PATHWORKS for Macintosh

digital

Introduction to the AppleTalk Network System

Order Number: AA–PBFEB–TE

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Contents

2 Appletalk Network System Cabling and Computers

3 Network Services in the Combined Apple and Digital Environment

4 AppleTalk Protocol Architecture

Glossary

Index

Figures

About This Guide

Manual Objectives

Introduction to the AppleTalk Network System describes the AppleTalk network system to the VMS system administrator and DECnet administrator. The purpose is to give an overview of basic concepts and terminology of the AppleTalk network system that the administrator needs to know to proceed with the installation and maintenance of the AppleTalk for VMS component of the PATHWORKS for Macintosh software.

This manual contains references to products not directly supported in PATHWORKS for Macintosh. For a complete list of the supported network configurations, see the Software Product Description (SPD 31–53.xx) for PATHWORKS for Macintosh.

Intended Reader

This manual addresses the VMS system administrator and DECnet administrator who are familiar with DECnet software and the VMS operating system, but not necessarily familiar with AppleTalk. The programmer is a possible secondary audience; the primary source of overview information for programmers is the *PATHWORKS for Macintosh Programmer's Guide*.

Manual Organization

This manual is organized as follows:

1. Chapter 1 provides an overview of Macintosh to VAX connectivity, followed by an introduction to basic AppleTalk network concepts.
2. Chapter 2 discusses the physical components of the AppleTalk network system—cabling and computers.
3. Chapter 3 describes how users in the combined Apple and Digital environment share files and printers, access DECnet services, exchange electronic mail, and use X Windows applications.
4. Chapter 4 provides an overview of AppleTalk protocols.

For More Information

The PATHWORKS for Macintosh documentation set consists of the following manuals. The set is visually represented by the illustration at the end of this section.

Network Services User's Guide
MacTerminal User's Guide
MacX User's Guide
DECnet for Macintosh User's Guide

Introduction to the AppleTalk Network System
Planning and Installation Guide
System Administrator's Guide
System Administrator's Reference Manual
MacTCP Administrator's Guide
Release Notes, Version 1.0 (available on line only)

Programmer's Guide
Programmer's Reference
Communications Toolbox Programmer's Reference
Data Access Language Programmer's Reference
DECnet for Macintosh Programmer's Reference

In addition, the following manuals provide information useful to system administrators.

From Digital:

Digital Technical Journal, No. 3, *Terminal Servers on Ethernet*

Local Area Networks
Local Area Transport (LAT) Architecture
Local Area Transport (LAT) Network Concepts

Published by Addison Wesley:

AppleTalk Network System Overview
Inside AppleTalk, Second Edition

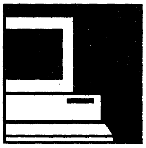
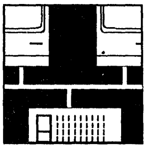
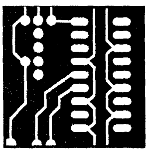
From Apple:

AppleTalk Internet Router Administrator's Guide
AppleTalk Phase 2 Introduction and Upgrade Guide
(packaged with the *Internet Router Administrator's Guide*)
The AppleTalk Phase 2 Protocol Specification
AppleShare File Server Administrator's Guide
AppleShare Print Server Administrator's Guide
LocalTalk Cable System Guide
The Advantages of AppleTalk Phase 2

Conventions Used

Terms that appear in the glossary are indicated in boldfaced type when they are first defined in text.

PATHWORKS for Macintosh Documentation Set

if you are...	*you should read...*	*to learn about...*
Macintosh user		
	■ *Network Services User's Guide*	Installing and using file service, print service, terminal services, and MacX
	■ *MacTerminal User's Guide*	Using the MacTerminal terminal emulation software
	■ *MacX User's Guide*	Using MacX DECwindows display server
	■ *DECnet for Macintosh User's Guide*	Installing, configuring, and using DECnet for Macintosh
VMS system administrator		
	■ *Introduction to the AppleTalk Network System*	AppleTalk network concepts, hardware, and protocols, and about the components of PATHWORKS for Macintosh
	■ *Planning and Installation Guide*	Planning and installing PATHWORKS for Macintosh
	■ *System Administrator's Guide*	Setting up and managing AppleTalk for VMS and VAXshare file and print services
	■ *System Administrator's Reference Manual*	AppleTalk for VMS management and VAXshare management commands
	■ *MacTCP Administrator's Guide*	Administering a MacTCP network, which can be used to access X clients running under ULTRIX
Macintosh or VMS programmer		
	■ *PATHWORKS for Macintosh Programmer's Guide*	Guidelines for programming in the AppleTalk for VMS and AppleTalk/DECnet Transport Gateway environments
	■ *PATHWORKS for Macintosh Programmer's Reference*	Details of application programming interface, AppleTalk ADSP Tool, and AppleTalk-DECnet Connection Tool
	■ *Communications Toolbox Macintosh Reference*	Writing programs that use the Macintosh Communications Toolbox
	■ *Data Access Language Programmer's Reference*	Using Data Access Language, a programming language that provides access to databases
	■ *DECnet for Macintosh Programmer's Reference*	Details of the DECnet application programming interface on the Macintosh

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1 Introduction

This chapter provides an overview of the PATHWORKS for Macintosh product and presents AppleTalk terms and concepts.

Overview of PATHWORKS for Macintosh

PATHWORKS for Macintosh integrates Macintosh personal computers and AppleTalk internets with VMS systems and DECnet networks. An AppleTalk internet is similar to a DECnet network. (See the following section, Overview of AppleTalk Network Terms and Concepts, for a more detailed definition of an internet.)

PATHWORKS for Macintosh consists of the following components:

Connectivity:	AppleTalk for VMS AppleTalk routing over DECnet AppleTalk/DECnet Transport Gateway DECnet for Macintosh LAT MacTCP
Network Services:	VAXShare File Services VAXShare Printer Services
Applications:	MacX MacTerminal (including LAT and CTERM) Mail for Macintosh ALL–IN–1 Mail (X.400)

Development Tools: Application Programming Interface for AppleTalk for VMS
Data Access Language
Macintosh Communications Toolbox (including the AppleTalk-DECnet tool, LAT tool, and VT320 tool)
Transport gateway access routines (session support interface)

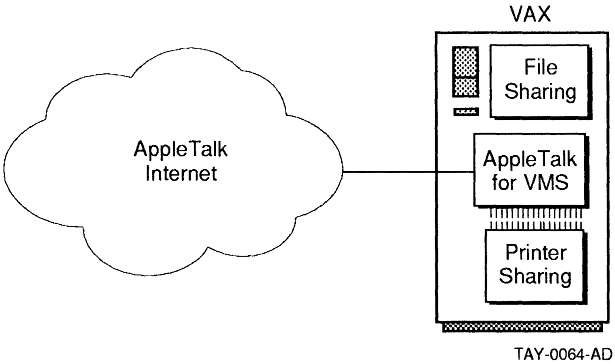
This manual focuses on AppleTalk for VMS, VAXshare, and the transport gateway. See the earlier section, For More Information, for a list of manuals describing the development tools and the applications.

The PATHWORKS for Macintosh product offers several methods by which AppleTalk internets can be integrated with VMS systems. These methods are as follows:

- Using a VMS system as a file and print server
- Integrating AppleTalk and DECnet networks
- Using DECnet links to connect AppleTalk networks

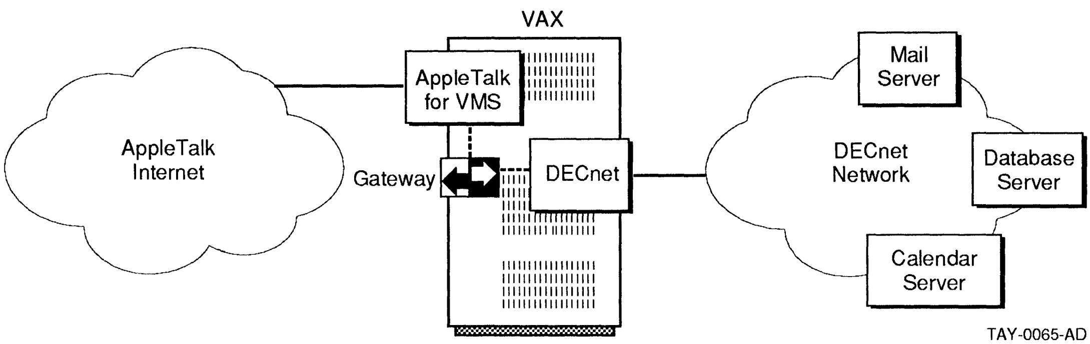
AppleTalk for VMS and VAXshare allow a VMS system to function as a server on an AppleTalk internet. **AppleTalk for VMS** is an implementation of the AppleTalk network protocols for the VMS operating system. (The AppleTalk protocols are described in Chapter 4.) **VAXshare** allows Macintosh users to share **files** and printers with one another and with VMS users. This level of integration is shown in Figure 1–1.

Figure 1–1 A VAX Computer as a Server



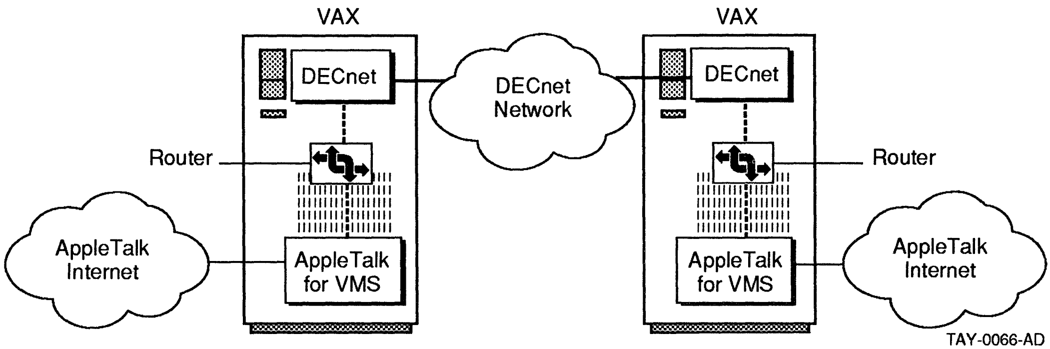
Another aspect of PATHWORKS for Macintosh is the integration of the two network systems, AppleTalk and DECnet. This integration is provided by the **AppleTalk/DECnet Transport Gateway** as shown in Figure 1–2. By linking the AppleTalk Data Stream Protocol (ADSP) to the Network Services Protocol (NSP), the gateway allows a Macintosh to access services over DECnet. Examples include mail services, database services, or calendar services. (See Chapter 3 for more details about the gateway.)

Figure 1–2 A VAX Computer as a Gateway



The third aspect of integration is the use of a **VMS system** to connect AppleTalk networks over long distances, as shown in Figure 1–3. Using a technique called **tunneling**, the AppleTalk packets are sent through a DECnet wide area network (WAN) and delivered to the correct AppleTalk node in the destination network. For tunneling to work, the VMS system must function as an AppleTalk router, meaning that it can move packets from one network to another. (Routing and tunneling are explained in more detail under the heading, Internet Routers, later in this chapter.)

Figure 1–3 DECnet Tunneling Between AppleTalk Internets



PATHWORKS for Macintosh provides an additional connection between Macintosh and VAX computers. The **Local Area Transport (LAT)** protocol, when implemented on a Macintosh, allows the computer to access LAT terminal services.

LAT is an **Ethernet**-based protocol designed by Digital that provides high-speed connections between terminals and hosts. A terminal server on an Ethernet **local area network (LAN)** implements LAT to enable terminals that are connected to the server to establish a session with any host node on the same Ethernet. The host node implements the host side of the LAT protocol. LAT is not part of DECnet.

