Chapter 2 Networking

Networking is composed of ONC, X11/NeWS, SunLink and Catalyst products

Sun provides a wide array of networking products under the umbrella term *Open Systems Network*. The goal of Open Systems Network is to make remote resources as easy to access as local resources. Sun's philosophy is that users should be able to concentrate more on using network resources and less on finding them. Open Systems Network products bring the power of all the resources in the network to the user's desktop. These resources are available to the user as if they were part of a single system.

The Open Systems Network is composed of four major networking product families: Open Network Computing (ONC™) environment, the X11/NeWS™ window environment, the SunLink™ product family, and the family of network products within the Catalyst™ Third Party program. These four product families combine to form a set of integrated solutions to a multitude of customer needs. Each of the four product families fills a specific role in Sun's Open Systems Network strategy. ONC is Sun's native networking architecture. It is bundled with SunOS and, therefore, provided on all Sun workstations. The ONC products address customer needs to access distributed resources, use and create distributed applications, and administer the network and systems within the network. X11/NeWS does for the user

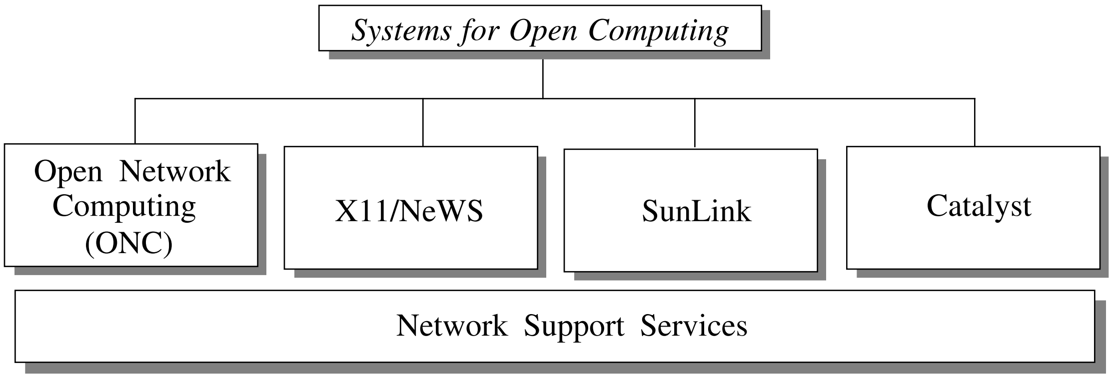

Figure 2-1. Open Systems Network

interface what the ONC environment does for access, applications, and administration: make the window system a network resource. SunLink's role in the Open Systems Network strategy is to extend both the geography of network-based computing as well as to provide a link to existing proprietary networks such as IBM® SNA and Digital DECnet®. Finally, Catalyst third-party vendors provide connectivity to environments not addressed by Sun and offer enhanced network services built on top of Sun networking products.

2.1 Open Network Computing

ONC offers a variety of services for network management and development of network-based applications

The ONC environment is a suite of network services, the ONC protocol platform, and the transport protocol stack. Currently, the transport stack used is TCP/UDP/IP. For detailed information on the ONC environment refer to the manual *Network Programming*. ONC enables a high degree of interoperability in a heterogeneous computer environment. To increase the use of ONC as a multivendor networking platform, Sun placed the specifications for key ONC components such as NFS, RPC, and XDR in the public domain. Sun also makes ONC implementations available through a licensing program. To date, more than 250 organizations have licensed ONC technology. The list of licensees includes Digital Equipment Corporation, Data General, Texas Instruments, Gould, Hewlett-Packard, NEC, Stratus, and Toshiba. Implementations of NFS already exist for UNIX 4.3/4.2 BSD, System V, VMS for DEC® VAX® systems, and MS-DOS®.

2.1.1 Network Services

ONC includes a set of RPC/XDR-based network services that enable network resources such as files to be managed remotely in the same way they are managed locally.

