unused slots, adapter positions, and power module bays.

5.2.5 Setting the Operating Mode of the MAU EMA

The MAU EMA contains a jumper that configures the operating mode of the card. The jumper can be used to configure the card for one of the following modes:

- FDX—Full-duplex mode (SQE heartbeat disabled). Use this mode when connecting the MAU EMA to an AUI connector that supports full-duplex operation.
- RPT—Repeater mode (half-duplex with SQE heartbeat disabled). Use this mode when connecting the MAU EMA to the AUI connection on a repeater.
- SQE—SQE mode (half-duplex with SQE heartbeat enabled). Use this mode when connecting the MAU EMA to the AUI connection on a workstation or server.

CAUTION

Static electricity can damage the electronic components. Refer to *Chapter 4, Safety and Environmental Requirements* for the appropriate precautions to be taken when handling PowerHub components.

For this procedure, a small flat-head screwdriver is required.

To set the operating mode of the MAU EMA:

1. If the MAU EMA is installed on a UEM that is in a PowerHub Chassis, use the procedure in Section 5.1.2 to remove the UEM.
2. If the MAU EMA is installed on a UEM, use the procedure in Section 5.2.3.2 to remove the MAU EMA.

CAUTION

Never attempt to add, remove, or modify components on a NIM when the module is still in the chassis. Components can break or be damaged by electrostatic discharge, or the module itself may crack as a result of improper handling.

3. Place the jumper on the back of the MAU EMA over the pins that correspond to the desired setting. Figure 5.9 shows the jumper positions for the three settings. This figure shows the component side of the adapters. Remember that the adapters are installed component side down.

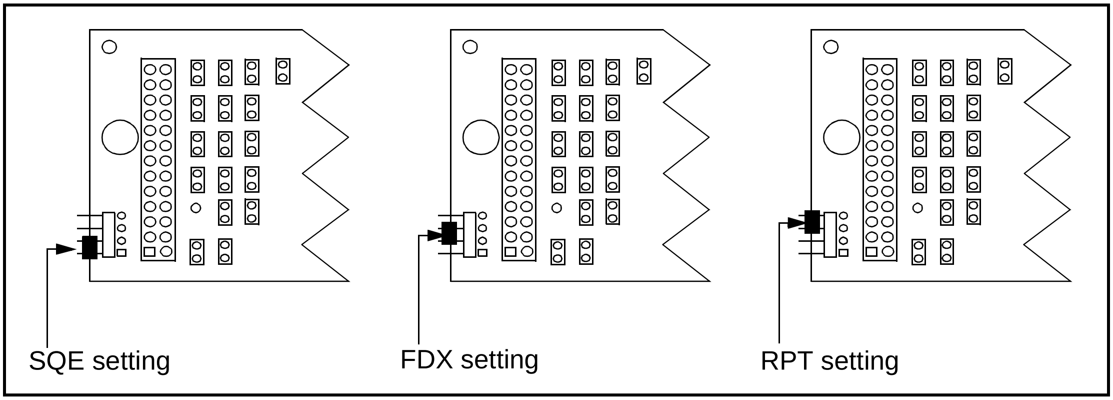


Figure 5.9 - Jumper Settings on MAU EMA

4. When the jumpers are set, use the procedure in Section 5.2.3.1 to install the MAU EMA in the UEM and Section 5.1.1 to install the UEM in the PowerHub chassis.

5.2.6 Configuring a MIC for a Specific Connection

This section describes the FDDI MICS and their connections and the plastic inserts restrict the kind of connections that the FDDI MIC can support. This section notes that the ST connectors on the single-mode FMAs support the four types of FDDI connections, but the ST connectors do not have the plastic inserts that provide the security feature. This section describes how to configure a MIC for a specific type of FDDI connection.

The FDDI MICs are versatile enough to accommodate any of the four types of FDDI connection. This versatility makes attaching the FDDI module to an FDDI ring, concentrator, or other device simple. It is not necessary to make any modifications to a MIC connector to use it for any of the four FDDI connection types.

However, a MIC can be configured for only a certain type of connection. In this case, use the plastic inserts provided with the FDDI module to prevent unwary users from accidentally using the connector for other connection types.

NOTE The ST connectors used on single-mode FMAs also support any of the four types of FDDI connections. However, these connectors do not use plastic inserts.

To configure a MIC for a specific type of FDDI connection:

1. Open the small plastic bag containing the four plastic inserts.
2. Select the insert corresponding to the FDDI connection type. Each insert is labeled with A, B, M, or S.
3. Slide the insert into the slot on the MIC connector until it snaps into place. This slot is located on the top of the MIC on the Single and Dual FDDI modules. On the multimode FMA, this slot is located on the bottom of the MIC. When the insert is properly placed, the insert label is facing out and the front of the insert is flush with the front of the MIC.
4. Repeat this procedure for each MIC to be configured.

To remove an insert:

1. Use a narrow object to press down the small tab that holds the insert in place.
2. Pull the insert out of the connector.
3. Repeat this procedure for each MIC.

5.2.7 Changing the Setting of the Lock Switch Jumper

The PE1 has two hardware mechanisms to restrict access to the PowerHub; the Lock/Unlock Switch and Lock/Unlock Jumpers.

Both the Lock/Unlock Switch and the Lock/Unlock Jumpers are located on the PE1. The Lock/Unlock Switch is located on the front panel and the Lock/Unlock Jumpers are located on the circuit board. The Lock/Unlock Jumpers are inaccessible without removing the PE1 from the chassis.

When the Lock/Unlock Switch is set on (L) a userid and password are required to access the PowerHub. When set to off (U), no userid or password is required and anyone can access the PowerHub through the TTY1/TTY2 ports or a Telnet session.

The Lock/Unlock Jumper has LOCK and UNLOCK jumper positions to override either position of the switch. A third position ‘SPARE’ can be used as a storage position if the Lock/Unlock Switch is to control access to the PowerHub. If the jumper is set to Lock or Unlock, changing the position of the Lock/Unlock Switch has no effect on the operation of the PowerHub.

The following procedure describes how to set the Lock/Unlock Jumper. Refer to Figure 5.2 for the location of the Lock/Unlock Jumpers on the PE1.

CAUTION

Never attempt to add, remove or modify components on a Packet Engine or NIM when the module is installed in the chassis. Components can become broken or damaged through electrostatic discharge, or the module itself can become cracked through improper handling.

1. Follow the procedure in Section 5.1.2 to remove the PE1 from the chassis.
2. Locate the Lock/Unlock Jumpers. Figure 5.10 shows a close-up of the Lock/unlock Jumpers on the PE1.
3. To set the Lock Switch Jumper, disabling the front panel Lock/Unlock Switch forcing restricted access, remove the jumper from the UNLOCK or SPARE pin headers and place it across the LOCK pin headers.
4. To set the Unlock Switch Jumper, disabling the front panel Lock/Unlock Switch allowing unrestricted access to the PowerHub, remove the jumper from the LOCK or SPARE pin headers and place it across the UNLOCK pin headers.

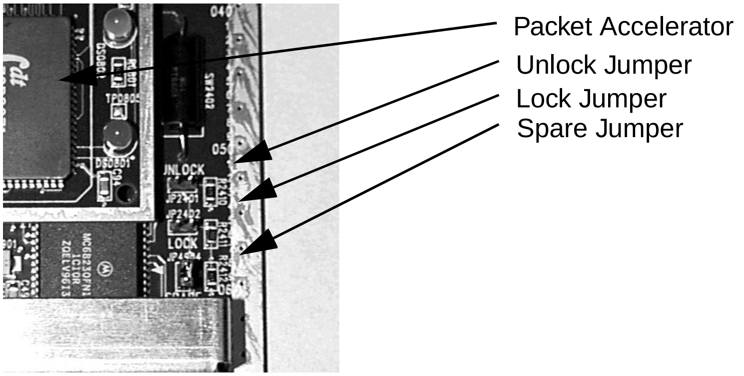


Figure 5.10 - Lock / Unlock Jumpers

5. To disable the Lock / Unlock Switch Jumper, enabling the front panel Lock / Unlock Switch, remove the jumper from the UNLOCK or LOCK pin headers and place it across the SPARE pin headers.

5.2.8 Replacing a Power Module

Power modules can be installed at any time, even while the hub is operating. If the chassis contains only one power module, always install the power module in the primary bay. If the chassis contains more than one power module, one of the modules must be installed in the primary bay. The primary power module bay is the upper-left bay

A #2 Phillips-head screwdriver is required to replace a failed power module.

To replace a failed power module:

1. Turn the power switch to the OFF position (marked **O**).
2. Loosen the two thumbscrews on the power module to be replaced. The thumbscrews should disengage from the chassis, but not from the power module.
3. Gently pull the power module from the power module bay, keeping the power supply level to avoid damaging any NIMs in the slot above the power supply bay.

NOTE

If a new power module is being installed in a power module bay that is currently empty and is covered by a protective cover plate, remove the two screws from the cover plate. Remove the cover plate. Do not place the plate or screws inside the power module bay.

4. Place the rear of the power module into the empty power-module bay, keeping the power module level. Tilting the power module upward may contact the NIM in the slot above it and damage the NIM.
5. Gently slide the power module all the way into the bay. Do not force the power module into place. If it does not slide easily into place, remove it and try again.
6. When the power module is fully in place, firmly tighten the thumbscrews.
7. Plug the power cable into the receptacle on the front of the power module.
8. Plug the other end of the cable into the appropriate 110-volt or 220-volt AC circuit or 40–60-volt DC power source. If installing a DC power module, connect the cable to the power source as follows:
   - Black wires -48-volt.
   - Red wires +48-volt.
   - Green wires Ground.

WARNING!

For the DC power module, connect the wires as described above. If the wires are connected differently and power is applied, the power module and the PowerHub might be damaged. Damage caused by incorrect wiring is not covered by warranty.

9. Turn the power switch to the ON position (marked |).

Provided a “load” is present in the chassis (at least a Packet Engine), the power module begins supplying current as soon as the power switch is turned on. (The power module does not activate if no load is present.) All three LEDs on the power module’s front panel light up. If any of these LEDs fails to light up, check the power connections and try again. If the problem persists, contact FORE Systems TAC.

CHAPTER 6 Boot PROM Commands

The PowerHub supports Boot PROM commands controlled from the Packet Engine firmware to manage and store files, view the configured Ethernet address, set or unset Non-Volatile Random Access Memory (nvram) boot order variables, and boot the system from either the default device or to designate a different boot source. The Boot PROM prompt is not accessible during normal runtime operation, but is displayed if the boot process is interrupted or if an error occurs during the boot sequence. The Boot PROM command prompt is displayed as `<PROM-7PE>` or `<PROM-8PE>`.

The Boot PROM commands are available to the user if the normal boot process is aborted at the 5-second delay prompt. A typical PowerHub 7000 boot screen display is shown in Figure 6.1. Figure 6.2 shows a typical PowerHub 8000 boot screen display.

```
Starting Packet Engine ...
Prom version: pe1p-3.0.0 (7887) 1998.05.06 13:01
I-cache 16KB OK
Entering cached code
I-cache execution OK
D-cache 4KB OK
SRAM 128KB OK
DRAM 24MB OK
Shared Memory 4MB OK
Entering Monitor

FORE Systems PowerHub 7000
FlashInit: found 4MB Flash Memory Module
Board Type: 7PE ,  CpuType: MCPU,  Instance: 1
Ethernet address: 00-00-ef-03-9a-b0

(normal start)

Hit any key now to abort boot [4]:

<PROM-7PE>
```

Figure 6.1 - PowerHub 7000 Boot Screen Display

```
FORE Systems PowerHub 8000 Packet Engine
Prom version: pe2p-2.0.0 (7846) (s) 1998.05.06 13:02
MCPU 1
MCPU local RAM tests:  basic, byte, burst, address, data
MCPU shared RAM tests: basic, byte, address, data
PACKET DESC RAM tests: basic, byte, address, data
PACKET DATA RAM tests: basic, byte, address, data
MCPU local RAM - 4MB
MCPU shared RAM - 32MB
PACKET DESC RAM - 1024KB
PACKET DATA RAM - 8MB
Entering Monitor
LOCK switch: UNLOCKED
ACTIVE/STANDBY switch: ACTIVE
Chassis: 10 slots
W Bus:
Slots that are equipped:
Slots that are equipped and latched:
Z Bus:
Slots that are equipped: 7
Slots that are equipped and latched: 7
X Bus:
Slots that are equipped: 3
Slots that are equipped and latched: 3
Y Bus:
Slots that are equipped: 2 1
Slots that are equipped and latched: 2 1
Board Type: 8pe,  CpuType: MCPU,  Instance: 1
Breaks enabled
Ethernet address: 00-00-ef-06-97-b0

(normal start)

Hit any key now to abort boot [1]:


<PROM-8PE>
```

Figure 6.2 - PowerHub 8000 Boot Screen Display

The display below shows the available Boot PROM commands that the user would normally access:

```
<PROM-7PE> ?
COMMANDS:
       boot:           boot|b [-n] [fd|net|fm]
       copy file:      copy|cp <src-file> <dest-file>
                       -or-
                       copy|cp <src-file> [<src-file>...] <device>
       ethaddr:        ethaddr|ea
       help:           help|? [COMMAND]
       expert help:    ??
       ls:             ls|dir
       more:           more [-[<rows>]] f1 [f2...[fn]]
       nvram:          nvram [set|unset|show <variable> [<value>]]
                       ("nvram set bo" sets disk/net boot order)
       remove file:    rm|del [-f] f1 [f2...[fn]]
       rename file:    rename|ren <oldfilename> <newfilename>
       zmodem receive: zreceive|zr|rz [-+27abcehtw] [<filename>]
       zmodem send:    zsend|zs|sz [-+27abehkLlNnoptwXYy]
<PROM-7PE>
```

Additional commands are available under expert help, accessed by entering two question marks (**??**). Most of the commands located under expert help should be used only as directed by FORE Systems TAC. Some of the commands are used when upgrading the Packet Engine firmware. Those commands the user is expected to use in the normal operation of the PowerHub are discussed in this chapter. Those commands which should be reserved for FORE Systems TAC use are not discussed. The complete set of Boot PROM commands are listed in the display below:

```
<PROM-7PE> ??
COMMANDS:
       boot:           boot|b [-n] [fd|net|fm]
       bootdef parser ver:             bpv
       breakpoint:     brk|bp [ADDRLIST]
       cacheflush:     cacheflush|cf [-i|-d]
       call:           call|ca ADDR [ARGLIST]
       compare:        compare|cmp [<-w|-h|-b>] RANGE dest
       continue:       cont|c
       copy file:      copy|cp <src-file> <dest-file>
                       -or-
                       copy|cp <src-file> [<src-file>...] <device>
       date:           date [YYMMDDhhmm[.ss]]
       debug int.:     dbgint|di [<-e|-d> <DEV>]
       debug (remote)  debug|db [SERIAL PORT]
       disassemble:    dis RANGE
       dump regs:      dr [<reg#|reg_name>]
       dump:           dump|d [-w|-h|-b] RANGE
       dumpw:          dumpw ADDR
       ethaddr:        ethaddr|ea
       fill:           fill|f [<-w|-h|-b|-l|-r>] RANGE [<value_list>]
```

```
        fill:           fillword|fw <word-address> <value>
        fill regs:      fr <reg#|reg_name><value>
        go:             go INITIAL_PC
        go until:       gotill|gt <brk addr>
        help:           help|? [COMMAND]
        expert help:    ??
        history:        history|h
        iop test:       iop
        load:           load|l [-b] fd-filename|tty0|tty1
        ls:             ls|dir
        more:           more [-[<rows>]] f1 [f2...[fn]]
        next:           next|n [COUNT]
        nvram:          nvram [set|unset|show <variable> [<value>]]
                        ("nvram set bo" sets disk/net boot order)
        radix select:   rad [<-o|-d|-h>]
        reg set select: regsel|rs [<-c|-h>]
        remove file:    rm|del [-f] f1 [f2...[fn]]
        rename file:    rename|ren <oldfilename> <newfilename>
        setbaud:        setbaud|sb tty1 <baud rate>
        search:         search|sr [<-w|-h|-b>] RANGE value [mask]
        select seg.:    seg [<-0|-1|-2|-u>]
        step:           step|s [COUNT]
        temperature:    temperature|temp
        unbrk:          unbrk|ub [BPNUMLIST]
        version:        ver
        Write Cache:    wc [-i][-w|h|b] <RANGE> <valuelist>
        Read Cache:     rc [-i][-w|h|b] <RANGE>
        zmodem receive: zreceive|zr|rz [-+27abcehtw] [<filename>]
        zmodem send:    zsend|zs|sz [-+27abehkLlNnoptwXYy]

COMMAND LINE OPTIONS:
        Memory reference options:
                -b=byte,  -h=halfword,  -w=word(default)
                -l=unaligned left,  -r=unaligned right
        Note: If no radix is specified, the default radix is used.
                One exception - COUNTS are ALWAYS DECIMAL
        RANGE's are specified as one of:
                BASE_ADDRESS/COUNT or START_ADDRESS-END_ADDRESS
        If less than a 32 bit address is specified
        the DEFAULT SEGMENT is or'ed into the address
        Erase single characters by CTRL-H or DEL
        Rubout entire line by CTRL-U
<PROM-7PE>
```

Notice the last two lines of the expert help display, above. These control-key sequences can be used to erase characters in a command line entry or the entire command entry. These control-key sequences may be affected by the terminal emulation being used to interface the PowerHub.

Table 6.1 lists the commands that would normally be used in the Boot PROM user interface. In some instances, additional syntax has been added to reflect the actual syntax of the respective command. Some of the Boot PROM commands have similar or identical commands available under the normal operating system user interface (UI). Those commands contain a reference to the respective chapter of this manual. Commands that should only be used under FORE Systems TAC direction are not listed.

Table 6.1 - Boot PROM Commands

<table>
<tr><th>Command</th><th>Description</th></tr>
<tr><td>boot|b [-n] [fd|net|fm]</td><td>Boots the system, using the device(s) specified in nvram as the boot source. Equivalent to system reboot.</td></tr>
<tr><td>copy|cp [<device>] <src-file> <dest-file>
-or-
[<device>] <src-file>
[<src-file>...] <device></td><td>Copies a file, or files to or from either a floppy diskette (fd:) or Flash Memory Module (fm:) of a PowerHub 7000. The only device available on the PowerHub 8000 is the Compact Flash Card (fc:). Equivalent to global help copy|cp.</td></tr>
<tr><td>date [YYMMDDhhmm[.ss]]</td><td>Sets or displays the current date and time. Equivalent to system date.</td></tr>
<tr><td>ethaddr|ea</td><td>Displays the MAC-layer hardware address. Equivalent to system ethaddr|ea.</td></tr>
<tr><td>go INITIAL_PC</td><td>Used in conjunction with the load|l command. After loading a file, the go command causes the loaded file to be executed. An initial program count (INITIAL_PC) can be specified if the loaded executable did not set an initial program count start point.</td></tr>
<tr><td>help|? [COMMAND]</td><td>Displays the commands available at the Boot PROM prompt. Equivalent to global help|?.</td></tr>
<tr><td>??</td><td>Displays all commands that are available at the Boot PROM prompt, including commands that are intended for use by FORE Systems TAC only. Equivalent to global help.</td></tr>
<tr><td>history|hi</td><td>Displays a list of the last 16 commands issued at the Boot PROM prompt. Equivalent to global help history|hi.</td></tr>
<tr><td>load|l [-b] fd-filename|tty0|tty1</td><td>Loads a file from the default device or a specified device. The specified device could be either a floppy diskette (fd:) or in the Flash Memory Module (fm:) of a PowerHub 7000, or the Compact Flash Card (fc:) of a PowerHub 8000.</td></tr>
</table>

Table 6.1 - Boot PROM Commands

Command	Description
ls|dir [<device>] [<*file-spec*> [<*file-spec*>...]]	Displays a directory of the files on either a floppy diskette (**fd:**) or Flash Memory Module (**fm:**) of a PowerHub 7000, or the Compact Flash Card (**fc:**) of a PowerHub 8000. Equivalent to **global help ls|dir**.
more [-<*rows*>] <*file-name*> [<*file-name*>...]	Displays to the terminal screen the contents of a file located on either a floppy diskette (**fd:**) or in the Flash Memory Module (**fm:**) of a PowerHub 7000, or the Compact Flash Card (**fc:**) of a PowerHub 8000. Similar to **global help type|cat**.
nvram [set|unset|show]	Sets, removes or displays nvram settings. Equivalent to commands in the **nvram** subsystem.
rm|del [<device>] [-f] f1 [f2...[fn]]	Deletes a file, or files, from the default or specified device. The floppy diskette (**fd:**) or the Flash Memory Module (**fm:**) of a PowerHub 7000, or the Compact Flash Card (**fc:**) of a PowerHub 8000. Equivalent to **global help rm**.
rename|ren [<device>] <oldfilename> [<device>] <newfilename>	Renames a file on the default or specified device a floppy diskette (**fd:**) or in the Flash Memory Module (**fm:**) of a PowerHub 7000, or the Compact Flash Card (**fc:**) of a PowerHub 8000. Equivalent to **global help rename|mv**.
setbaud|sb tty1 <baud rate>	Sets the TTY1 baud rate. Equivalent to **global help stty <speed>**.
temperature|temp	Displays the temperature of the PE. Equivalent to **system temperature|temp**.
ver	Displays the version number of the current PE firmware. Equivalent to **system version|ver**.
zreceive|zr|rz [-+27abcehtw] [<device>] [<*file-name*>]	Uploads a file from a PC or Macintosh that supports the ZMODEM or XMODEM protocol onto a floppy diskette (**fd:**) or in the Flash Memory Module (**fm:**) of a PowerHub 7000, or the Compact Flash Card (**fc:**) of a PowerHub 8000 via either the TTY1 or TTY2 terminal console ports.
zsend|zs|sz [-+27abehkLlNnoptwXYy] [<device>] [<*file-name*>]	Downloads a file to a PC or Macintosh that supports the ZMODEM or YMODEM protocols via either the TTY1 or TTY2 terminal console ports.

6.1 Booting the System Software

The system software can be loaded using any of the following methods:

NOTE

Configuration changes made since the last time the software was loaded should be saved using the **`system savecfg`** command before performing a cold reboot. For information on the **`savecfg`** command, refer to *PowerHub 7000/8000 Software Reference Manual*.

- Pressing the reset switch (labeled RST), on the front of the Packet Engine.
- Turning off, then on, the power supplies.
- Issuing the **`system reboot`** command from any system level command prompt.
- Issuing the **`boot`** command from the boot PROM command prompt.

For detailed information on the software systems, refer to the *PowerHub 7000/8000 Software Reference Manual*.

6.1.1 Displaying the Packet Engine Boot PROM

When rebooting or resetting the system, a power-on self-test is performed before the software is loaded. When the power-on self-test is complete, and before the software is loaded, the following message is displayed:

```
Hit any key now to abort boot [3]:
```

The PowerHub counts down for five seconds before it resumes the boot sequence. The PowerHub attempts to boot from the boot sources in the order specified by the **`nvram bo`** command. If no boot order was set, the PowerHub attempts to boot in the order specified in Section 6.2.1. If a key is pressed during the countdown, the PowerHub aborts the boot sequence and the boot PROM prompt is re-displayed.

Boot PROM Commands

6.1.2 Reset Switch

The reset switch is located on the Packet Engine front panel and is labeled RST. When the reset switch is pressed, the Packet Engine performs a "cold" restart. During a cold restart, the Packet Engine conducts a power-on self-test to check its various hardware components.

Depending on the boot preference(s) specified with the nvram command, the Packet Engine loads the appropriate files that are located in default-device or on a TFTP server (network booting) to configure the PowerHub for runtime operation.

6.1.3 Turning the Power Modules Off and On

Turning the power modules off and then on again, also causes the PowerHub to perform a cold restart.

NOTE If there is more than one power module installed in the chassis, turn all power modules off and then on, simultaneously.

6.1.4 Using the Reboot Command

To reboot the system from a runtime command prompt, issue the **`reboot`** command from the **`system`** subsystem or enter **`system reboot`** from within any subsystem. Entering **reboot** displays the following messages on the console:

```
66:PowerHub:system# reboot

FORE Systems PowerHub 7000 Packet Engine
Prom version: pe1p-3.0.0 (7887) 1998.05.06 13:01
I-cache 16KB OK
Entering cached code
I-cache execution OK
D-cache 4KB OK
SRAM 128KB OK
DRAM 24MB OK
Shared Memory 4MB OK
Entering Monitor
FlashInit: found 4MB Flash Memory Module
Board Type: 7PE ,  CpuType: MCPU,  Instance: 1
Ethernet address: 00-00-ef-03-9a-b0
(normal start)
Hit any key now to abort boot [5]:
<PROM-7PE>
```

6.2 Boot PROM Commands

The following sections explain how to use the Boot PROM commands. The Boot PROM commands are displayed by issuing the `help` command from a Boot PROM prompt. Refer to Section 6.2.4 for a description of the `help` command.

WARNING!

Execution of the additional commands listed under `expert help` are for FORE Systems Technical Assistance Center (TAC) use only. Users are cautioned not to execute any of the commands listed under the **`expert help`** command.

6.2.1 Boot

To reboot the system from a boot PROM prompt, issue the **`boot|b`** command. The syntax for the **`boot`** command is:

`boot|b [-n] [net|fd|fm]`

where

-n Instructs the Packet Engine not to start runtime execution. Only the Packet Engine image (PE1 or PE2) is loaded and the boot sequence is then automatically aborted.

net Boots the software over the network (the PowerHub must be configured for netbooting).

fd Boots the software from the floppy diskette (PowerHub 7000 only).

fm Boots the software from the Flash Memory Module.

fc Boots the software from the Compact Flash Card.

If a boot source is not specified, the boot order configured in NVRAM is used.

NOTE

The Packet Engine software image (PE1 or PE2) must be present on the boot source specified. The **boot** command does not affect the boot order specified in NVRAM. (Refer to the *PowerHub 7000/8000 Software Reference Manual* for information on setting the boot order in the NVRAM.)

6.2.2 Copy

To copy a file, or files, from the default device (Floppy Disk or Flash Memory Module in the PowerHub 7000 or Compact Flash Card in the PowerHub 8000) issue the copy file (**copy|cp**) command.

```
copy|cp [default-device|<device>]<src-file> <dest-file>
```

where

[default-device|<device>]	Specifies the source/destination device. If no device is specified, the default-device is used.
<src-file>	Specifies the file name of the source file to be copied.
<dest-file>	Specifies the destination file name.

6.2.3 Ethernet Address

Each Packet Engine contains a unique MAC-layer hardware address. This address is assigned at the factory and identifies the Packet Engine and by extension the chassis containing the Packet Engine. A label on the front panel of the Packet Engine displays the assigned MAC address. The MAC address is also displayed in boot messages. The **ethaddr** command can be used to display the MAC-layer hardware address of the Packet Engine. The **ethaddr** command displays the following information:

```
<PROM-7PE> ethaddr
Ethernet address: 00-00-ef-03-9a-b0
<PROM-7PE>
```

6.2.4 Help

Help is available from the Boot PROM prompt by issuing the **help|?|h** command. Additional help is available for the commands listed by entering **help|?|h [command]**. The syntax for the help command is:

help|?|h

Issuing **help|?|h** from the boot PROM prompt displays the following screen.

```
<PROM-7PE> ?
COMMANDS:
        boot:           boot|b [-n] [fd|net|fm|fc]
        copy file:      copy|cp <src-file> <dest-file>
                                -or-
                                copy|cp <src-file> [<src-file>...] <device>
        ethaddr:        ethaddr|ea
        help:           help|? [COMMAND]
        expert help:    ??
        ls:             ls|dir
        more:           more [-[<rows>]] f1 [f2...[fn]]
        nvram:          nvram [set|unset|show <variable> [<value>]]
                                ("nvram set bo" sets disk/net boot order)
        remove file:    rm|del [-f] f1 [f2...[fn]]
        rename file:    rename|ren <oldfilename> <newfilename>
        zmodem receive: zreceive|zr|rz [-+27abcehtw] [<filename>]
        zmodem send:    zsend|zs|sz [-+27abehkLlNnoptwXYy]
<PROM-7PE>
```

6.2.5 Expert Help

The command listed under expert help are for use by FORE Systems Technical Assistance Center (TAC) only. These commands are designed to aid TAC in diagnosing and troubleshooting the Packet Engine in the event of failure. Users are cautioned not to attempt execution of any of the help commands listed under expert help that are not listed under the help display.

6.2.6 Directory

The **ls** and **dir** commands display a directory of the files on the default-device. The default-device when at the Boot PROM prompt on a PowerHub 7000 is the Floppy Diskette and the Compact Flash Card in a PowerHub 8000. On the PowerHub 7000 files can also be viewed from the Flash Memory module by preceding the filespec with **fm:**. Each command displays the volume name and the files contained on the volume. The **ls** and **dir** commands display a DOS-like format, including the amount of free space on the volume. These commands differ from the **system ls|dir** commands in that all files on the specified device are listed. The **system ls|dir** commands allow entering a filespec option to filter specific files to be displayed. The syntax for the **ls|dir** commands is:

ls|dir <filespec>

where

<filespec> Limits the display to those files meeting <*filespec*>.

The display below shows an example of the use of the **ls** command listing the files located in the Flash Memory module:

```
<PROM-7PE> ls fm:7*
Volume in device is 10MB FLASH
7PE              1114312    8-26-0205   3:25p
7ATM              274921    8-26-0205   3:25p
7FDDI             148480    8-26-0205   3:25p
7FETH              70376    8-26-0205   3:26p
4 File(s)    2425344 bytes free
<PROM-7PE>
```

6.2.7 More

The **more** command can be used to display a file located on any available device. The syntax for this command is:

more [-[<rows>]] [<device>]f1 [f2...[fn]]

where

-<rows> Specifies how many rows of the file are to be displayed at a time.

f1 [f2...[fn]] Specifies a file, or files, to be displayed to the operator console.

6.2.8 NVRAM

The **nvram** command is used to set, unset or show initial nvram parameters. The syntax for the **nvram** command is:

```
nvram [set|unset|show <variable> [<value>]]
```

where

set|unset|show Specifies whether to set, unset, or show the nvram variables and/or values specified.

<variable> Specifies which nvram variable to set. The available options are:

bo	boot order
myip	local IP address
mysm	local subnet mask
fsip	file server address
gwip	boot gateway address
crashreboot	post-crash behavior
slotsegs[n]	reserve <num> segments in slot [n]

<value> Specifies the value for the respective <variable> above. The IP address is entered in dotted decimal notation, crashreboot is a boolean value and slotsegs is the number of segments allocated to [n] slot.

NOTE A valid configuration file must be present on the designated netboot device before booting off the network device can occur.

6.2.9 Remove File

To remove a file or files on the default-device, issue the remove file (**rm|del**) command. The default-device is the floppy disk on a PowerHub 7000 and the Compact Flash Card in a PowerHub 8000. On the PowerHub 7000 files can also be viewed from the Flash Memory module by preceding the filespec with **fm:**.

```
rm|del [-f] f1 [f2...[fn]]
```

where

-f Specifies to use non-interactive mode (“force” deletions). If the -f option is not used, the system responds with `remove` *`filename`*? and the user is required to respond with either ‘`y`’ (yes) or ‘`n`’ (no) to proceed.

f1 [f2...[fn]] Specifies the file, or file list, of files to be removed from the default device.

6.2.10 Rename File

To rename a file on the default-device, issue the rename file (**`rm|del`**) command. The default-device is the floppy disk on a PowerHub 7000 and the Compact Flash Card in a PowerHub 8000. On the PowerHub 7000 files can also be renamed from the Flash Memory module by preceding the filespec with **`fm:`**.

```
rename|ren <oldfilename> <newfilename>
```

where

<oldfilename> Specifies the name of the original file.

<newfilename> Specifies the name of the new file.

6.3 Uploading/Downloading Files

This section describes the ZMODEM support available from the Boot PROM command line. The two ZMODEM commands, **`zreceive`** and **`zsend`**, are discussed, as well as procedures to configure the PowerHub to utilize these commands.

The PowerHub supports ZMODEM file transfer protocol. Using the ZMODEM commands, files can be copied between the PowerHub and a PC or Macintosh running a ZMODEM protocol application. Files transferred using these commands are sent or received to or from the PowerHub default-device. The default-device on a PowerHub is the floppy disk, on a PowerHub 8000 it is the Compact Flash Card. If the PC or Macintosh supports XMODEM, the ZMODEM commands can be used to perform XMODEM transfers. To use the ZMODEM commands, a PC or Macintosh supporting ZMODEM must be connected to TTY1 or TTY2:

- If the management terminal on TTY1 contains the ZMODEM or XMODEM application, PowerHub commands can be issued to set up the transfer, then switch to the ZMODEM or XMODEM application to activate the transfer.
- Alternatively, the transfer can be set up from the management terminal on TTY1, then use the ZMODEM or XMODEM application on the device connected to TTY2 to complete the transfer.