LAT establishes a single virtual circuit between the terminal server and each host, over which individual sessions are multiplexed. A directory service permits terminal servers to be configured automatically, **receiving information** about hosts as these hosts become available. See the earlier section, For More Information, for a list of references that explain LAT in more detail.

The LAT connection tool in the Macintosh Communications Toolbox allows a Macintosh using LAT to function as a terminal connected to a VAX computer or other host system. The Communications Toolbox is system software, consisting of programs called managers and tools, that perform various networking functions. (The *Network Services User's Guide* describes how to set up and use LAT on a Macintosh.) Typical LAT terminal services might include word processing or accounting applications.

Overview of AppleTalk Network Terms and Concepts

An understanding of the AppleTalk network system in general and of how AppleTalk relates to AppleTalk for VMS in particular can help you to manage a combined Apple and Digital environment. This overview provides a framework for understanding network implementations that might already be on your site or ones that you might want to consider in the future. For example, Macintosh computers connected directly to Ethernet cables use the EtherTalk Link Access Protocol (ELAP). In addition, if some of your users print on LaserWriter printers, they are already using the LocalTalk Link Access Protocol (LLAP). Or perhaps you need to connect some Macintosh computers to a token ring network; the TokenTalk Link Access Protocol (TLAP) is available for that purpose.

This section introduces some of the key concepts of the AppleTalk network system. Figure 1–4 illustrates many of these concepts.

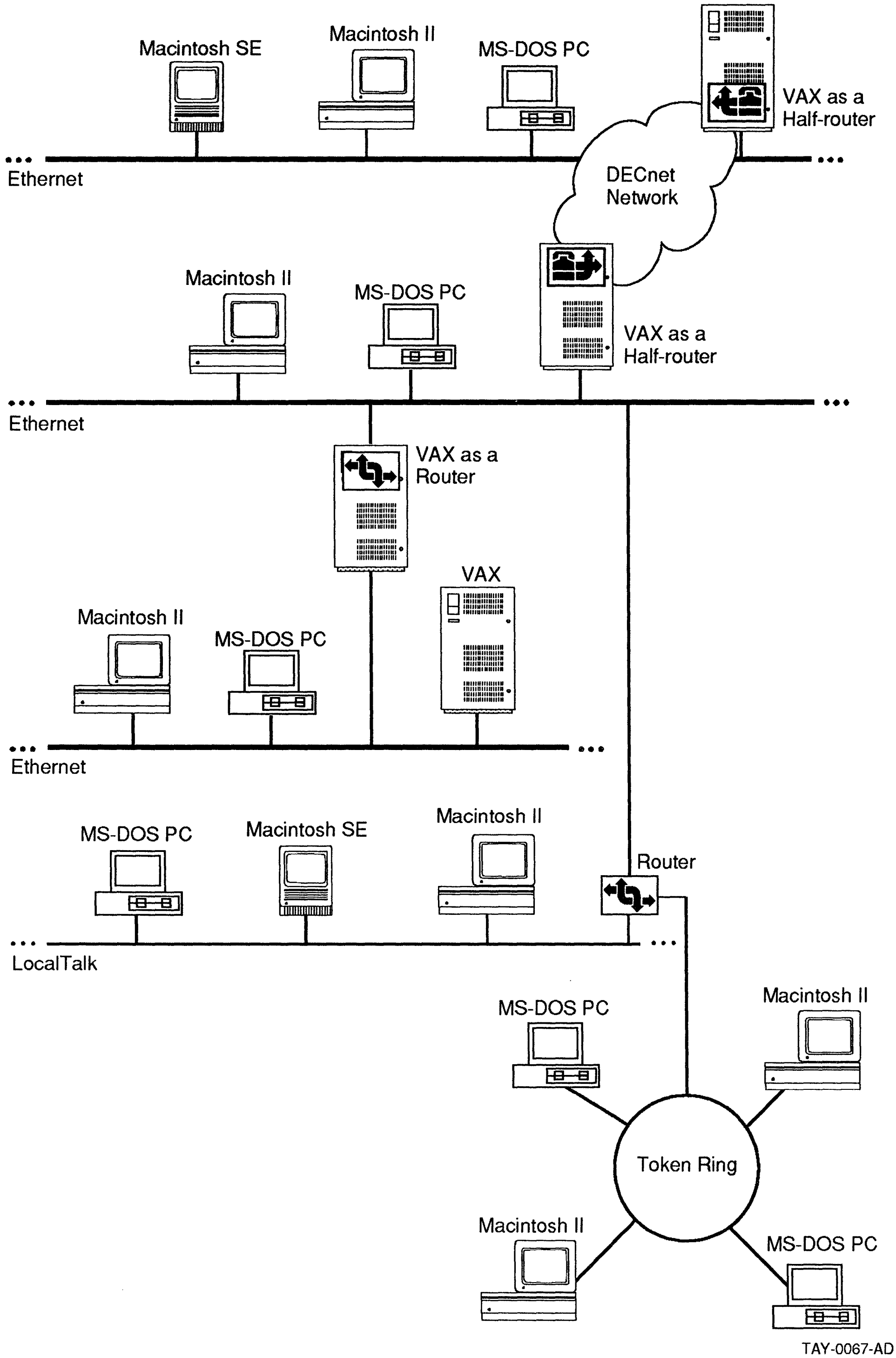
Network

A **network** is a collection of computers, server devices, and connecting devices that are connected through a transmission medium and are capable of communicating with each other.

Examples of transmission media include coaxial cables, optical fibers, and twisted-pair wiring.

In the AppleTalk network system, a network has its own unique identity. This identity is defined by either a single network number or a range of network numbers.

Figure 1–4 Typical Combined Apple and Digital Network Toplogy



The AppleTalk Network System

The AppleTalk network system, like any network system, is a communication environment that makes possible such activities as sharing files and printers, and sending messages. The network devices and software in the system observe a common set of rules for communicating. These rules are called network **protocols**, and they explicitly prescribe each step in the process of interaction between network devices, such as how network devices are identified and how data is formatted for transmission.

AppleTalk protocols are used by a wide variety of different devices and operate over many types of transmission media.

The design of AppleTalk allows you to select the type of transmission media that best suits the needs of your organization, while retaining the AppleTalk services and interface. Every Macintosh computer is equipped with a built-in LocalTalk network connection, which supports the LocalTalk cable system.

Other network connections include EtherTalk, for the higher performance of the Ethernet network standard, and TokenTalk, for connection to a token ring network. These network connections are available through special interface cards in certain Macintosh computers.

Nodes

Each individually addressable device connected to an AppleTalk network, such as a computer or a LaserWriter printer, is a **node**. A Macintosh is a single node on an AppleTalk network whereas a VAX computer may appear as one or more nodes (in contrast to a DECnet network, in which a VAX is only a single node).

Client

A **client** is a software process that makes use of the services of another software process.

Server

Servers are AppleTalk nodes or software processes within an AppleTalk node that provide a service to other nodes (clients) in the network, such as shared access to a file system (file server), shared access to network printers (print server), or storage of messages in a mail system (mail server). For example, PATHWORKS for Macintosh supports Macintosh computers as clients of VAXshare file and printer services.

Internet

An **internet** is any grouping of two or more networks connected by one or more internet routers.

Internet Routers

An **internet router** connects an AppleTalk network to one or more additional AppleTalk networks. A router maintains a logical map of the network and other routers in an internet, enabling the networks to retain separate identities and making it possible for the router to determine the most efficient path for transmitting data between networks.

Routers function at the network layer of the AppleTalk protocol architecture. (See the section Routing Table Maintenance Protocol (RTMP) in Chapter 4 for more information.)

The terms router and bridge have often been used interchangeably in network literature. In contrast to a router, a bridge joins two networks to form one expanded network, not an internet. A bridge operates at the data link layer.

In addition to routing packets in an internet, routers in the AppleTalk network system can connect networks that are of different types, such as LocalTalk and EtherTalk.

Another important use of routers is to isolate traffic on networks. For example, one group of network users performing frequent, high-volume printing tasks might cause network congestion for all other users. A router can separate such a network into two networks that can communicate with each other but are functionally independent—thereby isolating local traffic on each network and improving performance.

A VMS system running AppleTalk for VMS can function as an internet router. It can either be physically connected to two or more networks or it can function as a half router. **Half routers** connect networks over long-distance data communication links (such as telephone lines and modems). Each network is connected to a router, which in turn is connected to the data communications link. Thus, the router at each end serves as a "half router."

A VMS system functions as a half router using a technique called tunneling to route AppleTalk packets through a DECnet wide area network (WAN) to another VMS system. The AppleTalk packets are transmitted through DECnet logical links.

In a combined Apple and Digital environment, such as the one shown in Figure 1–4, VMS systems and Macintosh computers have different routing capabilities. Some of these capabilities are as follows:

- VMS systems can route over multiple DECnet tunnels and over multiple Ethernet networks.
- Macintosh computers can route between multiple Ethernet networks and one or two LocalTalk networks.
- Because VMS systems do not support LocalTalk, a router to a LaserWriter printer must be a Macintosh computer or some third-party router.
- Third-party routers can provide the preceding capabilities as well as other capabilities.

AppleTalk Zones

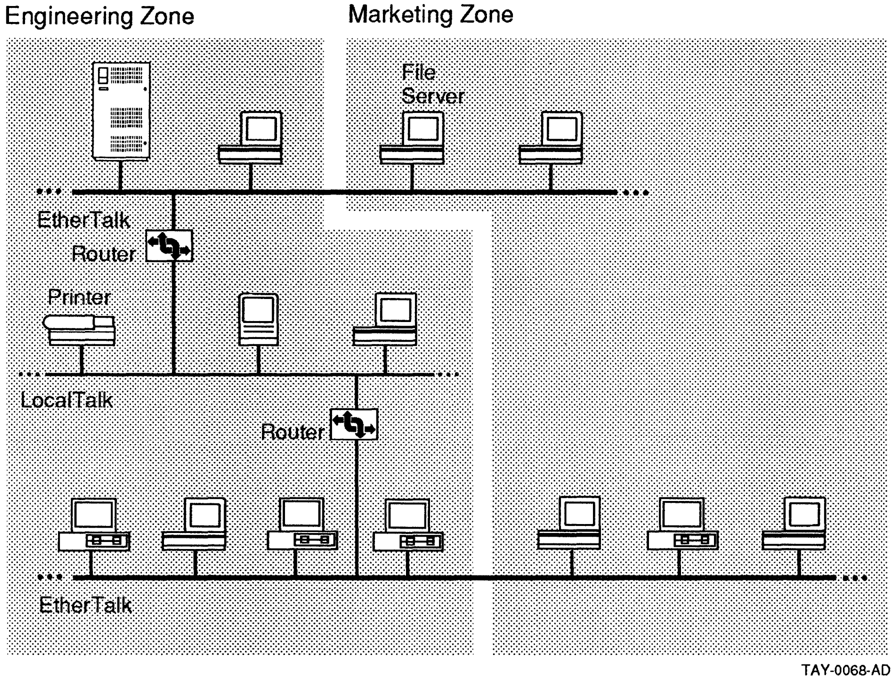
A **zone** in an AppleTalk internet is a means of conceptually grouping devices that makes it easier for users to locate and access network services. AppleTalk zones are created by internet routers (including the AppleTalk for VMS router). They have no physical boundaries. You define zones during the router setup process.

Figure 1–5 shows one zone called Marketing, the other Engineering. In the three networks shown, all nodes on the LocalTalk network belong to the same zone, but the nodes on the EtherTalk networks can belong to any zone that is entered in their network zone list during router setup.