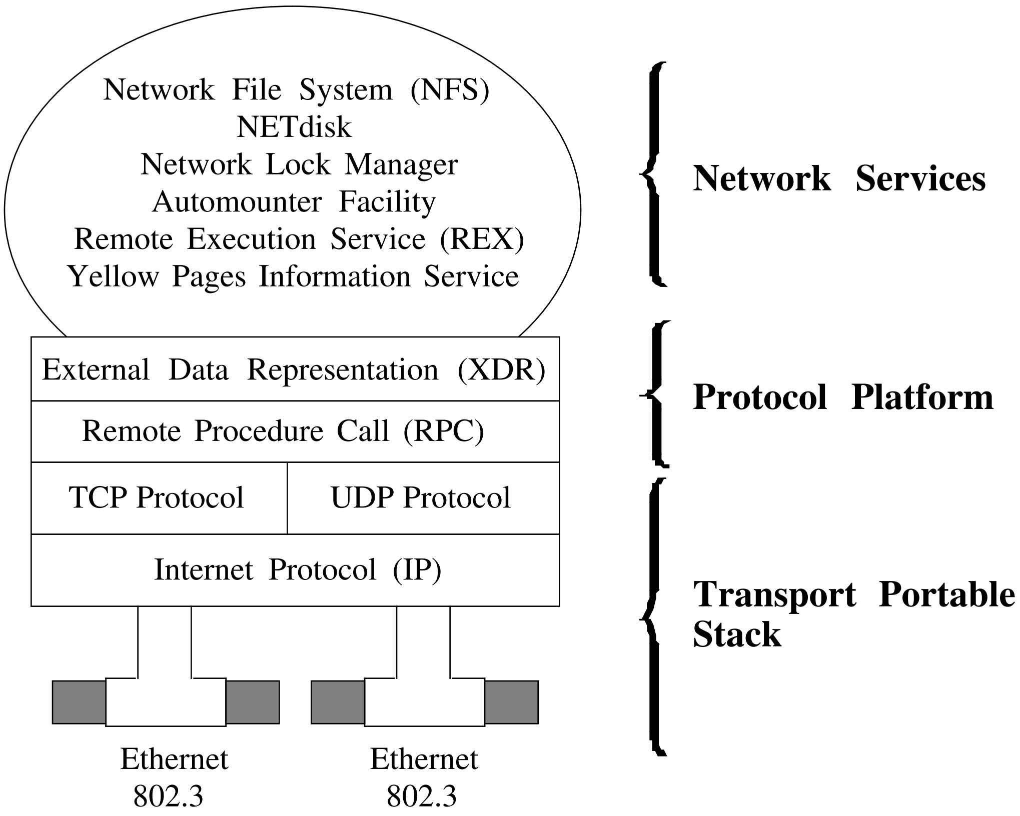

Figure 2-2. Open Network Computing (ONC) Product Family

2.1.1.1 Network File System

NFS allows sharing of file systems in a multivendor, heterogeneous environment

Accessing remote files transparently is made possible by the best known of Sun's network services, the Network File System (NFS). NFS facilitates the sharing of files and data in an environment consisting of different machines as well as different operating systems. More importantly, NFS allows the file systems of remote, heterogeneous machines to appear as if they were locally attached to the user's own system.

2.1.1.2 Network Lock Manager

SVID-compatible file and record locking

In conjunction with NFS, the Network Lock Manager allows coordinated access to files and records so that data can be protected from being accidentally overwritten. The Lock Manager prevents two or more users from inadvertently modifying the same file or record at the same time and destroying the data. The Lock Manager follows the industry standard for file and record locking as defined by the System V Interface Definition (SVID) published by AT&T. All applications written to this definition will be compatible with future releases of the UNIX operating system.

2.1.1.3 Remote Execution Service

Access to remote computing resources is particularly important in networked environments. The Remote Execution (REX) service allows a user to execute a command and/or program remotely while accessing the directories and system parameters the user has set locally. A remote program can be piped to a local program, thus manipulating the local data on a remote machine (e.g., an array processor or mainframe).

rpcgen is a high level data-description language for writing RPC-based applications

The RPC Protocol Compiler, or rpcgen, can be used to simplify the development of remote procedures. With rpcgen, a remote procedure can look exactly like a local procedure to the programmer who uses the procedure in an application. Briefly, rpcgen allows a user to compose a description of the client-server relationship in a high-level data description language. The RPC protocol compiler then outputs the C-language data structure definitions the client and server use, the XDR routines needed to generate these data structures, and the boilerplate calling routine code for both the client and server. The result is a set of C include files for compiling either the server or the client side of the application.