6.3.1 ZMODEM Receive

The **`zreceive`** command prepares the PowerHubto receive a file. After issuing the **`zreceive`** command, the ZMODEM or XMODEM application on the PC or Macintosh must be used to actually begin the transfer.

The **`zreceive`** command provides numerous options, but the defaults for those options are appropriate for most file transfers. The defaults are the same for XMODEM transfers, except that a file name must be specified. File names are not necessary when performing a ZMODEM transfer. The syntax for the **`zreceive`** command is:

`zreceive|zr|rz [-+27abcehtw] [<filename>]`

where

-	Introduces the argument list. If any arguments are specified, the argument list must be preceded by the **-** (hyphen). If arguments are not specified, do not use the **-** (hyphen).
+	Causes the file being received to be appended to an already existing file. Specify the file name at the end of the argument list (ex: zr -+ae hub1.log).

Boot PROM Commands

2 Causes the file transfer to take place through the TTY2 port, rather than the TTY1 port. By default, the transfer takes place over the TTY1 port.

7 Uses 7-bit bytes for the transfer. By default the ZMODEM program uses 8-bit bytes.

a Performs the transfer in ASCII mode, using the appropriate newline translation. By default, the transfer takes place in binary mode.

b Performs the transfer in binary mode. Binary is the default transfer mode.

c XMODEM only. Uses a 16-bit CRC.

e Ignores control characters.

h Sets the serial baud rate to 19.2 Kpbs.

t Sets the receive time-out to N/10 seconds (10 <= N <= 1000). Specify the file name at the end of the argument list (ex: zr -at 500). The default is 100; that is, 10 seconds.

w Sets the protocol window to N bytes. Specify the file name at the end of the argument list (ex: zr -aw 10).

<filename> Entering a filename causes the XMODEM protocol to be used. If using ZMODEM protocol it is not necessary to specify a file name. The PowerHub assumes the file is to be written to the floppy disk, for a PowerHub, or to the Compact Flash Card for a PowerHub 8000.

NOTE

The **zreceive** command only transfers files to the default-device, floppy disk on the PowerHub and Compact Flash Card on the PowerHub 8000. Use the **copy|cp** command to transfer the file(s) to the Flash Memory module.

If a filename is not specified, or none of the optional arguments are specified, the PowerHub uses the ZMODEM protocol to receive the file on TTY1, in binary mode, using 8-bit bytes. When the **zr** command is executed on the PowerHub, the ZMODEM application on the PC or Macintosh must be used to specify the file to be transferred and to perform the transfer.

Following are some examples of the use of the **zreceive** command. After issuing the command on the PowerHub, use the appropriate protocol application on the PC or Macintosh to transfer the file.

In the first example, ZMODEM is used to prepare the PowerHub to receive a binary file from a PC or Macintosh. All defaults are used. Notice that no file name is specified. When using ZMODEM, specify the file name on the PC or Macintosh.

```
<PROM 7PE> zreceive
```

In the following example, the PowerHub is prepared to receive a configuration file from a PC or Macintosh. All defaults are accepted, except the default for transfer mode. The **a** argument is used to change the transfer mode to ASCII, which is appropriate for PowerHub configuration, environment, and boot definition files. Notice that the hyphen (-) is used to introduce the argument list.

```
<PROM 7PE> zreceive -a
```

The following example shows how the PowerHub is prepared to upload a file using XMODEM. Because, XMODEM, unlike ZMODEM, does not send filenames from the sending device, the receiving device (the PowerHub in this case) must supply the file name.

```
PROM 7PE> zreceive 7pe
```

In the following example, ZMODEM is used to prepare the PowerHub to upload an ASCII file from the PC or Macintosh connected to TTY2. The **t** argument is used to specify the receive time-out. Notice that the receive time-out is specified after the argument list.

```
<PROM 7PE> zreceive -2a 10
```

If XMODEM were used instead of ZMODEM, the file name would follow the value **10**, as shown in the following example.

```
<PROM 7PE> zreceive -2a 10 monitor.env
```

6.3.2 ZMODEM Send

The **zsend** command is used to download a file from the PowerHub to a PC or Macintosh. This command can be used to perform transfers to devices supporting ZMODEM or YMODEM. Like the **zreceive** command, the **zsend** command provides many options, but the defaults for these options are appropriate for most transfers. The syntax for this command is:

zsend|zs|sz [-+27abehkLlNnoptwXYy]

where

- **-** Introduces the argument list. If any arguments are specified, the argument list must be preceded by a - (hyphen). If arguments are not to be used, do not specify the - (hyphen).
- **+** ZMODEM only. Causes the file to be appended to an existing file. Specify the file name at the end of the argument list (ex: zs -+a hub2.log).
- **2** Causes the file transfer to take place through the TTY2 port, rather than the TTY1 port. By default, the transfer takes place over the TTY1 port.
- **7** Uses 7-bit bytes for the transfer. By default the ZMODEM program uses 8-bit bytes.
- **a** Performs the transfer in ASCII mode, using the appropriate newline translation. By default, the transfer takes place in binary mode.
- **b** Performs the transfer in binary mode. Binary is the default transfer mode.
- **e** ZMODEM only. Escapes all control characters.
- **h** Sets the port baud rate to 19.2 Kpbs.
- **k** YMODEM only. Transfers the file in 1024-byte packets.
- **L** ZMODEM only. Limits the subpacket length to N bytes. Specify the file name at the end of the argument list (ex: **`zs -aL 64`**).
- **l** ZMODEM only. Limits the frame length to N bytes (l>=L). Specify the file name at the end of the argument list (ex: **`zs -al 64`**).
- **N** ZMODEM only. Transfers the file only if the version on the PowerHub is both newer and longer than the version on the PC or Macintosh. Otherwise, the file is not transferred.
- **n** ZMODEM only. Similar to N, except the file is transferred if it is newer, even if it is not longer than the identically named file on the PC or Macintosh.
- **o** ZMODEM only. Uses 16-bit CRC rather than the default 32-bit CRC.

p ZMODEM only. Protects the file specified by <*file-name*> if it already exists on the PC or Macintosh. If the file is already present on the device, it is not overwritten by the file on the PowerHub.

t Sets the receive time-out to N/10 seconds (10 <= N <= 1000). Specify the filename at the end of the argument list (ex: **`zs -at 500`**). The default is 600 (60 seconds).

w ZMODEM only. Sets the protocol window to N bytes. Specify the filename at the end of the argument list (ex: **`zs -aw 10`**).

X Uses the XMODEM protocol, rather than the ZMODEM protocol. Note that some of the other arguments are not valid with the ZMODEM protocol.

Y ZMODEM only. Overwrites the file specified by <*file-name*>, but skips the file altogether if the file is not present on the PC or Macintosh. If the file specified by <*file-name*> is not already present on the PC or Macintosh, the file is not written to that device.

y ZMODEM only. Overwrites the file specified by <*file-name*>. Unlike Y, the y argument does not skip the file if it is not on the PC or Macintosh. Even if the file is not on the device, the PowerHub writes the file to the device.

Following are some examples of the use of the **`zsend`** command. The first example uses ZMODEM to send a software image file from the PC or Macintosh. All the **`zsend`** defaults are used.

```
<PROM-7PE> zsend fore/images/7pe
```

In the following example, an environment file is sent to the PC or Macintosh connected to TTY1. The **a** argument is used to change the transfer mode to ASCII, which is appropriate for PowerHub configuration, environment, and boot definition files. In addition, the **N** argument is used to ensure that the file is transferred only if it is newer and longer than the identically named file on the PC or Macintosh. Notice that the hyphen (**-**) is used to introduce the argument list and no spaces separate the arguments in the list. A space does separate the file name from the argument list.

```
<PROM 7PE> zsend -aM root.env
```

CHAPTER 7 ATM Interfaces

Asynchronous Transfer Mode (ATM) is a high-performance technology for internetworking. ATM uses fixed-size cells to transport data, whereas current LAN technologies use packets that vary in size.

The PowerHub provides ATM connectivity through the PowerCell 700 ATM Module and ATM Media Adapters (AMAs). This chapter describes the PowerCell hardware features including the following ATM Media Adapters:

- OC-3 (Single-mode and Multimode)
- UTP

7.1 PowerCell ATM Module

The PowerCell 700 is an Intelligent Network Interface Module (INIM) that contains on-board CPUs to handle packet processing so that the Packet Engine resources are not consumed when a cell is received or transmitted on a segment. The PowerCell module contains the ATM physical layer (PHY) and ATM Segmentation and Reassembly (SAR) layers and can support up to 32 logical segments.

The PowerCell module is interoperable with all FORE Systems' ATM switches and can also be used with other vendors' ATM switches provided those switches conform to the ATM Forum standards that the PowerCell module supports. For example, other vendors' equipment must support the ATM Forum standards for LAN Emulation (LANE) 1.0 or 2.0 and User-Network Interface (UNI) 3.0 or 3.1 if it is to be used with the FORE Systems PowerCell module in a LANE 1.0 network.

Some PowerCell modules allow redundant connections to the ATM switch. The redundant connection is provided by a redundant port (PHY) that automatically takes over if the connection to the primary port (PHY) fails.

The FORE Systems PowerCell modules contain the following hardware features:

- AAL5 support.
- Support for up to 155 Mb/s.
- Choice of single-mode or multimode fiber on OC-3 or UTP interfaces.
- Traffic and status LEDs.
- Optional backup PHY that takes over if primary PHY fails.

7.1.1 PowerCell 700

The PowerCell 700 can contain one or two ATM Media Adapters (AMAs). Each AMA provides a single physical port for connection to an ATM switch. The PowerCell 700 can be installed in any available slot and the PowerHub can support up to four PowerCell Modules. The PowerCell can be configured to support up to 32 logical segments on each port. Each logical segment can be configured for one of the following protocols:

- LANE (LAN Emulation) 1.0 and 2.0
- RFC-1483 Routed and Bridge Encapsulation
- Classical IP over ATM (RFC 1577)
- FORE IP

Figure 7.1 shows the PowerCell 700 front panel. The PowerCell 700 shown in Figure 7.1 contains both a Primary and Backup AMA.

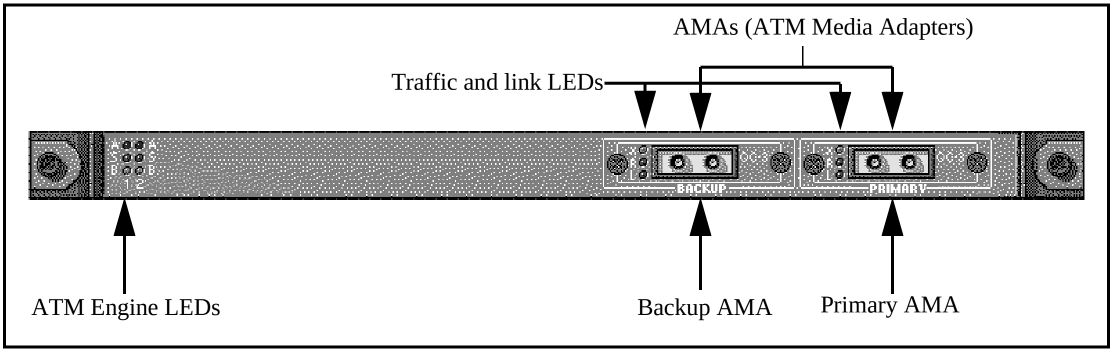


Figure 7.1 - PowerCell 700

The PowerCell 700 contains a single Segmentation and Reassembly (SAR) chip and can contain one or two Physical Layer (PHY) chips. Each PHY is contained in an AMA. The PowerCell 700 can be ordered with a single AMA (primary only) or with two AMAs (primary and backup). If the PowerCell 700 is ordered with only a primary AMA, a second can be installed later as a backup. Section 7.1.1.2 describes the operation of the backup AMA.

The AMA types differ according to the physical interface. The PowerCell 700 AMAs are described in the following sections. Refer to the *PowerHub 7000/8000 Protocols Reference Manual* for information configuring ATM ports.

7.1.1.1 ATM Engine LEDs

The PowerCell modules contain LEDs that provide a visual status of the ATM Engine, the ATM link and traffic LEDs. (See Figure 7.1.) The PowerCell LEDs are located on the left side of the PowerCell 700. Table 7.1 describes the operation of the PowerCell LEDs.

Table 7.1 - PowerCell 700 ATM Engine LEDs

Label	Color	Indicate the following Condition
A	Red	Alarm. These LEDs indicate that the PowerCell module has crashed and remain lit until the PowerCell module is rebooted.
S	Green	The ATM CPUs are functioning normally. If both of these LEDs go out during normal operation, there might be a problem in the ATM Engine. (It is normal for either of the LEDs to be dark sometimes.)
B	Amber	The PowerCell module is booting. These LEDs flash when the module is booting, then go dark as soon as the module is finished booting.

7.1.1.2 Backup Port

In a PowerCell module that contains two AMAs, the primary AMA is used for network traffic and the backup automatically takes over if the link on the primary fails. The **`active-ama|aa`** command, in the `atm` subsystem, is used to setup the backup AMA.

The PowerCell 700 allows ports to be installed or removed separately. Therefore, if the PowerCell 700 contains only one port and a backup port is to be added, an additional port can be installed on the PowerCell 700 module. Refer to *Chapter 5, Installation, Upgrade, and Removal Procedures* for procedures on installing a backup PowerCell AMA.

7.1.2 ATM Media Adapters

The PowerCell module AMAs support OC-3 (single-mode and multimode) and UTP ATM interfaces. The following paragraphs describe each of these AMA interface modules.

7.1.2.1 OC-3 Single-mode and Multimode Fiber AMA

The OC-3 AMA is available in both single-mode and multimode versions and provides bandwidth up to 155 Mb/s. The OC-3 AMA connects to the ATM network using a pair of fiber-optic cables. The type of cable and connectors for the single-mode differs from those for a multimode adapter. Figure 7.2 shows an OC-3 Multimode AMA front panel. The front panel indicates whether it is single-mode (SMF) or multimode (MMF). The function of the front-panel LEDs (X, R, and L) are described in Table 7.2.

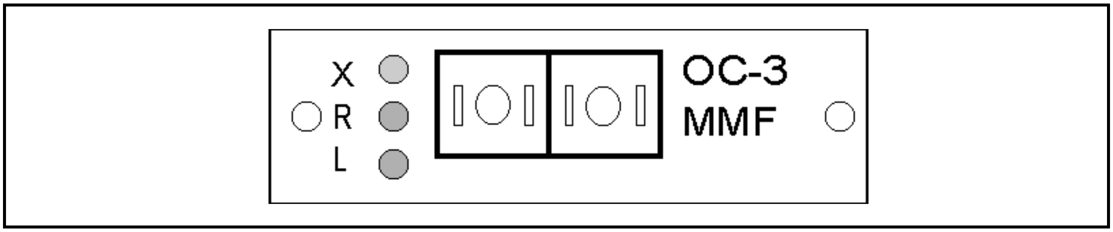


Figure 7.2 - OC-3 Multimode Fiber AMA

7.1.2.2 OC-3 UTP AMA

The OC-3 UTP AMA provides bandwidth up to 155 Mb/s and connects to the ATM network using twisted-pair cable and an RJ-45 connector. Figure 7.3 shows the UTP AMA front panel. The front panel indicates that it is an OC-3 module. The function of the front-panel LEDs (X, R, and L) are described in Table 7.2.

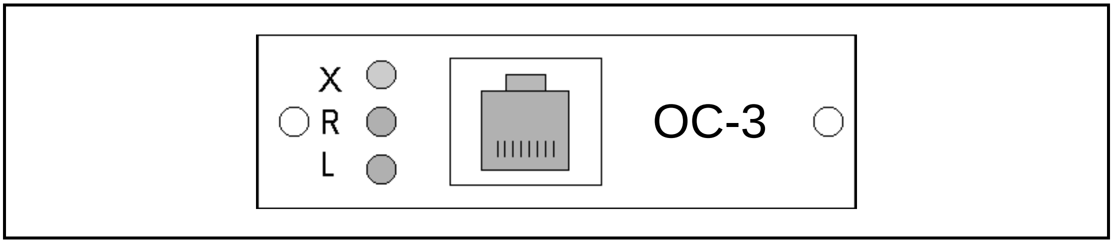


Figure 7.3 - OC-3 UTP AMA

7.1.3 AMA Traffic and Link LEDs

The AMA modules contain front-panel LEDs that provide traffic information and link status for the AMA. Table 7.2 describes the operation of the AMA LEDs.

Table 7.2 - PowerCell Traffic and Link LEDs

Label	Color	Indicates the following Condition
X	Amber	Transmit. Illuminates during runtime operation. When illuminated, indicates that the PowerCell module is transmitting cells.
R	Green	Receive. Illuminates during runtime operation. When illuminated, indicates that the PowerCell module is receiving cells.
L	Green	Link status. Displays the link status for the ATM connection. When glowing the ATM link is “good.” The PowerHub recognizes an unbroken physical connection to the ATM switch. The link-status LED goes dark if the cable is removed. If the cable is attached but the LED is still dark, the transmit and receive cables may be plugged into the wrong connectors, or a problem might exist in the ATM switch attached to the cable or in the cable itself.

CHAPTER 8 Ethernet Interfaces

There are two types of Ethernet interface modules supported by the PowerHub. These include Network Interface Modules (NIMs) and Ethernet Media Adapters (EMAs). This chapter describes the following Ethernet interface modules:

Network Interface Modules	13x1 Ethernet Module (Section 8.2.1).
	16x1 Ethernet Module (Section 8.2.1).
	4x4 Microsegment Ethernet Module (Section 8.2.2.1).
	4x6 Microsegment Ethernet Module (Section 8.2.2.2).
	Universal Ethernet Module (Section 8.2.3).
	6x1 Universal Fast Ethernet Module (Section 8.4.1).
Ethernet Media Adapters	BNC EMA (Section 8.2.3.4)
	UTP EMA (Section 8.2.3.5).
	MAU EMA (Section 8.2.3.6).
	Fast Ethernet Media Adapters (FEMAs) (Section 8.3).
	10Base-FL EMA (Section 8.2.3.2).
	10Base-FB EMA (Section 8.2.3.3).

8.1 NIMs and Ethernet Media Adapters

Physical connections to the PowerHub are made using interface cards and adapters installed in the chassis. These interfaces can be Network Interface Modules (NIMs) and Ethernet Media Adapters (EMAs) or Fast Ethernet Media Adapters (FEMAs).

NIMs are printed circuit boards that mount in a chassis slot, independent of the Packet Engine. Intelligent NIMs (INIMs) can perform some packet forwarding and processing functions without the help of the Packet Engine. If the NIMs are not Intelligent NIMs, all traffic is forwarded to the Packet Engine for processing. Media adapters are smaller printed circuit boards that mount on a Universal Ethernet Module (UEM).

8.2 10 Mb/s Interfaces

Ethernet NIMs provide 10 Mb/s Ethernet connections and can support up to 24 physical interfaces. The 10 Mb/s Ethernet interfaces available are described in the following paragraphs. These modules include:

- 13x1 and 16x1 Ethernet Modules
- Microsegment Ethernet Modules
- Universal Ethernet Modules with Ethernet Media Adapters

8.2.1 13x1 and 16x1 Ethernet NIMs

The 13x1 and 16x1 Ethernet modules provide connections to multiple, independent 10Base-T or 100Base-T twisted-pair Ethernet segments. The 13x1 Ethernet module provides connections to twelve 10Base-T segments and one 100Base-T segment for a total bandwidth of 220 Mb/s. The 16x1 Ethernet module provides connections to sixteen 10Base-T segments for a total bandwidth of 160 Mb/s (half-duplex operation). The 10Base-T connections are built into the modules. The 100Base-T connection on the 13x1 NIM is provided by installing one of three Fast Ethernet Media Adapters (FEMAs). The FEMA is an add-on media adapter and is described in Section 8.4.1.5. Each module contains the following major components which are described in the following paragraphs:

- Ethernet controllers, one for each segment.
- In the 13x1 Ethernet Module, one Fast Ethernet controller.
- RJ-45 connectors, one for each segment.
- Traffic and status LEDs.
- Temperature sensor.

8.2.1.1 Ethernet Controller

The 13x1 and 16x1 Ethernet modules contain Ethernet controllers that support each 10Base-T segment. The Ethernet controller transmits and receives packets and, when packets are received on a 10Base-T segment, places the packets on the Packet-Channel Backplane, which carries the packets to the Packet Engine. In the opposite direction, transmitted packets are sent from the Packet Engine across the Packet-Channel Backplane to the module, and through the controller to the corresponding 10Base-T segment.

8.2.1.2 Fast Ethernet Controller

The 13x1 Ethernet module contains an additional Fast Ethernet controller that supports any of the optional FEMAs. The Fast Ethernet controller performs the same tasks for the 100Base-T segment as does the 10Base-T Ethernet controller described in section 8.2.1.1.

8.2.1.3 RJ-45 Connectors

The 10Base-T connections are established using RJ-45 connectors that provide the same mechanical connection, pinouts, and electrical functions as specified by a standard IEEE 802.3 10Base-T hub. In addition, each segment supports full-duplex operation, which can be enabled using the **`media operating-mode`** command. (Refer to the *PowerHub 7000/8000 Software Reference Manual*.) Figure 8.1 shows the front panel of the 16x1 Ethernet Module. For a complete list of the pinouts on the RJ-45 connectors or the 100Base-TX connector (refer to *Appendix A, Pinouts*).

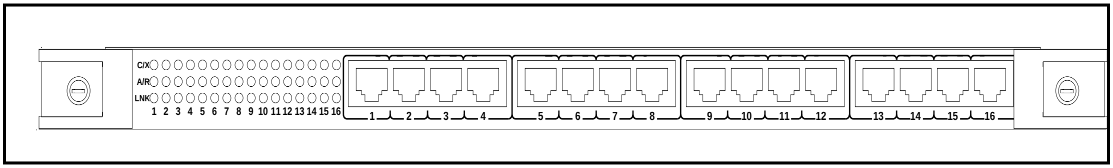


Figure 8.1 - 16x1 Ethernet Module

Segments are numbered left to right, from 1 through 16. However, actual numbers used to identify these segments in the user interface depends upon the position of the module in the chassis and other configuration options. (See *Chapter 1, Overview*.) The bank of LEDs to the left of the segment connectors provide traffic and link-status information for each segment. The LEDs are described in Section 8.2.1.5. Figure 8.2 shows the front panel of the 13x1 Ethernet Module.

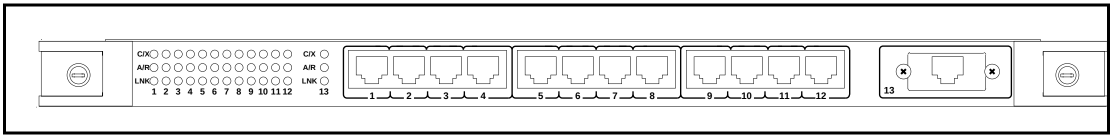


Figure 8.2 - 13x1 Ethernet Module

As with the 16x1, segments are numbered from left to right. Segments 1 through 12 are the 10Base-T segments. Segment 13 is the 100Base-TX FEMA, if installed. (See Section 8.2.1.4 for information about the FEMA.) Again, the actual segment numbers that appear in the user interface depend upon the position of the module in the chassis.

If a 13x1 was ordered without a FEMA, the position for the adapter is covered by a cover plate. To add the FEMA, remove the 13x1 Ethernet Module from the chassis. Refer to *Chapter 5, Installation, Upgrade, and Removal Procedures* for information about adding a FEMA.

8.2.1.4 FEMA on the 13x1 Ethernet Module

The 13x1 Ethernet Module contains an opening in which a FEMA can be installed. Figure 8.3 shows a FEMA.

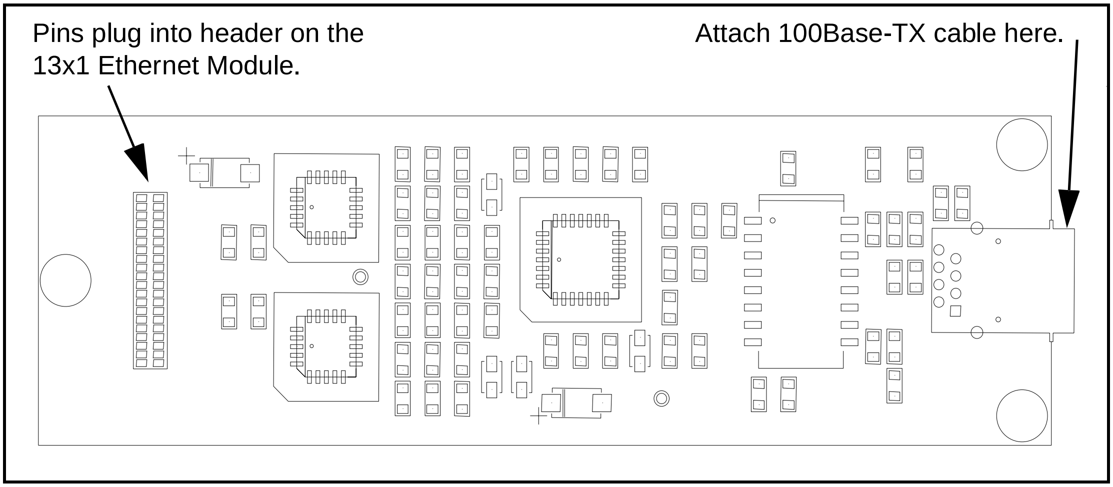


Figure 8.3 - 100Base-TX FEMA

The 100Base-TX FEMA front panel connector is a CAT-5 RJ-45 connector (see Figure 8.3). The pinouts are the same as a 10-Base-T RJ-45 connector, but the wire type is different. Voice-grade (CAT-3) wiring cannot be used. Instead, the 100Base-TX connector requires CAT-5 wiring and connections to the segment.

8.2.1.5 LEDs

The 13x1 and 16x1 Ethernet Modules have three LEDs for each segment that display information about the status of the corresponding segment. The system events that cause them to light differ depending upon their setting. The operating mode of the traffic LEDs (C/X and A/R) can be configured on each 13x1 or 16x1 module using the **`media led-config`** command. (Refer to the *PowerHub 7000/8000 Software Reference Manual*.)

LEDs are set as a group for the entire module, not individually on a segment-by-segment basis. Set the LEDs as C and A or X and R. The default setting is X and R. The LNK LED is not configured and always shows link status information for the corresponding segment. Table 8.1 describes the function of the LEDs on both the 13x1 and 16x1 Ethernet Modules

Table 8.1 - 13x1 and 16x1 LEDs

Label	Color	Indicates...
C/X	Amber	Transmit collisions or packet transmissions, depending upon the setting. Receive collisions (collisions occurring while a segment is not transmitting) do not occur on private-UTP segments. When set to C (transmit-collision mode), indicates transmit collisions. Each time a transmit collision occurs on the corresponding segment, this LED is illuminated for 5 – 10 ms. When set to X (transmit mode), indicates packet transmission. Each time a packet is transmitted on the corresponding segment, this LED is illuminated for 5 – 10 ms.
A/R	Green	Packet activity (transmit and receive) or receive activity only, depending upon the setting: When set to A (activity mode), indicates when a packet is transmitted or received. Each time a packet is transmitted or received on the corresponding segment, the LED is illuminated for 5 – 10 ms. When set to R (receive mode), indicates when packets are received. Each time a packet is received on the corresponding segment, the LED is illuminated for 5 – 10 ms.
LNK	Green	Link status. When a LNK LED is glowing, the corresponding segment is successfully detecting link-test pulses. A LNK LED goes dark if the twisted-pair cable attached to the corresponding segment is removed. If the cable is attached but the LED is still dark, a problem might exist in the segment or in another device attached to the cable.

8.2.1.6 Temperature Sensor

Like the Packet Engine and like all other NIMs, the 13x1 and 16x1 Ethernet Modules each contain a temperature sensor that reads the temperature of the module with an accuracy of plus or minus 0.5° C. Display the temperature using the **`system temperature`** command. (Refer to the *PowerHub 7000/8000 Software Reference Manual*.)

8.2.2 Microsegment Ethernet Modules

The 4x4 and 4x6 Microsegment Ethernet Modules provide Microsegmented 10Base-T connections. A *microsegmented connection* is a single Ethernet segment that is divided into multiple physical ports. These multiple physical ports are repeated and share the bandwidth of the segment. In addition, packets received by one port are automatically repeated to the other physical ports on the segment.

Each Microsegment Ethernet module provides four independent 10Mb/s Ethernet segments. The segments on the 4x4 are each microsegmented into four UTP ports using RJ-45 connectors. The segments on the 4x6 are microsegmented into six UTP ports using Champ 50-pin connectors (refer to *Appendix A, Pinouts*).

8.2.2.1 4x4 Microsegment Ethernet Module

The 4x4 Microsegment Ethernet module uses sixteen RJ-45 connectors, four for each segment supported by the module. Each connector provides a standard 10Base-T connection. Figure 8.4 shows the front panel of the 4x4 module.

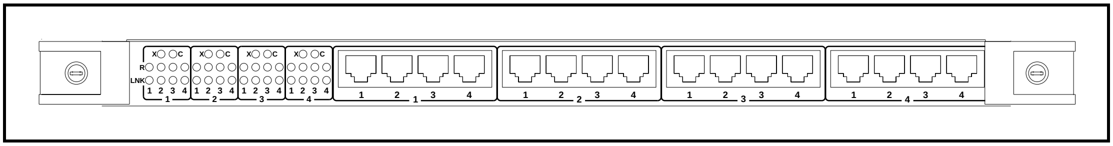


Figure 8.4 - 4x4 Module

As shown in Figure 8.4, the four UTP ports in a segment share the 10 Mb/s bandwidth of the segment. The segments are numbered from 1 to 4, left to right. Figure 8.5 shows a close-up view of a 4x4 10Base-T segment.

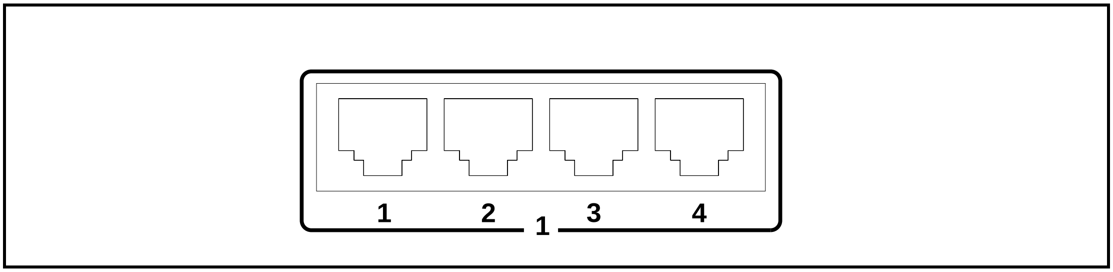


Figure 8.5 - Single 4x4 10Base-T Segment

As shown in Figure 8.5, the RJ-45 connectors that comprise a segment are grouped by a rounded rectangle drawn around the connectors. The segment number on the module appears in the bottom center of the rounded rectangle. The individual port numbers belonging to the segment appear directly underneath their respective ports. For a list of the pinouts on each RJ-45 connector, refer to *Appendix A, Pinouts*.

8.2.2.2 4x6 Microsegment Ethernet Module

The 4x6 Microsegment Ethernet module uses two Telco Champ 50-pin connectors, which typically are used with 25-pair cable systems. Each Champ connector provides a standard 10Base-T connection for twelve UTP ports, six ports to a segment. Figure 8.6 shows the front panel of the 4x6 module.

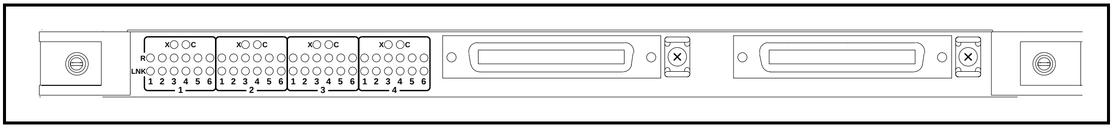


Figure 8.6 - 4x6 Module

Each Champ connector provides connection to two six-port Ethernet segments (refer to *Appendix A, Pinouts*). Figure 8.7 shows how the segments are organized on the connectors.