Key points to remember about zones:

- A zone has no physical size or shape; it can include one node, several nodes, or all the nodes on the entire internet.
- Nodes that belong to the same zone do not have to be physically contiguous, on the same network, or even on contiguous networks.
- Any node in a network can belong to any zone whose name appears in that network's zone list.
- A LocalTalk network can be associated with only one zone. All of the network's nodes belong to this zone.

Figure 1–5 Nodes and Zones



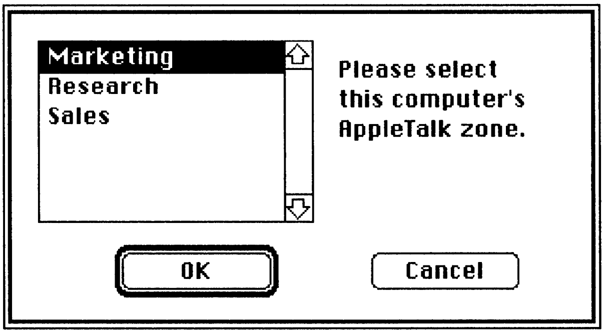
Zone Names and Zone Lists

A **zone name** identifies the zone in various router displays. The zone names also appear in zone lists on network nodes. During the router setup process, you can associate each network connected to the router with one or more zone names.

A node can belong to any zone associated with the node's network. If the node is a VAX computer, the system administrator selects the zone using the AppleTalk for VMS configuration utility, ATK$MANAGER. See the *System Administrator's Guide* for more information. If the node is a Macintosh on an EtherTalk or TokenTalk network, the list of zone names can be accessed through the Macintosh Control Panel, as shown in Figure 1–6.

Unless a node's zone is explicitly selected from this **zone list**, the node belongs to the **default zone** for the network, which is defined by the network administrator during router setup. See the *System Administrator's Guide* for a description of the procedures for setting up the router.

Figure 1–6 Display of Zone List Accessed from the Control Panel



A node can belong to only one zone, but the node's user can view and access **network services**, such as printers and file servers, in all zones. The list of all zones appears in the Macintosh **Chooser** window, as shown in Figure 1–7.

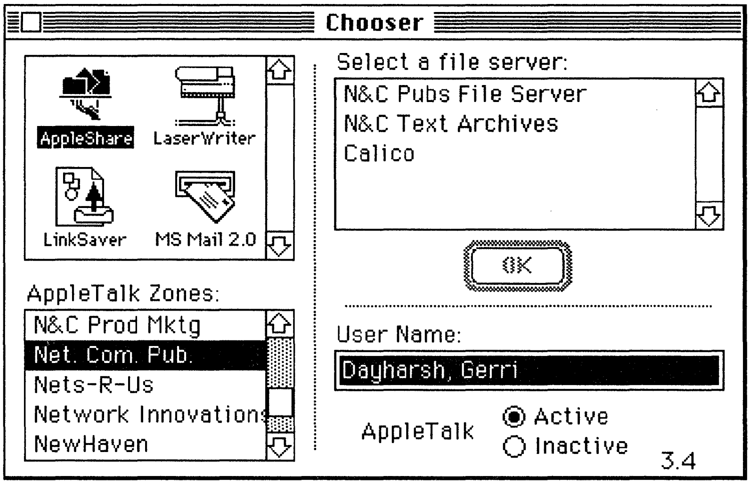
To view or use any service in an AppleTalk internet from a Macintosh, a user first selects a zone from a list shown in the Chooser window and indicates the type of service desired. The user is then presented with a list of all available services of the desired type within the selected zone only, eliminating the need to search through combined listings of all services on the internet.

AppleTalk Addressing

To transmit information, the AppleTalk network system uses an addressing scheme that identifies the sender and destination of the transmission using network and node addresses. An example of such a transmission is a request from a workstation to open a file on a server.

Data is transmitted to and from the source and destination addresses in the form of packets.

Figure 1–7 Display of Zone List in the Chooser Window



Packets

To prepare data for transmission, AppleTalk network software formats the data into **packets**. These packets include the addresses of the source and destination devices.

AppleTalk packets vary in length from a few characters to several hundred characters. A short network transmission might fit into a single packet, but a longer transmission, such as a document file, is usually broken up into multiple packets.

Some of the packets transmitted on a network are not sent by users, but by network software implementing AppleTalk protocols. An example of this is the exchange of network information among routers updating each other's routing tables.

Network Addresses

An AppleTalk network is identified by a **network address** that can be either a **network number** or a range of network numbers. These identifiers are defined by the system administrator during the router setup process.

- A LocalTalk network (or a LocalTalk-compatible network such as Farallon's PhoneNet network) is identified by a single network number, such as 20.

- Any other AppleTalk network is identified by a **network range**, which is a range of contiguous network numbers, such as 1–10. A network number can be any number from 1 to 65,279.

The network number or range must be unique in the internet: No two networks can have the same number, and no two network ranges can overlap or have any network numbers in common.

Each number in a network range is a network address that can be associated with up to 253 nodes. The size of the network range determines the maximum number of AppleTalk nodes on the physical network. For example, a network having the range 1–10 could contain up to 10 x 253 nodes, or 2530 nodes.

Node Addresses

Each node in an AppleTalk internet is identified by a **node address**.

A node address consists of these components:

- Network number
- Node number, known as the **node identifier** (node ID)

On a network identified by a network range, the first part of each node's address—the network number portion—is a number within that network range. For example, the address of a node on a network having the range 1–10 might be network number 1, node 77.

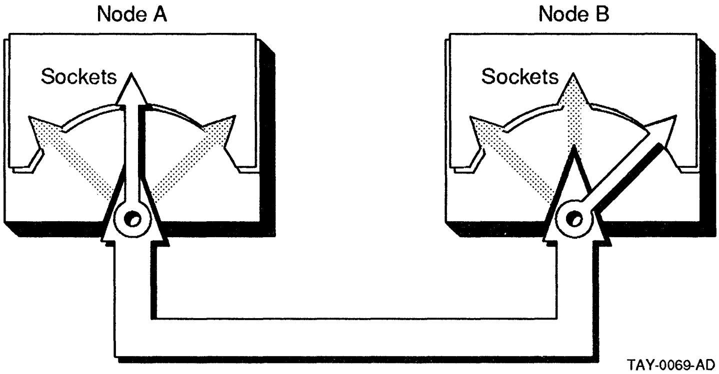
An AppleTalk node automatically acquires a node address when it is started up; the address does not need to be assigned by an administrator or a user. This is called **dynamic addressing**.

Since node addresses are dynamically assigned at startup time, a node may or may not have the same address each time it is turned on. When restarted, a node attempts to reclaim the address it previously used. If, while the node was off, its address was acquired by another node, the first node will acquire a new address.

Sockets

Sockets are logical entities within the nodes connected to an AppleTalk internet. Sockets are owned by socket clients. **Socket clients** are typically processes (or functions in processes) implemented in software in the node. A socket client can send and receive datagrams only through sockets that it owns. Figure 1–8 illustrates the communication between sockets.

Figure 1–8 Sockets Within Nodes



Each socket within a given node is identified by an 8-bit **socket number**. There can be at most 254 different socket numbers in a node.

Seed Routers

When more than one router is connected to an AppleTalk network, the identifying information for that network, such as its network range and zone list, needs to be defined in only one of the connected routers. If the network information is entered in more than one router, all routers must have the same information.

A router in which this identifying information about a network is defined is called a **seed router** for that network. Every network on an internet must have at least one seed router.

A seed router transmits identifying information about the network to all other routers directly connected to that network. A nonseed router is a router in which information about a network is not entered by the system administrator. Nonseed routers acquire network information from seed routers.

Each port on an AppleTalk for VMS router can be a seed or nonseed router. A **port** is a connection between a router and a network.

Hops

A **hop** is a unit count between networks on the internet. A hop signifies "one router away." For example, a network device located on a network separated from your network by three routers would be three hops away. You can define the number of hops between networks during router setup. See the *System Administrator's Guide* for detailed information.

AppleTalk protocols allow a maximum of 15 hops in any single transmission path.

Routing Tables

A **routing table** is a list of all networks in the internet that enables routers to determine the most efficient route for each packet. A routing table is maintained in each AppleTalk router.

The routing table serves as a logical map of the internet, specifying the address of the next router in the path to a given destination network and the distance (in hops) to other networks. The router uses the routing table to determine where and whether to forward a packet.

Each router periodically sends its routing table to other routers on each of its directly connected networks, enabling them to compare and update their own tables with the most recent record of connected networks and routes. In this way, routing tables are kept current as changes are made on the internet.

AppleTalk Phase 1

All of the concepts discussed in this manual pertain to AppleTalk Phase 2. The version of AppleTalk for VMS that is part of PATHWORKS for Macintosh only supports AppleTalk Phase 2, but you may have Phase 1 implementations at your site.

The differences that you need to be aware of are as follows:

- Extended addressing: Phase 2 provides for assignment of a range of network numbers to a single network segment, which allows up to 16 million AppleTalk nodes to be addressed on a single network.

- Zone assignment: Phase 2 allows non-LocalTalk networks to have nodes in different zones. Phase 1 required that all nodes on a particular cable belong to the same zone.

To use PATHWORKS for Macintosh, you must upgrade to AppleTalk Phase 2. The different strategies are as follows:

- Upgrading all routers at once: This works well for small-to-medium internets, in which upgrading can be completed in a short time. It is the simplest and most direct method, but disrupts user services longest. You must turn off all the routers, upgrade each router, and then restart all the routers, beginning with the seed routers.
- Maintaining full internet connectivity: You can incrementally upgrade your internet using an upgrade utility. Upgrade utilities translate the format of Phase 2 routing packets to Phase 1 format, thereby allowing an internet to remain fully operational with both Phase 1 and Phase 2 routers. However, the extended features of Phase 2 cannot be used until the upgrade is complete and all routers on the internet are upgraded to Phase 2.

  Nodes on a network upgraded to EtherTalk version 2.0, which supports only Phase 2, cannot communicate with nodes on EtherTalk networks that have not been upgraded. During the upgrade process, the AppleTalk Upgrade Utility can translate between the two networks, if both versions of the EtherTalk driver are installed in the router. However, using the router as a means of communication impairs network performance.
- Maintaining partial internet connectivity: You can isolate upgraded portions from portions that have not been upgraded. Using this method, you can set up extended addressing, multiple zone networks, and other Phase 2 extensions on routers as soon as they are upgraded. However, internet-wide routing cannot be reestablished until all routers have been upgraded.

2

Appletalk Network System Cabling and Computers

This chapter describes the types of cabling systems and computers that can be used in the AppleTalk network system.

Cabling Systems

An AppleTalk network can be set up using many of the widely available cabling and data-link technologies.

EtherTalk cables provide up to 10 megabits-per-second performance. Twisted-pair LocalTalk cables provide lower cost 230.4 kilobits-per-second bandwidth. In addition, wide-area links such as telephone lines can be used to extend the geographical reach of an AppleTalk network. TokenTalk cabling is available for access to token ring networks.

EtherTalk Cabling

EtherTalk provides high-speed connection of computing devices in the AppleTalk network system. It uses standard Ethernet technology including standard (thick wire) or ThinWire coaxial and twisted-pair cables with data transmission of up to 10 megabits per second. This high-bandwidth medium is desirable for network segments that carry heavy traffic. (See Chapter 4 for more information on EtherTalk.)

An EtherTalk network can support a theoretical maximum of over 16 million node addresses. (However, the maximum number of nodes is smaller than 16 million due to the physical limitations of the network.)