2.1.1.4 Yellow Pages Service

The creation of distributed environments requires access to certain types of organization-wide information as well as links to resources within the network. The ONC Yellow Pages (YP)

Yellow Pages is a distributed database lookup facility

service manages information needed on a network-wide basis such as a user's account name and password to verify a user's right to use a particular application. Yellow Pages is a distributed database lookup facility. YP is tolerant of system failures on the network so that if the primary server fails, another will take over. Additionally, data entered into one database is propagated over the network so no data is lost.

2.1.2 RPC/XDR

RPC and XDR together provide a mechanism to write network-based applications that are independent of the underlying hardware

The ONC protocol platform consists of the Remote Procedure Call (RPC) protocol and the External Data Representation (XDR) specification. The RPC mechanism allows a program to call a procedure that resides on a remote system. The technique used to invoke a remote procedure is similar to that used to call a local procedure. The relationship between the local program and remote procedure is a client-server relationship, with the main program being the client, and the remote procedure being the server.

The External Data Representation specification is the other half of the ONC protocol platform. What RPC does for the code portion of a subroutine, XDR does for the data the subroutine acts upon. Since many computer systems have different internal data representations, without a standard way of representing the data the server routine acts upon, the results of the operation will likely be incorrect. Thus, XDR solves a major problem in heterogeneous environments and architectural incompatibility, by providing a standard data representation for systems on a network.

2.1.3 Sockets and STREAMS

2.1.3.1 Sockets

Socket types and and protocol families

Sockets are not network independent

A socket is the basic building block for communications in 4.3/4.2BSD UNIX operating systems. A socket is an operating systems abstraction that facilitates interprocess communication. Consequently, SunOS supports sockets. The introduction of socket-based IPC in 4.2BSD and the extensions added to 4.3BSD and incorporated in SunOS allow processes to communicate transparently across machine boundaries. Processes can use a socket to establish a named path between themselves and another process. Normally, sockets are given a type (stream, datagram, raw, etc.) and a protocol family in which to operate. A communications domain (UNIX, DEC, X.25, OSI, etc.) establishes how sockets are addressed (referred to) and a set of protocols that implement the various socket types within that protocol family.

The way communications are carried out using sockets depends on the domain and the facilities of that domain. For example, the type of error conditions the process sees vary greatly by domain. Sockets are not a network-independent method of interprocess communication. Another example is byte ordering. The use of sockets does not guarantee that the data ordering transferred to the receiving process will be understood. This is one major advantage that RPC-based interprocess communication has over sockets. RPC-based communications are network independent, whereas sockets are not.

A general tutorial on the use of sockets and a more in-depth discussion of the programming interface is contained in Part 3 of the "Network Programming" section of the SunOS documentation under the heading "Socket-Based IPC". Another useful area is the RPC section of the same document that describes how RPC uses the socket interface, and how RPC can be tailored to a particular application with sockets.

2.1.3.2 STREAMS

Sun has support for streams for SVID compatibility

STREAMS is a collection of system calls, kernel resources, and kernel routines that systematize the existing UNIX character I/O and support the development of communications services. Developed by Dennis Ritchie in the Version 8 of UNIX System V, STREAMS is included in the AT&T release. As part of Sun's commitment to the unification of the UNIX operating system, the kernel-based IPC and communications mechanisms are being modified to use STREAMS. Although originally designed to deal with the inadequate character I/O mechanism within UNIX, STREAMS is a modular, flexible facility for development of all types of communications systems.

The design of STREAMS is consistent with the layered design of most modern communication architectures, so it is well suited for this type of work. For an introduction to STREAMS, please refer to Chapter 9, "Writing Device Drivers for the Sun Workstation" of the SunOS documentation set. Information about the programming of STREAMS-compatible device drivers is included.

In addition to STREAMS, AT&T has defined a common way for user processes to interface to STREAMS. The Transport Layer Interface (TLI) is envisioned as the standard way for user processes to interface to kernel-based communications subsystems. Support of TLI will facilitate the migration of applications from one communications architecture to another (e.g., TCP/IP to ISO). In addition to TLI, AT&T has defined a common kernel interface called the Transport Provider Interface (TPI.)