As shown in Figure 8.7, the left connector attaches to segments 1 and 2, the pins for segment 2 are on the left half of the connector, whereas the pins for segment 1 are on the right half of the connector. Similarly, the pins for segments 3 and 4 are on the right connector, organized so that segment 4 is on the left and segment 3 is on the right. The last two pins on the left side of the connector are ground pins and are not used by a UTP port. Figure 8.7 shows the locations of the pins for the individual UTP ports on each Champ connector.

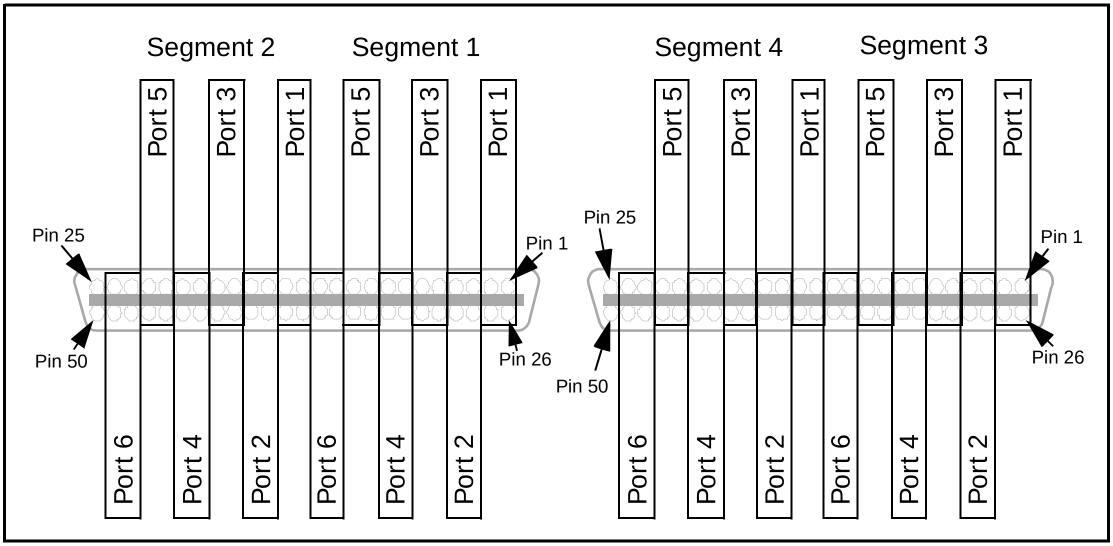


Figure 8.7 - Champ Connector UTP Ports

As shown in Figure 8.7, the UTP ports on each segment are numbered from right to left. Because the pins of the Champ connector also are numbered from left to right, this arrangement of segments and ports is actually quite natural. When attaching UTP wiring to the 4x6 module, make sure it is organized according to the segment and port numbering scheme shown above. For a complete list of the pinouts on each Champ connector, refer to *Appendix A, Pinouts*.

8.2.2.3 Microsegment Module Hardware

The 4x4 and 4x6 modules use very similar electronics. Each module contains the following major components:

- Ethernet controller.
- Four repeaters, one for each segment.
- RJ-45 (4x4) or Telco Champ (4x6) microsegment connectors.
- Collision and status LEDs.
- Temperature sensor.

These components are described in detail in the following sections.

8.2.2.3.1 Ethernet Controller

Each 4x4 and 4x6 module contains four Ethernet controllers, one for each segment. The Ethernet controllers transmit and receive packets. When a module receives packets, the Ethernet controller transmits the packets to the Packet Channel backplane, which carries the packets to the Packet Engine. When a module receives packets from the Packet Channel Backplane to be forwarded onto one of its segments, the corresponding Ethernet controller transmits the packets to the segment's repeater chip, which in turn transmits the packets to all enabled ports on the segment.

8.2.2.3.2 Repeater Chips

When a segment receives packets on one of its enabled UTP ports, the segment's repeater chip repeats the packets to the other enabled UTP ports in the segment. The repeater chip also repeats the packets to the segment's Ethernet chip, which then transmits the packets to the Packet Channel Backplane.

When a module receives packets from the Packet Channel Backplane to be forwarded onto one of its segments, the corresponding Ethernet controller transmits the packets to the segment's repeater chip, which in turn transmits the packets to all enabled ports on the segment.

In addition to transmitting and receiving data packets, the repeater chips transmit and listen for link-test pulses to determine whether the twisted-pair connection to the port is present and "good." The link-test pulses transmitted and received by the repeater chips are based on the IEEE 10Base-T standard.

8.2.2.3.3 RJ-45 (4x4) and Telco Champ (4x6) Microsegment Connectors

The 10Base-T connections are established using RJ-45 connectors. The 4x4 Microsegment Ethernet module uses sixteen RJ-45 connectors. The 4x6 Microsegment Ethernet module uses two Telco Champ 50-pin connectors.

8.2.2.3.4 Collision and Status LEDs

The 4x4 and 4x6 modules have LEDs that give at-a-glance information of the status of each segment and port on the module. Table 8.2 describes the operation and function of the LEDs on the 4x4 and 4x6 modules.

Table 8.2 - 4x4 and 4x6 LEDs

Label	Color	Indicates
C	Amber	Transmit collision. Collisions are shown on a per-segment basis, not on a per-port basis. Receive collisions do not cause this LED to flash; however, statistics can be displayed for receive collisions.
X	Green	Transmit. Flashes each time the Ethernet chip associated with a segment transmits packets through its repeater chip to the enabled ports.
R	Green	Receive. Flashes each time a packet is received by the corresponding port.
LINK	Green	Link status. Each LINK LED shows the link status for a single UTP port. When a LINK LED is glowing, the corresponding link is "good"; that is, it is successfully detecting link-test pulses from the twisted-pair cable attached to the port. A LINK LED goes dark if the twisted-pair cable attached to the corresponding port is removed. If the cable is attached but the LED is still dark, a problem might exist in the device attached to the cable or in the cable itself. If no device is attached to the other end of the cable, this LED is dark.

8.2.2.3.5 Temperature Sensor

Like the Packet Engine and like all other NIMs, the 4x4 and 4x6 Microsegment Ethernet Modules each contain a temperature sensor that reads the temperature of the module with an accuracy of plus or minus 0.5° C. The temperature can be displayed using the **`system temperature`** command (refer to the *PowerHub 7000/8000 Software Reference Manual*).

8.2.3 Universal Ethernet Module (UEM)

The Universal Ethernet Module (UEM) contains positions for six independent Ethernet connections. The following types of Ethernet connections can be installed on a UEM:

- AUI (10Base-5 or any other external transceiver type).
- 10Base-FL (FOIRL-compatible).
- 10Base-FB.
- BNC (10Base-2).
- MAU EMA (connects directly to an AUI segment using a standard transceiver cable).
- UTP (10Base-T).

Each connection is provided by either an Ethernet Media Adapter (EMA), a daughter card installed directly onto the UEM, or an AUI Media Cable, also installed directly onto the UEM. The UEM has two rows of connector pins on the circuit board. The rear row of pins is for connecting AUI Media Cables (DB-15 cables). The front row of pins is used by EMAs. All of the Ethernet segments can operate at the full 10 Mb/s theoretical line speed. In addition, 10Base-FL, MAU, and UTP Media Adapters can be configured for full-duplex operation, for a maximum of 20 M/bs. Figure 8.8 shows a UEM containing a variety of Ethernet connection types.

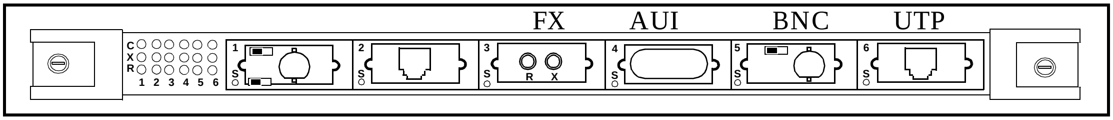


Figure 8.8 - Universal Ethernet Module

Each EMA and AUI Media Cable provides connection to an Ethernet network segment. When the PowerHub is ordered, specified Media Adapters or AUI Media Cables are installed on the UEM. However, Media Adapters or AUI Media Cables can be added, removed, or exchanged at any time.

In fact, Media Adapters or AUI Media Cables can be changed even while the PowerHub is operating. (This is known as *live insertion*.) For example, if the Media Adapters on a UEM are to be changed, remove the UEM, change the Media Adapters, then reinsert the UEM, without powering down. Use the **`system card-swap`** command to take the UEM in or out of service (refer to the *PowerHub 7000/8000 Software Reference Manual*).

8.2.3.1 Universal Ethernet Module LEDs

The UEM has four LEDs for each Media Adapter or AUI Media Cable. Three of the LEDs are in columns and are located on the left side of the UEM. Each column is labeled to indicate the segment position to which it corresponds; column 1 corresponds to segment position 1, and so on.

The fourth LED is located near the lower left corner of the corresponding segment position. Table 8.3 lists and describes the function and operation of the UEM LEDs.

Table 8.3 - Universal Ethernet Module LEDs

Label	Color	Indicates...
C	Amber	A packet collision. The LED is illuminated for 5 – 10 ms when this segment is attempting to transmit and a collision is detected.
X	Green	The segment is transmitting packets onto the attached cable. The LED is illuminated for 5 – 10 ms when a packet is transmitted.
R	Green	The segment is receiving packets from the attached cable. The LED is illuminated for 5 – 10 ms when a packet is received.
S	Green	The segment has been enabled by the software and that the segment's diagnostic state is "good." The methods used by the software to determine the state of a segment differ according to the segment type, and are described with the individual Media Adapter types.

8.2.3.2 10Base-FL EMA

This section describes the 10Base-FL EMA, provides a picture of the EMA, and describes how it is connected to the UEM. This section also describes the transmit and receive connectors, the power values, and the optical budget. Also, the full-duplex capability of this EMA and descriptions of the status LED, are provided.

The 10Base-FL Media Adapter provides a single 10Base-FL connection that is fiber optic inter-repeater link (FOIRL) compatible. This Media Adapter provides a signal compatible with legacy equipment that uses the FOIRL standard. Figure 8.9 shows a 10Base-FL Media Adapter.

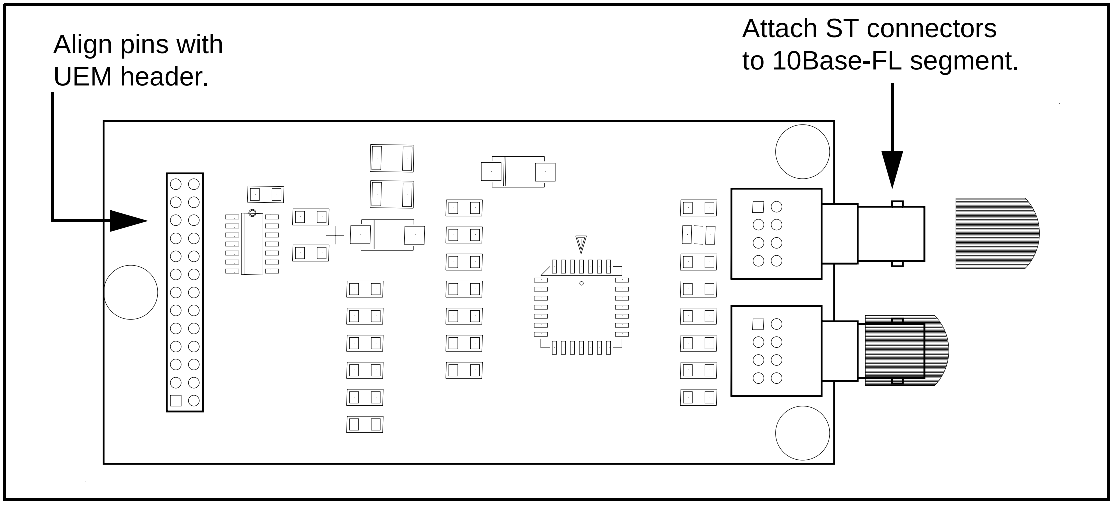


Figure 8.9 - 10Base-FL Media Adapter

The adapter is installed component side down and the rows of pins shown on the left side of the card plug into a header on the UEM. The two ST Fiber connectors on the right side of Figure 8.9 attach to the 10Base-FL cables. The connector shown on the top is gray-colored and is the receive connector. When installed on the UEM, it is on the left and labeled R. The connector shown on the bottom is white-colored and is the transmit connector. When installed on the UEM, it is on the right and labeled X. Make sure the 10Base-FL cables are attached accordingly.

Refer to Table 8.4 as a guideline in determining the optical power budget for the cabling used with the 10Base-FL EMAs.

Table 8.4 - 10-Base-FL Power Values

Cable Type	Transmit Power
62.5 / 125	Minimum average transmit power: –20 dBm. Maximum average transmit power: –12 dBm. Minimum average receiving power: –32.5 dBm.
50 / 125	Minimum average transmit power: –23.8 dBm. Maximum average transmit power: –15.8 dBm. Minimum average receiving power: –32.5 dBm.

As shown in Table 8.4, the minimum average receiving power of the 10Base-FL EMA is the same regardless of which type of cable used. However, the minimum and maximum average transmit power differs depending upon the cable type. If using 62.5/125 cable, the transmitted power is approximately 3.8 decibels lower than if using 50/125 cable. Consequently, a smaller optical budget is attained if the 50/125 cable is used. Note that a 10Base-FL segment can span up to 2 km, but the actual effective distance might be less depending upon the number of splices in the cable.

When shipped, this card has rubber caps over the connectors to protect them from dust. Do not remove these caps until ready to attach network segments to the connectors. Always replace the caps when segments are not attached.

The 10Base-FL Media Adapter supports full-duplex operation, which enables the use of the **`media operating-mode`** command (refer to the *PowerHub 7000/8000 Software Reference Manual*).

A green status LED, indicates that the segment is enabled and its diagnostic state is “good.” The PowerHub uses standard 10Base-FL link-beat pulses to determine the state of the segment.

8.2.3.3 10Base-FB EMA

The 10Base-FB EMA provides a single 10Base-FB connection. In accordance with the 10Base-FB standard, the 10Base-FB EMA increases the number of repeaters allowed between end stations from five (as in 10Base-FL) to twelve. Also, following the 10Base-FB standard, the 10Base-FB EMA allows for remote fault detection at both end stations connected by 10Base-FB. Figure 8.10 shows a 10Base-FB EMA.

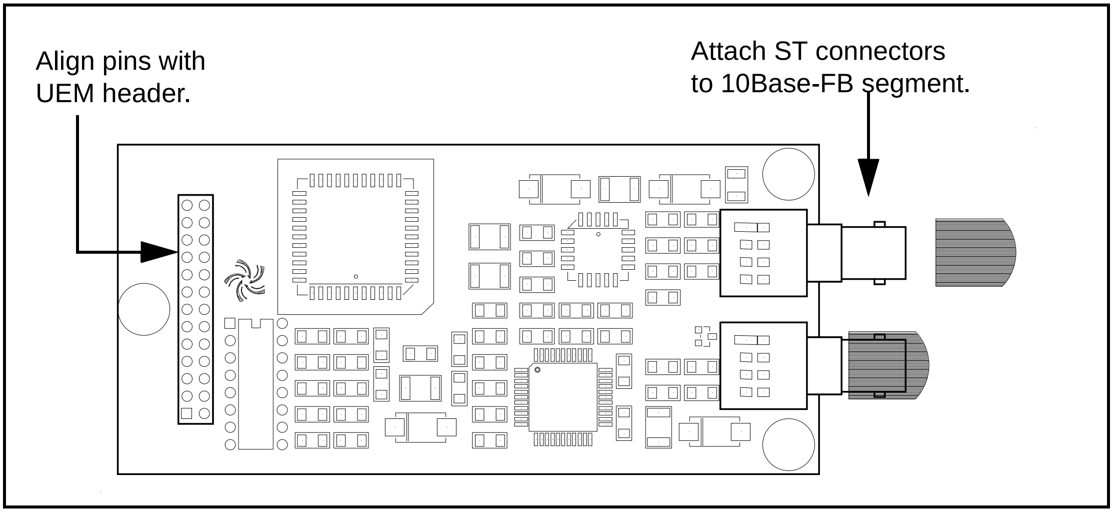


Figure 8.10 - 10Base-FB EMA

As shown in this figure, the 10Base-FB EMA, like the 10Base-FL EMA, uses two ST Fiber connectors. These connectors attach to fiber optic cables. As in the case of the 10Base-FL EMA, the connector shown on the top is the receive connector. When installed on the UEM, it is on the left and labeled R. The connector shown on the bottom is the transmit connector. When installed on the UEM, this connector is on the right and labeled X. Ensure that the 10Base-FB cables are attached accordingly. The power values for the 10Base-FB are the same as those for the 10Base-FL. Refer to Table 8.4 to determine the correct optical power budget.

When shipped, the 10Base-FB EMA card has rubber caps over the connectors to protect them from dust. Do not remove these caps until ready to attach network segments to the connectors. Always replace the caps when segments are not attached.

The 10Base-FB EMA, like other EMAs, provides connection status information to the UEM. The connection status is shown by the green S (Status) LED, located to the lower left of the EMA's position on the UEM. When glowing, this LED indicates the segment is enabled and its diagnostic state is "good."

The 10Base-FB EMA uses remote-link diagnostics signalling to determine the state of the 10Base-FB segment. Unlike other Ethernet EMAs, the 10Base-FB can sense the link state at both ends of the segment connection. If a link fails, the 10Base-FB EMA transmits a Remote Fault sequence that can be detected by the network. The Remote Fault sequence allows fault detection at both ends of the link. Table 8.5 describes how to interpret the behavior of the S LED.

Table 8.5 - 10Base-FB S LEDs

Behavior	Indicates
LED glows steadily.	The link between the 10Base-FB and the remote device is good.
LED is dark.	Bad or missing link. Check the cable and make sure the connections to the 10Base-FB are secure. If the connection and cable are good and the hub is powered on, make sure the UEM and 10Base-FB are properly installed. Also make sure that the segment has not been disabled by the software (automatic segment-state detection or **`bridge port`** command).
LED flashes on and off.	Remote fault. The remote device is not acknowledging receipt of data from the 10Base-FB. Check the cable, connections, and the remote device.

8.2.3.4 BNC EMA

The BNC Media Adapter provides a single 10Base2 “thin net” coax connection. Each BNC Media Adapter contains an internal 50-ohm termination resistor which can be activated using the switch on the front panel of the Media Adapter. The switch has two positions: U (unterminated) and T (terminated). The position of the switch is sensed by software and displayed using the **`system config`** command (refer to the *PowerHub 7000/8000 Software Reference Manual*). Figure 8.11 shows a BNC Media Adapter.

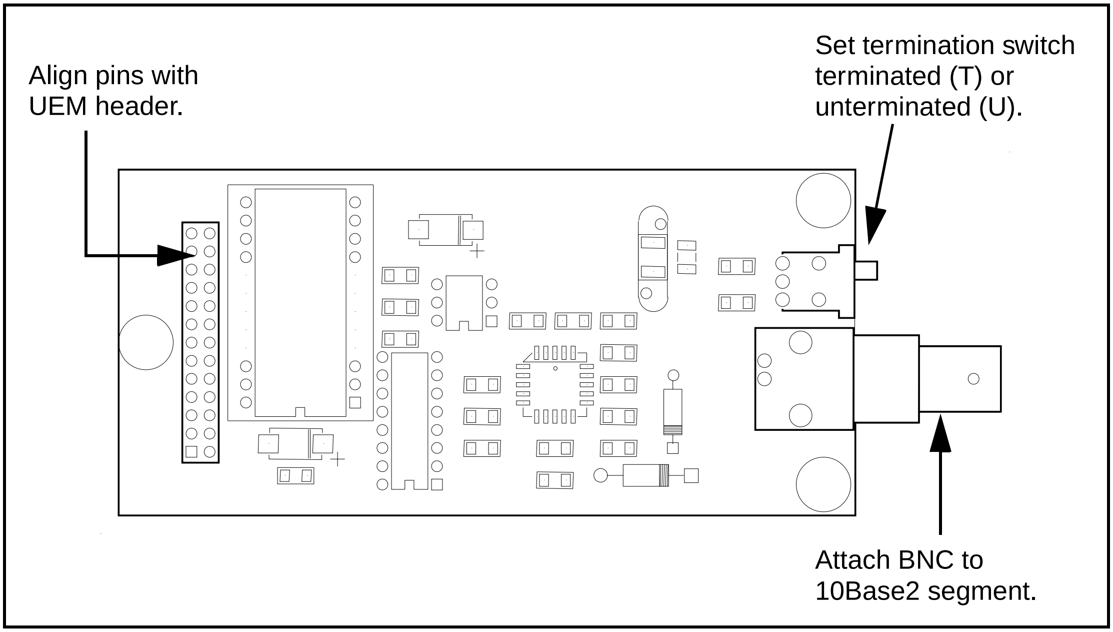


Figure 8.11 - BNC Media Adapter

The rows of pins shown on the left side of Figure 8.11 plug into a header on the UEM. Attach a coaxial cable to the BNC connector shown on the right side of Figure 8.11. Because this EMA is mounted facedown on the UEM, the BNC terminator switch is located to the left of the BNC connector.

The BNC Media Adapter, like other Media Adapters, provides connection status information to the UEM. The connection status is shown by the green S (Status) LED, located to the lower left of the Media Adapter's position on the UEM. When glowing, this LED indicates the segment is enabled and its diagnostic state is "good." The PowerHub uses heuristic methods to determine the BNC diagnostic state. If no packets are received from the segment and most transmissions sent on the segment result in collisions, then the segment state is determined to be "bad." When the segment state is bad, the LED is dark.

8.2.3.5 UTP EMA

The 10Base-T Media Adapter provides a single 10Base-T twisted-pair connection. The connection is established using an RJ-45 connector that provides the same mechanical connection, pinouts, and electrical functions as standard IEEE 802.3 10Base-T. Figure 8.12 shows a 10Base-T Media Adapter.

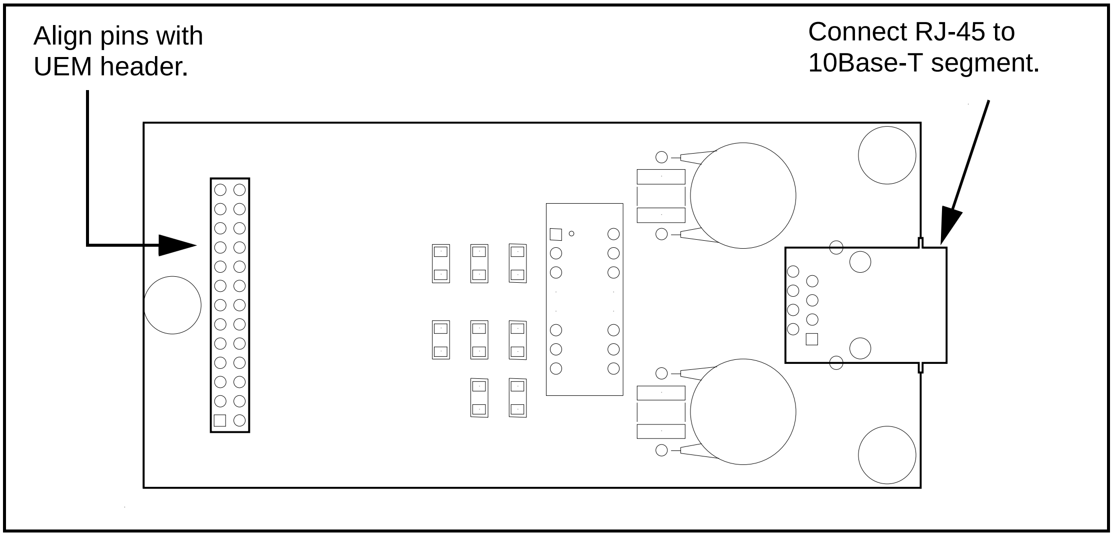


Figure 8.12 - 10Base-T Media Adapter

The rows of pins shown on the left side of the Media Adapter plug into a header on the UEM. The card is installed component-side down. The RJ-45 connector, shown on the right of Figure 8.12, attaches to a UTP cable.

The 10Base-T EMA provides connection status information to the UEM. The UEM shows the connection status using the green S (Status) LED located to the lower left of the Media Adapter's position on the UEM front panel. When glowing, this LED indicates the segment is enabled and its diagnostic state is "good." The PowerHub uses standard 10Base-T link-beat pulses to determine the state of the segment. Polarity reversal is automatically detected and corrected.

The 10Base-T Media Adapter supports full-duplex operation, which enables use of the **`media operating-mode`** command (refer to the *PowerHub 7000/8000 Software Reference Manual* for information on the media subsystem commands).

8.2.3.6 Medium Access Unit EMA

This section describes the Medium Access Unit (MAU) EMA, how it is connected to the AUI interface on the UEM, the connector type and explains the jumper that allow configuring the operating mode of the EMA.

The MAU EMA provides a single MAU interface for connection to the AUI interface on another device using a standard Ethernet transceiver cable. The MAU EMA contains circuitry that allows the PowerHub to be directly connected to an AUI Ethernet adapter on another device without using an external transceiver on the other device. Multiple PowerHubs can be connected together without external transceivers by installing a MAU EMA on one side and an AUI Media Cable on the other side. Then a standard straight-through AUI cable (with a male receptacle on one end and a female on the other end) is used to connect the PowerHubs together. Figure 8.13 shows the MAU EMA.

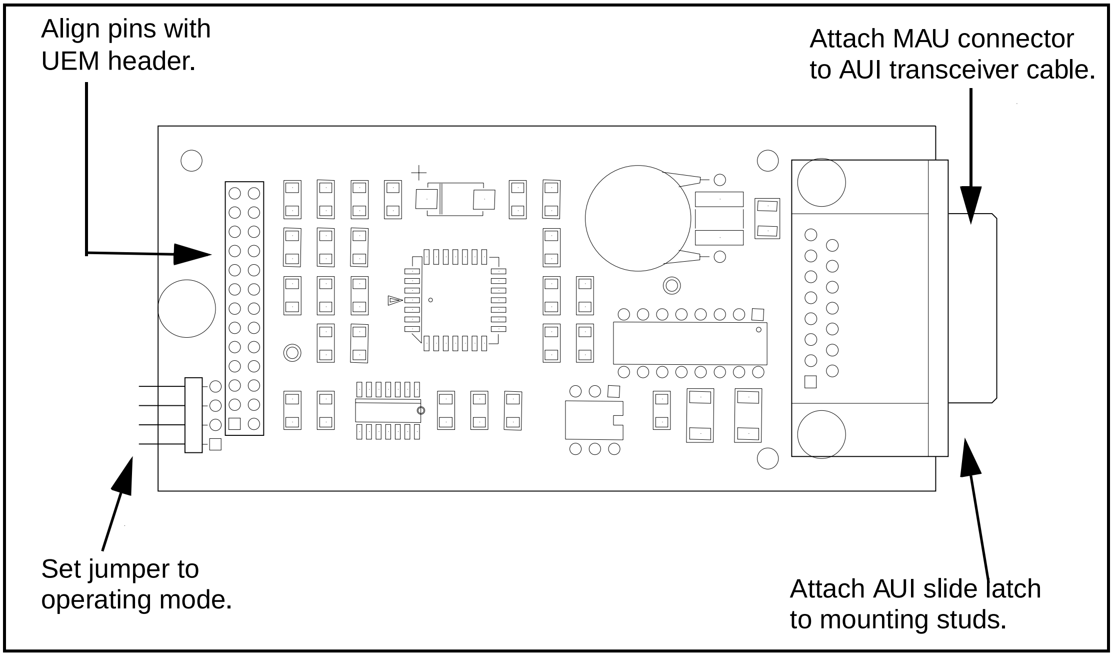


Figure 8.13 - MAU EMA

The two rows of pins shown on the left side of Figure 8.11 connect to a header on the UEM. Like other Media Adapters, the MAU is installed component-side down. Attach the female end of the AUI cable to the MAU connector shown on the right side of Figure 8.11(refer to *Chapter 5, Installation, Upgrade, and Removal Procedures* for procedures to install an AUI cable).

The MAU EMA contains a jumper that configures the operating mode of the card. The jumper is used to configure the card for one of the following modes:

- FDX—Full-duplex mode (SQE heartbeat disabled).
- RPT—Repeater mode (half-duplex with SQE heartbeat disabled).
- SQE—SQE mode (half-duplex with SQE heartbeat enabled).

Use the **`system config`** command to display the operating mode of the MAU EMA (refer to the *PowerHub 7000/8000 Software Reference Manual*). Like other EMAs, the MAU provides connection status information to the UEM. The connection status is shown by the S (Status) LED to the lower left of the MAU. When attaching an AUI cable carrying +12-volt current (standard for AUI) to the MAU, the LED is lit. If the cable is removed, the LED goes dark.

8.3 100 Mb/s Interfaces

The IEEE 802.3 Standards Committee has defined a set of standards for carrying Ethernet frames at 100 Mb/s, using the CSMA/CD protocol. Collectively, this set of standards is called “100Base.” However, 100Base standards have been defined for different physical media types. The PowerHub uses NIMs and FEMAs that conform to the following media types:

100Base-TX Uses two twisted pairs CAT-5 (data-grade) wiring, one for transmit and one for receive. Because there are separate pairs for transmit and receive, full-duplex operation is possible. Connection is provided by an RJ-45 connector.

100Base-FX Uses two multimode fiber-optic cables using ST type connectors, for multimode connections. For single-mode, provides connection to two single-mode fiber cables, using SC connectors. In each case, one cable is used for transmit and the other is used for receive, so full-duplex operation is possible.

10/100 Uses two twisted pairs CAT-5 (data-grade) wiring, one for transmit and one for receive. Because there are separate pairs for transmit and receive, full-duplex operation is possible. Connection is provided by an RJ-45 connector.

Each segment can be configured for full-duplex operation. When all segments are running in full-duplex mode, the total bandwidth supported is 320 Mb/s—twice the line speed of half-duplex. When all segments (including the FEMA) are running in full-duplex, the total bandwidth is 440 Mb/s.

8.4 Fast Ethernet Modules

The following Fast Ethernet interfaces are supported:

- 6x1 Fast Ethernet Module

8.4.1 6x1 FE Module

The 6x1 Fast Ethernet Module (6x1FE) provides six independent Fast Ethernet segments. The 6x1FE can contain up to six FEMAs in any combination of 100Base segment types. Figure 8.14 shows the 6x1FE module.

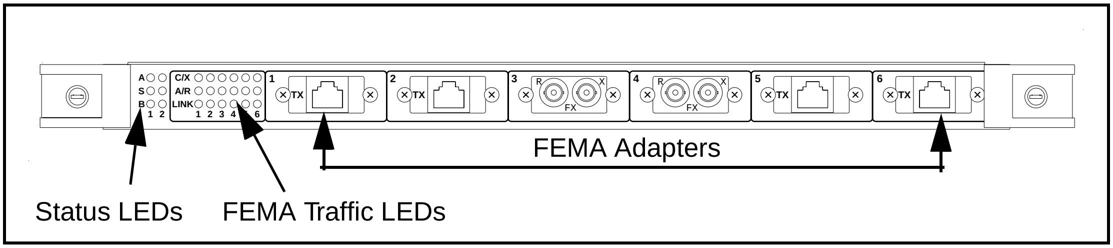


Figure 8.14 - 6x1 Universal Fast Ethernet Module

8.4.1.1 Software Features

The 6x1FE supports Port Monitoring, automatic segment-state detection, packet statistics, and other standard PowerHub features. The commands for using these standard features are documented in the *PowerHub 7000/8000 Software Reference Manual*.

8.4.1.2 Distance Limitations

FEMAs are designed to operate according to the specifications in the IEEE 802.3u-1995. Clauses 23-26 specify the maximum distances for 100Base segments. The specification allows for unbroken cable links up to 100 meters in length for 100Base-TX links.

Point-to-point 100Base-FX links up to 400 meters in length, and repeated 100Base-FX links up to 300 meters in length are also supported. Full-duplex, point-to-point 100Base-FX links are not subject to the 400-meter length restriction normally imposed by collisions. Instead, the limit is 2 km for multimode fiber and 20 km for single-mode fiber.

8.4.1.3 Full-Duplex and Half-Duplex Modes

The default operating mode for the 100Base-TX, the 100Base-FX, and 10/100 FEMA is full-duplex mode. In full-duplex mode, these FEMA types are capable of transmitting and receiving simultaneously. Moreover, segments being used in full-duplex mode do not experience collisions. The exception to the full-duplex mode default is when the 10/100 is connecting to a legacy device that does not support auto-negotiation or to a device whose auto-negotiating function has been turned off. In this case, the 10/100 defaults to half-duplex. To over-ride this default, you must turn off the auto-negotiation and manually set the speed and mode to coincide with that of the connecting device.