LocalTalk Cabling

The Apple LocalTalk product connects local work groups using inexpensive, easily configurable cabling to link workstations and other computing devices in an AppleTalk network system.

Since the transmitter and receiver hardware for LocalTalk is built into every Macintosh and Apple IIGS computer, LaserWriter printer, and many peripheral devices, setting up the network is a simple process of connecting the devices with appropriate user-installable cables and connectors. LocalTalk hardware is also available for Apple IIe and MS–DOS computers, and for ImageWriter II and ImageWriter LQ printers.

LocalTalk is laid out in a **bus topology**, meaning that conceptually all devices are joined in a line with no circular connections. The physical characteristics of the LocalTalk twisted-pair cable allow it to reliably support a recommended maximum of 32 devices. One LocalTalk network can span up to 300 meters.

The operation of a single LocalTalk network is managed by the LocalTalk Link Access Protocol (LLAP). (See Chapter 4 for more information on LLAP.)

Several third-party vendors have implemented data links based on LLAP but have used different physical media. These include the following media types:

- Twisted pair, telephone cables connected in a star topology with a central hub
- Fiber-optic cables
- Infrared light waves

TokenTalk Cabling

TokenTalk uses shielded twisted-pair cables. It connects to the TokenTalk NB Card, a NuBus communications card installed in a Macintosh II computer. (See Chapter 4 for more information on TokenTalk.)

A TokenTalk network can support a theoretical maximum of over 16 million node addresses. (However, the maximum number of nodes is smaller than 16 million due to the physical limitations of the network.)

Computers in an AppleTalk Network

A variety of computers can participate in the AppleTalk network system.

Macintosh Computers

All Macintosh computers include built-in software and hardware that allows them to connect to an AppleTalk network. The software, which is part of the Macintosh Operating System, consists of the **AppleTalk Manager**, which provides an interface to a set of AppleTalk drivers. These drivers allow programs to send and receive information over an AppleTalk network. The built-in hardware provides access over LocalTalk cables.

VAX Computers

VAX computers connect to an AppleTalk internet using AppleTalk for VMS. Most computer systems represent only a single node on an AppleTalk internet; however, a single VAX can function as one or more nodes. In addition, the same VAX can function as a router.

Apple II Computers

Apple IIGS and Apple IIe computers can gain access to the print and file services of an AppleTalk network by using an AppleShare or AppleShare-compatible file server or print server. LocalTalk hardware is built into the Apple IIGS; the Apple IIe requires the use of a plug-in Apple II Workstation Card.

PCs and Compatibles

IBM PCs and compatibles can connect to an AppleTalk network in several ways.

IBM PCs and compatibles can connect to an AppleTalk network with AppleShare PC software and a LocalTalk PC Card. The card contains firmware to control the link between the AppleTalk network and the PC. The LocalTalk PC driver software implements many of the AppleTalk protocols and interacts with the card to send and receive packets.

In addition, with AppleShare PC 2.0, third-party cards allow PCs to connect directly to TokenTalk or EtherTalk.

PC users can also share file, print, mail, database, and other services with Macintosh users without actually being part of an AppleTalk internet. PATHWORKS for Macintosh, PATHWORKS for DOS, and PATHWORKS for OS/2 are part of Digital's Personal Computer System Architecture (PCSA). They use common services or services that can interconnect.

3

Network Services in the Combined Apple and Digital Environment

The PATHWORKS for Macintosh product includes file and printer services, the AppleTalk/DECnet Transport Gateway, electronic mail, and MacX, which allows interaction with DECwindows. In addition, PATHWORKS for Macintosh includes DECnet for Macintosh, which is documented in the *DECnet for Macintosh User's Guide*.

File and Printer Services

You can access file and printer services in a combined Apple and Digital environment in several ways. You can share files using **AppleShare file service** on a Macintosh computer or using the VAXshare file service on a VMS system. Because VAXshare is based on AppleShare, an understanding of AppleShare is important.

Printers can be accessed by direct network printing, background printing, or spooler/server printing. Both AppleShare and VAXshare support spooler/server printing (discussed in the section, Printing With a Spooler, later in this chapter). VAXshare is described in more detail in the *System Administrator's Guide* and the *System Administrator's Reference Manual*.

AppleShare File Services

Using AppleShare file server software, a Macintosh computer with one or more hard disk drives can become a dedicated **file server** on the network. Each hard disk attached to the AppleShare file server is called a **volume**.

To be able to use an AppleShare file server, a user is registered on the server, given a password, and placed into one or more user groups, as appropriate. Gaining access to the file server involves a log-on process where the server asks for the user's identification. This identification consists of a user name and a password. Once the server has examined its registered user database and validated the user, the selected server volumes' icons, much like a hard disk icon, appear on the user's Macintosh desktop.

The log-on process assures confidentiality; users must be registered and must enter a password before they can gain access to protected portions of server volumes. Unregistered users can log on as guests; that is, they can obtain access to unprotected information if logging on as a guest is allowed by the system administrator.

Within a server volume, files are stored in folders. Folders on a Macintosh computer are analogous to directories on a VMS system. Both folders and directories are named entities that hold files or other folders and directories. You open and save files and create folders on a file server volume the same as on a local disk.

Each AppleShare **folder** has an owner, who determines which users may have what type of access to the folder. A folder can be kept private, shared by a group of users, or shared by all network users. The user information placed in the server's user database allows the server to determine a user's access privileges when the user tries to access the contents of a folder.

It is important to note that the folders, not files, have access privileges associated with them.

The **access privileges** for a folder or volume let the owner, the group, or guests see folders, see files, and make changes inside the folder. Users can select folders and view their access privileges for those folders. In addition, a folder's owner can examine and change the access privilege information, which includes the owner's name, the folder's associated group, the owner's privileges, group privileges, and guest privileges. The owner can transfer the folder's ownership to another user.

The dialog between a user's computer and an AppleShare file server is conducted using the **AppleTalk Filing Protocol (AFP)**. See Chapter 4 for detailed information on AFP. AFP calls provide services for managing a shared desktop view of the file server's volumes. Changes made by the user of one Macintosh computer are automatically reflected on the desktop of any other Macintosh computer user viewing the same folder or volume.

AppleShare file servers can be accessed by different types of client computers. Using additional software available from Apple, PC-compatible and Apple IIGS computers can also connect as clients to AppleShare file servers.

VAXshare File Services

VAXshare is Digital's implementation of the AFP file service, and it is compatible with AppleShare file service. VMS files look like Macintosh files to the Macintosh user. In addition, VMS and Macintosh users and applications can share the same folders and files.

VAXshare offers the full range of file operations, such as reading, writing, and deleting files. VAXshare also provides file and byte-range locking for file sharing between systems, as well as access control and full integration with the Macintosh user interface.

VAXshare offers full VMS file system security. AppleShare log-on sequences use the VMS user name and password, and file access is granted in accordance with VMS access restrictions.

Macintosh and VMS users and applications can share data, because the Macintosh **hierarchical file system (HFS)** is mapped to the VMS file structure, allowing VMS and Macintosh users and applications to access the same files. VMS and Macintosh users and applications can also share the same directory (volume or folder). For example, users can access VMS login directories as Macintosh folders. See the *System Administrator's Guide* for more information about file sharing.

The Macintosh user gains access to a VAXshare file server by selecting an AppleShare server with the Chooser and logging on with a user name and password. The user name and password are the same as the user's VMS account. Additionally, VAXshare allows you to assign passwords to volumes.

From the Macintosh, the user or application can create, access, and manipulate files just as the user would with any other AppleShare server. VAXshare and the AppleShare workstation software ensure that the Macintosh file integrity and desktop environment is maintained. Macintosh applications that want to manipulate shared data can use file and byte-range locking to synchronize simultaneous data access in the same way as with AppleShare.

VMS users and applications can access Macintosh files as files on a VAX computer. The VMS user or application can create new directories or files. The first time that a Macintosh accesses the file or directory, the file server automatically creates the necessary auxiliary files to implement the Macintosh view of the file.

AppleTalk Printer Services

Several different hardware and software configurations enable you to print on an AppleTalk network. AppleTalk networks support both direct printing and printing with a spooler. AppleShare printing is an example of printing with a **spooler/server**.

Direct Network Printing **Direct network printing** occurs when a workstation sends a print job directly to a printer connected to the network system.

When a user issues a command to print a document, the application begins a series of AppleTalk calls attempting to establish a connection to the printer. Once the connection is established, the PostScript commands are sent to the printer and the document is printed.

Although PATHWORKS for Macintosh supports only PostScript printers, you may have Apple ImageWriter printers at your site. The ImageWriter II and ImageWriter LQ are dot-matrix printers that can be used to print either draft-quality or high-quality documents. These printers are generally used for printing from Macintosh computers.

Printing With a Spooler A **print spooler** is a hardware or software application that interacts with a printer to print documents. When a computer sends a file to be printed, the print spooler intercepts the file and manages all printer interaction, freeing the computer for other tasks. Two types of spooler implementations are used with AppleTalk:

- Background spooler
- Spooler/server

A **background spooler** is a software application that operates in the user's computer as a background process and spools print jobs to the user's local disk. An example of an application that allows background printing is the PrintMonitor application included with the Macintosh MultiFinder. This is similar to the print spooling function on a VAX computer.

A spooler/server is an application that runs on a computer that is set up to be a print spooler and is connected to the AppleTalk network system. A spooler/server works by setting itself up as a surrogate printer; that is, when the computer receives a print command, it recognizes the spooler/server as a printer. When the user gives a print command, the user's computer produces the print data and sends it to the spooler/server. Since the spooler/server stores the print data on its hard disk, it is able to quickly accept this information from the user's computer, which is freed for other use. The spooler/server then takes charge of the more time-consuming task of getting the data processed by the printer.

Printers accept only one job, or connection, at a time. Spooler/servers can accept several connections at a time, thereby minimizing the problems that occur when several workstations send print commands simultaneously. AppleShare includes a spooler/server for printing on Apple printers.

VAXshare Printer Services

VAXshare printer services consist of the following components:

- A VAXshare print spooler that is compatible with the AppleShare print server. It receives a print stream from AppleTalk, writes it to a VMS file, and submits a print request to the VMS print job controller.
- LaserPrep-compatible PostScript dictionaries for Digital PostScript printers.
- A print **symbiont** that allows VMS users (and the VAXshare print spooler) to print on AppleTalk LaserWriter printers that are connected to an AppleTalk network or that are serially connected to the VMS system.

VAXshare printer services provide the following printing capabilities:

- Macintosh users can print files on Digital high-speed, high-resolution printers accessible from a VAX computer. These users can use the VMS Distributed Queuing Service to access printers on other VMS nodes. The Digital printers include the PrintServer 20 (LPS20), the PrintServer 40 (LPS40), the PrintServer 40 Plus, and the LN03R ScriptPrinter.

- Macintosh users can use VMS queuing services to spool output for LaserWriter printers that are connected to an AppleTalk network or connected serially.
- VMS users can print files on LaserWriter printers connected to the AppleTalk network or connected serially.

Because VAXshare is compatible with the AppleShare print server, Macintosh users and applications select and print to Digital printers in the same way that they select LaserWriter printers connected to an AppleTalk network. Digital printers and LaserWriter printers connected to a VMS system appear on the Macintosh Chooser menu as additional printers on the AppleTalk network.

VMS users and applications access LaserWriter print queues in the same way that they access other VMS print queues, by using VMS system services utilities and the DCL PRINT command.