2.1.3.3 Sockets to STREAMS Migration

Sun will continue to support sockets while providing support for streams and streams-based applications

Figure 2-3 shows the interrelationships between user processes and the kernel-based STREAMS modules. In SunOS 4.0 the character I/O drivers within the kernel have been modified to be STREAMS compatible. As part of Sun's support of System V Release 4.0, all kernel-based driver mechanisms are being converted from sockets to STREAMS. The migration from sockets to STREAMS for the communications drivers will take place as follows. First, the kernel-based communication drivers will be converted to use STREAMS. Second, SunOS will offer a TLI-compatible applications interface. Finally, and perhaps most important, a sockets compatibility library will be provided. This library will provide a sockets-compatible interface to the TPI. It is not clear at this time whether sockets compatibility will be through a library call interface or a set of system calls. Sun is committed to maintaining support for sockets in the highest performance manner possible. This implies a system call level interface, but it may not be necessary. Figure 2-3 illustrates this migration strategy. Application programs that are written for the sockets interface will continue to be supported in System V Release 4.0 via this compatibility module.

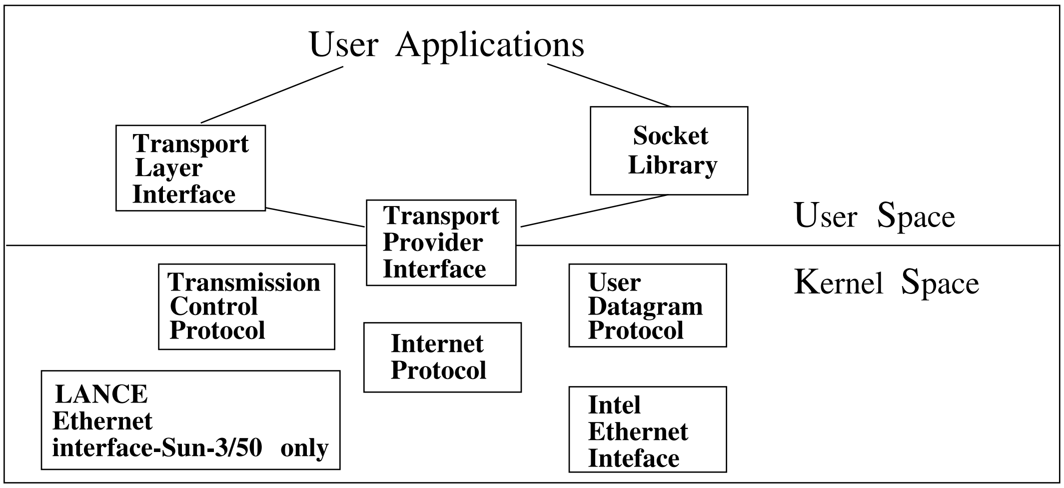

Figure 2-3. IPC and Driver Support in System V Release 4.0

2.2 SunLink

SunLink is a family of unbundled data communication hardware and software products that allow Sun workstations to communicate with other vendors' systems and products. SunLink products use a broad range of industry-standard communication methods. The SunLink data communication product family consists of the products described below.

2.2.1 IBM Connectivity

2.2.1.1 SunLink Local 3270, SNA 3270, and BSC 3270

SunLink Local 3270, SunLink SNA 3270, and SunLink BSC 3270 software products allow Sun systems to communicate with IBM and IBM-compatible mainframes. Like the entire SunLink product family, these SunLink 3270 communication gateway products are part of Sun's Open Systems Network. SunLink Local 3270 runs on the SunLink Channel Adapter and works with standard IBM channel protocols. SunLink SNA 3270 provides compatibility with mainframes that conform to IBM Systems Network Architecture (SNA). SunLink BSC 3270 provides 3270 functionality by conforming to the Binary Synchronous Communication (BSC) conventions. All SunLink 3270 products function like their IBM counterparts with respect to buffering and communication. With SunLink 3270 software products running on Sun systems, no modifications are necessary for application programs running on IBM or IBM-compatible hosts.