The alternative to full-duplex mode is half-duplex mode. In half-duplex mode, the FEMA can transmit and receive, but not simultaneously. At any given moment, the FEMA is either transmitting or receiving (or is inactive).

The maximum bandwidth available on a Fast Ethernet segment operating in half-duplex is 100 Mb/s. Thus a maximum of 100Mb/s can be used to either send or receive.

The operating mode for one or more FEMAs can be changed by using the **`media operating-mode`** command. Refer to the *PowerHub 7000/8000 Software Reference Manual* for more information on setting the operating mode.

CAUTION

Note that if you are connecting to a device that either does not support auto-negotiation or whose auto-negotiating function has been turned off, you must configure mode and speed manually. Inconsistent mode settings on connecting devices may result in data corruption.

8.4.1.4 Power Requirements

Table 8.6 lists the current requirements for the 6x1FE Module and FEMAs. If adding the 6x1FE to an installed system, use the information in Table 8.6 along with the information in *Chapter 4, Safety and Environmental Requirements* to determine whether additional power modules are required. For a fully-configured 6x1FE (containing six FEMAs), the total +5V current requirement is 9 Amps.

Table 8.6 - 6x1FE Current Requirements

	+5V Current	+12V* Current
Fast Ethernet Engine	6.0	0.1
FEMA (any type)	0.5	n/a
*The +12V estimate includes the 6x1FE and six FEMAs of any type.		

8.4.1.5 Fast Ethernet Media Adapters (FEMAs)

Fast Ethernet Media Adapters enable high bandwidth performance and are easily integrated into existing Ethernet networks. Three different types of FEMAs that can be installed in the 13x1 Ethernet NIM. These are the 100Base-TX, 100Base-FX Multimode, and the 100Base-FX Single-mode adapters. The 10/100 FEMA can be installed in the 6x1 Universal Fast Ethernet Module only and can accommodate some ports running at 10Mb/s and others running at 100Mb/s. To detect at what rate to send and receive data (10Mb/s or 100Mb/s), the 10/100 FEMA supports auto-negotiation. Because the 10/100 FEMA supports auto-negotiation, there is no need to manually configure or physically move cables if the device at the other end also supports auto-negotiation and its auto-negotiating function has been enabled. In such a scenario, the two devices will automatically adjust mode and speed to match each other. However, if the 10/100 FEMA is connected to a legacy device that does not support auto-negotiation or a device whose the auto-negotiation feature is turned off, it will be necessary to manually configure speed and mode. There is no need to physically change cabling, however, since the 10/100 is able to connect to 10MB as well as 100MB cards. As part of its auto-negotiating feature, a display command may be entered for the 10/100 FEMA connection to view the state of the connecting device.

The 100 Base-TX and 10/100 FEMAs use CAT-5 (data-grade) wiring. Connection is provided by an RJ-45 connector. Figure 8.15 shows the segment connector of the 100Base-TX and 10/100 FEMA:

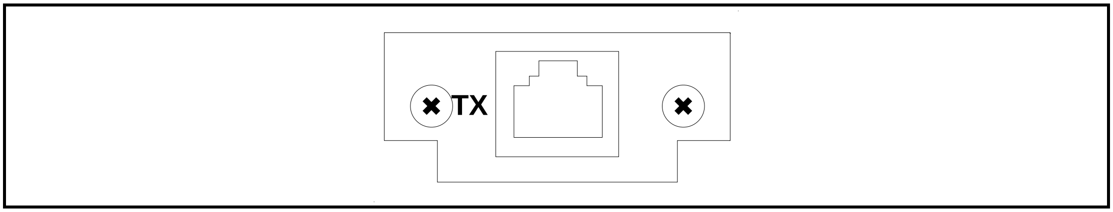


Figure 8.15 - 100Base-TX FEMA Segment Connector

The 100Base-FX FEMA uses a fiber-optic cable, the same type as used in FORE Systems' Fiber Distributed Data Interface (FDDI) segments (refer to *Chapter 9, FDDI Interfaces* for more information of FDDI interfaces). Depending upon the FEMA type installed, connection is provided by a pair of ST or SC connectors. The multimode 100Base-FX FEMA uses ST connectors, as shown in Figure 8.16.

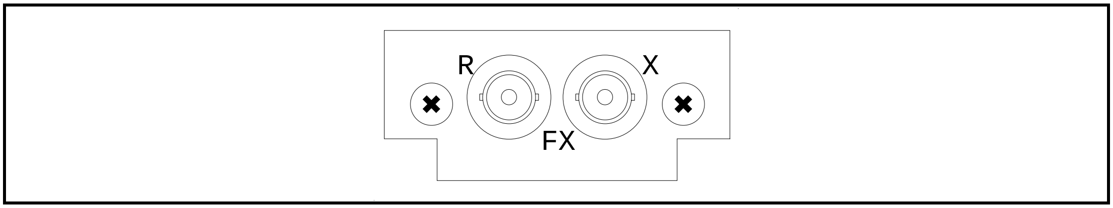


Figure 8.16 - 100Base-FX FEMA Multimode Segment Connector

The single-mode 100Base-FX FEMA uses an SC connector, as shown in Figure 8.17.

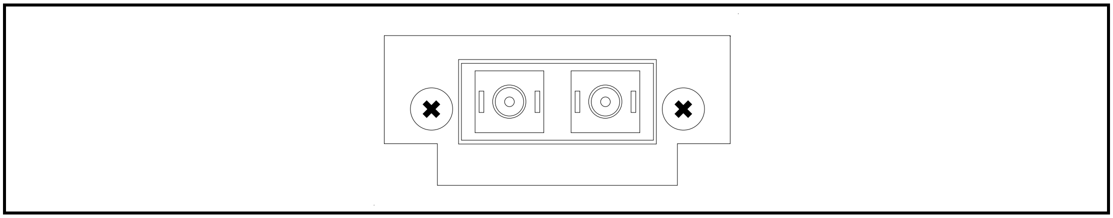


Figure 8.17 - 100Base-FX FEMA Single-mode Segment Connector

Both types of 100Base FEMAs shown here provide the same features. They differ only in the connector type and the type of fiber-optic cable used to attach the FEMA to the network. Additionally, the 10/100 FEMA supports autonegotiation. For information on installing or removing Ethernet NIMs, see *Chapter 5, Installation, Upgrade, and Removal Procedures*.

8.4.1.6 6x1FE LEDs

The 6x1FE contains two sets of LEDs:

- Status
- Traffic

8.4.1.6.1 Status LEDs

The Fast Ethernet Engine LEDs provide status information about the two 6x1FE CPUs. Table 8.7 describes the function and operation of the Status LEDs.

Table 8.7 - 6x1FE Status LEDs

Label	Color	Indicates...
A	Red	Alarm. These LEDs indicate that the 6x1FE has crashed. One or both LEDs remain lit until the 6x1FE Module or the PowerHub is reset. To reset the 6x1FE Module, use **system card-swap** commands. (See the *PowerHub Software Reference Manual*) To reset the PowerHub system, press the RST (Reset) button, or issue the **system reboot** command.
S	Green	The CPUs of the Fast Ethernet Engine are functioning normally. If both of these LEDs go dark during normal operation, there might be a problem in the Fast Ethernet Engine. Contact FORE Systems TAC. (It is normal for one of the LEDs to be dark sometimes.)
B	Amber	The 6x1FE is booting. These LEDs flash when the module is booting, then go dark as soon as the module is finished booting.

8.4.1.6.2 FEMA Traffic LEDs

The connection LEDs provide status information about each segment on the 6x1FE. Table describes the connection LEDs.

Table 8.8 - 6x1FE LEDs

Label	Color	Indicates....
C/X	Amber	Transmit collisions or packet transmissions, depending upon the setting. Receive collisions (collisions occurring while a segment is not transmitting) do not occur on private segments on modules such as the 6x1FE. When set to C (transmit-collision mode), indicates transmit collisions. Each time a transmit collision occurs on the corresponding segment, this LED is illuminated for 5 – 10 ms. When set to X (transmit mode), indicates packet transmission. Each time a packet is transmitted on the corresponding segment, this LED is illuminated for 5 – 10 ms. This is the default setting. The **`media ledmode`** command is used to change the LED setting. Refer to the *PowerHub 7000/8000 Software Reference Manual* for information on changing the LED settings.
A/R	Green	Packet activity (transmit and receive) or receive activity only, depending upon the setting: When set to A (activity mode), indicates when a packet is transmitted or received. Each time a packet is transmitted or received on the corresponding segment, this LED is illuminated for 5 – 10 ms. When set to R (receive mode), this LED indicates when a packet is received. Each time a packet is received on the corresponding segment, this LED is illuminated for 5 – 10 ms. This is the default setting. The **`media ledmode`** command is used to change the LED setting. Refer to the *PowerHub 7000/8000 Software Reference Manual* for information on changing the LED settings.
LINK	Green	Link status. When a LINK LED is glowing, the corresponding segment is successfully detecting link-test pulses through the twisted-pair wire or fiber-optic cable attached to the segment. A LINK LED goes dark if the twisted-pair cable attached to the corresponding segment is removed. If the cable is attached but the LED is still dark, a problem might exist in the cabling, in another device attached to the cable, or in the segment. For example, the device at the other end of the cable might have been powered off.

CHAPTER 9 FDDI Interfaces

This chapter describes the Fiber Distributed Data Interface (FDDI) Network Interface modules (NIMs). All FDDI NIMs support the ANSI X3T9.5 FDDI standard. Refer to *Chapter 7, ATM Interfaces* for information on ATM and *Chapter 8, Ethernet Interfaces* for information on Ethernet modules and adapters. This chapter describes the following FDDI related subjects:

- FDDI Cabling Considerations
- FDDI Software Support
- FDDI Network Interface Modules (NIMs)
- FDDI Connections

The following NIMs are documented in this chapter:

- Single and Dual NIMs
- Universal FDDI NIMs
- 6 Port FDDI Concentrator NIM
- 16 Port FDDI Concentrator NIM

9.1 FDDI Cabling Considerations

The Universal Single and Dual FDDI modules can support any combination of single-mode or multimode fiber, as well as UTP connections. Single-mode connections support single-mode fiber optic cabling with maximum distances of 20 km. Multimode connections support multimode fiber optic cabling with a maximum distance between stations of 2 km.

Single-mode FDDI connections, using ST connectors, differ from the multimode connections (MICs) only in their optical components. All other aspects of the connections remain unchanged including the software interface, forwarding rates and routing protocols. Moreover, the meaning of the six LEDs, three at each Dual Attachment Station (DAS) connection, are identical to multimode DAS connections. See Section 9.3.4.3 for information on the LEDs.

ANSI X3.184-1993 Single Mode Fiber PMD (ANSI SMF-PMD) specifies Category 1 and Category 2 classes of single-mode fiber installations. FORE Systems provides Category 1 equipment. Category 2 equipment can extend to greater distances (~35 km) but exceeds “Class 1" laser safety guidelines. Class 1 lasers require specialized safety and installation procedures as well as specially trained personnel which most customers are not equipped to provide. Category 1 SMF equipment requires no special safety or handling procedures beyond those already in use for FDDI multimode fiber optic installations.

9.1.1 Cable Type and Connectors

The only restriction on the single-mode cable type is that the cable should not be *dispersion shifted*. Dispersion shifted fiber optic cable is an uncommon type designed primarily for undersea cables and is optimized for 1500 nm transmission systems. Use of this cable type would give unpredictable loss and dispersion when operated at FDDI's wavelength of 1300 nm.

9.1.2 Cable Plant, Maximum Distance, and Power Budget

FORE Systems’ single-mode FDDI connections typically permit FDDI connections in excess of 20 km compared to the 2 km maximum distance of the multimode option. The actual maximum distance depends on the details of the particular installation including the length of all fiber segments (including patch cords) and the number and type of all connectors and splices (including patch panels). The totality of this is called the *cable plant*. Most single-mode cable plants are installed by specialists who characterize every segment of the cable plant. This characterization data includes information on optical loss. Maximum requirements for optical loss are defined in ANSI SMF-PMD Category 1 installations. Qualified cable installers should be familiar with these requirements.

The single-mode connections have an optical power budget of 10 dB as required by the ANSI Category 1 SMF-PMD. By comparison, the multimode PMD has an optical budget of 11 dB. However, single mode fiber has extremely low loss and dispersion compared to multimode fiber so it can span much greater distances. As a rough estimate, assume that single-mode fiber has a loss of 0.2 - 0.5 dB/km. Therefore a worst-case 20 km span would just exhaust the optical budget (20 km x 0.5 dB/km = 10d B). This very simplified example neglects any connectors (typical loss ~0.5 dB each) or splices (typical loss ~0.25 dB each).

Note that although ANSI SMF-PMD permits greater station-to-station distance than the multimode PMD, the 200 km total token path length restriction of FDDI remains. Therefore the use of several long distance single-mode links within a single FDDI network may not be advisable. In this case, dividing the network into two or more distinct FDDI rings using two FDDI DAS connections might be the best choice. Contact FORE Systems TAC for assistance.

Since cable is delivered in lengths up to 2 km, it is likely that any single-mode fiber installation of significant length has at least a few splices. In addition, there are likely to be several connectors and additional cable segments from the point where the long-distance cable enters the building, usually in the building basement, and where it is made available to the PowerHub, usually in an equipment cabinet or computer room, some distance away.

When estimating the maximum distance, be careful not to rule out the use of this option simply because the fiber run is greater than 20 km. The only absolute way to determine if these options work with the cable plant in question (without trying it) is to know the detailed loss budget. Again, this information should be provided by the cable installer. FDDI power budget permits the maximum and minimum power levels as listed in Table 9.1.

Table 9.1 - FDDI Power Levels

FDDI Power Budget	Power Level
Maximum transmit power at transmitter	-14 dB
Minimum transmit power at transmitter	-20 dB
Maximum loss between neighboring stations at downstream neighbor	11 dB
Maximum receive power at receiver	-14 dB
Minimum receive power at receiver	-31 dB
Maximum fiber loss per kilometer	2.5 dB

9.1.3 Distance Limitations

Distance limitations on an actual FDDI network depend on the effect of fiber connectors, optical bypass switches, and other devices on the power levels within this budget. Maximum fiber loss is not regulated in the standard, but a value of 2.5 dB/km is typical of the 62.5/125-µm multimode optical fiber. Ordinarily, the permitted signal attenuation of 11 dB between neighbors permits a cable run of approximately 2 km.

The maximum total token distance permitted is typically about 200 km (100 km for each counter-rotating ring, allowing for wrap in case of primary ring failure).

9.2 FDDI Software Support

This section describes the Station Management (SMT) software features and introduces the FDDI subsystem that supports the FDDI interfaces.

9.2.1 Station Management (SMT)

The PowerHub software contains an implementation of SMT software version 7.3, and is compatible with older versions of SMT. SMT software is responsible for inserting the PowerHub into the FDDI ring and maintaining ring integrity in the event of ring failure either upstream or downstream of the FDDI module. It includes a complete SMT MIB that can be monitored and controlled on the FDDI ring using any third-party network management station running an SNMP-based manager. In addition private FDDI MIB objects not available in the standard FDDI MIB can be displayed using a software command available in the **fddi** subsystem.

9.2.2 FDDI Subsystem

The commands used to configure and manage private Ethernet segments also are used for FDDI segments. In addition to these commands, commands in the **fddi** subsystem allow the following tasks to be performed:

- Display FDDI MIB objects as defined in RFC 1512.
- Display private FDDI MIB objects.
- Configure for FDDI Concentrators.
- Adjust the T_REQ or TVX hardware timers.

Refer to *PowerHub Software Reference Manual* for a discussion of the FDDI subsystem commands.

9.3 FDDI Modules

The Single and Dual FDDI Modules contain FDDI segments that can be used as DAS connections or as pairs of FDDI Single Attach Station (SAS) connections. The Single FDDI Module contains one FDDI segment while the Dual FDDI Module contains two FDDI segments. The FDDI segments on these modules provide standard media interface connectors (MICs) and can only be used with multimode fiber-optic cable. Figure 9.1 and Figure 9.2 show the single and dual FDDI modules.

The Universal Single and Dual FDDI Modules also provide one or two FDDI segments, respectively. However, unlike the Single and Dual FDDI Modules, the Universal FDDI modules provide connection to any combination of UTP, single-mode fiber-optic, and multimode fiber-optic cables. For each A or B port, connection is provided by the FDDI Media Adapter (FMA), a separate module installed at the A or B port position in the FDDI segment. Figure 9.3 and Figure 9.4 show the Universal Single and Dual FDDI modules.

Universal FDDI modules are configured at the factory with the specified combination of single-mode, multimode, and UTP FMAs. However, a Universal FDDI module can be reconfigured by removing FMAs and replacing them with other FMA types. *Chapter 5, Installation, Upgrade, and Removal Procedures* describes these procedures.

A 6 Port and 16 port Concentrator Module repeat FDDI traffic within the ring to which the modules are attached. The 6 Port Concentrator Module contains six type-M fiber ports while the 16 port Concentrator Module provides 16 type-M UTP ports. Note that the FDDI Concentrators require a single or dual FDDI module to be installed in the PowerHub. See Section 9.3.3 for more information on the Concentrator modules.

All FDDI ports on all FDDI module types can handle FDDI packets at the full 100 Mb/s line speed. Moreover, all types of FDDI modules are fully compatible with other PowerHub hardware.

NOTE

FDDI modules require more power than Ethernet modules. It may be necessary to install additional power modules to support the FDDI modules. See *Chapter 4, Safety and Environmental Requirements* to determine how many power modules are required to support a particular FDDI configuration.

9.3.1 Single and Dual

The Single FDDI Module contains one FDDI segment, which can be attached to a single FDDI ring. The Dual FDDI Module contains two FDDI segments, which can be connected to two independent FDDI rings. The FDDI segments provide standard MIC interfaces and can only be connected to multimode fiber-optic cable. Figure 9.1 shows the Single FDDI Module.

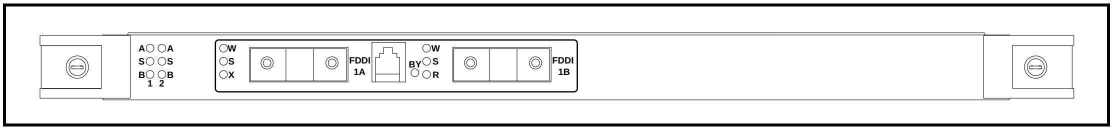


Figure 9.1 - Single FDDI Module

As shown in Figure 9.1, the Single FDDI Module contains FDDI Engine status LEDs and one FDDI segment. The FDDI segment contains connection LEDs, two MICs, and an optical bypass connector. The components of the FDDI segment are described in Section 9.3.4. The FDDI Engine LEDs are described in Section 9.3.4.3.

The Single and Dual FDDI Modules locally forward packets destined for other modules, thereby reducing the work load on the Packet Engine. (See Section 9.3.5.1.)

The Dual FDDI Module is very similar to the Single FDDI Module, but it contains two FDDI segments instead of one. In addition, the Dual FDDI Module uses local FDDI bridging, local IP routing, and local IPX routing to directly bridge or route packets from one FDDI segment to the other on the same module. Figure 9.2 shows the Dual FDDI Module.

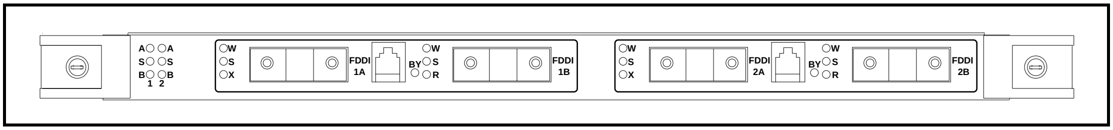


Figure 9.2 - Dual FDDI Module

9.3.2 Universal FDDI Modules

The Universal FDDI modules contain positions for single-mode, multimode, and UTP FMAs. Each FMA functions as an A or B port, depending on the position in which it is installed. Like the MICs used on the Single and Dual FDDI Modules, the FMAs can also be used as S or M ports.

The Universal Single FDDI Module contains one FDDI segment, with room for two FMAs. The Universal Dual FDDI Module contains two FDDI segments, with room for a total of four FMAs. Any combination of single-mode and multimode FMAs may be installed.

Both Universal modules contain the same features as the corresponding Single FDDI and Dual FDDI Modules, including the LEDs and the optical bypass connector. Figure 9.3 shows the Universal Single FDDI Module with multimode FMAs installed.

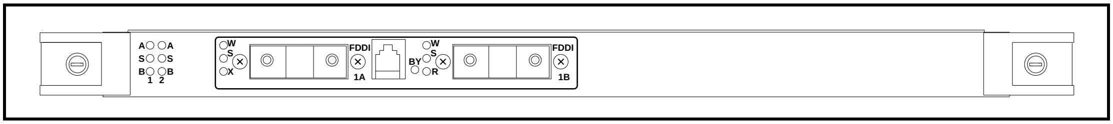


Figure 9.3 - Universal Single FDDI Module

Figure 9.4 shows the Universal Dual FDDI Module. This figure uses FDDI MICs for both connections. UTP (RJ-45) connectors are also available. Like the Dual FDDI Module, the Universal Dual FDDI Module supports local forwarding, local bridging, local IP routing, and local IPX routing. (See Section 9.3.5.1.)

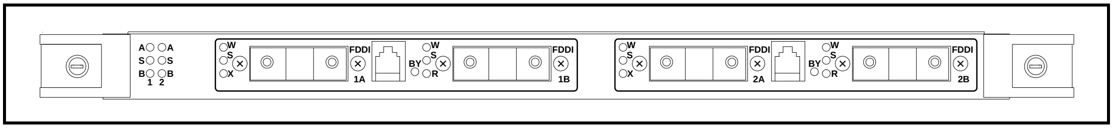


Figure 9.4 - Universal Dual FDDI Module

9.3.3 FDDI Concentrators

FDDI Concentrator modules repeat FDDI traffic within a FDDI ring to which the modules are attached. The 6 Port Concentrator module provides six MICs, which can be used only as type-M ports, not as S, B, or A ports. Figure 9.5 shows the 1x6 FDDI Concentrator Module.

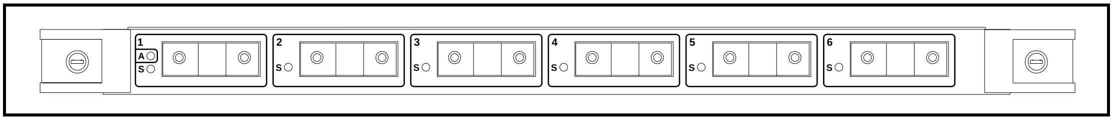


Figure 9.5 - 1x6 Concentrator Module

The 16 Port Concentrator Module provides 16 TP-PMD interfaces, with RJ-45 connectors. To use the 16 port, Category 5 (data grade) wire is required, the same type of wire used for 100Base-TX cables. Figure 9.6 shows the 16 port FDDI Concentrator Module.

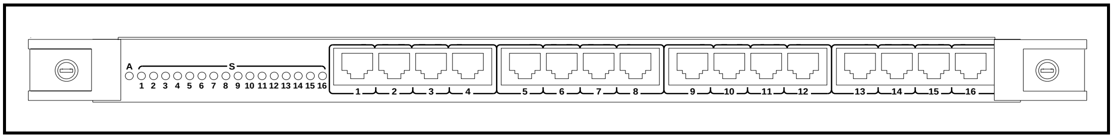


Figure 9.6 - 16 port Concentrator Module

Refer to Section 9.4 for configuration information for the Concentrator modules.

9.3.3.1 Chassis Placement

FDDI Concentrator modules can only be placed in slots 3 through 7 in a PowerHub 7000 10-slot chassis and slots 6 through 10 in a PowerHub 8000 10-slot chassis. On a PowerHub 8000 15-slot chassis, FDDI Concentrator modules can be placed in slots 3 through 7 and slots 11 through 15. The 5-slot chassis does not support FDDI Concentrators.

Table 9.2 - FDDI Channel Locations

Chassis	Slots	FDDI Channels	FDDI Channel location
7000	5	None	None
	10	1	Slots 3-7
8000	5	None	None
	10	1	Slots 6-8
	15	2	Slots 3-7 and 11-13

9.3.4 FDDI Module Components

FDDI segments on the Single, Dual, and Universal FDDI modules contain the same basic components:

- Connection LEDs.
- A and B ports (containing MICs or ST connectors).
- Optical bypass connector and corresponding LED.
- FDDI Engine

Figure 9.7 shows a of one FDDI segment. The FDDI segment in this example contains two MICs and the components are described in the following sections.

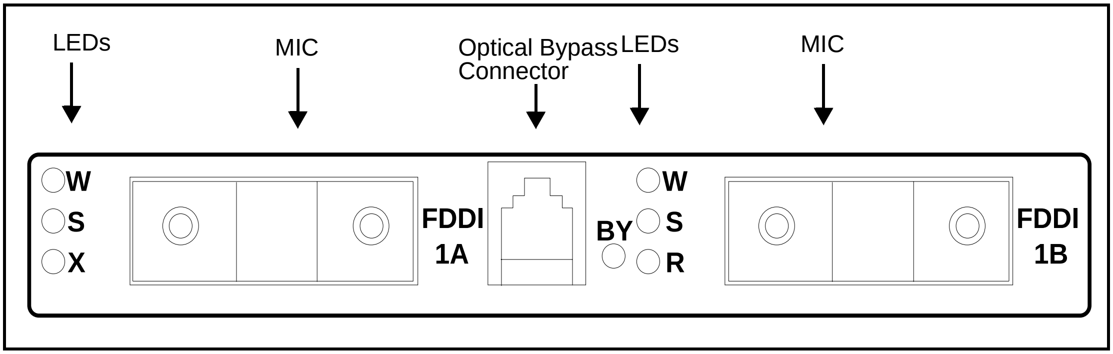


Figure 9.7 - FDDI Segment Connectors and LEDs

9.3.4.1 A and B Ports

This section describes the A and B ports of the FDDI segments. (The A and B port connections are made by MIC or ST connectors).

9.3.4.1.1 Media Interface Connector (MIC)

Each FDDI segment in the Single and Dual FDDI Modules contains two MICs. The MICs used are mechanically configured for DAS connections (type A and B), but can be used for type M or S connections. As shown in Figure 9.7, the left MIC (labeled 1A or 2A) on each DAS provides a type A connection and the right MIC (labeled 1B or 2B) provides a type B connection.

NOTE

The MIC on the multimode FMA is upside down, relative to the MICs on the Single and Dual FDDI Modules.

It is not necessary to perform any configuration steps to use a MIC as a specific type of FDDI port. Simply plug the FDDI cable into the MIC. The FDDI module automatically detects the port type and configures the MIC accordingly. The MICs are only used with multimode fiber-optic cable.

FDDI modules that contain MICs are shipped with a set of plastic inserts. Each set contains one insert for each of the four FDDI port types. Depending upon requirements, ensure that a MIC is used only for the port type desired by installing the appropriate insert in the slot on the MIC. See *Chapter 5, Installation, Upgrade, and Removal Procedures* for instructions on installing the inserts.

When shipped from the factory, each MIC is covered with a protective dust cap. Always keep the dust caps on the MICs until ready to attach the FDDI module to the FDDI segments. Always replace the dust caps when the MICs are not in use.

9.3.4.2 FDDI Media Adapters (FMAs)

The Universal FDDI modules use FMAs and can be configured to connect to any combination of single-mode and multimode fiber-optic cable, using the following FMA types:

- Multimode; provides a standard MIC.
- Single-mode; provides ST connectors.
- TP-PMD; provides an RJ-45 connector.

The FMA types are described in the following sections.

9.3.4.2.1 Single-Mode

Single-Mode FMAs contain a pair of ST connectors for use with single-mode fiber-optic cable. Figure 9.8 shows the bottom (component side) of the single-mode FMA.

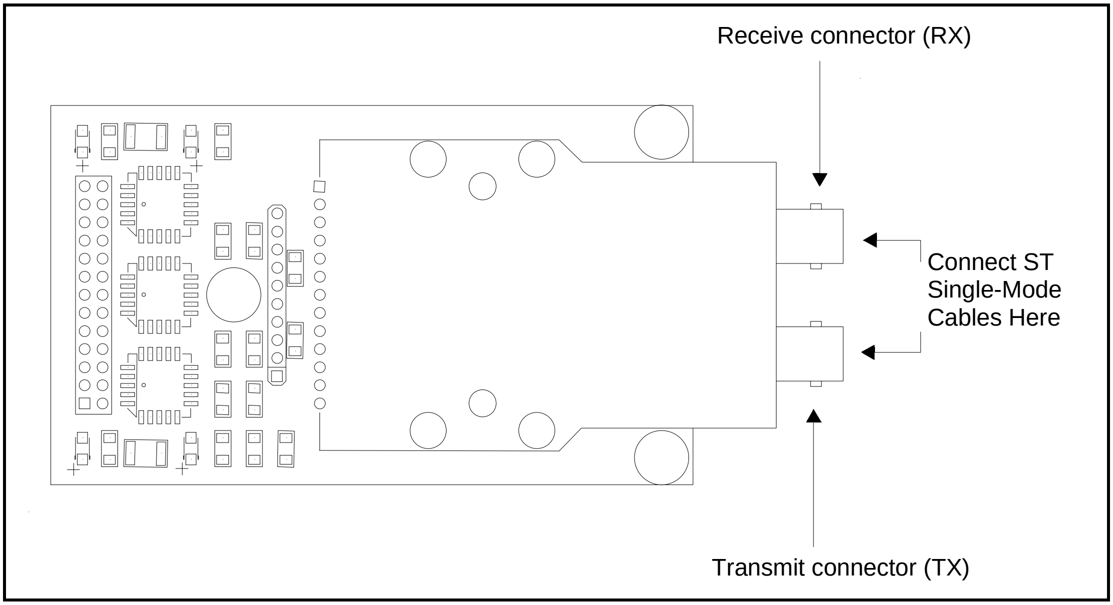


Figure 9.8 - Single-Mode FMA

As viewed from the component side the connector on the top is the receive connector and the connector on the bottom is the transmit connector. When the FMA is installed on the Universal FDDI module, the receive connector is on the left and the transmit connector is on the right

When the FMA is installed, only the ST connectors are visible. When shipped from the factory, the single-mode FMA has rubber caps over the connectors to protect them from dust. Do not remove these caps until ready to attach the connectors to the FDDI ring.

9.3.4.2.2 Multimode

The multimode FMA provides one MIC connector for use as an A or B port. The MIC is identical to the MICs provided in the FDDI segments on the Single FDDI Module and Dual FDDI Module, and is used only for multimode fiber-optic cable. Figure 9.9 shows the bottom (component side) of the multimode FMA.

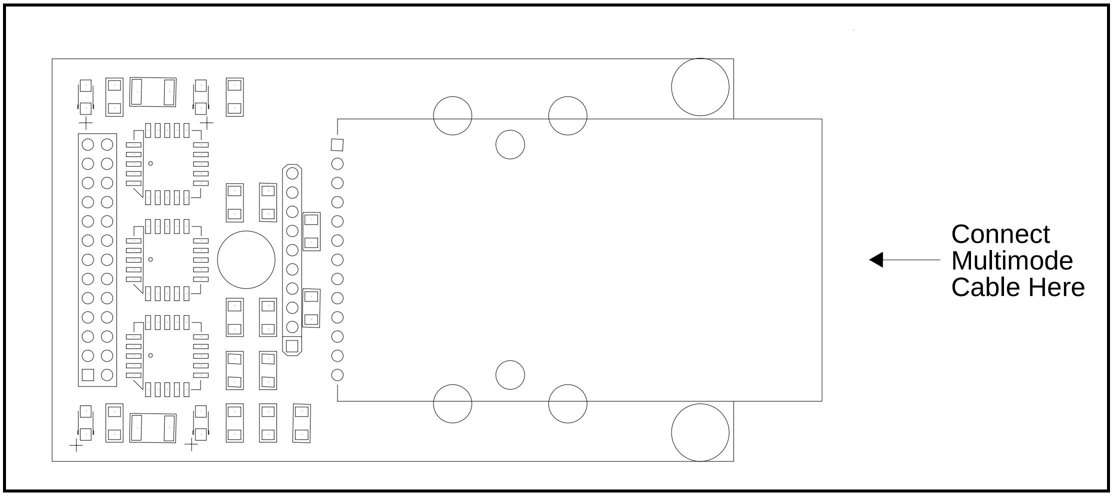


Figure 9.9 - Multimode FMA

When this FMA is installed, only the front of the MIC is visible. When shipped from the factory, each multimode FMA is covered by a protective dust cap that keeps the MIC free of dust. Keep the dust cap installed until ready to attach the FMA to the FDDI ring. Always replace the dust cap whenever the FMA is not in use.