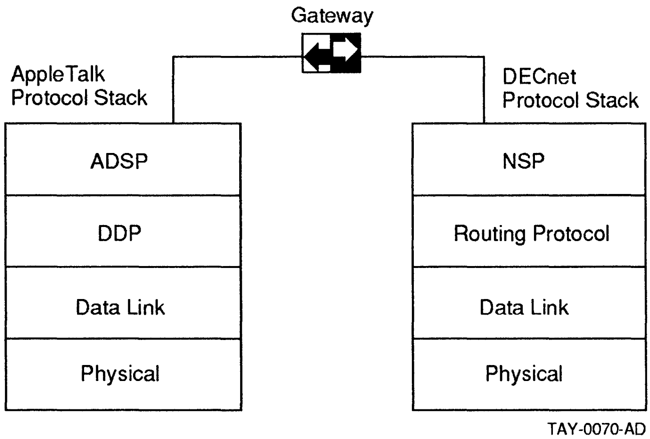
AppleTalk/DECnet Transport Gateway

The AppleTalk/DECnet Transport Gateway is VMS software that offers reliable, high-performance connections between AppleTalk and DECnet networks. The gateway is a bidirectional transport relay, meaning that it moves data in both directions at the transport level. The gateway provides end-to-end session links between clients or servers communicating with entities in the other network.

Through the gateway, Macintosh applications can use the AppleTalk Data Stream Protocol (ADSP) to communicate with applications that use Digital's Network Services Protocol (NSP). From a Macintosh computer, the gateway appears as any other service on the AppleTalk internet. In fact, the gateway registers its name on the internet in much the same way that AppleShare servers or LaserWriter printers register their names. Likewise, DECnet applications can use NSP to communicate with AppleTalk-based applications that use ADSP. (See the *System Administrator's Guide*, the *Programmer's Guide*, and the *Programmer's Reference* for more information about the gateway.)

Figure 3–1 provides an illustration of the communicating protocols used by the gateway.

Figure 3–1 The AppleTalk/DECnet Transport Gateway



Electronic Mail

PATHWORKS for Macintosh includes a VMS Mail server and a Macintosh client application, which together allow access to Digital's VMS Mail system. You can access the VMS Mail server from Macintosh computers and from MS–DOS computers. The server performs all the typical VMS Mail operations, such as reading, replying, forwarding, editing, and sending mail, as well as creating folders in mail and creating files from mail messages (extracting).

The Macintosh client application, which is based on the Communications Toolbox, uses the mail server to allow Macintosh users access to their VMS mail messages. This client application permits local editing of messages.

MacX and X Window System

Apple and Digital support the industry-standard X Window System (X), Version 11 (X11), developed by the Massachusetts Institute of Technology (MIT). X11 is a set of software components that lets you build applications with distributed, graphics-based, and hardware-independent interfaces. All major desktop platforms can access applications written to the X11 standard.

Unlike most windowing systems, X11 offers network transparency. That is, the user interacts with an application in the same way, whether the application runs on a local personal computer or on a computer across the network.

The X server, which runs on the computer comprising the user's keyboard and screen, provides low-level graphics, windowing, and user-input functions. Clients communicate with an X server through the network or "wire" protocol, also known as the X protocol. The X protocol can be exchanged between clients and server over different transport protocols such as those of AppleTalk, DECnet, or TCP/IP.

Notice that the X client resides on the host computer, while the X server resides on the workstation.

MacX is Apple's implementation of X. It consists of an X server running under the Macintosh Operating System. Through this server, you can interact with X client applications running on remote hosts, such as DECwindows on VMS systems. Digital's DECwindows software is an implementation and extension of X11 running under VMS.

See the *MacX User's Guide* for more information on MacX, and the appropriate manuals from Digital for more information on DECwindows.

4

AppleTalk Protocol Architecture

AppleTalk and DECnet are both layered architectures, as shown in Figures 4–1 and 4–2. A network protocol at one layer is a client of the services provided by protocols at lower layers. For a complete specification of the AppleTalk protocols, see *Inside AppleTalk, Second Edition*; the DECnet protocols are described in the *Guide to DECnet-VAX Networking* and the *VMS Networking Manual.*

This chapter provides an overview of the AppleTalk protocols.

Physical and Data Link Protocols

This section discusses the protocols at the two lowest layers of the AppleTalk protocol architecture. The **EtherTalk Link Access Protocol (ELAP)**, **LocalTalk Link Access Protocol (LLAP)**, and **TokenTalk Link Access Protocol (TLAP)** provide connections to Ethernet, LocalTalk, and token ring networks, respectively. ELAP and TLAP use the AppleTalk Address Resolution Protocol (AARP) to translate between the node address and the particular data link.

Figure 4–1 DECnet Protocols

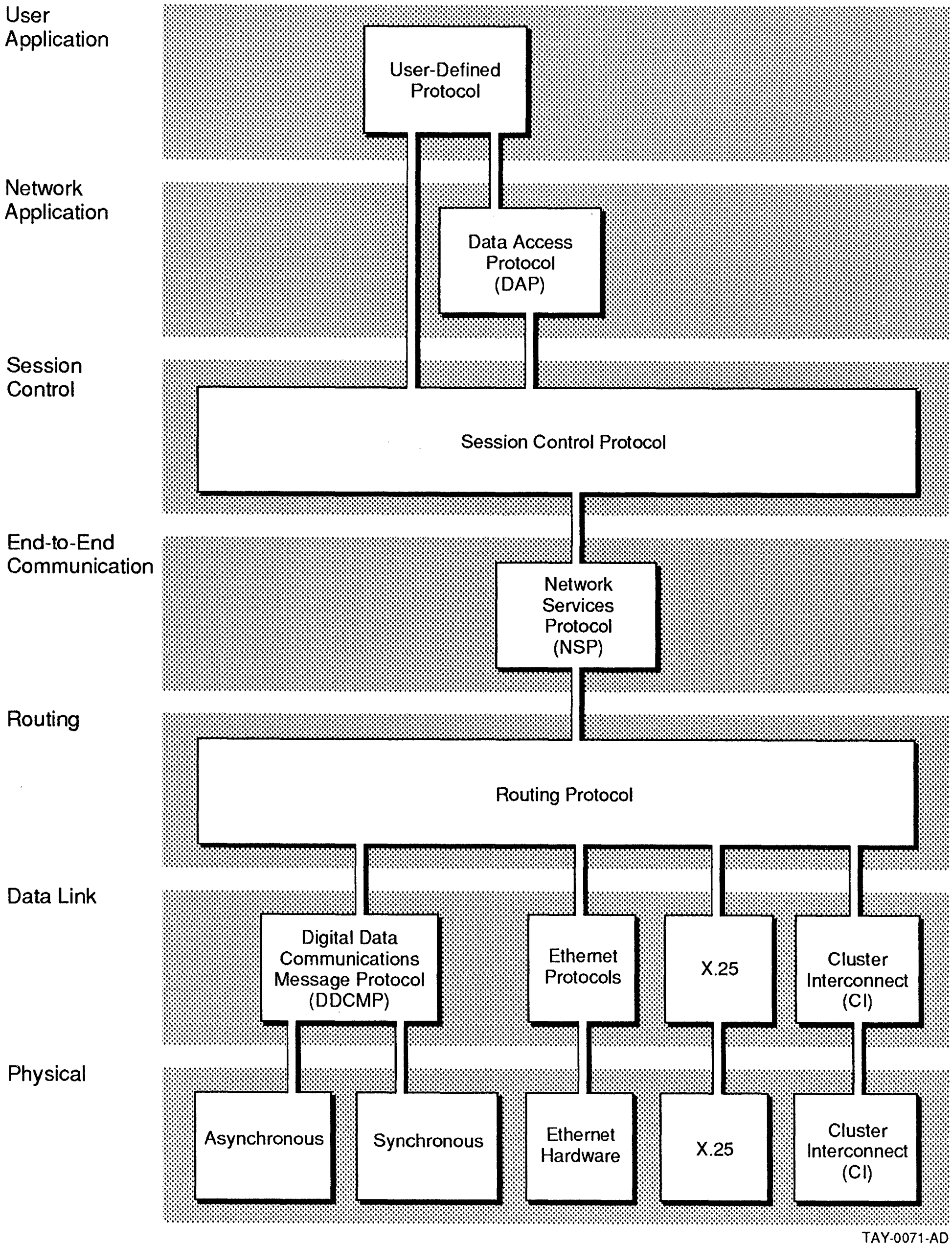
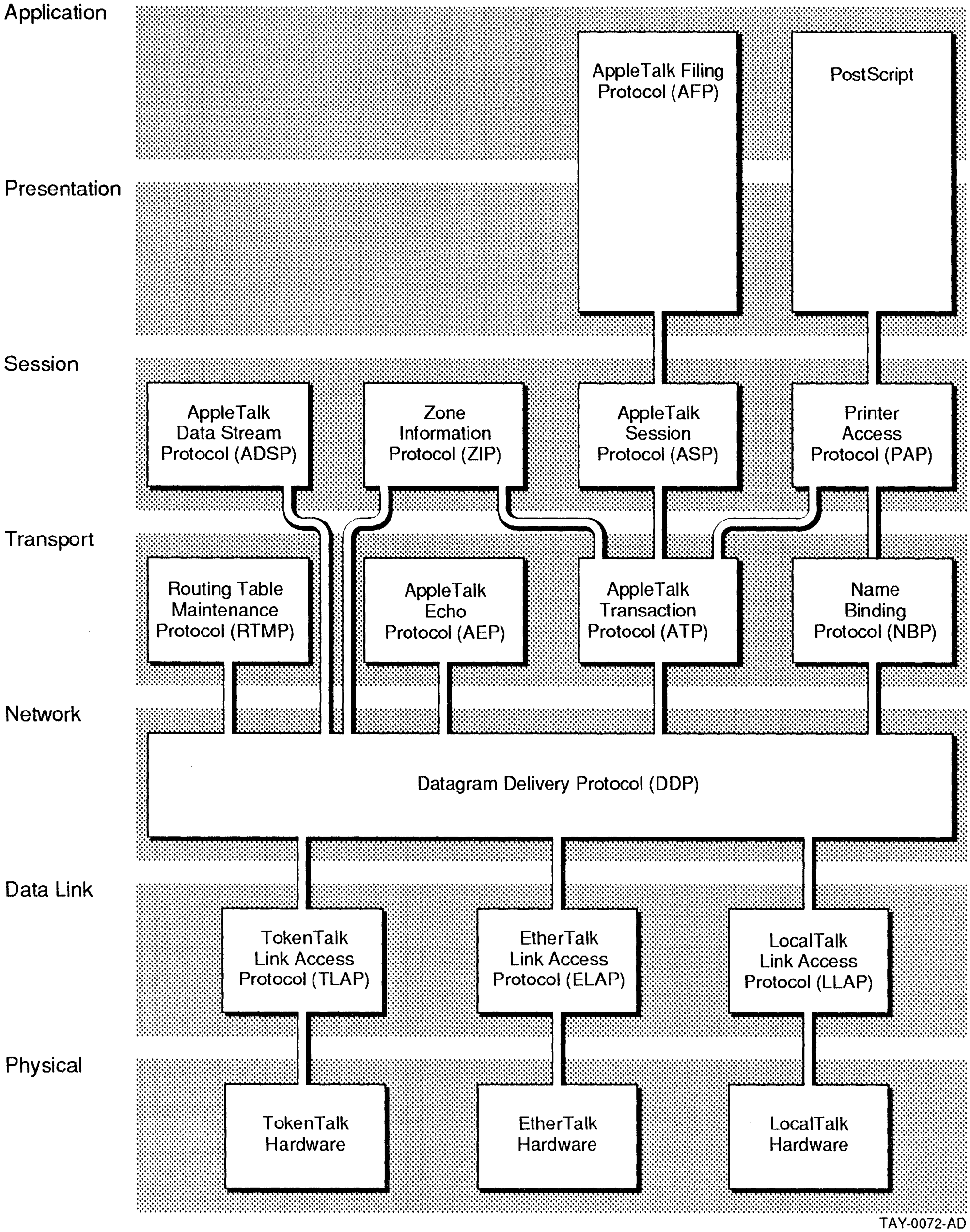


Figure 4–2 AppleTalk Protocols



EtherTalk Link Access Protocol (ELAP)

EtherTalk was developed by Apple as an extension of the Ethernet data link. The extension allows the use of an Ethernet data link and cabling in the AppleTalk network. The extended data-link protocol used by EtherTalk is called the EtherTalk Link Access Protocol (ELAP).