Each SunLink 3270 package consists of a gateway component and a workstation component. The SunLink Local 3270 gateway accesses the mainframe through the SunLink Channel Adapter using standard channel protocols. In SunLink SNA 3270, the gateway component includes the SDLC process and the SNA process. The gateway component of SunLink BSC 3270 provides similar functions through the BSC driver. The workstation component in all SunLink 3270 products includes the terminal and printer emulators and the 3270 datastream application interface (DAI) library of routines for programmatic access to the 3270 datastream. The workstation and gateway components communicate over the network by using TCP/IP.

The 3270 datastream is the set of IBM-defined operations that flow between the IBM host applications and the device emulations. The DAI is a set of subroutines that can be called by C programs to allow communication with IBM applications. The DAI provides a programmatic interface to the 3270 datastream for distributed applications in which one component of the application runs on an IBM system and the other runs on a Sun system. A sample DAI client program is included in the workstation component of the software. DAI client programs must handle the format and application-dependent aspects of the data.

For more information on SunLink Local 3270, SNA 3270, and BSC 3270, the following documentation may be of interest:

- *SunLink 3270 User's Guide*
- *SunLink 3270 Programmer's Guide*
- *SunLink SNA 3270 System Administration Guide*
- *SunLink SNA 3270 (SunLink 5.0) READ THIS FIRST*

- *SunLink SNA 3270 (SunLink 5.1) READ THIS FIRST*
- *SunLink BSC 3270 System Administration Guide*
- *SunLink BSC 3270 (SunLink 3.0) READ THIS FIRST*
- *SunLink Local 3270 System Administration Guide*
- *SunLink Local 3270 (SunLink 5.0) READ THIS FIRST*
- *SunLink SNA 3270, BSC 3270 and SunLink Local 3270 Product Brief*

2.2.1.2 SunLink CG3270

SunLink CG3270 (Color Graphic 3270) allows Sun systems to communicate with IBM and IBM-compatible mainframes. In conjunction with one of the SunLink 3270 communication gateway products, SunLink Local 3270, SunLink SNA 3270, SunLink BSC 3270, or, SunLink CG3270 provides IBM 3179G display terminal emulation windows on Sun workstations.

SunLink CG3270 is based on NeWS™, Sun's Network/extensible Window System. Based on the PostScript® language, NeWS generates sophisticated text and graphic screen images. Because SunLink CG3270 emulates an IBM 3179G display terminal, it displays both text and host-based graphics such as those generated by IBM GDDM, a part of IBM SAA (Systems Application Architecture). SunLink CG3270 displays the standard seven colors and black, as well as most extended attributes.

For more information on SunLink CG3270, the following documentation may be of interest:

- *SunLink CG3270 User's Manual*
- *SunLink CG3270 Product Brief*

2.2.1.3 SunLink BSC RJE

With SunLink BSC RJE, Sun workstations communicate with the systems and products of other vendors. The Binary Synchronous Communication (BSC) Remote Job Entry (RJE) product allows Sun workstations to exchange files and execute remote batch programs by using the industry-standard communication conventions of BSC 2780, BSC 3780, and HASP.

The SunLink BSC RJE package has two main components: a gateway component and a workstation component. The gateway uses the BSC protocol to submit and queue jobs to the host system. Because the gateway component performs these tasks, they are isolated from the workstation component. The workstation communicates BSC RJE user commands to the gateway, which is then responsible for executing the user commands. A programming interface to the gateway allows C programs to submit jobs and lets users design a customized user interface to the gateway.

For more information on SunLink BSC RJE, the following documentation may be of interest:

- *SunLink BSC RJE System Administration Guide*
- *SunLink BSC RJE User's Guide*
- *SunLink BSC RJE Product Brief*

2.2.1.4 SunLink SNA Peer-to-Peer

SunLink SNA Peer-to-Peer expands the IBM connectivity of Sun's Open Systems Network by offering customers an Advanced Program-to-Program Communications (APPC) development toolkit. With SunLink SNA Peer-to-Peer, programmers can create Sun application programs that will communicate with applications on other vendors' systems using IBM APPC or Document Interchange Architecture (DIA). Included in the product are an SNA LU 6.2 communication gateway and APPC and DIA programming libraries for C programs.