9.3.4.2.3 Twisted-Pair Physical Medium Dependent

The Twisted-Pair Physical Medium Dependent (TP-PMD) FMA provides a TP-PMD FDDI connection. The pinouts are the same on the PowerHub and at the workstation, in accordance with ANSI X3T9.5 TP-PMD standard (See *Appendix A, Pinouts*). To establish a valid connection between the PowerHub and the workstation, implement a crossover cable. Figure 9.10 shows a component view of the TP-PMD FMA. When this FMA is installed, only the RJ-45 connector is visible.

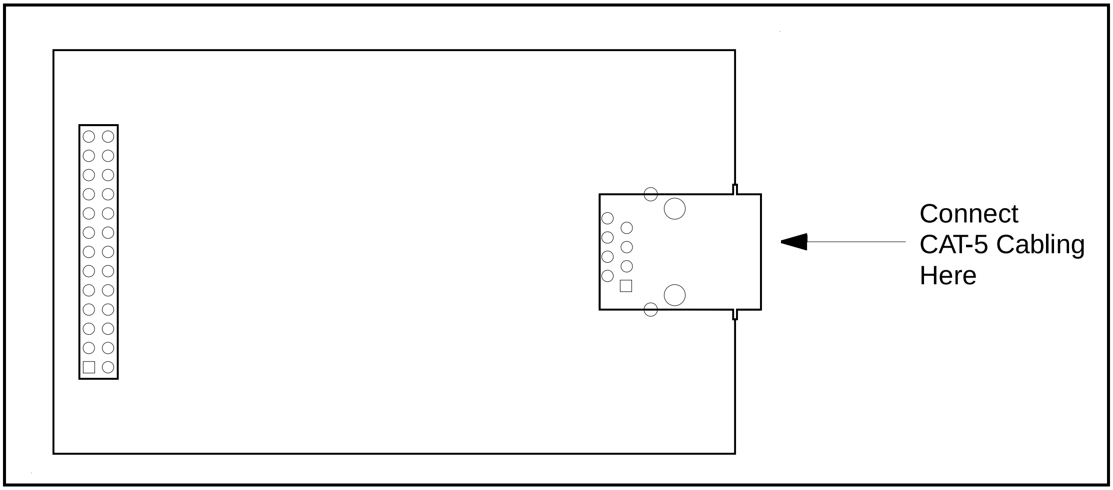


Figure 9.10 - TP-PMD FMA

FDDI Interfaces

9.3.4.3 Segment LEDs

Each MIC and ST connector has three LEDs. The LEDs show the same information for the MICs in both Single and Dual FDDI Modules, and for single-mode, multimode, and TP-PMD FMAs. Table 9.3 list the LEDs.

Table 9.3 - FDDI Connection LEDs

Label	Color	Indicates…
W	Amber	Wrap. For a DAS connection, left or right “Wrap” LED is lit when the connection is in the wrap-A or wrap-B state, respectively. If only one A or B port is being used as a SAS connection, its W LED *and* S LEDs are lit.
S	Green	Status. During a normal DAS connection (neither port is wrapping), both S LEDs are lit. If only one port is being used as a SAS connection, its W LED is also lit.
X	Green	Transmit. Associated with the entire FDDI segment, regardless of whether one or both ports are in use. The X LED indicates when packets are being transmitted onto the attached segment. If the FDDI segment is configured as a Dual Access Concentrator (DAC) for managing FDDI Concentrator modules, the X LED is lit each time a Concentrator Module attached to the segment transmits packets. NOTE: Some modules have a T in place of an X on the front panel. An LED labeled by T indicates exactly the same thing that an LED labeled with an X.
R	Green	Receive. Like the X LED, this LED is associated with the entire FDDI segment, regardless of whether one or both ports are in use. The R LED indicates when packets are being received from the attached segment. If the FDDI segment is configured as a DAC for managing FDDI Concentrator modules, the R LED is lit each time a Concentrator Module attached to the MIC receives packets.

9.3.4.4 Concentrator LEDs

As shown in Figure 9.5 and Figure 9.6, the Concentrator modules contain two types of LEDs as described in Table 9.4.

Table 9.4 - FDDI Concentrator Module LEDs

Label	Color	Indicates…
A	Green	Attachment to the DAC. When lit, the Concentrator module is attached to an FDDI segment. (See Section 9.4 for information on attaching a FDDI Concentrator module to a FDDI segment.)
S	Green	Status. The port is attached to a live FDDI node.

9.3.4.5 Optical Bypass Connector

Each FDDI segment on the Single, Dual, and Universal FDDI modules contains an optical bypass connector, physically located between the A and B ports. This connector enables an optical bypass device to be used to “heal” the ring in the event that a FDDI module, or the PowerHub containing the module, ever fails. Normally, if a PowerHub or other device attached to an FDDI ring fails, the ring is broken, forcing the adjacent devices to “wrap” around the device. However, the optical bypass connector mechanically bypasses the optical transmitters and receivers in the A and B ports in the unlikely event that the FDDI segment or the FDDI module itself fails.

To use the optical bypass connector, refer to the documentation accompanying the bypass device, configure the bypass device as needed, then plug the bypass device into the FDDI segment’s optical bypass connector.

A green LED, labeled BY, indicates when the connector is in use. During normal operation, this LED is dark.

NOTE

Single-mode cable is significantly different from multimode cable and does not work reliably with optical bypass devices. A Universal FDDI module containing single-mode FMAs does not prevent attempting to use the bypass connector with the single-mode FMAs, but the bypass is not effective. This is true for FDDI segments with two single-mode FMAs and for FDDI segments that contain only one single-mode FMA.

9.3.5 FDDI Engine

FDDI modules are "intelligent" modules. Each module contains a FDDI Engine, which has hardware and firmware similar to the Packet Engine. The FDDI Engine can locally filter packets, as well as make forwarding decisions for bridge, IP, and IPX packets. Moreover the FDDI Engine can locally bridge or route the packets for packets destined from one segment to another on the same module. The following sections describe the function and components of the FDDI Engine.

9.3.5.1 Local Forwarding

The FDDI Engine locally forwards packets destined either for another segment on the same module, or a segment on a another module. The FDDI Engine maintains copies of the bridge, IP, and IPX caches to perform the following types of local forwarding:

Intra-module forwarding When a packet is received by a segment on a FDDI module destined for another segment on the same module, the FDDI Engine checks the appropriate on-board cache for bridging or routing information for the packet. If an entry is found in cache, the FDDI Engine forwards the packet directly to the destination segment, bypassing the Packet Engine. If an entry is not found in the appropriate cache, the packet is sent along the Xplane to the Packet Engine for forwarding.

Inter-module forwarding When a packet is received by a segment on a FDDI module destined for a segment on another module, the FDDI Engine checks for an entry in the appropriate cache, as in intra-module forwarding. If an entry is found, the FDDI Engine alters the packet as necessary for bridging or routing, tags the packet with its destination segment, then sends the packet to the Packet Engine. The Packet Engine then sends the packet along the Xplane to the NIM containing the destination segment. If an entry for bridging or routing the packet is not found in the appropriate cache on the FDDI Engine, the packet is sent the Packet Engine for forwarding.

Local FDDI forwarding enhances network throughput by reducing the amount of packet traffic on the Packet Channel backplane and Packet Engine and by reducing the amount of time the PowerHub spends processing the bridged packets for forwarding.

For the Dual and Dual Universal FDDI Modules, the **fddi showcounter** command is used to display how many packets have been forwarded between FDDI segments since the module was booted. (Refer to *PowerHub Software Reference Manual* for more information on obtaining FDDI Statistics.)

9.3.5.2 Local Bridge Filtering

Depending on the network configuration, the FDDI Engine sometimes receives a packet whose destination address is for a station attached to the same segment as the one on which the FDDI module received the packet. When this occurs, the FDDI Engine locally “filters” the packet, dropping it rather than needlessly forwarding it to other segments. The packet is received by its destination without being needlessly forwarded to other segments or sent to the Packet Engine.

By filtering out these packets locally, the FDDI Engine enhances performance by preventing the unnecessary forwarding of traffic onto the other segments attached to the FDDI module and by preventing local FDDI traffic from needlessly being sent to the Packet Engine.

The **fddi status show counter** command displays how many packets the module has locally filtered since it was booted. (Refer to *PowerHub Software Reference Manual* for more information on obtaining FDDI Statistics.)

9.3.5.3 Components

The FDDI Engine contains the following components:

- Two RISC CPUs (RCPU1 and RCPU2)
- FDDI Controllers
- Bus-Memory Interface (BMI) ASICs
- LEDs
- Fast Path Memory
- Shared Memory
- Main Memory
- Boot PROM
- Temperature Sensor

9.3.5.3.1 Central Processing Units (CPUs)

Each FDDI module contains two CPUs, designated RCPU1 and RCPU2, that control the FDDI ring(s). The RCPUs locally filter FDDI traffic, run the SMT code, and initialize and service the firmware in the DAS interfaces. Both RCPUs access the Shared Memory as well as DRAM Main Memory and other peripherals described later in this section.

9.3.5.3.2 FDDI Controllers

For each FDDI segment, an FDDI controller connects to the physical layer interface, provides MAC-layer functions, and maintains buffers in Shared Memory and communicates with the RCPUs. The FDDI controllers also manage data transfers between the FDDI Engine and the Packet Channel backplane, which links the FDDI Engine to the Packet Engine. The dual modules contain two FDDI controllers while the single modules contain one FDDI controller.

9.3.5.3.3 Bus Memory Interface (BMI) ASICs

FORE Systems' proprietary Bus-Memory Interface (BMI) ASICs provide multiple ports for Packet Channels, RCPUs, and FDDI controllers to access memory. The FDDI Engine uses the following BMI ASICs:

- One connects the FDDI Engine to the Xplane's Packet Channels, which carries data to and from the Packet Engine.
- Two connect the RCPUs (RCPU1 and RCPU2) to Shared Memory.
- A BMI connects each FDDI controller to Shared Memory.

Access to the Shared Memory ports is prioritized. The RCPU ports have the highest priority, followed by the FDDI controller ports.

9.3.5.3.4 LEDs

In addition to the LEDs on the FDDI segments, each FDDI module contains two columns of LEDS for the FDDI Engine itself. Table 9.5 lists these LEDs.

Table 9.5 - FDDI Engine LEDs

Label	Color	Indicates…
A	Red	Alarm. These LEDs indicate that a crash has occurred and remain lit until the FDDI module is rebooted.
S	Green	The RCPUs are functioning normally. If both of these LEDs go out during normal operation, there might be a problem in the FDDI Engine. Contact FORE Systems TAC.
B	Amber	The FDDI module is booting. These LEDs flash when the module is booting, then go dark as soon as the module is finished booting

9.3.5.3.5 Fast Path Memory

RCPU1 and RCPU2 can each access their own fast path memory (also called “SRAM”), independent of the DRAM Main Memory and Shared Memory. Software uses this fast-path memory to hold frequently used instructions or data, thereby enhancing performance.

9.3.5.3.6 Shared Memory

The FDDI Engine has 2 MB of multiport Shared Memory that provides 800 Mb/s of bandwidth (32 bits at 25 MHz). This bandwidth is more than sufficient for wire-speed, non-blocking operation of two 100 Mb/s FDDI rings plus RCPU access.

Shared Memory contains one port for each of the FDDI controllers in the FDDI segments and one port for each of the RCPUs.

9.3.5.3.7 Main Memory

Each FDDI module contains 4 MB of main memory, which is used by RCPU1 and RCPU2.

9.3.5.3.8 Boot PROM

Each FDDI module contains a boot PROM that contains software used by the FDDI Module during start up. It is not necessary to configure the boot PROM. However, this PROM can be upgraded in the field, if needed. Use the **system show idprom** command to display the version of this PROM installed on the FDDI module.

9.3.5.3.9 Temperature Sensor

The FDDI module, like the Packet Engine and other NIMs, has a temperature sensor that reads the temperature of the module within 0.5 degrees Celsius.

9.4 FDDI Connections

Depending upon the attached devices, each FDDI segment automatically configures itself into one of the following modes:

- A DAS attachment to the FDDI backbone. In this configuration, the MICs on the FDDI segment function as A and B ports.
- A Null-attached concentrator. In this configuration, two MICs are used as M ports to attach two SAS stations.
- A Dual-homed device. The two MICs of one FDDI segment are attached to the M ports of two separate concentrators in the same ring. In this configuration, the MICs are each configured as S ports. This configuration provides backup in case one of the connections fails. The B MIC (1B or 2B) has precedence, but if the B MIC or the concentrator it is attached to fails, the A MIC (1A or 2A) takes over automatically.

In a typical configuration, one FDDI segment is used as A and B ports to attach to the FDDI enterprise backbone, while the other FDDI segment is used as M ports to attach to high-performance workgroup file servers.

NOTE

FDDI segments on the same module cannot be directly linked to one another. Both FDDI segments on the Dual and Universal Dual FDDI Modules have the same MAC-layer hardware address. Because FDDI requires that each device attached to a ring have a unique MAC address, attaching the FDDI segments together causes the ring to fail. Likewise, the FDDI segment on one module cannot be linked to a FDDI segment on another module in the same PowerHub. All FDDI segments in a given PowerHub have the same MAC-layer address.

The following sections describe each connection mode. All figures in these examples depict a Dual FDDI Module; however, the examples are valid for the other FDDI module types as well. The connection modes for the two rings supported by the Dual FDDI Modules are independent of each other.

NOTE

The transmit and receive sides of the multimode FMA are the reverse of those in the MICs in the Single and Dual FDDI Modules, because the MIC connectors are upside down. The MICs in the Single and Dual FDDI Modules receive on the left and transmit on the right side of the MIC. The multimode FMA transmits on the left side and receives on the right side. All of the examples in this section are based on the MICs in the Single and Dual FDDI Modules.

9.4.1 FDDI Port Types and Connectors

ANSI X3T9.5 defines four FDDI port types (shown in Figure 9.11) and described in Table 9.6:

- **A** or Primary In / Secondary Out (PI / SO) connects dual-attachment devices (concentrators or stations) to trunk rings and to each other. It uses both the primary and secondary rings.
- **B** or Primary Out / Secondary In (PO / SI) also connects dual-attachment devices to trunk rings and to each other. It also uses both the primary and secondary rings.
- **M** or Master (PI / PO) connects a concentrator to single-attachment devices. It uses only the primary ring.
- **S** or Slave (PI / PO) connects single-attachment devices to a concentrator. It also uses only the primary ring.

Table 9.6 - FDDI Port Type

Type	Description
A	Also called Primary In/Secondary Out (PI/SO). A ports connect dual-attachment devices (concentrators or stations) to trunk rings and to each other. A ports use both the primary and secondary rings.
B	Also called Primary Out/Secondary In (PO/SI). Like A ports, B ports connect dual-attachment devices to trunk rings and to each other. Also like A ports, B ports use both the primary and secondary rings.
M	Also called Primary In/Primary Out (PI/PO) or Master. M ports connect concentrators to single-attachment devices. M ports use only the primary ring.
S	Also called Primary In/Primary Out (PI/PO) or Slave. Like M ports, S ports connect single-attachment devices to concentrators. Also like M ports, S ports use only the primary ring.

Figure 9.11 shows examples of how each port type is used in a typical FDDI ring.

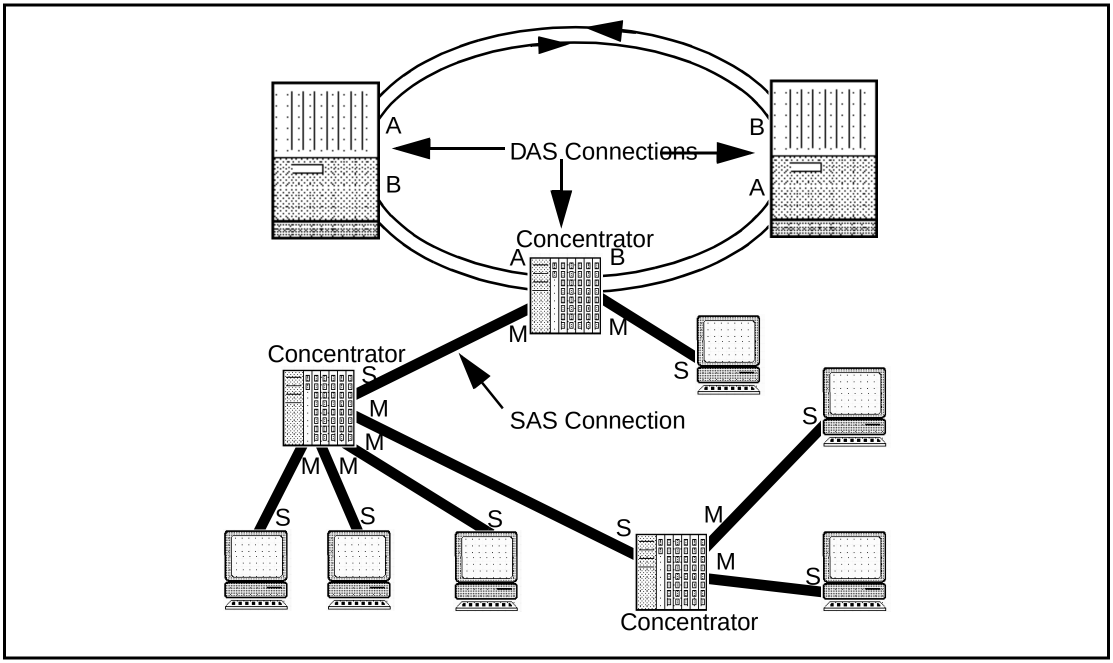


Figure 9.11 - FDDI Port Types

9.4.1.1 Valid Connections

The following are valid FDDI connections:

- **A** to **B**: the typical connection between two adjacent dual-attachment concentrators on the trunk ring.
- **M** to **S**: the typical connection between a concentrator and an SAS on the tree attached to the concentrator.
- **A** to **M** or **B** to **M:** a connection between a concentrator's M-port and a DAS A- or B-port, used for dual homing. If both A and B ports are connected to the ring, the B connection takes precedence. If the B connection fails, the A connection automatically takes over.
- **S** to **S**: an uncommon but valid connection between two single-attachment stations, creating an isolated ring.

9.4.1.2 Undesirable Connections

The following connections are valid but undesirable FDDI connections:

- **A** to **A** or **B** to **B**: connects SO to PI or PO to SI of the next dual-attachment device, creating a twisted ring (the data path crosses from the primary to the secondary ring). Use A to B or B to A instead.
- **A** to **S** or **B** to **S**: connects SO to PI or PO to SI at the same port, creating a wrapped ring. Use M to S instead.

9.4.2 Simple SAS Connection

The simplest connection between a Single DAS and another FDDI device consists of a single FDDI cable joining the A or B port on the Single DAS to an S port at an end station, as shown in Figure 9.12.

In this type of connection, the A or B port on the Dual DAS configures itself as an M port. Because the Single DAS has "B precedence," this example shows port B (FDDI B) being used. However, can be used port A (FDDI A) as a SAS connection.

The thick solid line in Figure 9.12 shows a multimode FDDI cable. The thin solid lines at the ends of the cable indicate the two separate filaments in the cable. When a MIC is used as an M or S port, each filament of the cable carries one direction of traffic.[1]

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[1] On the single-mode Single DAS, separate transmit and receive cables attach to the transmit and receive connectors on each port of the Single DAS. However, the FDDI traffic flows the same regardless of whether single-mode Single DAS or the multimode Single DAS is being used.

The arrows next to the FDDI cable indicate the direction in which traffic flows through each filament. The dotted lines that connect the receive and send terminals in the ports show the traffic flow within the circuitry of the ports. These lines pass through the MAC (Media Access Control), which operates in the Single DAS at the data-link layer to manage token passing and other operations. Note that the MAC is internal to the Single DAS and is shown in this example and the following examples for completeness.

9.4.3 A and B Connection to a Dual Ring

Figure 9.12 shows an example of how the FDDI ports on the Single DAS can be used as type A and type B ports to attach to a dual ring. This particular type of configuration uses the Single DAS in the “three” mode.

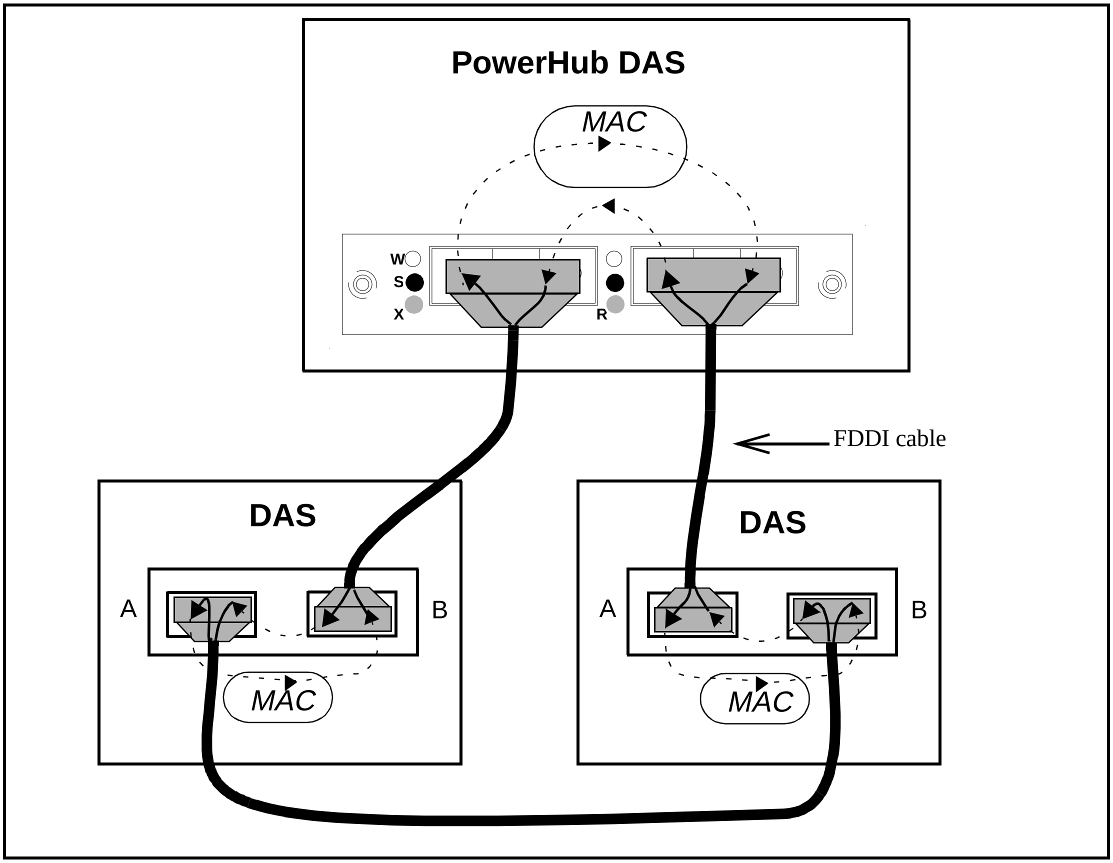

Figure 9.12 - Dual FDDI, Counter-rotating FDDI Ring

In this configuration, two independent, counter-rotating rings connect the Single DAS to the other DAS devices. Unlike configurations using SAS connections, where both filaments in the fiber cable are used to pass traffic, a dual ring configuration uses only one filament for normal traffic. This filament comprises the primary ring and is indicated by the solid lines joining the FDDI cables to the ports.

The other filament, indicated by dashed lines, comprises the secondary ring and is used for normal traffic only if a break occurs in the primary ring. During normal operation, FDDI traffic passes through the primary ring.

If a break occurs in the primary ring, the FDDI software causes the Single DAS to wrap around the break, as shown in Figure 9.13.

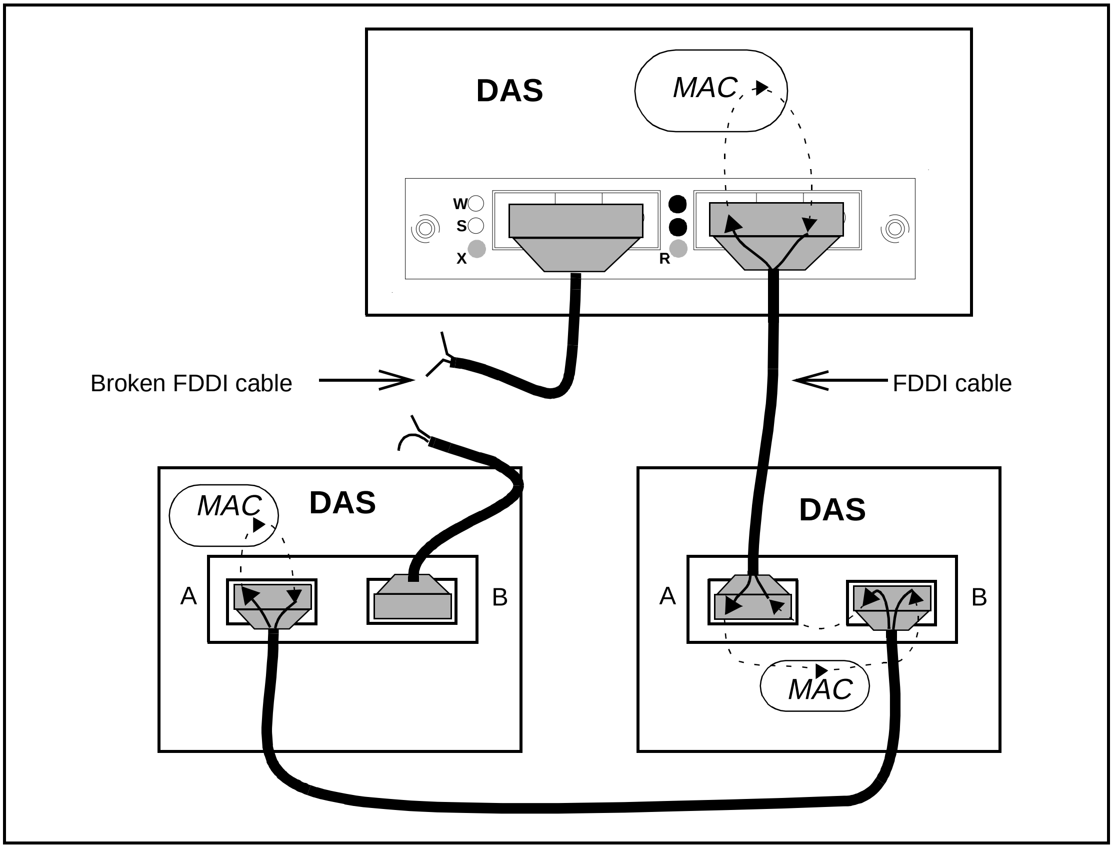

Figure 9.13 - Wrapping Around A Disconnected Node.

FDDI Interfaces

As shown in this figure, the FDDI segment on the Single DAS wraps around the disconnected device and creates a single ring. In this situation, the Wrap LED (W) for port B lights up, indicating that port A has lost connection and that port B is wrapping to compensate for the lost connection.

9.4.4 Null-Attached Connection

This section explains that in the illustrations in the SAS connection section, if the ring was broken, connection would stop. However, if a second FDDI device was attached to the B port (so that there are two SAS connections) this would constitute a null-attached connection. A picture describes the null attached connection. Note that in this configuration the two FDDI ports are configured as M ports. In this configuration, the traffic does not loopback through the B port. The software detects how the MICs are being used and configures them for a single ring.

This section describes and provides illustrations of how the traffic flows in a null-attached connection when the ring is broken. The software detects the break in the ring and heals the ring by wrapping the traffic through the other FDDI device bypassing the disconnected node. In this situation, the W (Wrap) LED illuminates to show that the ring is being wrapped through the B port.

With a simple SAS connection (illustrated in Figure 9.13): if a break occurs in the cable connecting the Single DAS to the other FDDI device, the ring is broken and communication stops.

Suppose a second FDDI device is attached to the Single DAS, as shown in Figure 9.14.

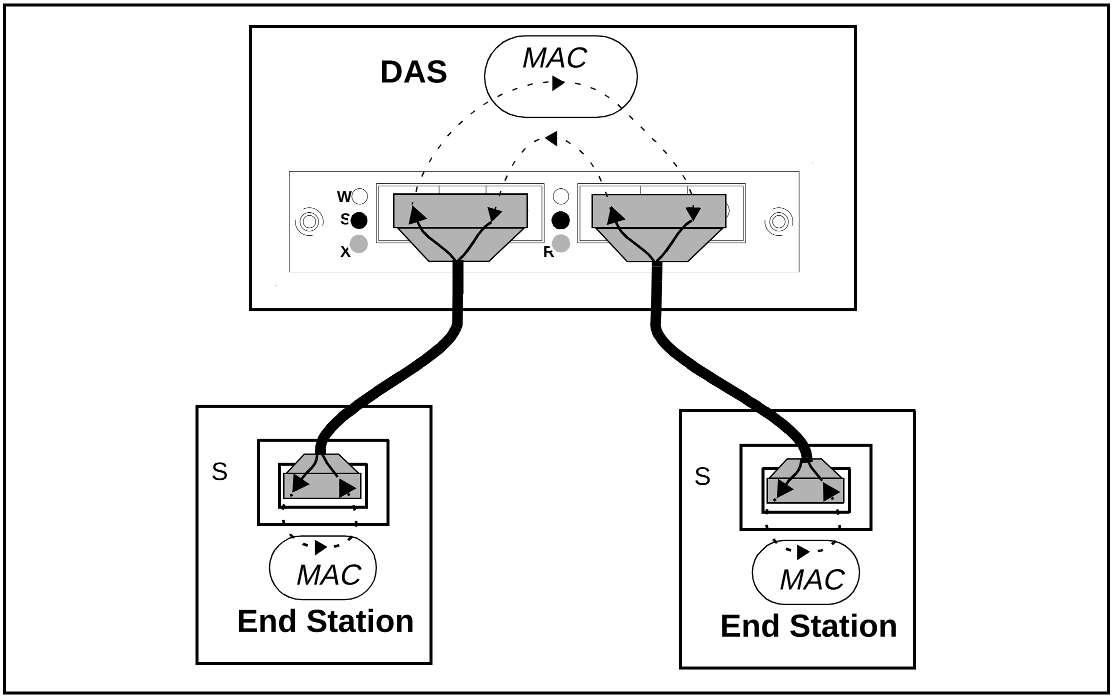

Figure 9.14 - Two SAS Configuration

In this configuration, ports A and B on the Single DAS are both being used as M ports. This type of connection is a *null-attached* connection. Notice the flow of traffic in this configuration. Port B is attached to an end station as it is in Figure 9.16. However, in the configuration shown in Figure 9.14, the traffic flow does not loop back through port B as it does in Figure 9.15. In this configuration, both FDDI devices attached to the Single DAS can communicate with each other through the ring. The PowerHub FDDI software automatically detects how the Single DAS's ports are being used and configures them for a single ring.

When the Single DAS's ports are used for SAS connections (M or S ports), FDDI traffic flows as shown in Figure 9.14. However, suppose that one of the FDDI cables in Figure 9.14 is broken, as shown in Figure 9.15.