In the case of EtherTalk, the AppleTalk network system uses the Institute of Electrical and Electronic Engineers (IEEE) 802.2 standard Ethernet communication as the underlying data link. Ethernet uses 48-bit hardware addresses to identify the network nodes. The **hardware address** is the unique node address that is determined by the physical and data link layers of the network. Consequently, the EtherTalk product must translate the 24-bit AppleTalk **protocol address** into the 48-bit Ethernet hardware address before the packet can be transmitted to its destination node.

ELAP uses the AppleTalk Address Resolution Protocol (AARP) to do this translation. When the AppleTalk **protocol stack** is initialized, ELAP also uses AARP to acquire the node's 24-bit AppleTalk data link address. AARP is described later in this chapter.

LocalTalk Link Access Protocol (LLAP)

The LocalTalk Link Access Protocol (LLAP) allows network devices to share the communication medium. This protocol provides the basic service of packet transmission between the nodes of a single LocalTalk or compatible network.

LLAP encapsulates data in an LLAP data packet. The encapsulation inserts a destination node address into the packet, allowing LLAP to deliver the data packet to its destination node. The sending node's address is also inserted into the packet before delivery to the data's recipient.

Furthermore, LLAP ensures that any packets damaged in transit are discarded and not delivered to their destination node. In that situation, however, LLAP itself makes no effort to ensure delivery of the packet. It provides a best-effort delivery.

The primary responsibilities of LLAP are as follows:

- Provide link access control (using **Carrier Sense Multiple Access with Collision Avoidance [CSMA/CA]**)
- Provide a way to assign node addresses (using dynamic node ID assignment)

- Perform data transmission and reception (using control packets, which are used for internal protocol control purposes, and data packets, which include data provided by LLAP's client)

TokenTalk Link Access Protocol (TLAP)

TokenTalk uses AppleTalk protocols within a token ring environment, which yields a high-performance AppleTalk network. A **token ring network** is both a topology and a protocol defined by the IEEE 802 committee. The topology is a ring and the protocol is token-passing. The actual token ring access method, or how to interface with the physical media, is defined in the IEEE 802.5 standard. On a Macintosh computer, physical access to the token ring network is provided by the TokenTalk NB Card itself, as are the 802.2 logical link control functions.

The token ring network interface adheres to the **International Standards Organization Open System Interconnection (ISO–OSI)** reference model. The 802.2 Logical Link Control (LLC) interface provided for the TokenTalk NB Card corresponds to the ISO–OSI model.

AppleTalk Address Resolution Protocol (AARP)

The **AppleTalk Address Resolution Protocol (AARP)** makes a correlation (called a mapping) between any two sets of addresses at any protocol level. Specifically, in the AppleTalk protocol architecture, AARP is used to map between AppleTalk node addresses and the addresses of the underlying data link. AARP makes it possible for AppleTalk systems to run on any data link.

An AARP implementation has as its clients the various protocol stacks in a given node. AARP uses the node's data link to perform these tasks:

- Translate a protocol address into a hardware address

  Given a protocol address for a particular protocol family, AARP determines the hardware address of the node that is currently using that protocol address.

  To accomplish this translation, each node stores a cache of mappings between the various protocol addresses and the corresponding hardware addresses. This cache is called the **Address Mapping Table (AMT)**. When AARP needs to find an address, it starts by looking in the AMT for the appropriate mapping. In the event that the necessary mapping is not found in the AMT, then AARP queries all the nodes on the data link for the desired mapping.

- Determine the node's protocol address

  AARP dynamically assigns a protocol address to a stack in the node. AARP ensures that this address is unique among all nodes on the network of that protocol family.

- Filter incoming packets

  AARP interposes itself in the packet reception path between the data link and each protocol stack. For all data packets received by the node, AARP verifies that the packet's destination protocol address is equal to either the node's protocol address or the broadcast protocol address for that protocol family. Otherwise, AARP discards the packet.

Network Layer and Routing (End-to-End Data Flow Protocols)

This section describes the protocols that facilitate transmission of data across an internet. Routers forward packets by using an address extension provided by the Datagram Delivery Protocol (DDP). Additionally, routers use routing tables, which are maintained by the **Routing Table Maintenance Protocol (RTMP)**.

The **AppleTalk Echo Protocol (AEP)** provides the ability to measure round-trip travel times between any two nodes.

Datagram Delivery Protocol (DDP)

The **Datagram Delivery Protocol (DDP)** is the network-layer protocol that is responsible for the socket-to-socket delivery of datagrams over an AppleTalk internet. It provides the address extension, known as a network number, that is required by routers.

Since DDP is a simple, best-effort protocol for internet-wide, socket-to-socket delivery of datagrams, it does not provide a mechanism for recovery from packet loss or error situations.

The primary function of the DDP module is to form the DDP header on the basis of the destination address, determine the datagram's address on the directly connected network, and then to pass the datagram to the appropriate data link. Similarly, for datagrams received from the data-link layer, DDP must examine the datagram's destination address in the DDP header and route the datagram accordingly.

To route datagrams, DDP uses internet socket addresses. Each of these addresses consists of a 16-bit network number, an 8-bit node ID, and an 8-bit socket number.

Routing Table Maintenance Protocol (RTMP)

Internet routers (IR) use the Routing Table Maintenance Protocol (RTMP) to establish and maintain the routing tables that are central to the process of forwarding datagrams from any source socket to any destination socket on an internet.

Internet Topologies RTMP allows internets to consist of AppleTalk networks interconnected through routers in any arbitrary topology. A limitation imposed on an AppleTalk internet is that for each router, no two of its ports can be on the same network. Nodes on any network can only communicate with nodes on networks that are 15 or fewer hops away (by the shortest path).

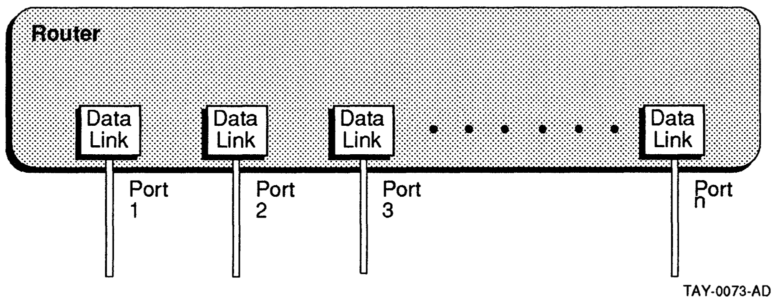
Routing Tables All routers maintain complete routing tables that allow them to determine how to forward a datagram on the basis of its destination network number. Routers use RTMP to exchange their routing tables periodically. In this process, a router receiving the routing table of another router compares and updates its own table to record the shortest path for each destination network. This exchange allows the routers to respond to changes in the connectivity of the internet (for example, when a router goes down or when a new router is installed).

A routing table that has stabilized to all changes consists of one entry for each reachable network in the internet. Each entry provides the number of the port through which packets for that network must be forwarded by the router, the node ID of the next IR to which the packet must be sent, and a measure of the distance to the destination network. The entry in the routing table corresponds to the shortest path known to that router for the corresponding destination network.

The distance to a network is measured in terms of hops, with each hop representing one IR that the packet traverses in its path from the current router to the destination network. The distance corresponding to a network to which the router is directly connected is always 0.

It is a requirement that the routers on a particular network not have conflicting network numbers for that network. See Figure 4–3 for an illustration of the relationship of ports and data links in a router.

Figure 4–3 A Router Model



AppleTalk Echo Protocol (AEP)

The AppleTalk Echo Protocol (AEP) is implemented in each node as a process on a socket known as the Echoer socket. The Echoer listens for packets received through this socket. Whenever a packet is received, the Echoer examines its Datagram Delivery Protocol (DDP) type and the DDP data length in the packet to determine if the packet is an AEP packet. If it is, then a copy of the packet is returned to the sender.

AEP can be used in the following ways:

- By any DDP client to determine whether a particular node, known to have an Echoer, is accessible over an internet.
- To obtain an estimate of the round-trip time for a typical packet to reach a particular remote node. (This time estimate is useful for various network management functions and for setting retry timers in transport-level and session-level protocols.)

Named Entity Protocols

This section describes the protocols that convert network entity names to addresses.

Name Binding Protocol (NBP)

AppleTalk protocols rely on numeric identifiers, such as node IDs, socket numbers, and network numbers, to provide the addressing capability essential for communication over the network. However, numbers are sometimes hard for users to memorize and are easily confused and misused. For network users, names are a more familiar form of identification. If an entity is referred to by name, the name must be converted into a network address for use by the other protocols. The **Name Binding Protocol (NBP)** performs the conversion of entity names into addresses.

Since an AppleTalk network dynamically assigns a node's ID at node start-up time, network applications cannot use permanently configured (hard-coded) network addresses. The name binding approach provides a way of translating names, which change infrequently, into addresses, which can change every time a node restarts.

To perform name-binding, NBP uses entity names in names tables and names directories.

Entity names apply to **network-visible entities (NVE)**. An NVE is any entity that is accessible over an AppleTalk network system through the Datagram Delivery Protocol (DDP). Thus, the socket clients, not the nodes, on an internet are its NVEs. For example, users of the network system are not network-visible. But a user can have an electronic mailbox on a mail server. This mailbox is network-visible and has a network address. Although the network does not provide protocols for conversing directly with the individual user, the protocols communicate with applications and services to which the user has access.

An NVE can assign itself a name, called an entity name, although not all NVEs need to have names. Entity names are character strings. A particular entity could, in fact, possess several names (aliases).

An entity name is a character string consisting of three fields—object, type, and zone—in this order with a colon (:) and at-sign (@) separators; for example, ThirdFloor:LaserWriter@Engineering. Each field is a string of a maximum of 32 characters.

Each node maintains a **names table** that contains name-to-entity internet socket address mappings of all entities in that node. The **names directory** (ND) is a distributed database of name-to-address mappings; it is the combination of the individual names tables in the nodes of the internet.

Name binding is accomplished by using NBP to look up the entity's address in the names directory.

Zone Information Protocol (ZIP)

The **Zone Information Protocol (ZIP)** is the AppleTalk session-layer protocol that is used to discover and maintain the internet-wide mapping of network numbers to zone names. ZIP is used by NBP to determine which networks belong to a zone.

An important feature of ZIP is that most of its services are transparent to nonrouter nodes. In fact, a nonrouter node does not need to implement a ZIP process unless it needs to be aware of the details of the internet's zone structure. Nonrouter nodes that need this information implement a small subset of ZIP. But routers are the primary users of ZIP. ZIP provides the following two major services:

- Maintains the mapping of network number to zone name in the internet
- Supports various commands that may be needed by nonrouter nodes for obtaining and possibly changing this mapping

The first of these services applies only to routers; the second applies to both router and nonrouter nodes.