For more information on SunLink SNA Peer-to-Peer, the following documentation may be of interest:

- *SunLink SNA Peer-to-Peer System Administration Guide*
- *SunLink SNA Peer-to-Peer API Programmer's Manual*
- *SunLink SNA Peer-to-Peer DIA Programmer's Guide*
- *SunLink SNA Peer-to-Peer Product Brief*

2.2.1.5 SunLink Channel Adapter

The SunLink Channel Adapter expands the IBM connectivity of Sun's Open Systems Network by providing a high-speed local connection to an IBM or IBM-compatible mainframe processor.

The SunLink Channel Adapter consists of a double VME board assembly, a set of bus and tag interface cables, and Channel Supervisor software. Together, these components allow the hosting Sun processor to physically, electrically, and logically connect to an IBM mainframe block multiplexer channel. A single IBM channel can address up to 256 different devices (numbered 00 to FF). Up to eight physically separate control units or 16 logically separate control units can be attached to a channel. A Sun server with a SunLink Channel Adapter can simulate one or more of these control units, up to the maximum allowable number on the channel. If multiple control units are emulated simultaneously, they can be either of the same or different control unit types.

The Channel Supervisor software consists of code common to any control-unit emulation. It also includes channel controller software for handling realtime communication events. The Channel Supervisor software provides a documented programming interface, so customers can write custom control-unit emulation programs. A Channel Adapter can simultaneously run multiple separate control unit emulations for concurrent emulations of different control units. Customer-developed emulations can operate concurrently with Sun-supplied emulations on the same Channel Adapter board set.

For more information on SunLink Channel Adapter, the following documentation may be of interest:

- *SunLink Channel Adapter Installation Guide*
- *SunLink Channel Adapter Card Cage Slot Assignment Guide*
- *SunLink Channel Adapter Hardware Installation Notes*
- *SunLink Channel Adapter Software Installation and Configuration Guide*
- *SunLink Channel Adapter Programmer's Guide*
- *SunLink Channel Adapter Product Brief*

2.2.2 DEC Connectivity

- SunLink DNI* provides Phase IV DECnet-VAX end node capabilities to Sun systems
- SunLink TE100* is a DEC VT100™ window-based terminal emulation program for Sun systems

2.2.3 Wide-Area Internetworking

The SunLink Internetwork Router* allows transparent links between remote Sun local-area networks via wide-area transmission facilities. Users retain TCP/IP services such as rlogin, email, ftp, and telnet over IR links. The Internetwork Router supports a variety of bit-synchronous transmission media, including leased lines, T-1 subchannels, PBX circuits, and broadband channels.

For more information on the SunLink Internetwork Router, the following documentation may be of interest:

- *SunLink Internetwork Router Product Brief*
- *SunLink Internetwork Router READ THIS FIRST*
- *SunLink Internetwork Router System Administration Guide*

SunLink X.25** allows Sun networks to link to public and private networks adhering to CCITT X.25 protocols. It permits routing of TCP/IP and OSI traffic and incorporates X.29/X.3 protocols for terminal-to-host connectivity.SunLink X.25 includes programmatic interfaces at the X.25 packet

* Available on Sun386i calendar Q388

** Available on Sun386i calendar Q488

level and HDLC device driver level.

For more information on SunLink X.25, the following documentation may be of interest :

- *SunLink X.25 Product Brief*
- *SunLink X.25 READ THIS FIRST*
- *SunLink X.25 System Administration Guide*
- *SunLink X.25 User's Guide*
- *SunLink X.25 Programmer's Guide*

SunLink DDN allows Sun-3™ and Sun-4™ systems to reliably exchange packets with other systems connected to the Defense Data Network (DDN). Sun DDN gateways can be hosts on the DDN and provide access between local TCP/IP nodes and other DDN hosts. SunLink DDN permits the use of 1822/HDH, X.25, and Basic X.25 host-to-packet switching node interface standards.

For more information on SunLink DDN, the following documentation may be of interest :

- *SunLink DDN Product Brief*
- *SunLink DDN READ THIS FIRST*
- *SunLink DDN System Administration Guide*

SunLink Multiprotocol Optional add-on board enhances Communication Processor performance of Sun-3 and Sun-4 workstations/servers and supports SunLink IR, DDN, X.25, BSC RJE, SNA Peer-to-Peer, and SNA3270 to establish higher line speed.