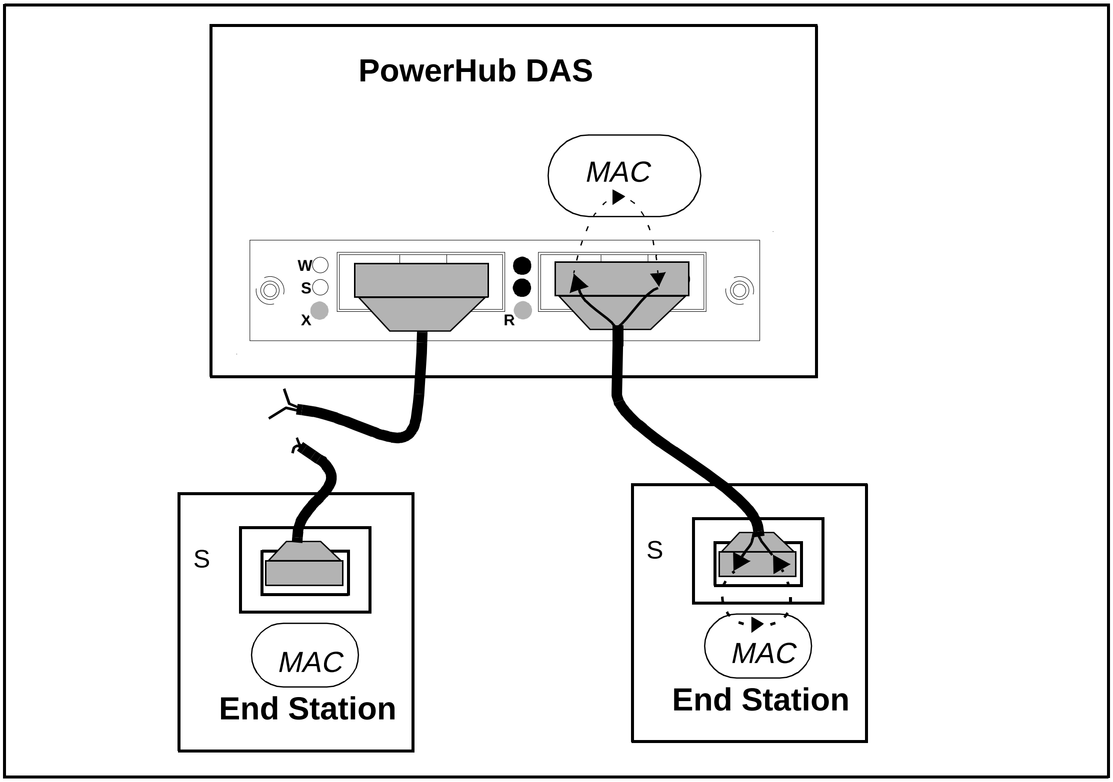

Figure 9.15 - Wrapping Around Lost Connection

If a break occurs, the FDDI software detects the break and “wraps” around the disconnected node. In this example, communication with the device attached to port A is lost. The PowerHub FDDI software detects this and automatically compensates by internally looping the send and receive sides of port B on the Single DAS. When port B starts wrapping, its Wrap LED (W) lights up to alert that a connection is broken and the port is wrapping.

9.4.5 Dual-Homed Connection

The FDDI ring in an enterprise backbone is generally a dual, counter-rotating ring using DAS connections. If the PowerHub is not to be attached onto the backbone ring, connect the Single DAS to a dual-attached concentrator that is attached to the enterprise backbone. In this type of connection, a port on the Single DAS is configured as an S port and is used to attach the PowerHub to the concentrator.

To provide a redundant connection (and allow wrapping to occur if needed), set up the Single DAS for dual homing. *Dual homing* ensures that FDDI traffic reaches the dual-homed device even if one of the dual-attached concentrators or cables fails. Figure 9.16 shows an example of how a Single DAS can be attached to a dual-attached concentrator for dual homing.

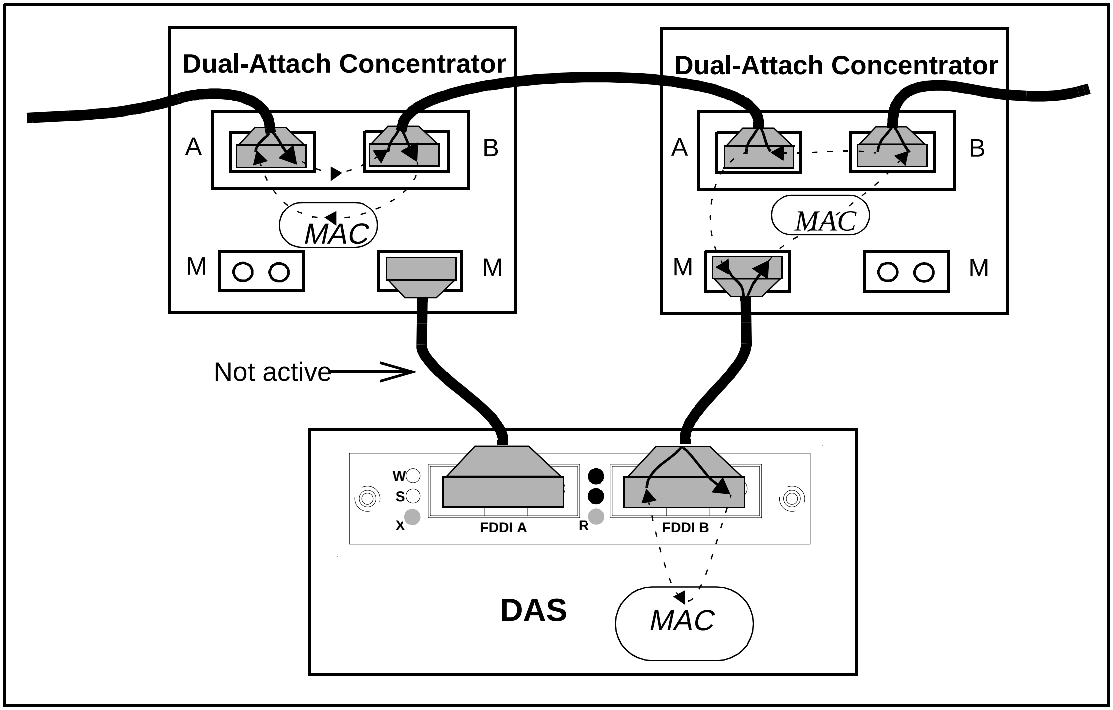

Figure 9.16 - Single DAS Used As Type S Connectors For Dual Homing

In this configuration, the concentrators at the top of the figure are attached to the FDDI backbone, which is a dual, counter-rotating ring. Each concentrator also is attached to one of the ports on the Single DAS.

Notice that on the Single DAS, normal traffic is flowing through port B, but not through port A. In a dual-homed configuration, in which port A is attached to one concentrator on the trunk ring, and port B is attached to a second concentrator on the trunk ring, port B has precedence. This is known as “B precedence” and is standard in FDDI and SMT.

Due to B precedence, only port B is used in this configuration. However, if the connection used by port B fails, port A automatically takes over, restoring the connection.

9.4.6 Combining Single-Mode and Multimode Connections

If the FDDI module is a Universal Single FDDI Module or a Universal Dual FDDI Module, the module with can be configured any combination of single-mode, multimode, and UTP FMAs. The multimode FMA provides a MIC for connection to multimode cable. The single-mode FMA provides ST connectors for connection to a single-mode cable.

Figure 9.17 shows four FDDI modules, installed in different PowerHubs. The three modules on the left are located within a single building, but are not installed in the same chassis.[1] The module on the right is 20 km away from the other three. As with any FDDI network, DAS connections have their A port connected to a neighboring station's B port and so on until a continuous ring is formed.

Note that in the Universal Dual FDDI module, either FDDI segment could be used in this configuration. As long as the appropriate connection type (single-mode or multimode) is used for the cable, either FDDI segment can be used.

1. Remember that all FDDI modules in a given PowerHub chassis share the same MAC address and cannot be connected together and used as separate stations in the same FDDI ring. Consequently, the configuration shown in Figure 9.17 is valid only if the FDDI modules are acting as unique stations with unique MAC addresses, in separate PowerHub chassis.

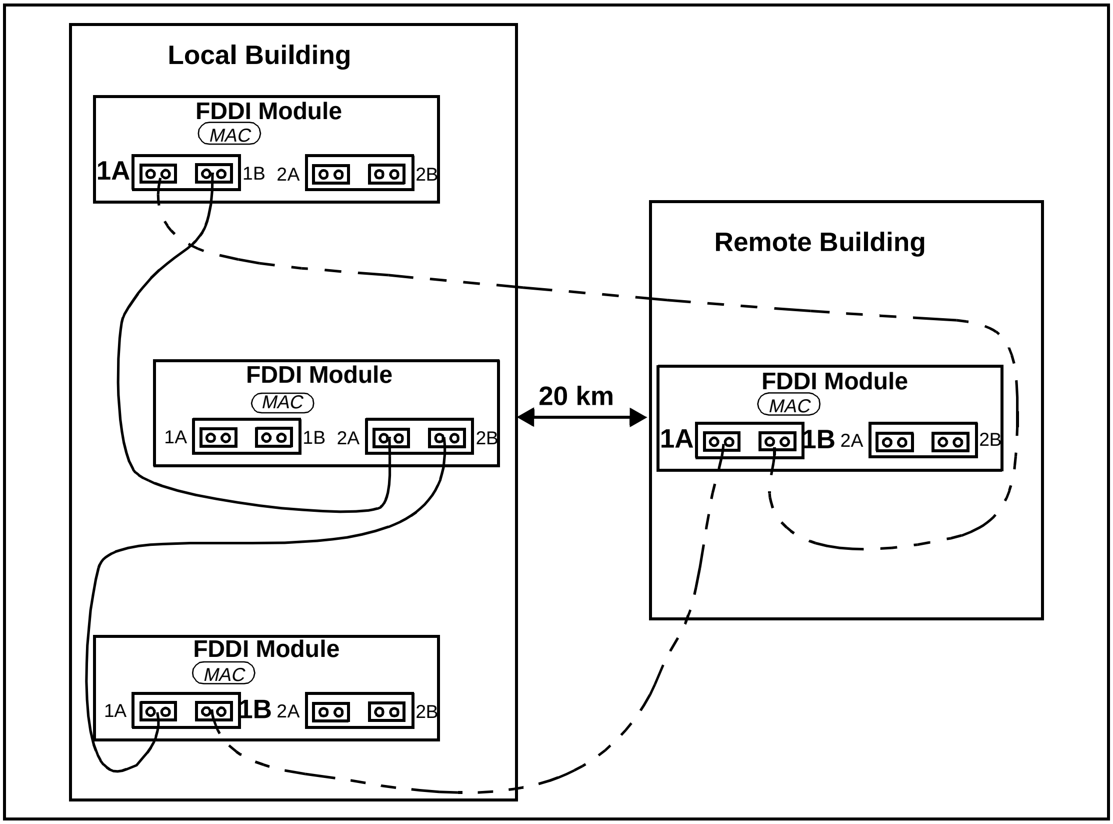

Figure 9.17 - Single-mode and Multimode Connections

NOTE

The use of single mode fiber is not restricted to DAS connections on dual attached rings. Do not confuse the term single-mode fiber (SMF) with single attached station (SAS)!

The dashed lines in Figure 9.17 indicate single-mode cable and the solid lines indicate multimode cable. The single-mode FMAs are labeled using bold type (**1A** and **1B**). In this configuration, single-mode FMAs are required for all A and B ports connected to the single-mode cable. All the FDDI modules except the middle FDDI module in the building are Universal Dual FDDI Modules. The middle module, because it does not need to be attached to single-mode cable, can be a Single FDDI Module, a Dual FDDI Module, or a Universal FDDI module. In this example, it is a Dual FDDI Module.

Notice that the remote FDDI module uses two single-mode FMAs to connect to the other modules. The modules connected to the remote module need single-mode FMAs only for the ports that are connected to the remote module. The ports that connect to other FDDI modules with the building can use multimode FMAs.

Figure 9.18 shows two FDDI modules connected to one server through an FDDI ring. One of the modules resides in the same building as the server and is connected to it by multimode cable. The second module is located remotely and connects by single-mode cable. In this case, the local module is operating as a Null-Attachment Concentrator (NAC), as described in Section 9.4.4. The remote module is operating as a SAS (single-attached station).

On the local FDDI module, port 1A is a multimode FMA and is attached to the multimode cable connected to the server. Port 1B is a single-mode FMA and is attached to the single-mode cable connected to the remote FDDI module. On the remote FDDI module, port 1A is a single-mode FMA. Port 1B can be either a single-mode FMA or a multimode FMA, depending upon the connection requirements. Although both modules in this example are Universal Dual FDDI modules, Universal Single FDDI Modules could be used.

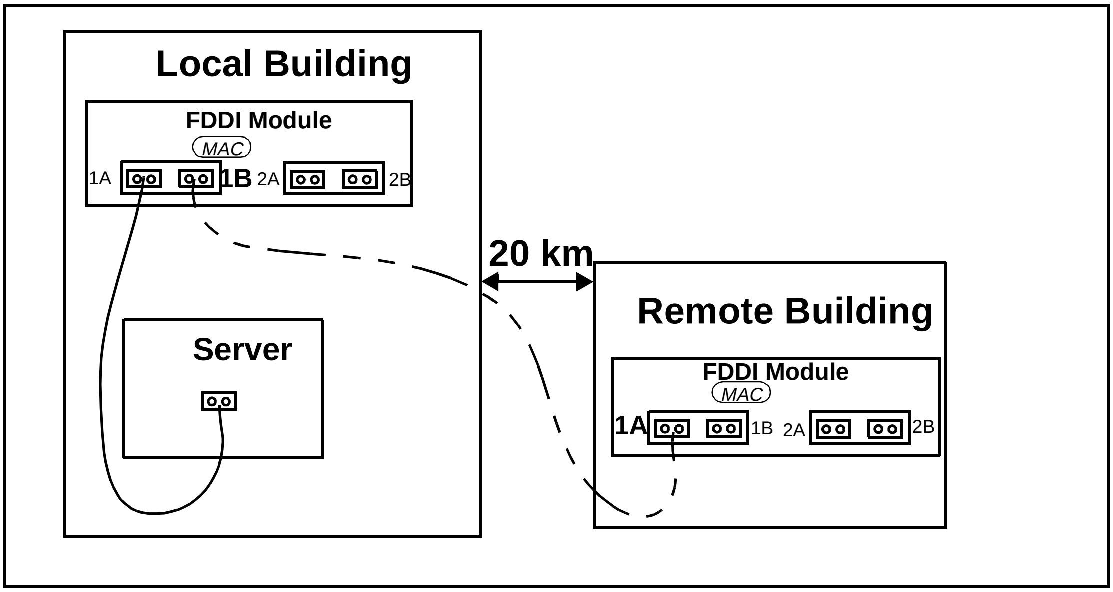

Figure 9.18 - Local Server and Remote FDDI Connection

9.4.7 FDDI Concentrator Connections

The FDDI Concentrator modules repeat FDDI traffic within the ring to which the modules are attached. Each FDDI Concentrator module provides type-M FDDI ports for connection to other concentrators or to end nodes. Concentrator modules are driven by a DAS FDDI segment on a Single, Dual, or Universal FDDI module. The **fddi attach concentrator** command attaches the Concentrator module to a DAS segment. When the Concentrator is attached, the segment becomes a DAC (Dual Attach Concentrator) and is designated as such in the software. The functions and characteristics of ports B of A DAC remain the same as DAS. Figure 9.19 shows how traffic flows among Concentrator ports and the DAC.

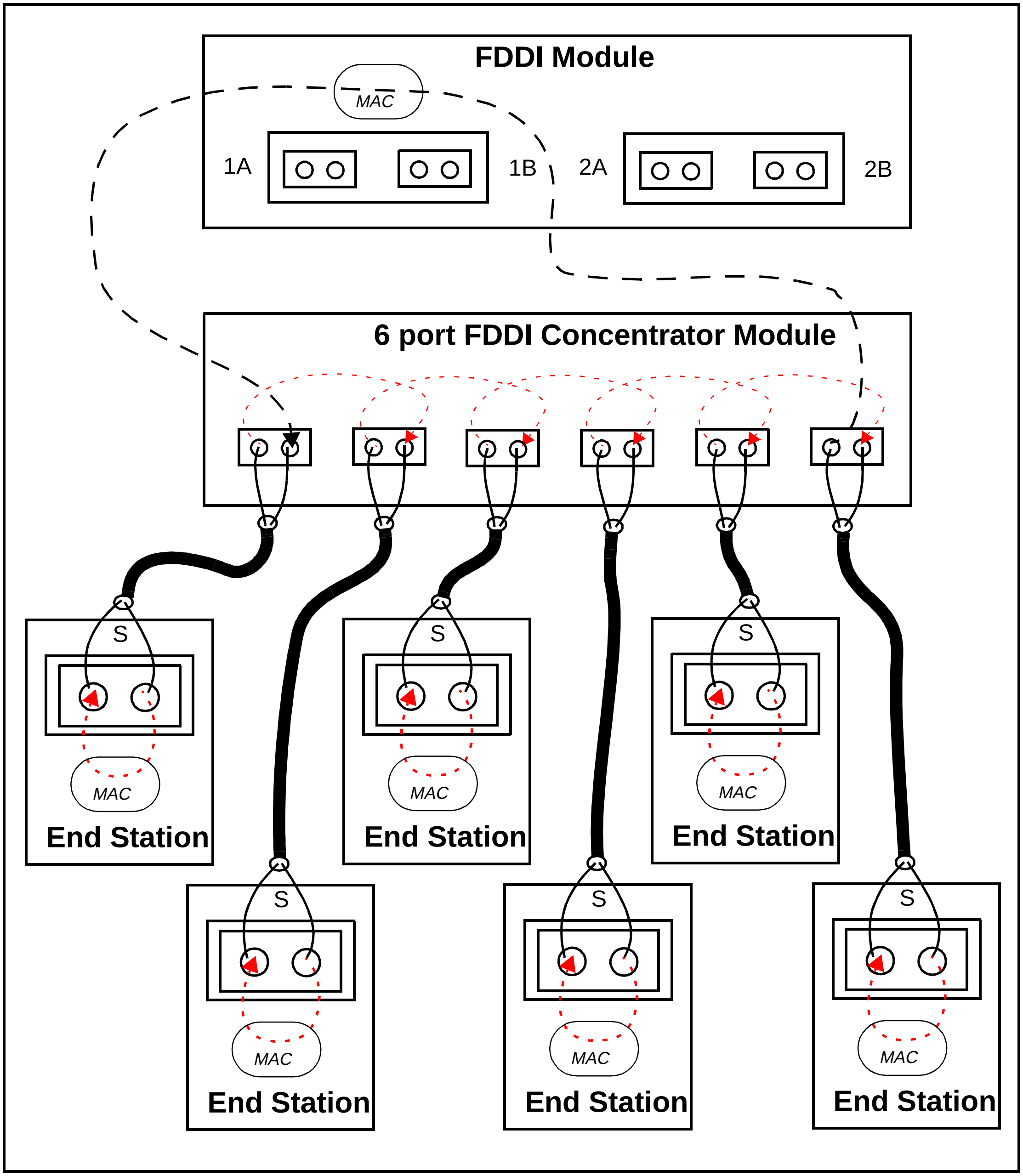

Figure 9.19 - Traffic Flow Among Concentrator Ports and the DAC

As shown in this figure, the DAC, the Concentrator modules, and all the devices attached to the DAC and Concentrator modules are all connected to the same FDDI ring. Therefore, they all share the same 100 Mb/s token-passing domain. The dashed lines indicate traffic flow and the solid lines indicate the FDDI cables. This example does not show specific connections to the ports on the FDDI module.

A DAS configured as a DAC, to manage the Concentrator modules, can still be used for standard FDDI connections. Use the connection information in Section 9.4.1.1 on page 9-23 as a guide if unsure whether a specific segment connection configuration to the DAC is desirable.

Regardless of how many Concentrator modules are attached to one DAC, or their physical arrangement within the chassis, traffic always flows within a Concentrator module as shown in Figure 9.19; that is, from left to right. If a port is empty (has no segment cable attached), the traffic bypasses the port and goes through the next connected port.

To use the FDDI Concentrator modules:

- Configure a DAS segment on an installed FDDI module as a DAC (Dual Attach Concentrator). Up to four Concentrator modules can be attached, for a total of up to 64 concentrator ports, to the DAS segment.
- The FDDI module containing the DAC and the modules themselves must all be installed in slots serviced by the FDDI Channel. In the 10-slot chassis, the FDDI Channel serves NIM slots 3-7.
- Only one FDDI module on the FDDI Channel can be used to manage FDDI Concentrator modules. However, if the FDDI module is a Dual or a Universal Dual module, each DAS segment can be attached to one or more FDDI Concentrator modules, provided the same Concentrator module(s) are not attached to both DAS segments. In this configuration, each DAS is attached to a separate ring.

NOTE

The FDDI Channel is not present in all configurations of the PowerHub.

Table 9.7 lists the PowerHub configurations and indicates whether or not they support FDDI concentrator modules

.

Table 9.7 - FDDI Concentrator Support

Slots	Packet Channels	Concentrator Support
5	2	no
10	4	yes
15	4	yes

See Section 9.2.2 for a description of the commands used to attach FDDI segments to FDDI Concentrator modules. The commands are documented in the *PowerHub 7000/8000 Software Reference Manual*.

APPENDIX A Pinouts

This appendix shows the pinouts for the following connectors:

- 10Base-T
- 100Base-TX
- TP-PMD
- Telco Champ connector

A.1 RJ-45 Pinouts

RJ-45 connectors are used by the UTP (10Base-T), 100Base-TX, and TP-PMD ports and segments. The UTP, 100Base-TX, and TP-PMD connectors use only four of these pins. Figure A.1 shows the pin locations on the RJ-45 connector. The tables that follow list the pinouts for the specific media types using RJ-45 connector.

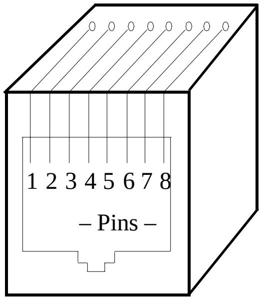

Figure A.1 - RJ-45 Pin Locations

NOTE Although the pinouts used by 10Base-T and 100Base-TX are identical to each other, they are different from those used by TP-PMD (FDDI-over-copper standard).

A.1.1 10Base-T (UTP) Pinouts

Table A.1 lists pinouts for the 10Base-T segments using the RJ-45 connector. Signal names are defined with respect to a TP-MAU at the workstation or other network node. Pins 1 and 2 are outputs at the TP-MAU and inputs at the PowerHub switch.

Table A.1 - 10Base-T RJ-45 Pinouts

Pin No.	Signal Name	Hub	Workstation (TP-MAU)
1	MAU XMT POS	Input	Output
2	MAU XMT NEG	Input	Output
3	MAU RCV POS	Output	Input
4	unused	unused	n/a
5	unused	unused	n/a
6	MAU RCV NEG	Output	Input
7	unused	unused	n/a
8	unused	unused	n/a

A.1.2 100Base-TX Pinouts

Table A.2 lists the pinouts for the 100Base-TX RJ-45 connector. Signal names are defined with respect to a workstation with a DTE interface. Pins 1 and 2 are outputs at the workstation and inputs at the PowerHub 8000/7000. Pins 4, 5, 7, and 8 are used as pseudo-grounds to reduce EMI (electromagnetic interference).

Table A.2 - 100Base-TX RJ-45 Pinouts

Pin No.	Signal Name	Hub	Workstation (DTE)
1	MAU XMT POS	Input	Output
2	MAU XMT NEG	Input	Output
3	MAU RCV POS	Output	Input
4	Pseudo-ground	Pseudo-ground	Pseudo-ground
5	Pseudo-ground	Pseudo-ground	Pseudo-ground
6	MAU RCV NEG	Output	Input
7	Pseudo-ground	Pseudo-ground	Pseudo-ground
8	Pseudo-ground	Pseudo-ground	Pseudo-ground

A.1.3 TP-PMD Pinouts

Table A.3 lists the pinouts for the TP-PMD RJ-45 connector. The pinouts are the same on the hub and at the workstation, in accordance with ANSI X3T9.5 TP-PMD standard. To establish a valid connection between the hub and the workstation, a crossover must be implemented in the cable plant. Pins 3, 4, 5, and 6 are used as pseudo-grounds to reduce EMI (electromagnetic interference).

Table A.3 - TP-PMD RJ-45 Pinouts

Pin No.	Signal Name	Hub	Workstation (DTE)
1	XMT POS	Output	Output
2	XMT NEG	Output	Output
3	Pseudo-ground	Pseudo-ground	Pseudo-ground
4	Pseudo-ground	Pseudo-ground	Pseudo-ground
5	Pseudo-ground	Pseudo-ground	Pseudo-ground
6	Pseudo-ground	Pseudo-ground	Pseudo-ground
7	RCV POS	Input	Input
8	RCV NEG	Input	Input

A.2 UTP Champ Pinouts

Champ connectors used on the 4x6 module each support two segments, six UTP ports per segment. Figure A.2 shows the pin locations on each Champ connector. Note that pins 25 and 50 are not used. Table A.4 lists the pinouts for the Champ connectors.

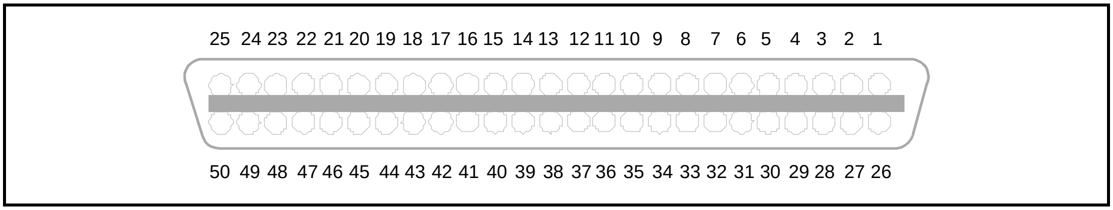

Figure A.2 - Champ Connector Pin Locations

Table A.4 - Champ Connector (Sheet 1 of 2)

Segment No.	Port No.	Pin No.	Signal
1,3	1	26	HUB RVC POS
		1	HUB RCV NEG
		27	HUB XMT POS
		2	HUB XMT NEG
	2	28	HUB RVC POS
		3	HUB RCV NEG
		29	HUB XMT POS
		4	HUB XMT NEG
	3	30	HUB RVC POS
		5	HUB RCV NEG
		31	HUB XMT POS
		6	HUB XMT NEG
	4	32	HUB RVC POS
		7	HUB RCV NEG
		33	HUB XMT POS
		8	HUB XMT NEG
	5	34	HUB RVC POS
		9	HUB RCV NEG
		35	HUB XMT POS
		10	HUB XMT NEG
	6	36	HUB RVC POS
		11	HUB RCV NEG
		37	HUB XMT POS
		12	HUB XMT NEG

Table A.4 - Champ Connector (Sheet 2 of 2)

Segment No.	Port No.	Pin No.	Signal
2,4	1	38	HUB RVC POS
		13	HUB RCV NEG
		39	HUB XMT POS
		14	HUB XMT NEG
	2	40	HUB RVC POS
		15	HUB RCV NEG
		41	HUB XMT POS
		16	HUB XMT NEG
	3	42	HUB RVC POS
		17	HUB RCV NEG
		43	HUB XMT POS
		18	HUB XMT NEG
	4	44	HUB RVC POS
		19	HUB RCV NEG
		45	HUB XMT POS
		20	HUB XMT NEG
	5	46	HUB RVC POS
		21	HUB RCV NEG
		47	HUB XMT POS
		22	HUB XMT NEG
	6	48	HUB RVC POS
		23	HUB RCV NEG
		49	HUB XMT POS
		24	HUB XMT NEG

APPENDIX B Balancing Bandwidth

The packet-forwarding capacity of a system, as measured in bits-per-second, is determined by the bandwidth of the system bus and buffer memories. In the case of the PowerHub, the packet-forwarding capacity is determined by the bandwidth of the Packet Channels and the Packet Engine Shared Memory.

Depending on the bandwidth utilization in the network, two basic types of configurations can be implemented:

Non-blocking The system has sufficient bandwidth to forward all packets when all segments are being offered traffic at the maximum theoretical bit-per-second rate (“wire speed”). In a non-blocking configuration, the NIMs are distributed in such a way that neither the Packet Channels nor the Shared Memory can ever be offered more bandwidth than it can handle. Non-blocking configurations are important in networks that experience frequent, sustained periods of peak bandwidth utilization

Blocking The theoretical maximum wire speed exceeds the bandwidth of the Packet Channels and Shared Memory. In a blocking configuration, individual networks can have peak bandwidth requirements that approach 100% of the theoretical maximum wire speed, but the system configuration does not support sustained, simultaneous peak bandwidth usage on all segments.

Although the architecture is designed to balance high throughput with processing power, it is possible for some configurations, during peak utilization, to overload the capacities of the Packet Channels and the Shared Memory. This can occur when multiple high-capacity modules such as the Dual FDDI or Universal FDDI modules are used on the same Packet Channel. In addition, the Packet Engine’s Shared Memory can become overloaded if the combined bandwidth offered by the Packet Channels is greater than the maximum amount the Shared Memory can receive.

Each Packet Channel can accommodate loads of up to 800 Mb/s; the Shared Memory can accommodate from 640 – 720 Mb/s. If the total load offered by the modules connected to a Packet Channel exceeds 800 Mb/s, the Packet Channel is unable to accept the entire load. As a result, packets may be dropped. Similarly, if the load offered by the Packet Channels exceeds the capacity of the Shared Memory, packets may be dropped.

Most networks rarely operate at peak utilization over sustained periods. Moreover, during brief periods of peak utilization (generally less than one second), the on-board Shared Memory of intelligent modules, such as the Dual FDDI module, buffers the packets, preventing them from being dropped. Additionally, higher-layer protocols, such as Van Jacobsen's slow-start algorithm for TCP, quickly reduce the offered load to a level the system can sustain during these peak periods.

B.1 Non-Blocking Configurations

Table B.1 lists the maximum bandwidth for each type of NIM in a non-blocking configuration. The second column shows the peak Packet-Channel load for each module type, including overhead on the Packet Channel. In general, about two-thirds efficiency on a Packet Channel can be achieved. The remaining one third is system overhead (that is, not useful data). The third column shows the peak Shared-Memory load; there is no overhead because of the Shared Memory's pipeline and overlapped design.

Table B.1 - Non-blocking Configuration Bandwidth Requirements

Module Type	Peak Packet-Channel Load	Peak Shared Memory Load
UEM	20 Mb/s per segment, per direction	10 Mb/s per segment, per direction
Single FDDI	150 Mb/s	100 Mb/s
Dual FDDI	300 Mb/s	200 Mb/s
4x4 Microsegment	80 Mb/s	40 Mb/s
4x6 Microsegment	80 Mb/s	40 Mb/s
16x1 Ethernet	18 Mb/s per segment, per direction	10 Mb/s per segment, per direction
13x1 Ethernet with Fast Ethernet	18 Mb/s per 10BaseT segment, per direction; 180 Mb/s per 100Base-T segment, per direction	10 Mb/s per 10BaseT segment, per direction; 100 Mb/s per 100Base-T segment, per direction
6x1 FE		
2x8 FE		
PowerCell 700		

To implement a non-blocking configuration:

1. For each Packet Channel, add the peak Packet-Channel loads for each module attached to that Packet Channel.
2. For all modules installed in the chassis, add the peak Shared Memory loads together. (Do not add the Packet-Channel total to the Shared-Memory total.)

A non-blocking configuration for the Packet Channel exists if the total peak load for the Packet Channel is lower than 800 Mb/s. A blocking configuration exists if the total is higher than 800 Mb/s. Consider rearranging the NIMs in the chassis until a non-blocking configuration exists. *Chapter 2, Chassis and Packet Engines* explains how the slots map to the Packet Channels on the PowerHub.

A non-blocking configuration also exists if the total peak Shared Memory load is lower than 640 – 720 Mb/s for all Packet Channels. A blocking configuration exists if the total is higher than 720 Mb/s.

B.2 Blocking Configurations

Although a non-blocking configuration is always desirable, if a non-blocking configuration is not possible, a blocking configuration can be achieved that does not impair the throughput on the network.

The bandwidth requirements for a blocking configuration depend upon the amount of blocking that is acceptable for the network. For example, if the peak utilization on the network rarely exceeds 50% of the maximum bandwidth supported by the NIMs, a 50% blocking configuration can be implemented. Note that "peak utilization" refers to the total load offered at any time by all the segments attached to a Packet Channel or the Shared Memory. For example, if half of the Ethernet segments are running at 100% and half are running at 50%, then the peak utilization is 75%, not 100%. If the network is expected to achieve a peak utilization of 75%, a 75% blocking configuration can be implemented without impairing the throughput on the network.

The numbers in Table B.1 (on the previous page) can be adjusted for blocking configurations simply by multiplying them by the expected peak utilization percentage. For example, Table B.2 lists the maximum bandwidth for each type of NIM in a 75% blocking configuration.

Table B.2 - 75%-Blocking Configuration Bandwidth Requirements

Module Type	Peak Packet-Channel Load	Peak Shared Memory Load
UEM	15 Mb/s per segment, per direction	7.5 Mb/s per segment, per direction
Single FDDI	112.5 Mb/s	75 Mb/s
Dual FDDI	225 Mb/s	150 Mb/s
4x4 Microsegment	60 Mb/s	30 Mb/s
4x6 Microsegment	60 Mb/s	30 Mb/s
16x1 Ethernet	13.5 Mb/s per segment, per direction	7.5 Mb/s per segment, per direction
13x1 Ethernet with Fast Ethernet	13.5 Mb/s per 10BaseT segment, per direction; 150 Mb/s per 100Base-T segment, per direction	7.5 Mb/s per 10BaseT segment, per direction; 75 Mb/s per 100Base-T segment, per direction
6x1 FE		
2x8 FE		
PowerCell 700		

Table B.3 lists the maximum bandwidth for each type of NIM in a 50% blocking configuration.