Reliable Data Delivery Protocols

This section discusses the protocols that add reliability to AppleTalk end-to-end data delivery. The AppleTalk Data Stream Protocol (ADSP) is based on the data steam model of reliable data flow. The AppleTalk Transaction Protocol (ATP), Printer Access Protocol (PAP), and AppleTalk Session Protocol (ASP) are based on the data transaction model.

AppleTalk Data Stream Protocol (ADSP)

The **AppleTalk Data Stream Protocol (ADSP)** is a symmetric, connection-oriented protocol that makes possible the establishment and maintenance of full-duplex streams of data bytes between two sockets in an AppleTalk internet. Data flow on an ADSP connection is reliable; ADSP guarantees that data bytes are delivered in the same order as they were sent and that they are free of duplicates. In addition, ADSP includes a flow-control mechanism that uses information supplied by the intended destination. These features are implemented by using sequence numbers logically associated with the data bytes.

Using ADSP, the client can open a connection with a remote end, send data to and receive data from the remote end, and close the connection.

The client can either send a continuous stream of data or logically break the data into messages that can be understood by the remote end client. ADSP also provides an attention message mechanism that the client can use for its own internal control. A forward-reset mechanism allows the client to abort the delivery of an outstanding stream of bytes to the remote client

AppleTalk Transaction Protocol (ATP)

The **AppleTalk Transaction Protocol (ATP)** satisfies the transport needs of a large variety of peripheral devices, as well as needs of network applications and services that benefit from a transaction-oriented protocol. ATP is designed for easy implementation and maximum performance. Furthermore, nodes with limited memory space are able to support a sufficient subset of ATP.

Often, a socket client must request the client of another socket to perform a particular high-level function and then to report the outcome. This interaction between a requester and a responder is called a **transaction**.

The basic structure of a transaction in the context of an AppleTalk network requires that the requester initiate the transaction by sending a Transaction Request packet from the requester's socket to the responder's socket. The responder executes the request and returns a Transaction Response packet reporting the transaction's outcome. ATP binds the request and response together to ensure the reliable exchange of request-response pairs.

An ATP transaction takes one of two forms:

- An **at-least-once (ALO) transaction** is an ATP transaction wherein the request is executed every time it is received, thereby assuring that it is executed at least one time.
- An **exactly-once (XO) transaction** is an ATP transaction wherein the request is delivered for execution only one time, even if it is received more than once.

Printer Access Protocol (PAP)

The AppleTalk **Printer Access Protocol (PAP)** is a session-level protocol that enables communication between clients and servers. It is a connection-oriented protocol, which handles the following processes:

- Connection setup
- Connection maintenance

- Connection closure
- Data transfer over the connection

To understand how PAP works, you can envision a server node as containing one or more processes that are accessible to clients through PAP. In this discussion, these processes are referred to as servers. A server makes itself visible over the network by opening a **session-listening socket** on which it registers its name.

The word printer in the name of this protocol is purely historical. The protocol was originally designed for communication with print servers, such as the Apple LaserWriter and ImageWriter printers. However, the protocol has no special features for printing and can be used by other kinds of servers.

AppleTalk Session Protocol (ASP)

The **AppleTalk Session Protocol (ASP)** uses the services of ATP to provide session establishment, maintenance, and teardown, along with request sequencing.

A **session** is a logical relationship (connection) between two network entities; it is identified by a unique session identifier. The concept of a session is central to ASP. Two network entities, one in a client and the other in a server, can set up an ASP session between themselves. For the duration of the session, the client entity can (through ASP) send a sequence of commands to the server entity. ASP ensures that the commands are delivered without duplication in the same order as they were sent and conveys the results of these commands (known as a command reply or reply) back to the client entity.

ASP sessions are inherently asymmetrical. The process of setting up a session is always initiated by the client entity (when it wishes to use the server entity's advertised service). Once the session is established, the client entity sends commands, and the server entity replies to the commands. Servers cannot send commands to clients. However, ASP provides an attention mechanism by which the server can inform the client of a need for attention.

More than one client can establish a session with the same server at the same time. ASP uses the session identifier (session ID) to distinguish between commands received during these various sessions. The session ID is unique among all the sessions established with the same server.

ASP and PAP are similar in several ways. However, ASP is much more asymmetrical than PAP. In PAP, only the connection-opening sequence is asymmetrical while the rest of the exchange is symmetrical.

User Services: AppleTalk Filing Protocol (AFP)

The AppleTalk Filing Protocol (AFP) is a presentation-layer protocol that allows users to share files and application programs that reside on a file server.

Sharing files across a network requires that the user's application know where and how to find a file. A program running on a workstation (the workstation client or AFP client) requests and manipulates files by using the workstation's **native file system commands**. These commands work with files on a disk that is physically connected to the workstation (a local resource).

Through AFP, a workstation program can use the same native file system commands to manipulate files on a shared disk that resides on a different node (a remote resource). The analogy with VMS is that the hierarchical file system (HFS), the Macintosh filing system, understands AFP just as the Record Management System (RMS), the VMS filing system, understands DECnet.

A workstation program sends a file system command through the **Native Filing Interface (NFI)** in the workstation. A data structure in local memory indicates whether the volume is managed by the native file system or by some external file system. The native file system discovers whether the requested file resides locally or remotely by looking at this data structure. If the data structure indicates an external file system, the native file system then routes the command to the AFP translator.

The **AFP translator**, as its name implies, translates the native commands into AFP calls and sends them through the **AppleTalk Filing Interface (AFI)** to the file server that manages the remote resource.

The AFP specification defines the AFI part of the file access model. The translator is not defined in the AFP specification; it is up to the application programmer to design it.

Three system components make up AFP:

- File system structure
- AFP calls
- Algorithms associated with the calls

The first component, the AFP file system structure, is made up of resources (such as file servers, volumes, directories, files, and forks) that are addressable through the network.

AFP calls, the second component, are the commands that the workstation uses to manipulate the AFP file system structure. As mentioned earlier, the translator sends file system commands to the file server in the form of AFP calls, or the workstation application can make AFP calls directly.

The third software component of AFP is the set of algorithms associated with AFP calls. These algorithms specify the actions performed by the calls.

AFP is designed to take into account different file systems, among which are RMS, HFS, UNIX, MS–DOS, and ProDOS.

Glossary

AARP

See AppleTalk Address Resolution Protocol.

access privileges

The privileges given to or withheld from users to open and make changes to a directory and its contents. Through the setting of access privileges, you control access to the information that is stored on a file server.

Address Mapping Table (AMT)

A collection of protocol-to-hardware address mappings for each protocol stack that a node supports. The AMT is updated by the AppleTalk Address Resolution Protocol (AARP) to ensure that current addressing information is available.

address resolution

The translation of node addresses between different node-numbering schemes.

ADSP

See AppleTalk Data Stream Protocol.

AEP

See AppleTalk Echo Protocol.

AFI

See AppleTalk Filing Interface.

AFP

See AppleTalk Filing Protocol.

AFP calls

Commands that the workstation uses to manipulate the AFP file system structure. The AFP translator sends file system commands to the file server in the form of AFP calls, or the workstation application can make AFP calls directly.

AFP translator

Workstation software that translates native file system commands to AppleTalk Filing Protocol (AFP) calls; the AFP translator obtains the commands from the Native Filing Interface (NFI) and translates them to the AppleTalk Filing Interface (AFI) for transmission over the network to a file server.

ALO transaction

See at-least-once transaction.

AMT

See Address Mapping Table.

AppleShare file server

A file server that consists of a Macintosh computer, AppleShare software, and one or more hard disks.

AppleTalk for VMS

An implementation of the AppleTalk network protocols on the VMS operating system.

AppleTalk Address Resolution Protocol (AARP)

The protocol that maps between AppleTalk node addresses and the address of the underlying data link.

AppleTalk Data Stream Protocol (ADSP)

A connection-oriented protocol that provides a reliable, full-duplex, byte-stream service between any two sockets in an AppleTalk internet. ADSP ensures in-sequence, duplicate-free delivery of data over its connections.

AppleTalk/DECnet Transport Gateway

The gateway that provides Macintosh users access to DECnet-based applications. Performs data translation between AppleTalk (ADSP) and DECnet (NSP) protocols.

AppleTalk Echo Protocol (AEP)

A simple protocol that allows a node to send a packet to any other node in an AppleTalk internet and to receive an echoed copy of that packet in return.

AppleTalk Filing Interface (AFI)

The interface to an AppleTalk Filing Protocol (AFP) file server through which workstations can gain access to server volumes, files, directories, and forks.

AppleTalk Filing Protocol (AFP)

The presentation-layer protocol that allows users to share data files and application programs that reside in a shared resource, known as a file server.

AppleTalk Manager

An interface to a set of Macintosh device drivers that enable Macintosh programs to send and receive information using an AppleTalk network.

AppleTalk Session Protocol (ASP)

A general-purpose protocol that uses the services of the AppleTalk Transaction Protocol (ATP) to provide session establishment, maintenance, and teardown, along with request sequencing.

AppleTalk Transaction Protocol (ATP)

A transport protocol that provides a loss-free transaction service between sockets. This service allows exchanges between two socket clients in which one client requests the other to perform a particular task and to report the results; ATP binds the request and response together to ensure the reliable exchange of request–response pairs.

ASP

See AppleTalk Session Protocol.

at-least-once (ALO) transaction

An AppleTalk Transaction Protocol (ATP) transaction in which the transaction is executed at least once by the responder. However, it may be executed more than once.

ATP

See AppleTalk Transaction Protocol.

background spooler

A print-spooling process that runs in the background on an originating computer.

bus

A single, shared communication link. Messages are broadcast along the whole bus, and each network device listens for and receives messages directed to its unique address. Both Ethernet and LocalTalk networks use bus media.

bus topology

A network layout that uses a single cable to connect all the devices in a line. This cable is terminated at both ends and does not connect to itself. On a bus network, all devices have equal access to the network and can hear all the messages passed along the cables. Individual devices, however, select and receive only those messages with their specific addresses.

Carrier Sense Multiple Access with Collision Avoidance (CSMA/CA)

A technique that allows multiple stations to gain access to a transmission medium (multiple access) by listening until no signals are detected (carrier sense), and then signaling their intent to transmit before transmitting. When contention occurs, transmission is based on a randomly selected order (collision avoidance). The LocalTalk Link Access Protocol (LLAP), used for node-to-node delivery in a LocalTalk environment, uses the CSMA/CA technique.

Carrier Sense Multiple Access with Collision Detection (CSMA/CD)

A technique that allows multiple stations to gain access to a transmission medium (multiple access) by listening until no signals are detected (carrier sense), and then transmitting the packet. Each station can detect overlapping transmissions by other stations (collision detection) and back off and retransmit.

Chooser

A Macintosh desk accessory that lets you select specific AppleTalk devices and services.

client

A software process that makes use of the services of another software process. See socket client.

command reply

The result of a command sent by a workstation to a server entity during an AppleTalk Session Protocol (ASP) session.

Control Panel

A Macintosh desk accessory that lets you change features such as to which zone your Macintosh belongs, the speaker volume, and the desktop pattern.

datagram

A self-contained packet of data, independent of other packets travelling through an internet. The Datagram Delivery Protocol (DDP) is responsible for delivering AppleTalk transmissions as datagrams.

Datagram Delivery Protocol (DDP)

The network-layer protocol that is responsible for the socket-to-socket delivery of datagrams over an AppleTalk internet.

DDP

See Datagram Delivery Protocol.