Table B.3 - 50%-Blocking Configuration Bandwidth Requirements

Module Type	Peak Packet-Channel Load	Peak Shared Memory Load
UEM	10 Mb/s per segment, per direction	5 Mb/s per segment, per direction
Single FDDI	75 Mb/s	50 Mb/s
Dual FDDI	150 Mb/s	100 Mb/s
4x4 Microsegment	40 Mb/s	20 Mb/s
4x6 Microsegment	40 Mb/s	20 Mb/s
16x1 Ethernet	9 Mb/s per segment, per direction	5 Mb/s per segment, per direction
13x1 Ethernet with Fast Ethernet	9 Mb/s per 10BaseT segment, per direction; 100 Mb/s per 100Base-T segment, per direction	5 Mb/s per 10BaseT segment, per direction; 50 Mb/s per 100Base-T segment, per direction
6x1 FE		
2x8 FE		
PowerCell 700		

To determine whether a blocking configuration fits within a given peak utilization percentage:

1. For each Packet Channel, add the peak Packet-Channel loads for each module attached to that Packet Channel.
2. For all modules installed in the chassis, add the peak Shared Memory loads together. (Do not add the Packet-Channel total to the Shared-Memory total.)

If the total peak load for a Packet Channel is lower than 800 Mb/s, the configuration meets the peak utilization target for that Packet Channel. If the total is higher than 800 Mb/s, consider rearranging the NIMs in the chassis.

If the total peak Shared Memory load is lower than 640 to 720 Mb/s, the configuration meets the peak utilization target for the Shared Memory. If the total is higher than 720 Mb/s, packet loss may be experienced if the network is as busy as estimated. Statistics in the **bridge** subsystem can help determine the current and peak utilization of network segments and whether packet loss is occurring. Refer to the *PowerHub Software Reference Manual* or *PowerHub ATM Software Reference Manual*.

Balancing Bandwidth

Acronyms

The networking terms in the following list are defined in the Glossary of this manual. Glossary items are listed alphabetically according to the full term.

AAL	ATM Adaptation Layer
ABR	Available Bit Rate
ACM	Address Complete Message
ACR	Allowable Cell Rate
ADPCM	Adaptive Differential Pulse Code Modulation
AHFG	ATM-attached Host Functional Group
AIMUX	ATM Inverse Multiplexing
AIS	Alarm Indication Signal
AMI	Alternate Mark Inversion
AMI	ATM Management Interface
ANSI	American National Standards Institute
APCM	Adaptive Pulse Code Modulation
API	Application Program Interface
APP	Application Program
APS	Automatic Protection Switching
ARP	Address Resolution Protocol
ASCII	American Standard Code for Information Interchange
ATDM	Asynchronous Time Division Multiplexing
ATM	Asynchronous Transfer Mode
AUI	Attachment User Interface
B8ZS	Bipolar 8 Zero Substitution
BCOB	Broadband Connection Oriented Bearer
BCOB-A	Bearer Class A
BCOB-C	Bearer Class C
BCOB-X	Bearer Class X
BECN	Backward Explicit Congestion Notification
BER	Bit Error Rate
BES	Bursty Errored Seconds
BGP	Border Gateway Protocol
B-ICI	B-ISDN Inter-Carrier Interface.
BIP	Bit Interleaved Parity
B-ISDN	Broadband Integrated Services Digital Network
B-ISUP	Broadband ISDN User’s Part
BITS	Building Integrated Timing Supply
BNC	Bayonet-Neill-Concelman

BPDU	Bridge Protocol Data Unit
bps	Bits per Second
BPV	Bipolar Violation
B-TE	Broadband Terminal Equipment
BUS	Broadcast and Unknown Server
CAC	Connection Admission Control
CAS	Channel Associated Signaling
CBDS	Connectionless Broadband Data Service
CBR	Constant Bit Rate
CCITT	International Telephone and Telegraph Consultative Committee
CCS	Common Channel Signaling
CDV	Cell Delay Variation
CE	Connection Endpoint
CEI	Connection Endpoint Identifier
CES	Circuit Emulation Service
CGA	Carrier Group Alarm
CIP	Carrier Identification Parameter
CIR	Committed Information Rate
CLIP	Classical IP
CLP	Cell Loss Priority
CLR	Cell Loss Ratio-1-15
CLS	Connectionless service
CMIP	Common Management Interface Protocol
CMR	Cell Misinsertion Rate
CPE	Customer Premise Equipment
CRA	Cell Rate Adaptation
CRC	Cyclic Redundancy Check
CRS	Cell Relay Service
CS	Controlled Slip, **or** Convergence Sublayer
CSU	Channel Service Unit
CTD	Cell Transfer Delay
CTS	Clear To Send
DACS	Digital Access and Cross-Connect System
DARPA	Defense Advanced Research Projects Agency
DCC	Data Country Code
DCE	Data Communications Equipment
DCS	Digital Cross-connect System
DES	Destination End Station
DFA	DXI Frame Address
DLCI	Data Link Connection Identifier
DNS	Domain Naming System
DSn	Digital Standard n (n=0, 1, 1C, 2, and 3)

DSR	Data Set Ready
DTE	Data Terminal Equipment
DTR	Data Terminal Ready
EEPROM	Electrically Erasable Programmable Read Only Memory
EFCI	Explicit Forward Congestion Indication
EGP	Exterior Gateway Protocol
EIA	Electronics Industries Association
EISA	Extended Industry Standard Architecture
ELAN	Emulated Local Area Network
EMI	Electromagnetic Interference
EPROM	Erasable Programmable Read Only Memory
EQL	Equalization
ER	Explicit Rate
ES	End System, **or** Errored Second
ESF	Extended Super Frame
ESI	End System Identifier
EXZ	Excessive Zeroes (Error Event)
FC	Face Contact
FCC	Federal Communications Commission
FCS	Frame Check Sequence
FDDI	Fiber Distributed Data Interface
FDM	Frequency Division Multiplexing
FEBE	Far End Block Error
FEC	Forward Error Correction
FECN	Forward Explicit Congestion Notification
FERF	Far End Receive Failure
FIFO	First-In, First-Out
FRS	Frame-Relay Service
FTP	File Transfer Protocol
FT-PNNI	ForeThought PNNI
FUNI	Frame-Based UNI
GCAC	Generic Connection Admission Control
GCRA	Generic Cell Rate Algorithm
GFC	Generic Flow Control
HDB3	High Density Bipolar
HDLC	High Level Data Link Control
HEC	Header Error Control
HIPPI	High Performance Parallel Interface
HSSI	High-Speed Serial Interface
ICMP	Internet Control Message Protocol
IDU	Interface Data Unit
IEEE	Institute of Electrical and Electronics Engineers

IETF	Internet Engineering Task Force
ILMI	Interim Local Management Interface
IP	Internet Protocol
IPX	Internetwork Packet Exchange
IS	Intermediate system
ISDN	Integrated Services Digital Network
ISO	International Standards Organization
ITU-T	International Telecommunication Union Telecommunication
IWF	Interworking Function
IXC	Interexchange Carriers
JPEG	Joint Photographic Experts Group
Kbps	Kilobits per second
LAN	Local Area Network
LANE	LAN Emulation
LAPB	Link Access Procedure, Balanced
LATA	Local Access and Transport Area
LBO	Line Build Out
LCV	Line Code Violations
LE_ARP	LAN Emulation Address Resolution Protocol
LEC	LAN Emulation Client
LECS	LAN Emulation Configuration Server
LES	LAN Emulation Server
LLC	Logical Link Control
LOF	Loss Of Frame
LOP	Loss Of Pointer
LOS	Loss Of Signal
LSB	Least Significant Bit
MAC	Media Access Control
MAN	Metropolitan Area Network
MAU	Media Attachment Unit
MBS	Maximum Burst Size
MCDV	Maximum Cell Delay Variance
MCLR	Maximum Cell Loss Ratio
MCR	Minimum Cell Rate
MCTD	Maximum Cell Transfer Delay
MIB	Management Information Base
MIC	Media Interface Connector
MID	Message Identifier
MMF	Multimode Fiber Optic Cable
MPEG	Motion Picture Experts Group
MPOA	Multiprotocol over ATM
MSB	Most Significant Bit
MTU	Maximum Transmission Unit

NM	Network Management Entity
NML	Network Management Layer
NMS	Network Management Station
NNI	Network-to-Network Interface or Network Node Interface
NPC	Network Parameter Control
NRZ	Non Return to Zero
NRZI	Non Return to Zero Inverted
NSAP	Network Service Access Point
NTSC	National TV Standards Committee
OAM	Operation and Maintenance Cell
OC-n	Optical Carrier level-n
OID	Object Identifier
OOF	Out-of-Frame
OSI	Open Systems Interconnection
OSPF	Open Shortest Path First Protocol
OUI	Organizationally Unique Identifier
PAD	Packet Assembler Disassembler
PAL	Phase Alternate Line
PBX	Private Branch Exchange
PCI	Peripheral Component Interconnect
PCM	Pulse Code Modulation
PCR	Peak Cell Rate
PDN	Public Data Network
PDU	Protocol Data Unit
PHY	Physical Layer
ping	Packet Internet Groper
PLCP	Physical Layer Convergence Protocol
PLP	Packet Level Protocol
PM	Physical Medium
PMD	Physical Medium Dependent
PNNI	Private Network Node Interface or Private Network-to-Network Interface
PPP	Point-to-Point Protocol
PROM	Programmable Read-Only Memory
PRS	Primary Reference Source
PSN	Packet Switched Network
PT	Payload Type
PVC	Permanent Virtual Circuit (or Channel)
PVCC	Permanent Virtual Channel Connection
PVPC	Permanent Virtual Path Connection
QD	Queuing Delay
QoS	Quality of Service
RD	Routing Domain
RFCs	Requests For Comment

RFI	Radio Frequency Interference
RIP	Routing Information Protocol
RISC	Reduced Instruction Set Computer
RTS	Request To Send
SA	Source Address
SA	Source MAC Address
SAP	Service Access Point
SAR	Segmentation And Reassembly
SC	Structured Cabling, **or** Structured Connectors, **or** Stick and Click
SCR	Sustainable Cell Rate
SCSI	Small Computer Systems Interface
SDLC	Synchronous Data Link Control
SDU	Service Data Unit
SEAL	Simple and Efficient Adaptation Layer
SECAM	Systeme En Coleur Avec Memoire
SEL	Selector
SES	Severely Errored Seconds
SF	Super Frame
SGMP	Simple Gateway Management Protocol
SIR	Sustained Information Rate
SLIP	Serial Line IP
SMDS	Switched Multimegabit Data Service
SMF	Single Mode Fiber
SMTP	Simple Mail Transfer Protocol
SNA	Systems Network Architecture
SNAP	SubNetwork Access Protocol
SNI	Subscriber Network Interface
SNMP	Simple Network Management Protocol
SONET	Synchronous Optical Network
SPANS	Simple Protocol for ATM Network Signalling
SPARC	Scalable Processor Architecture Reduced instruction set Computer
SPE	Synchronous Payload Envelope
SPVC	Smart PVC
SS7	Signaling System No. 7
SSCOP	Service Specific Connection Oriented Protocol
SSCS	Service Specific Convergence Sublayer
ST	Straight Tip, **or** Stick and Turn
STM	Synchronous Transfer Mode
STP	Shielded Twisted Pair, Spanning Tree Protocol
STS	Synchronous Transport Signal

SVC	Switched Virtual Circuit (or Channel)
SVCC	Switched Virtual Channel Connection
SVPC	Switched Virtual Path Connection
TAXI	Transparent Asynchronous Transmitter / Receiver Interface
TC	Transmission Convergence
TCP	Transmission Control Protocol
TCP/IP	Transmission Control Protocol / Internet Protocol
TCR	Tagged Cell Rate
TCS	Transmission Convergence Sublayer
TDM	Time Division Multiplexing
TE	Terminal Equipment
TFTP	Trivial File Transfer Protocol
TM	Traffic Management
UAS	Unavailable Seconds
UBR	Unspecified Bit Rate
UDP	User Datagram Protocol
UNI	User-to-Network Interface
UPC	Usage Parameter Control
UTOPIA	Universal Test & Operations Interface for ATM
UTP	Unshielded Twisted Pair
VBR	Variable Bit Rate
VC	Virtual Channel (or Circuit)
VCC	Virtual Channel Connection
VCI	Virtual Channel Identifier
VCL	Virtual Channel Link
VINES	Virtual Network Software
VLAN	Virtual Local Area Network
VP	Virtual Path
VPC	Virtual Path Connection
VPDN	Virtual Private Data Network
VPI	Virtual Path Identifier
VPL	Virtual Path Link
VPN	Virtual Private Network
VPT	Virtual Path Terminator
VS/VD	Virtual Source / Virtual Destination
VT	Virtual Tributary
WAN	Wide-Area Network
ZBTSI	Zero Byte Time Slot Interchange

Glossary

10Base-T - a 10 Mbps baseband Ethernet specification utilizing twisted-pair cabling (Category 3, 4, or 5). 10BaseT, which is part of the IEEE 802.3 specification, has a distance limit of approximately 100 meters per segment.

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

Adapter - A fitting that supplies a passage between two sets of equipment when they cannot be directly interconnected.

Adaptive Differential Pulse Code Modulation (ADPCM) - A technique that allows analog voice signals to be carried on a 32K bps digital channel. Sampling is done at 8Hz with 4 bits used to describe the difference between adjacent samples.

Adaptive Pulse Code Modulation (APCM) - A technique that effectively reduces occupied bandwidth per active speaker by reducing sampling rates during periods of overflow peak traffic.

Address - A unique identity of each network station on a LAN or WAN.

Address Complete Message (ACM) - A B-ISUP call control message from the receiving exchange to sending exchange indicating the completion of address information.

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.

Address Prefix - A string of 0 or more bits up to a maximum of 152 bits that is the lead portion of one or more ATM addresses.

Address Resolution - The procedure by which a client associates a LAN destination with the ATM address of another client or the BUS.

Address Resolution Protocol (ARP) - 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.

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

alarm - an unsolicited message from a device, typically indicating a problem with the system that requires attention.

Alarm Indication Signal (AIS) - In T1, an all ones condition used to alert a receiver that its incoming signal (or frame) has been lost. The loss of signal or frame is detected at the receiving end, and the failed signal is replaced by all the ones condition which the receiver interprets as an AIS. The normal response to this is AIS is for the receiving end to generate a yellow alarm signal as part of its transmission towards the faulty end. (The AIS itself is sometimes called a Blue Signal).

A-Law - The PCM coding and companding standard used in Europe.

Allowable Cell Rate (ACR) - parameter defined by the ATM Forum for ATM traffic management. ACR varies between the MCR and the PCR, and is dynamically controlled using congestion control mechanisms.

Alternate Mark Inversion (AMI) - A line coding format used on T1 facilities that transmits ones by alternate positive and negative pulses.

Alternate Routing - A mechanism that supports the use of a new path after an attempt to set up a connection along a previously selected path fails.

American National Standards Institute (ANSI) - 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.

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

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.

Application Layer - Layer seven of the ISO reference model; provides the end-user interface.

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

Application Program Interface (API) - 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.

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 its active ports.

Asynchronous Time Division Multiplexing (ATDM) - 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.

Asynchronous Transfer Mode (ATM) - 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 Adaptation Layer (AAL) - the AAL divides user information into segments suitable for packaging into a series of ATM cells. AAL layer types are used as follows:

AAL-1 - constant bit rate, time-dependent traffic such as voice and video
AAL-2 - still undefined; a placeholder for variable bit rate video transmission
AAL-3/4 - variable bit rate, delay-tolerant data traffic requiring some sequencing and/or error detection support (originally two AAL types, connection-oriented and connectionless, which have been combined)
AAL-5 - variable bit rate, delay-tolerant, connection-oriented data traffic requiring minimal sequencing or error detection support

ATM Address - Defined in the UNI Specification as 3 formats, each having 20 bytes in length.

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 Inverse Multiplexing (AIMUX) - A device that allows multiple T1 or E1 communications facilities to be combined into a single broadband facility for the transmission of ATM cells.

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 Management Interface (AMI) - 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.

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.

ATM-attached Host Functional Group (AHFG) - The group of functions performed by an ATM-attached host that is participating in the MPOA service.

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

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.

Attachment User Interface (AUI) - IEEE 802.3 interface between a media attachment unit (MAU) and a network interface card (NIC). The term AUI can also refer to the rear panel port to which an AUI cable might attach.

Auto-logout - a feature that automatically logs out a user if there has been no user interface activity for a specified length of time.

Automatic Protection Switching (APS) - Equipment installed in communications systems to detect circuit failures and automatically switch to redundant, standby equipment.

Available Bit Rate (ABR) - 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.

Backbone - the main connectivity device of a distributed system. All systems that have connectivity to the backbone connect to each other, but systems can set up private arrangements with each other to bypass the backbone to improve cost, performance, or security.

Backplane - High-speed communications line to which individual components are connected.

Backward Explicit Congestion Notification (BECN) - A Resource Management cell type generated by the network or the destination, indicating congestion or approaching congestion for traffic flowing in the direction opposite that of the BECN cell.

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

Baud - unit of signalling speed, equal to the number of discrete conditions or signal events per second. If each signal event represents only one bit, the baud rate is the same as bps; if each signal event represents more than one bit (such as a dibit), the baud rate is smaller than bps.

Bayonet-Neill-Concelman (BNC) - a bayonet-locking connector used to terminate coaxial cables. BNC is also referred to as Bayonet Network Connector.

Bipolar 8 Zero Substitution (B8ZS) - a technique used to satisfy the ones density requirements of digital T-carrier facilities in the public network while allowing 64 Kbps clear channel data. Strings of eight consecutive zeroes are replaced by an eight-bit code representing two intentional bipolar pulse code violations (000V10V1).

Bipolar Violation (BPV) - an error event on a line in which the normal pattern of alternating high (one) and low (zero) signals is disrupted. A bipolar violation is noted when two high signals occur without an intervening low signal, or vice versa.

B-ISDN Inter-Carrier Interface (B-ICI) - An ATM Forum defined specification for the interface between public ATM networks to support user services across multiple public carriers.

Bit Error Rate (BER) - A measure of transmission quality, generally shown as a negative exponent, (e.g., 10^{-7} which means 1 out of 10^{7} bits [1 out of 10,000,000 bits] are in error).

Bit Interleaved Parity (BIP) - 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.

Bit Robbing - The use of the least significant bit per channel in every sixth frame for signaling.

Bit Stuffing - A process in bit-oriented protocols where a zero is inserted into a string of ones by the sender to prevent the receiver from interpreting valid user data (the string of ones) as control characters (a Flag character for instance).

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

bps - bits per second

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).

Bridge Protocol Data Unit (BPDU) - A message type used by bridges to exchange management and control information.

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.

Broadband Connection Oriented Bearer (BCOB) - Information in the SETUP message that indicates the type of service requested by the calling user.

BCOB-A (Bearer Class A) - Indicated by ATM end user in SETUP message for connection-oriented, constant bit rate service. The network may perform internetworking based on AAL information element (IE).

BCOB-C (Bearer Class C) - Indicated by ATM end user in SETUP message for connection-oriented, variable bit rate service. The network may perform internetworking based on AAL information element (IE).

BCOB-X (Bearer Class X) - Indicated by ATM end user in SETUP message for ATM transport service where AAL, traffic type and timing requirements are transparent to the network.

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

Broadband ISDN User's Part (B-ISUP) - A protocol used to establish, maintain and release broadband switched network connections across an SS7/ATM network.

Broadband Terminal Equipment (B-TE) - An equipment category for B-ISDN which includes terminal adapters and terminals.

Broadcast - Data transmission to all addresses or functions.

Broadcast and Unknown Server (BUS) - 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.

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

Buffer - A data storage medium used to compensate of a difference in rate of data flow or time of occurrence of events when transmitting data from one device to another.

Building Integrated Timing Supply (BITS) - a master timing supply for an entire building, which is a master clock and its ancillary equipment. The BITS supplies DS1 and/or composite clock timing references for synchronization to all other clocks and timing sources in that building.

Bursty Errored Seconds (BES) - a BES contains more than 1 and fewer than 320 path coding violation error events, and no severely errored frame or AIS defects. Controlled slips are not included in determining BESs.

Bursty Second - a second during which there were at least the set number of BES threshold event errors but fewer than the set number of SES threshold event errors.

Byte - A computer-readable group of bits (normally 8 bits in length).

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.

Carrier - a company, such as any of the "baby Bell" companies, that provide network communications services, either within a local area or between local areas.

Carrier Group Alarm (CGA) - A service alarm generated by a channel bank when an out-of-frame (OOF) condition exists for some predetermined length of time (generally 300 milliseconds to 2.5 seconds). The alarm causes the calls using a trunk to be dropped and trunk conditioning to be applied.

Carrier Identification Parameter (CIP) - A 3 or 4 digit code in the initial address message identifying the carrier to be used for the connection.

cchan - a FORE program that manages virtual channels on a *ForeRunner* switch running `asxd`.

Cell - an ATM Layer protocol data unit (PDU). The basic unit of information transported in ATM technology, each 53-byte cell contains a 5-byte header and a 48-byte payload.

Cell Delay Variation (CDV) - a quantification of cell clumping for a connection. The cell clumping CDV (yk) is defined as the difference between a cell's expected reference arrival time (ck) and its actual arrival time (ak). The expected reference arrival time (ck) of cell k of a specific connection is max. T is the reciprocal of the negotiated peak cell rate.

Cell Delineation - the protocol for recognizing the beginning and end of ATM cells within the raw serial bit stream.

Cell Header - ATM Layer protocol control information.

Cell Loss Priority (CLP) - 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.

Cell Loss Ratio - In a network, cell loss ratio is (1-x/y), where y is the number of cells that arrive in an interval at an ingress of the network; and x is the number of these y cells that leave at the egress of the network element.

Cell Loss Ratio (CLR) - CLR is a negotiated QoS parameter and acceptable values are network specific. The objective is to minimize CLR provided the end-system adapts the traffic to the changing ATM layer transfer characteristics. The Cell Loss Ratio is defined for a connection as: Lost Cells/Total Transmitted Cells. The CLR parameter is the value of CLR that the network agrees to offer as an objective over the lifetime of the connection. It is expressed as an order of magnitude, having a range of 10-1 to 10-15 and unspecified.

Cell Misinsertion Rate (CMR) - the ratio of cells received at an endpoint that were not originally transmitted by the source end in relation to the total number of cells properly transmitted.

Cell Rate Adaptation (CRA) - a function performed by a protocol module in which empty cells (known as unassigned cells) are added to the output stream. This is because there always must be a fixed number of cells in the output direction; when there are not enough cells to transmit, unassigned cells are added to the output data stream.

Cell Relay Service (CRS) - a carrier service which supports the receipt and transmission of ATM cells between end users in compliance with ATM standards and implementation specifications.

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

Cell Transfer Delay (CTD) - This is defined as the elapsed time between a cell exit event at the measurement point 1 (e.g., at the source UNI) and the corresponding cell entry event at the measurement point 2 (e.g., the destination UNI) for a particular connection. The cell transfer delay between two measurement points is the sum of the total inter-ATM node transmission delay and the total ATM node processing delay.

Channel - A path or circuit along which information flows.

Channel Associated Signaling (CAS) - a form of circuit state signaling in which the circuit state is indicated by one or more bits of signaling status sent repetitively and associated with that specific circuit.

Channel Bank - A device that multiplexes many slow speed voice or data conversations onto high speed link and controls the flow.

Channel Service Unit (CSU) - An interface for digital leased lines which performs loopback testing and line conditioning.

Channelization - capability of transmitting independent signals together over a cable while still maintaining their separate identity for later separation.

Circuit - A communications link between points.

Circuit Emulation Service (CES) - The ATM Forum circuit emulation service interoperability specification specifies interoperability agreements for supporting Constant Bit Rate (CBR) traffic over ATM networks that comply with the other ATM Forum interoperability agreements. Specifically, this specification supports emulation of existing TDM circuits over ATM networks.

Classical IP (CLIP) - IP over ATM which conforms to RFC 1577.

Clear to Send (CTS) - and RS-232 modem interface control signal (sent from the modem to the DTE on pin 5) which indicates that the attached DTE may begin transmitting; issuance in response to the DTE's RTS.

Clocking - Regularly timed impulses.

Closed User Group - A subgroup of network users that can be its own entity; any member of the subgroup can only communicate with other members of that subgroup.

Coaxial Cable - Coax is a type of electrical communications medium used in the LAN environment. This cable consists of an outer conductor concentric to an inner conductor, separated from each other by insulating material, and covered by some protective outer material. This medium offers large bandwidth, supporting high data rates with high immunity to electrical interference and a low incidence of errors. Coax is subject to distance limitations and is relatively expensive and difficult to install.

Cold Start Trap - an SNMP trap which is sent after a power-cycle (see *trap*).

Collision - Overlapping transmissions that occur when two or more nodes on a LAN attempt to transmit at or about the same time.

Committed Information Rate (CIR) - CIR is the information transfer rate which a network offering Frame Relay Services (FRS) is committed to transfer under normal conditions. The rate is averaged over a minimum increment of time.

Common Channel Signaling (CCS) - A form signaling in which a group of circuits share a signaling channel. Refer to SS7.

Common Management Interface Protocol (CMIP) - An ITU-TSS standard for the message formats and procedures used to exchange management information in order to operate, administer maintain and provision a network.

Concatenation - The connection of transmission channels similar to a chain.

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

Configuration - The phase in which the LE Client discovers the LE Service.

Congestion Management - traffic management feature that helps ensure reasonable service for VBR connections in an ATM network, based on a priority, sustained cell rate (SCR), and peak cell rate (PCR). During times of congestion, bandwidth is reduced to the SCR, based on the priority of the connection.

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

Connection Admission Control (CAC) - 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.

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

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

Connectionless Broadband Data Service (CBDS) - A connectionless service similar to Bellcore's SMDS defined by European Telecommunications Standards Institute (ETSI).

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.

Connectionless Service (CLS) - A service which allows the transfer of information among service subscribers without the need for end-to- end establishment procedures.

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.

Constant Bit Rate (CBR) - 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).

Controlled Slip (CS) - a situation in which one frame's worth of data is either lost or replicated. A controlled slip typically occurs when the sending device and receiving device are not using the same clock.

Convergence Sublayer (CS) - 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.

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

cpath - a FORE program used to manage virtual paths on a *ForeRunner* switch running asxd.

cport - a FORE program that monitors and changes the state of ports on a *ForeRunner* switch running asxd.

Cross Connection - a mapping between two channels or paths at a network device.

Customer Premise Equipment (CPE) - equipment that is on the customer side of the point of demarcation, as opposed to equipment that is on a carrier side. See also point of demarcation.

Cut Through - Establishment of a complete path for signaling and/or audio communications.

Cyclic Redundancy Check (CRC) - 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.

D3/D4 - Refers to compliance with AT&T TR (Technical Reference) 62411 definitions for coding, supervision, and alarm support. D3/D4 compatibility ensures support of digital PBXes, M24 services, Megacom services, and Mode 3 D3/D4 channel banks at DS-1 level.

D4 Channelization - refers to compliance with AT&T Technical Reference 62411 regarding DS1 frame layout (the sequential assignment of channels and time slot numbers within the DS1).

D4 Framed/Framing Format - in T1, a 193-bit frame format in which the 193rd bit is used for framing and signaling information (the frame/framing bit). To be considered in support of D4 Framing, a device must be able to synchronize and frame-up on the 193rd bit.

Data Communications Equipment (DCE) - a definition in the RS232C standard that describes the functions of the signals and the physical characteristics of an interface for a communication device such as a modem.

Data Country Code (DCC) - This specifies the country in which an address is registered. The codes are given in ISO 3166. The length of this field is two octets. The digits of the data country code are encoded in Binary Coded Decimal (BCD) syntax. The codes will be left justified and padded on the right with the hexadecimal value “F” to fill the two octets.

Data Link - Communications connection used to transmit data from a source to a destination.

Data Link Connection Identifier (DLCI) - connection identifier associated with frame relay packets that serves the same functions as, and translates directly to, the VPI/VCI on an ATM cell.

Data Link Layer - Layer 2 of the OSI model, responsible for encoding data and passing it to the physical medium. The IEEE divides this layer into the LLC (Logical Link Control) and MAC (Media Access Control) sublayers.

Data Set Ready (DSR) - an RS-232 modem interface control signal (sent from the modem to the DTE on pin 6) which indicates that the modem is connected to the telephone circuit. Usually a prerequisite to the DTE issuing RTS.

Data Terminal Equipment (DTE) - generally user devices, such as terminals and computers, that connect to data circuit-terminating equipment. They either generate or receive the data carried by the network.

Data Terminal Ready (DTR) - an RS232 modem interface control signal (sent from the DTE to the modem on pin 20) which indicates that the DTE is ready for data transmission and which requests that the modem be connected to the telephone circuit.

Datagram - a packet of information used in a connectionless network service that is routed to its destination using an address included in the datagram's header.

DECnet - Digital Equipment Corporation's proprietary LAN.

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

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

Destination End Station (DES) - An ATM termination point which is the destination for ATM messages of a connection and is used as a reference point for ABR services. See SES.

Digital Access and Cross-Connect System (DACS) - Digital switching system for routing T1 lines, and DS-0 portions of lines, among multiple T1 ports.

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

Digital Standard n (0, 1, 1C, 2, and 3) (DSn) - a method defining the rate and format of digital hierarchy, with asynchronous data rates 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

DIP (Dual In-line Package) Switch - 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.

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

Duplex - Two way communication.

DXI - a generic phrase used in the full names of several protocols, all commonly used to allow a pair of DCE and DTE devices to share the implementation of a particular WAN protocol. The protocols define the packet formats used to transport data between DCE and DTE devices.

DXI Frame Address (DFA) - a connection identifier associated with ATM DXI packets that serves the same functions as, and translates directly to, the VPI/VCI on an ATM cell.

Dynamic Allocation - A technique in which the resources assigned for program execution are determined by criteria applied at the moment of need.

E.164 - A public network addressing standard utilizing up to a maximum of 15 digits. ATM uses E.164 addressing for public network addressing.

E1 - Wide-area digital transmission scheme used predominantly in Europe that carries data at a rate of 2.048 Mbps. E1 lines can be leased for private use from common carriers.

E3 - Wide-area digital transmission scheme used predominantly in Europe that carries data at a rate of 34.368 Mbps. E3 lines can be leased for private use from common carriers.

Edge Device - A physical device which is capable of forwarding packets between legacy interworking interfaces (e.g., Ethernet, Token Ring, etc.) and ATM interfaces based on data-link and network layer information but which does not participate in the running of any network layer routing protocol. An Edge Device obtains forwarding descriptions using the route distribution protocol.

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. Lets the user set the NSAP address of the LAN Emulation Configuration Server, display the list of Emulated LANs 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.

Electrically Erasable Programmable Read Only Memory (EEPROM) - an EPROM that can be cleared with electrical signals rather than the traditional ultraviolet light.

Electromagnetic Interference (EMI) - signals generated and radiated by an electronic device that cause interference with radio communications, among other effects.

Electronics Industries Association (EIA) - a USA trade organization that issues its own standards and contributes to ANSI; developed RS-232. Membership includes USA manufacturers.

Embedded SNMP Agent - an SNMP agent can come in two forms: embedded or proxy. An embedded SNMP agent is integrated into the physical hardware and software of the unit.

Emulated Local Area Network (ELAN) - A logical network initiated by using the mechanisms defined by LAN Emulation. This could include ATM and legacy attached end stations.

End System (ES) - a system where an ATM connection is terminated or initiated (an originating end system initiates the connection; a terminating end system terminates the connection).

End System Identifier (ESI) - This identifier distinguishes multiple nodes at the same level in case the lower level peer group is partitioned.

End-to-End Connection - when used in reference to an ATM network, a connection that travels through an ATM network, passing through various ATM devices and with endpoints at the termination of the ATM network.

Enterprise - Terminology generally referring to customers with multiple, non-contiguous geographic locations.

Equalization (EQL) - the process of compensating for line distortions.

Erasable Programmable Read Only Memory (EPROM) - A PROM which may be erased and rewritten to perform new or different functions (normally done with a PROM burner).

Errored Second (ES) - a second during which at least one code violation occurred.

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

Excessive Zeroes (EXZ) Error Event - An Excessive Zeroes error event for an AMI-coded signal is the occurrence of more than fifteen contiguous zeroes. For a B8ZS coded signal, the defect occurs when more than seven contiguous zeroes are detected.

Explicit Forward Congestion Indication (EFCI) - the second bit of the payload type field in the header of an ATM cell, the EFCI bit indicates network congestion to receiving hosts. On a congested switch, the EFCI bit is set to "1" by the transmitting network module when a certain number of cells have accumulated in the network module's shared memory buffer. When a cell is received that has its EFCI bit set to "1," the receiving host notifies the sending host, which should then reduce its transmission rate.

Explicit Rate (ER) - The Explicit Rate is an RM-cell field used to limit the source ACR to a specific value. It is initially set by the source to a requested rate (such as PCR). It may be subsequently reduced by any network element in the path to a value that the element can sustain. ER is formatted as a rate.

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

Extended Super Frame (ESF) - a T1 framing format that utilizes the 193rd bit as a framing bit, but whose Superframe is made up of 24 frames instead of 12 as in D4 format. ESF also provides CRC error detection and maintenance data link functions.

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

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

Far End Block Error (FEBE) - 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.

Far End Receive Failure (FERF) - 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.

Far-End - in a relationship between two devices in a circuit, the far-end device is the one that is remote.

Face Contact (FC) - Designation for fiber optic connector designed by Nippon Telegraph and Telephone which features a movable anti-rotation key allowing good repeatable performance despite numerous mating. Normally referred to as Fiber Connector, FC actually stands for Face Contact and sometimes linked with PC (Point Contact), designated as FC or FC-PC.

FCC Part 68 - The FCC rules regulating the direct connection of non-telephone company provided equipment to the public telephone network.

Federal Communications Commission (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.

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

File Transfer Protocol (FTP) - 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.

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

Flag - a bit pattern of six binary “1”s bounded by a binary “0” at each end (forms a 0111 1110 or Hex “7E”). It is used to mark the beginning and/or end of a frame.

Flow Control - The way in which information is controlled in a network to prevent loss of data when the receiving buffer is near its capacity.

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

Forward Error Correction (FEC) - A technique used by a receiver for correcting errors incurred in transmission over a communications channel without requiring retransmission of any information by the transmitter; typically involves a convolution of the transmitted bits and the appending of extra bits by both the receiver and transmitter using a common algorithm.

Forward Explicit Congestion Notification (FECN) - Bit set by a Frame Relay network to inform data terminal equipment (DTE) receiving the frame that congestion was experienced in the path from source to destination. DTE receiving frames with the FECN bit set can request that higher-level protocols take flow control action as appropriate.

Fractional T1 - the use of bandwidth in 64Kbps increments up to 1.544Mbps from a T1 facility.

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

Frame Check Sequence (FCS) - In bit-oriented protocols, a 16-bit field that contains transmission error checking information, usually appended to the end of the frame.

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.

Frame Synchronization Error - an error in which one or more time slot framing bits are in error.

Frame-Based UNI (FUNI) - An ATM switch-based interface which accepts frame-based ATM traffic and converts it into cells.

Frame-Relay Service (FRS) - A connection oriented service that is capable of carrying up to 4096 bytes per frame.

Framing - a protocol that separates incoming bits into identifiable groups so that the receiving multiplexer recognizes the grouping.

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

Gbps - gigabits per second (billion)

Generic Cell Rate Algorithm (GCRA) - 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.

Generic Connection Admission Control (GCAC) - This is a process to determine if a link has potentially enough resources to support a connection.

Generic Flow Control (GFC) - 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.

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

High Density Bipolar (HDB3) - A bipolar coding method that does not allow more than 3 consecutive zeroes.

High Level Data Link Control (HDLC) - An ITU-TSS link layer protocol standard for point-to-point and multi-point communications.

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

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

Host - In a network, the primary or controlling computer in a multiple computer installation.

HPUX - the Hewlett-Packard version of UNIX.

Hub - a device that connects 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.

Institute of Electrical and Electronics Engineers (IEEE) - the world's largest technical professional society. Based in the U.S., 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 members, and promotes standardization.

IEEE 802 - Standards for the interconnection of LAN computer equipment. Deals with the Data Link Layers of the ISO Reference Model for OSI.
IEEE 802.1 - Defines the high-level network interfaces such as architecture, internetworking and network management.
IEEE 802.2 - Defines the Logical Link Control interface between the Data Link and Network Layers.
IEEE 802.3 - Defines CSMA/CD (Ethernet).
IEEE 802.4 - Defines the token-passing bus.
IEEE 802.5 - Defines the Token Ring access methodology. This standard incorporates IBM's Token Ring specifications.
IEEE 802.6 - Defines Metropolitan Area Networks.
IEEE 802.7 - The broadband technical advisory group.
IEEE 802.8 - The fiber optics technical advisory group.
IEEE 802.9 - Defines integrated data and voice networks.

Integrated Services Digital Network (ISDN) - 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.

Interexchange Carriers (IXC) - Long-distance communications companies that provide service between Local Access Transport Areas (LATAs).

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.

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

Interim Local Management Interface (ILMI) - 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.

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

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

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

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

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. Default network masks are as follows:

Class A - 255.0.0.0

Class B - 255.255.0.0

Class C - 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.

Internet Control Message Protocol (ICMP) - 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.

Internet Engineering Task Force (IETF) - 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.

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

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

Interoperability - The ability of software and hardware on multiple machines, from multiple vendors, to communicate.

Interworking Function (IWF) - provides a means for two different technologies to interoperate.

IP Address - a unique 32-bit integer used to identify a device in an IP network. You will most commonly see IP addresses written in “dot” notation (e.g., 192.228.32.14).

IP Netmask - a 32-bit pattern that is combined with an IP address to determine which bits of an IP address denote the network number and which denote the host number. Netmasks are useful for sub-dividing IP networks. IP netmasks are written in “dot” notation (e.g., 255.255.0.0).

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.

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

International Telecommunications Union Telecommunications (ITU-T) - an international body of member countries whose task is to define recommendations and standards relating to the international telecommunications industry. The fundamental standards for ATM have been defined and published by the ITU-T (Previously CCITT).

J2 - Wide-area digital transmission scheme used predominantly in Japan that carries data at a rate of 6.312 Mbps.

Jitter - analog communication line distortion caused by variations of a signal from its reference timing position.

Joint Photographic Experts Group (JPEG) - An ISO Standards group that defines how to compress still pictures.

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.

Kbps - kilobits per second (thousand)

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.

LAN Emulation Address Resolution Protocol (LE_ARP) - A message issued by a LE client to solicit the ATM address of another function.

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

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 addresses of the LES and BUS associated with each ELAN.

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

LAN Emulation (LANE) - technology that allows an ATM network to function as a LAN backbone. The ATM network must provide multicast and broadcast support, address mapping (MAC-to-ATM), SVC management, and a usable packet format. LANE also defines Ethernet and Token Ring ELANs.

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.

Latency - The time interval between a network station seeking access to a transmission channel and that access being granted or received.

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).

Leaky Bucket - informal cell policing term for the Generic Cell Rate Algorithm which in effect receives cells into a bucket and leaks them out at the specified or contracted rate (i.e., PCR).

Least Significant Bit (LSB) - lowest order bit in the binary representation of a numerical value.

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

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.

Line Build Out (LBO) - Because T1 circuits require the last span to lose 15-22.5 dB, a selectable output attenuation is generally required of DTE equipment (typical selections include 0.0, 7.5 and 15 dB of loss at 772 KHz).

Line Code Violations (LCV) - Error Event. A Line Coding Violation (LCV) is the occurrence of either a Bipolar Violation (BPV) or Excessive Zeroes (EXZ) Error Event.

Link - An entity that defines a topological relationship (including available transport capacity) between two nodes in different subnetworks. Multiple links may exist between a pair of subnetworks. Synonymous with logical link.

Link Access Procedure, Balanced (LAPB) - Data link protocol in the X.25 protocol stack. LAPB is a bit-oriented protocol derived from HDLC. See also HDLC and X.25.

Link Down Trap - an SNMP trap, sent when an interface changes from a normal state to an error state, or is disconnected.

Link Layer - layer in the OSI model regarding transmission of data between network nodes.

Link Up Trap - an SNMP trap, sent when an interface changes from an error condition to a normal state.

Load Sharing - Two or more computers in a system that share the load during peak hours. During periods of non peak hours, one computer can manage the entire load with the other acting as a backup.

Local Access and Transport Area (LATA) - Geographic boundaries of the local telephone network, specified by the FCC, in which a single LEC may perform its operations. Communications outside or between LATAs are provided by IXCs.

Local Area Network (LAN) - 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.

Logical Link Control (LLC) - 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.

Loopback - a troubleshooting technique that returns a transmitted signal to its source so that the signal can be analyzed for errors. Typically, a loopback is set at various points in a line until the section of the line that is causing the problem is discovered.

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

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

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

Loss Of Signal (LOS) - a type of transmission error that may occur in wide-area carrier lines, or a condition declared when the DTE senses a loss of a DS1 signal from the CPE for more the 150 milliseconds (the DTE generally responds with an all ones “Blue or AIS” signal).

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

Maximum Burst Size (MBS) - the Burst Tolerance (BT) is conveyed through the MBS which is coded as a number of cells. The BT together with the SCR and the GCRA determine the MBS that may be transmitted at the peak rate and still be in conformance with the GCRA.

Maximum Burst Tolerance - the largest burst of data that a network device is guaranteed to handle without discarding cells or packets. Bursts of data larger than the maximum burst size may be subject to discard.

Maximum Cell Delay Variance (MCDV) - This is the maximum two-point CDV objective across a link or node for the specified service category.

Maximum Cell Loss Ratio (MCLR) - This is the maximum ratio of the number of cells that do not make it across the link or node to the total number of cells arriving at the link or node.

Maximum Cell Transfer Delay (MCTD) - This is the sum of the fixed delay component across the link or node and MCDV.

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

Mbps - megabits per second (million)

Media Access Control (MAC) - 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).

Media Attachment Unit (MAU) - device used in Ethernet and IEEE 802.3 networks that provides the interface between the AUI port of a station and the common medium of the Ethernet. The MAU, which can be built into a station or can be a separate device, performs physical layer functions including conversion of the digital data from the Ethernet interface, collision detection, and injection of bits onto the network.

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

Message Identifier (MID) - message identifier used to associate ATM cells that carry segments from the same higher layer packet.

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).

Metropolitan Area Network (MAN) - network designed to carry data over an area larger than a campus such as an entire city and its outlying area.

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

Minimum Cell Rate (MCR) - parameter defined by the ATM Forum for ATM traffic management, defined only for ABR transmissions and specifying the minimum value for the ACR.

Most Significant Bit (MSB) - highest order bit in the binary representation of a numerical value.

Motion Picture Experts Group (MPEG) - ISO group dealing with video and audio compression techniques and mechanisms for multiplexing and synchronizing various media streams.

MPOA Client - A device which implements the client side of one or more of the MPOA protocols, (i.e., is a SCP client and/or an RDP client. An MPOA Client is either an Edge Device Functional Group (EDFG) or a Host Behavior Functional Group (HBFG).

MPOA Server - An MPOA Server is any one of an ICFG or RSFG.

MPOA Service Area - The collection of server functions and their clients. A collection of physical devices consisting of an MPOA server plus the set of clients served by that server.

MPOA Target - A set of protocol address, path attributes, (e.g., internetwork layer QoS, other information derivable from received packet) describing the intended destination and its path attributes that MPOA devices may use as lookup keys.

Mu-Law - The PCM coding and companding standard used in Japan and North America.

Multicasting - The ability to broadcast messages to one node or a select group of nodes.

Multi-homed - a device having both an ATM and another network connection, like Ethernet.

Multimode Fiber Optic Cable (MMF) - fiber optic cable in which the signal or light propagates in multiple modes or paths. Since these paths may have varying lengths, a transmitted pulse of light may be received at different times and smeared to the point that pulses may interfere with surrounding pulses. This may cause the signal to be difficult or impossible to receive. This pulse dispersion sometimes limits the distance over which a MMF link can operate.

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-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 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.

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.

Multiprotocol over ATM (MPOA) - An effort taking place in the ATM Forum to standardize protocols for the purpose of running multiple network layer protocols over ATM.

Narrowband Channel - sub-voicegrade channel with a speed range of 100 to 200 bps.

National TV Standards Committee (NTSC) - Started in the US in 1953 from a specification laid down by the National Television Standards Committee. It takes the B-Y and R-Y color difference signals, attenuates them to I and Q, then modulates them using double-sideband suppressed subcarrier at 3.58MHz. The carrier reference is sent to the receiver as a burst during the back porch. An industry group that defines how television signals are encoded and transmitted in the US. (See also PAL, SECAM for non-U.S. countries).

Near-End - in a relationship between two devices in a circuit, the near-end device is the one that is local.

Network Layer - Layer three In the OSI model, the layer that is responsible for routing data across the network.

Network Management Entity (NM) - body of software in a switching system that provides the ability to manage the PNNI protocol. NM interacts with the PNNI protocol through the MIB.

Network Management Layer (NML) - an abstraction of the functions provided by systems which manage network elements on a collective basis, providing end-to-end network monitoring.

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

Network Module - ATM port interface cards which may be individually added to or removed from any *ForeRunner* ATM switch to provide a diverse choice of connection alternatives.

Network Parameter Control (NPC) - Defined as the set of actions taken by the network to monitor and control traffic from the NNI. Its main purpose is to protect network resources from malicious as well as unintentional misbehavior which can affect the QoS of other already established connections by detecting violations of negotiated parameters and taking appropriate actions. Refer to UPC.

Network Redundancy - Duplicated network equipment and/or data which can provide a backup in case of network failures.

Network Service Access Point (NSAP) - OSI generic standard for a network address consisting of 20 octets. ATM has specified E.164 for public network addressing and the NSAP address structure for private network addresses.

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

Node - A computer or other device when considered as part of a network.

Non Return to Zero (NRZ) - a binary encoding scheme in which ones and zeroes are represented by opposite and alternating high and low voltages and where there is no return to a zero (reference) voltage between encoded bits.

Non Return to Zero Inverted (NRZI) - A binary encoding scheme that inverts the signal on a “1” and leaves the signal unchanged for a “0”. (Also called transition encoding.)

Nonvolatile Storage - Memory storage that does not lose its contents when power is turned off.

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

nx64K - This refers to a circuit bandwidth or speed provided by the aggregation of nx64 kbps channels (where n= integer > 1). The 64K or DS0 channel is the basic rate provided by the T Carrier systems.

Nyquist Theorem - In communications theory, a formula stating that two samples per cycle is sufficient to characterize a bandwidth limited analog signal; in other words, the sampling rate must be twice the highest frequency component of the signal (i.e., sample 4 KHz analog voice channels 8000 times per second).

Object Identifier (OID) - the address of a MIB variable.

Octet - a grouping of 8 bits; similar, but not identical to, a byte.

One’s Density - The requirement for digital transmission lines in the public switched telephone network that eight consecutive “0”s cannot be in a digital data stream; exists because repeaters and clocking devices within the network will lose timing after receiving eight “0”s in a row; a number of techniques are used to insert a “1” after every seventh-consecutive “0” (see Bit Stuffing).

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

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

OpenView - Hewlett-Packard's network management software.

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

Optical Carrier level-n (OC-n) - The optical counterpart of STS-n (the basic rate of 51.84 Mbps on which SONET is based is referred to as OC-1 or STS-1).

Organizationally Unique Identifier (OUI) - Part of RFC 1483. A three-octet field in the SubNetwork Attachment Point (SNAP) header, identifying an organization which administers the meaning of the following two octet Protocol Identifier (PID) field in the SNAP header. Together they identify a distinct routed or bridged protocol.

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

Out-of-Frame (OOF) - a signal condition and alarm in which some or all framing bits are lost.

Packet - An arbitrary collection of data grouped and transmitted with its user identification over a shared facility.

Packet Assembler Disassembler (PAD) - interface device that buffers data sent to/from character mode devices, and assembles and disassembles the packets needed for X.25 operation.

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

Packet Level Protocol (PLP) - Network layer protocol in the X.25 protocol stack. Sometimes called X.25 Level 3 or X.25 Protocol.

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

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

Payload Scrambling - a technique that eliminates certain bit patterns that may occur within an ATM cell payload that could be misinterpreted by certain sensitive transmission equipment as an alarm condition.

Payload Type (PT) - 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.

Peak Cell Rate - at the PHY Layer SAP of a point-to-point VCC, the Peak Cell Rate is the inverse of the minimum inter-arrival time T0 of the request to send an ATM-SDU.

Peak Cell Rate (PCR) - parameter defined by the ATM Forum for ATM traffic management. In CBR transmissions, PCR determines how often data samples are sent. In ABR transmissions, PCR determines the maximum value of the ACR.

Peer Entities - entities within the same layer.

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

Permanent Virtual Channel Connection (PVCC) - A Virtual Channel Connection (VCC) is an ATM connection where switching is performed on the VPI/VCI fields of each cell. A Permanent VCC is one which is provisioned through some network management function and left up indefinitely.

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

Permanent Virtual Path Connection (PVPC) - A Virtual Path Connection (VPC) is an ATM connection where switching is performed on the VPI field only of each cell. A PVPC is one which is provisioned through some network management function and left up indefinitely.

Phase Alternate Line (PAL) - Largely a German/British development in the late 60s, used in the UK and much of Europe. The B-Y and R-Y signals are weighted to U and V, then modulated onto a double-sideband suppressed subcarrier at 4.43MHz. The V (R-Y) signal's phase is turned through 180 degrees on each alternate line. This gets rid of NTSC's hue changes with phase errors at the expense of de-saturation. The carrier reference is sent as a burst in the back porch. The phase of the burst is alternated every line to convey the phase switching of the V signal. The burst's average phase is -V. (see NTSC for U.S.).

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

Physical Layer 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.

Physical Layer Convergence Protocol (PLCP) - a framing protocol that runs on top of the T1 or E1 framing protocol.

Physical Medium (PM) - Refers to the actual physical interfaces. Several interfaces are defined including STS-1, STS-3c, STS-12c, STM-1, STM-4, DS1, E1, DS2, E3, DS3, E4, FDDI-based, Fiber Channel-based, and STP. These range in speeds from 1.544Mbps through 622.08 Mbps.

Physical Medium Dependent (PMD) - 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.

Plesiochronous - two signals are plesiochronous if their corresponding significant instants occur at nominally the same rate, with variations in rate constrained to specified limits.

Point of Demarcation - the dividing line between a carrier and the customer premise that is governed by strict standards that define the characteristics of the equipment on each side of the demarcation. Equipment on one side of the point of demarcation is the responsibility of the customer. Equipment on the other side of the point of demarcation is the responsibility of the carrier.

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.

Point-to-Point Protocol (PPP) - Provides a method for transmitting packets over serial point-to-point links.

Policing - the function that ensures that a network device does not accept traffic that exceeds the configured bandwidth of a connection.

Port Identifier - The identifier assigned by a logical node to represent the point of attachment of a link to that node.

Presentation Layer - Sixth layer of the OSI model, providing services to the application layer.

Primary Reference Source (PRS) - Equipment that provides a timing signal whose long-term accuracy is maintained at 1 x 10 -11 or better with verification to universal coordinated time (UTC) and whose timing signal is used as the basis of reference for the control of other clocks within a network.

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

Priority - the parameter of ATM connections that determines the order in which they are reduced from the peak cell rate to the sustained cell rate in times of congestion. Connections with lower priority (4 is low, 1 is high) are reduced first.

Private Branch Exchange (PBX) - 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.

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

Programmable Read-Only Memory (PROM) - 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.

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

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.

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

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

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.

Quality of Service (QoS) - Quality of Service is defined on an end-to-end basis in terms of the following attributes of the end-to-end ATM connection:

Cell Loss Ratio
Cell Transfer Delay
Cell Delay Variation

Queuing Delay (QD) - refers to the delay imposed on a cell by its having to be buffered because of unavailability of resources to pass the cell onto the next network function or element. This buffering could be a result of oversubscription of a physical link, or due to a connection of higher priority or tighter service constraints getting the resource of the physical link.

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

Real-Time Clock - a clock that maintains the time of day, in contrast to a clock that is used to time the electrical pulses on a circuit.

Red Alarm - In T1, a red alarm is generated for a locally detected failure such as when a condition like OOF exists for 2.5 seconds, causing a CGA, (Carrier Group Alarm).

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

Redundancy - In a data transmission, the fragments of characters and bits that can be eliminated with no loss of information.

Registration - The address registration function is the mechanism by which Clients provide address information to the LAN Emulation Server.

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.

Request To Send (RTS) - an RS-232 modem interface signal (sent from the DTE to the modem on pin 4) which indicates that the DTE has data to transmit.

Requests For Comment (RFCs) - 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.

RFC1483 - Multiprotocol Encapsulation over ATM Adaptation Layer 5.
RFC1490 - Multiprotocol Interconnect over Frame Relay.
RFC1577 - Classical IP and ARP over ATM.
RFC1755 - ATM Signaling Support for IP over ATM.

Robbed-Bit Signaling - In T1, refers to the use of the least significant bit of every word of frames 6 and 12 (D4), or 6, 12, 18, and 24 (ESF) for signaling purposes.

Route Server - A physical device that runs one or more network layer routing protocols, and which uses a route query protocol in order to provide network layer routing forwarding descriptions to clients.

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

Routing Domain (RD) - A group of topologically contiguous systems which are running one instance of routing.

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

Routing Protocol - A general term indicating a protocol run between routers and/or route servers in order to exchange information used to allow computation of routes. The result of the routing computation will be one or more forwarding descriptions.

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

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

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

Segmentation And Reassembly (SAR) - 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.

Selector (SEL) - A subfield carried in SETUP message part of ATM endpoint address Domain specific Part (DSP) defined by ISO 10589, not used for ATM network routing, used by ATM end systems only.

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

Serial Line IP (SLIP) - A protocol used to run IP over serial lines, such as telephone circuits or RS-232 cables, interconnecting two systems.

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

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

Service Specific Connection Oriented Protocol (SSCOP) - an adaptation layer protocol defined in ITU-T Specification: Q.2110.

Service Specific Convergence Sublayer (SSCS) - The portion of the convergence sublayer that is dependent upon the type of traffic that is being converted.

Session Layer - Layer 5 in the OSI model that is responsible for establishing and managing sessions between the application programs running in different nodes.

Severely Errored Seconds (SES) - a second during which more event errors have occurred than the SES threshold (normally 10-3).

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, where load-balancing means configuring data flows to maximize network efficiency.

Shielded Pair - Two insulated wires in a cable wrapped with metallic braid or foil to prevent interference and provide noise free transmission.

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

Signaling System No. 7 (SS7) - The SS7 protocol has been specified by ITU-T and is a protocol for interexchange signaling.

Simple and Efficient Adaptation Layer (SEAL) - 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.

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

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

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

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

Single Mode Fiber (SMF) - Fiber optic cable in which the signal or light propagates in a single mode or path. Since all light follows the same path or travels the same distance, a transmitted pulse is not dispersed and does not interfere with adjacent pulses. SMF fibers can support longer distances and are limited mainly by the amount of attenuation. Refer to MMF.

Small Computer Systems Interface (SCSI) - a standard for a controller bus that connects hardware devices to their controllers on a computer bus, typically used in small systems.

Smart PVC (SPVC) - 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).

snmpd - an SMNP agent for a given adapter card.

Source - Part of communications system which transmits information.

Source Address (SA) - The address from which the message or data originated.

Source MAC Address (SA) - A six octet value uniquely identifying an end point and which is sent in an IEEE LAN frame header to indicate source of frame.

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.

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

Statistical Multiplexing - a technique for allowing multiple channels and paths to share the same link, typified by the ability to give the bandwidth of a temporarily idle channel to another channel.

Stick and Click (SC) - Designation for an Optical Connector featuring a 2.5 mm physically contacting ferrule with a push-pull mating design. Commonly referred to as Structured Cabling, Structured Connectors or Stick and Click

Stick and Turn (ST) - A fiber-optic connector designed by AT&T which uses the bayonet style coupling rather than screw-on as the SMA uses. The ST is generally considered the eventual replacement for the SMA type connector.

Store-and-Forward - the technique of receiving a message, storing it until the proper outgoing line is available, then retransmitting it, with no direct connection between incoming and outgoing lines.

Straight Tip (ST) - see *Stick and Turn*.

Structured Cabling (SC) - see *Stick and Click*.

Structured Connectors (SC) - see *Stick and Click*.

Sublayer - a logical subdivision of a layer.

SubNetwork Access Protocol (SNAP) - a specially reserved variant of IEEE 802.2 encoding SNAP indicates to look further into the packet where it will fine a Type field.

Subscriber Network Interface (SNI) - the interface between an SMDS end user's CPE and the network directly serving the end user, supported by either a DS1 or DS3 access arrangement.

Super Frame (SF) - a term used to describe the repeating 12 D4 frame format that composes a standard (non-ESF) T1 service.

Super User - a login ID that allows unlimited access to the full range of a device's functionality, including especially the ability to reconfigure the device and set passwords.

Sustainable Cell Rate (SCR) - ATM Forum parameter defined for traffic management. For VBR connections, SCR determines the long-term average cell rate that can be transmitted.

Sustained Information Rate (SIR) - In ATM this refers to the long-term average data transmission rate across the User-to-Network Interface. In SMDS this refers to the committed information rate (similar to CIR for Frame Relay Service).

Switch - Equipment used to interconnect lines and trunks.

Switched Connection - A connection established via signaling.

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

Switched Virtual Channel Connection (SVCC) - A Switched VCC is one which is established and taken down dynamically through control signaling. A Virtual Channel Connection (VCC) is an ATM connection where switching is performed on the VPI/VCI fields of each cell.

Switched Virtual Circuit (or Channel) (SVC) - 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 Virtual Path Connection (SVPC) - a connection which is established and taken down dynamically through control signaling. A Virtual Path Connection (VPC) is an ATM connection where switching is performed on the VPI field only of each cell.

Switching System - A set of one or more systems that act together and appear as a single switch for the purposes of PNNI routing.

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

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

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

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

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

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

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

Systeme En Coleur Avec Memoire (SECAM) - Sequential and Memory Color Television - Started in France in the late 60s, and used by other countries with a political affiliation. This is. The B-Y and R-Y signals are transmitted on alternate lines modulated on an FM subcarrier. The memory is a one line delay line in the receiver to make both color difference signals available at the same time on all lines. Due to FM, the signal is robust in difficult terrain.

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

T1 - a specification for a transmission line. The specification details the input and output characteristics and the bandwidth. T1 lines run at 1.544 Mbps and provide for 24 data channels. In common usage, the term “T1” is used interchangeably with “DS1.”

T1 Link - A wideband digital carrier facility used for transmission of digitized voice, digital data, and digitized image traffic. This link is composed of two twisted-wire pairs that can carry 24 digital channels, each operating at 64K bps at the aggregate rate of 1.544M bps, full duplex. Also referred to as DS-1.

T3 - a specification for a transmission line, the equivalent of 28 T1 lines. T3 lines run at 44.736 Mbps. In common usage, the term “T3” is used interchangeably with “DS3.”

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.

Tagged Cell Rate (TCR) - An ABR service parameter, TCR limits the rate at which a source may send out-of-rate forward RM-cells. TCR is a constant fixed at 10 cells/second.

Telephony - The conversion of voices and other sounds into electrical signals which are then transmitted by telecommunications media.

Telnet - a TCP/IP protocol that defines a client/server mechanism for emulating directly-connected terminal connections.

Terminal Equipment (TE) - Terminal equipment represents the endpoint of ATM connection(s) and termination of the various protocols within the connection(s).

Throughput - Measurement of the total useful information processed or communicated by a computer during a specified time period, i.e. packets per second.

Time Division Multiplexing (TDM) - a method of 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.

Traffic Management (TM) - The traffic control and congestion control procedures for ATM. ATM layer traffic control refers to the set of actions taken by the network to avoid congestion conditions. ATM layer congestion control refers to the set of actions taken by the network to minimize the intensity, spread and duration of congestion. The following functions form a framework for managing and controlling traffic and congestion in ATM networks and may be used in appropriate combinations:

Connection Admission Control
Feedback Control
Usage Parameter Control
Priority Control
Traffic Shaping
Network Resource Management
Frame Discard
ABR Flow Control

Traffic Parameter - A parameter for specifying a particular traffic aspect of a connection.

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.

Transmission Control Protocol (TCP) - 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.

Transmission Control Protocol/Internet Protocol (TCP/IP) - 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.

Transmission Convergence (TC) - 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.

Transmission Convergence Sublayer (TCS) - This is part of the ATM physical layer that defines how cells will be transmitted by the actual physical layer.

Transparent Asynchronous Transmitter/Receiver Interface (TAXI) - Encoding scheme used for FDDI LANs as well as for ATM; supports speed typical of 100 Mbps over multimode fiber.

Transport Layer - Layer Four of the OSI reference model that is responsible for maintaining reliable end-to-end communications across the network.

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.

Trivial File Transfer Protocol (TFTP) - Part of IP, a simplified version of FTP that allows files to be transferred from one computer to another over a network.

Twisted Pair - Insulated wire in which pairs are twisted together. Commonly used for telephone connections, and LANs because it is inexpensive.

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

Unavailable Seconds (UAS) - a measurement of signal quality. Unavailable seconds start accruing when ten consecutive severely errored seconds occur.

UNI 3.0/3.1 - the User-to-Network Interface standard set forth by the ATM Forum that defines how private customer premise equipment interacts with private ATM switches.

Unicasting - The transmit operation of a single PDU by a source interface where the PDU reaches a single destination.

Universal Test & Operations Interface for ATM (UTOPIA) - Refers to an electrical interface between the TC and PMD sublayers of the PHY layer.

Unshielded Twisted Pair (UTP) - 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.

Unspecified Bit Rate (UBR) - 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.

Uplink - Represents the connectivity from a border node to an upnode.

Usage Parameter Control (UPC) - mechanism that ensures that traffic on a given connection does not exceed the contracted bandwidth of the connection, responsible for policing or enforcement. UPC is sometimes confused with congestion management (see *congestion management*).

User Datagram Protocol (UDP) - 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.

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

V.35 - ITU-T standard describing a synchronous, physical layer protocol used for communications between a network access device and a packet network. V.35 is most commonly used in the United States and Europe, and is recommended for speeds up to 48 Kbps.

Variable Bit Rate (VBR) - 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).

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

Virtual Channel Connection (VCC) - 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.

Virtual Channel Identifier (VCI) - the address or label of a VC; a value stored in a field in the ATM cell header that identifies an individual virtual channel to which the cell belongs. VCI values may be different for each data link hop of an ATM virtual connection.

Virtual Channel Link (VCL) - 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.

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 Connection - an endpoint-to-endpoint connection in an ATM network. A virtual connection can be either a virtual path or a virtual channel.

Virtual Local Area Network (VLAN) - Work stations connected to an intelligent device which provides the capabilities to define LAN membership.

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

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

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

Virtual Path Identifier (VPI) - the address or label of a particular VP; a value stored in a field in the ATM cell header that identifies an individual virtual path to which the cell belongs. A virtual path may comprise multiple virtual channels.

Virtual Path Link (VPL) - 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.

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.

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

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

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

Virtual Source/Virtual Destination (VS/VD) - An ABR connection may be divided into two or more separately controlled ABR segments. Each ABR control segment, except the first, is sourced by a virtual source. A virtual source implements the behavior of an ABR source endpoint. Backwards RM-cells received by a virtual source are removed from the connection. Each ABR control segment, except the last, is terminated by a virtual destination. A virtual destination assumes the behavior of an ABR destination endpoint. Forward RM-cells received by a virtual destination are turned around and not forwarded to the next segment of the connection.

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

Warm Start Trap - an SNMP trap which indicates that SNMP alarm messages or agents have been enabled.

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

Wideband Channel - Communications channel with more capacity (19.2K bps) than the standard capacity of a voice grade line.

X.21 - ITU-T standard for serial communications over synchronous digital lines. The X.21 protocol is used primarily in Europe and Japan.

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.

Yellow Alarm - An alarm signal sent back toward the source of a failed signal due to the presence of an AIS (may be used by APS equipment to initiate switching).

Zero Byte Time Slot Interchange (ZBTSI) - A technique used with the T carrier extended superframe format (ESF) in which an area in the ESF frame carries information about the location of all-zero bytes (eight consecutive “0”s) within the data stream.

Zero Code Suppression - The insertion of a “1” bit to prevent the transmission of eight or more consecutive “0” bits. Used primarily with T1 and related digital telephone company facilities, which require a minimum “1’s density” in order to keep the individual subchannels of a multiplexed, high speed facility active.

Zero-Bit Insertion - A technique used to achieve transparency in bit-oriented protocols. A zero is inserted into sequences of one bits that cause false flag direction.

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