DECnet tunnel

A DECnet logical link used to connect two or more geographically separate AppleTalk internets.

default zone

The zone to which any node on an extended network will automatically belong until a different zone is explicitly selected for that node.

direct network printing

A process wherein a workstation sends a print job directly to a printer connected to the network system.

directory

A construct for organizing information stored on a disk; disk directories can contain files and other directories. Each directory for a disk volume has an identifier, through which it and the files and other directories that it contains can be addressed. Sometimes called folder.

dynamic addressing

See dynamic node address assignment.

dynamic node address assignment

An addressing scheme that assigns node addresses dynamically, rather than associating a permanent address with each node. Dynamic node address assignment facilitates adding and removing nodes from the network by preventing conflicts between old node addresses and new node addresses.

ELAP

See EtherTalk Link Access Protocol.

entity name

A name that a network-visible entity (NVE) may assign itself. Although not all NVEs have names, NVEs can possess several names (or aliases). An entity name is made up of three character strings: object, type, and zone.

entity type

The part of an entity name that describes to what class the entity belongs; for example, "LaserWriter" or "AFPServer."

Ethernet

A high-speed local area network system that uses a special type of cabling, known as Ethernet cabling. Ethernet interconnects different kinds of computers, information processing products, and office equipment at a local site without requiring a switching logic or control by a central computer.

EtherTalk

Apple's data-link product that allows an AppleTalk network to be connected by Ethernet cables.

EtherTalk Link Access Protocol (ELAP)

The link-access protocol used in an EtherTalk network. ELAP is built on top of the standard Ethernet data-link layer.

exactly-once (XO) transaction

An AppleTalk Transaction Protocol (ATP) transaction in which the request is executed only one time.

extended AppleTalk network

An AppleTalk network that allows addressing of more than 254 nodes and can support multiple zones.

file

A collection of related information that is stored on a disk. A file on a disk has a name through which it is accessible. Related files may be grouped together in a common directory.

file server

Specialized software that provides network users with access to files on a shared disk or other mass storage device. By extension, a computer running this software is often called a file server.

folder

See directory.

frame

A group of bits forming a distinct transmission unit that is sent between data-link-layer entities. Each frame contains its own control information for addressing and error checking. The first several bits in a frame form a header that contains address and other control information, followed by the data (or message) being sent, and ending with a check sequence for error detection.

gateways

Nodes or software processes that separate and manage communication between different types of networks; for example, a gateway is used to connect an AppleTalk protocol-based network to a non-AppleTalk protocol-based system.

half router

An internet router used primarily to connect two remote AppleTalk networks. Each remote network contains an internet router that interconnects to the router attached to the other network through a long-distance communication link. This combination of two half-routers serves, in effect, as a single routing unit.

hardware address

The unique node address that is determined by the physical and data-link layers of the network.

HFS

See hierarchical file system.

hierarchical file system (HFS)

The file system used on Macintosh hard disks and 800K floppy disks.

hop count

The number of internet routers that a datagram passes through on the way to its destination; each internet router is counted as one hop.

International Standards Organization-Open System Interconnection (ISO-OSI) reference model

A seven-layer network architecture reference model established by the ISO and adhered to by the Consultative Committee on International Telephone & Telegraph (CCITT). The OSI model provides a common basis for coordinating the development of standards aimed at systems interconnection, while allowing existing standards to be placed in perspective within a common framework. The model represents a network as a hierarchical structure of layers of function; it segments the data communication concept into seven layers and defines the functionality of each layer. Each layer provides a set of functions accessible to the layer above it. In the "open" philosophy, the services provided by one layer to another are strictly defined, but the manner used to provide the services is left open to interpretation.

internet

One or more AppleTalk networks connected by intelligent nodes referred to as internet routers.

internet router (IR)

An intelligent node that connects AppleTalk networks and serves as the key component in extending the datagram delivery mechanism to an internet setting. An IR functions as a packet-forwarding agent to allow datagrams to be sent between any two nodes of an internet by using a store-and-forward process.

internet socket address

The address of a socket in an AppleTalk internet. This address is made up of the socket number and the node ID and network number of the node in which the socket is located; the internet address provides a unique identifier for any socket in an AppleTalk internet.

ISO-OSI reference model

See International Standards Organization-Open System Interconnection reference model.

LAP

See Link Access Protocol.

link

Any data transmission medium shared by a set of nodes and used for communication among these nodes.

Link Access Protocol (LAP)

A link-level protocol that is responsible for the transmission of data across the physical link and that ensures data integrity on this link. Sometimes called data-link access protocol. The LocalTalk Link Access Protocol (LLAP) is the LAP protocol used in a LocalTalk environment.

LLAP

See LocalTalk Link Access Protocol.

local area network (LAN)

A network in one location. A typical local area network is joined by a single transmission cable and is located within a small area, such as a single building or section of a building.

Local Area Transport (LAT)

An Ethernet protocol, used in local area networks, that transfers data on a character-by character basis.

LocalTalk Link Access Protocol (LLAP)

The link-level protocol that manages node-to-node delivery of data in a LocalTalk environment. LLAP manages bus access, provides a node-addressing mechanism, and controls data transmission and reception, ensuring packet length and integrity.

Name Binding Protocol (NBP)

The AppleTalk transport-level protocol that translates a character string name into the internet address of the corresponding socket client. NBP allows AppleTalk protocols to understand user-defined zones and device names by providing and maintaining translation tables. These tables map the names to corresponding socket addresses.

names directory (ND)

A distributed database of entity-name to entity-internet-address mappings; the ND is the union of the individual names tables in all the nodes of an internet.

names table

A table in each node that contains entity-name to entity-internet-address mappings (known as Name Binding Protocol [NBP] tuples) of all named network-visible entities (NVEs) in the node.

native file system commands

Commands used to manipulate files on a disk or other memory resource that is physically connected to a workstation.

Native Filing Interface (NFI)

The interface through which native file system commands are made; the NFI defines the nature and format of parameters passed in and returned by the command.

NBP

See Name Binding Protocol.

network

A collection of individually-controlled computers, printers, modems, and other electronic devices interconnected so that they can all communicate with each other. Networks also include all the software used to communicate on the network and the wires, cables, connector modules, and other hardware that make the physical connections.

network address

See network number.

network number

A 16-bit number used to indicate the AppleTalk network to which a node is connected. Nodes choose their network number from within the network number range assigned to their network.

network number range

The range of network numbers that are valid for use by nodes on a given AppleTalk network.

network protocol

See protocol.

network services

Capabilities that the network system delivers to users, such as printing on network printers or file sharing on network file servers. Additional services include mail and database access.

network-visible entity (NVE)

Resources that are addressable through a network. Typically, the NVE is a socket client for a service available in a node.

NFI

See Native Filing Interface.

node

A data-link addressable entity on a network.

node address

The unique combination of a node's network number and node identifier.

node ID

See node identifier.

node identifier (node ID)

An 8-bit number that, when combined with the AppleTalk network number of a node, is used to uniquely identify each node on a network.

nonextended network

An AppleTalk network that supports addressing of up to 254 nodes and supports only one zone.

NVE

See network-visible entity.

packet

A group of bits, including data and control elements, that is transmitted together as a unit within a frame; the control elements include a source address, a destination address, and possibly error-control information.

PAP

See Printer Access Protocol.

port

A connection between a router and a network.

Printer Access Protocol (PAP)

The AppleTalk protocol that manages interaction between workstations and print servers; PAP handles connection setup, maintenance, and termination, as well as data transfer.

print spooler

Software or a combination of hardware and software that intercepts printable document files and that interacts with a printer to print the document, freeing the originating computer of this responsibility.

protocol

A set of procedural rules for information exchange over a communication medium; these rules govern the content, format, timing, sequencing, and error control of messages exchanged in a network.

protocol address

The unique address that a node assigns to identify the protocol client that is to receive a packet for a particular protocol stack. An example of a protocol address is the 16-bit AppleTalk network number and 8-bit node ID protocol address that the Datagram Delivery Protocol (DDP) and the AppleTalk Address Resolution Protocol (AARP) use to verify that an incoming packet is intended for the particular DDP node.

protocol family

A collection of related protocols that together enable transmission and reception of information over a network. Most protocol families correspond to the layers of the International Standards Organization-Open System Interconnection (ISO–OSI) reference model. The combination of all AppleTalk protocols is an example of a protocol family.

protocol stack

A particular implementation of a protocol family within a node.

router

See internet router.

routing table

A table, resident in each AppleTalk internet router, that serves as a mapping of the internet, specifying the path and distance (in hops) between the internet router and other networks. Routers use routing tables to determine whether and where a router will forward a data packet.

Routing Table Maintenance Protocol (RTMP)

The AppleTalk protocol used to establish and maintain the routing information that is required by internet routers in order to route datagrams from any source socket to any destination socket in the internet. Using RTMP, internet routers dynamically maintain routing tables to reflect changes in internet topology.

RTMP

See Routing Table Maintenance Protocol.

seed router

An internet router, connected to an AppleTalk network, that contains the network number range for that network. Each AppleTalk network in an internet must have at least one seed router. This router will define the network number range for the other routers in that network.

server

A network node or software process that provides a service to the other nodes in the network, such as shared access to a file system (a file server), control of a printer (a printer server), or storage of messages in a mail system (a mail server).

session

A logical connection between two network entities (typically, a workstation and a server) that facilitates establishment and maintenance of an exclusive dialog between the two entities. In an AppleTalk network, the AppleTalk Session Protocol (ASP) can be used to establish, maintain, and tear down sessions; ASP also ensures that the commands transmitted during a session are delivered in the same order as they were sent and that the results of the commands are conveyed back to the originating entity.

session listening socket

A socket in a server on which the server registers its name and listens for requests to open a session.

socket

An addressable entity within a node connected to an AppleTalk network; sockets are owned by software processes known as socket clients.

socket client

A software process or function implemented in a network node.

socket number

An 8-bit number that identifies a socket. A maximum of 254 different socket numbers can be assigned in a node.

spooler/server

A combination of hardware and software that stores documents sent to it over a network and manages the printing of those documents on a printer.

symbiont

A VMS process that takes disk files and prepares them for a printer.

token ring network

Both a topology and a protocol defined by the Institute of Electrical and Electronics Engineers (IEEE) 802 committee. The topology is a ring and the protocol is token-passing. The actual token ring access method, or how to interface with the physical media, is defined in the IEEE 802.5 standard.

TokenTalk

Apple's data-link product that allows an AppleTalk network to be connected by token ring cables.

TokenTalk Link Access Protocol (TLAP)

The link-access protocol used in a TokenTalk network. TLAP is built on top of the standard token ring data-link layer.

transaction

An exchange of information between a source and a destination client that accomplishes a particular action or result. In an AppleTalk environment, the AppleTalk Transaction Protocol (ATP) provides a transaction service that enables a source client's request to be bound to the destination client's response.

tunneling

A process that allows a DECnet wide area network to connect two or more geographically separate AppleTalk internets. See DECnet tunnel.

VAXshare

Software that makes VMS files and printers available to Macintosh users. Compatible with AppleShare version 2.0.

volume

A file storage unit. Each disk attached to an AppleTalk file server is considered a volume, although some disks may contain multiple volumes. In VAXshare, each volume corresponds to a specific VMS directory.

zone

A means of conceptually grouping devices that makes it easier for users to locate and access network services. Zones are created by internet routers.

Zone Information Protocol (ZIP)

The AppleTalk session-layer protocol that is used to maintain and discover the internet-wide mapping of network number ranges to zone names; ZIP is used by the Name Binding Protocol (NBP) to determine which networks contain nodes that belong to a zone.

zone list

A list that specifies the zone names that can be chosen by nodes on the network.

zone name

A name assigned to a zone.

Index

A

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PATHWORKS for Macintosh
Introduction to the AppleTalk Network System
AA–PBFEB–TE

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