For more information on SunLink DDN, the following documentation may be of interest :

- *SunLink MCP Product Brief*
- *SunLink MCP READ THIS FIRST*
- *SunLink MCP Software Installation and Configuration Guide*
- *SunLink MCP Card Cage Slot Assignments and Backplane Configuration Procedures*
- *SunLink MCP Configuration Procedures*
- *SunLink MCP Field Service Manual and Installation Notes*

Currently, the Sun386*i*™ can use the above products via a Sun-3 workstation.

2.2.4 International Standards

2.2.4.1 SunLink OSI

SunLink, Open System Interconnect (OSI), supports OSI protocols from the physical to the application layer of the OSI model. When SunLink OSI is used with the complementary SunLink Message Handling System (MHS) and SunLink X.25 products, Sun workstations can fulfill most roles on OSI networks.

As an end system, SunLink OSI includes the following application layer protocols and services: File Transfer, Access, and Management (FTAM), Manufacturing Automation Protocol/Technical and Office Protocol (MAP/TOP) Network Management, and MAP/TOP Directory Service. With SunLink MHS, users can exchange electronic mail with users of public mail services and heterogeneous computer systems worldwide using CCITT's X.400 electronic mail standard.

In addition to addressing the needs of end users, SunLink OSI gives programmers a versatile platform for developing additional ISO protocols, custom protocols, and distributed applications. SunLink OSI provides UNIX operating system kernel interfaces based on 4.2BSD sockets to the session, transport, network, and Link Layer Control (LLC) layers. Linkable library interfaces are furnished for session, MAP CASE, and MAP Directory; two distinct library interfaces are provided for FTAM.

The transport layer supports classes 4 and 0, which run over connectionless and connection-mode network services, respectively. SunLink OSI uses three types of subnetworks: IEEE 802.3 CSMA/CD local area networks, IEEE 802.4 token-passing bus local area networks, and CCITT X.25 packet-switching wide area networks.

As intermediate systems, Sun systems running SunLink OSI can connect local area networks to form an internetwork. These intermediate systems route traffic at the network layer using the routing functions of the OSI Internet Protocol Connectionless Network Protocol (CLNP). An important distinction between Sun and other OSI intermediate systems is that with Sun systems, an intermediate system can simultaneously serve as an end system, filling such roles as fileserver, bulletin-board server, or mail server.

A Sun intermediate system can route between the following subnetworks:

802.3 <=> 802.3

802.3 <=> 802.4

802.4 <=> 802.4

802.3 <=> X.25 <=> 802.3

802.3 <=> X.25 <=> 802.4

802.4 <=> X.25 <=> 802.4

For more information on SunLink OSI, the following documentation may be of interest:

- *SunLink OSI Product Brief*
- *SunLink OSI System Administration Guide*
- *SunLink OSI Programmer's Guide*
- *SunLink OSI READ THIS FIRST*

2.2.4.2 SunLink MHS

SunLink Message Handling System (MHS) extends the range of electronic-mail communication — linking Sun users to public mail services and heterogeneous computer systems worldwide. It is based on the CCITT X.400 Recommendations of OSI networks, the most accepted mail interchange convention.

SunLink MHS is based on ISO X.400, accepted as a standard for exchanging electronic mail

With SunLink MHS, users of standard Sun mail programs, such as the window-based mailtool, can transparently exchange electronic messages with users of private or public mail systems that conform to X.400 and ISO protocols. Users can reach this broader community without affecting their current electronic-mail routines. SunLink MHS is both a gateway and a message relay (Message Transfer Agent, MTA, in CCITT terminology). The gateway translates standard Sun mail messages conforming to DoD Simple Mail Transfer Protocol (SMTP) specifications to and from the format specified by X.400. The MTA provides full message analysis and routing. SunLink MHS builds the SunLink OSI foundation for messaging over a local area network, and SunLink OSI combined with SunLink X.25 for use over packet-switched data networks.

For more information on SunLink OSI, the following documentation may be of interest:

- *SunLink MHS Product Brief*
- *SunLink MHS System Administration Guide*
- *SunLink MHS READ THIS FIRST*

2.3 Personal Computer Connectivity

Sun offers PC connectivity through the TOPS® product line and through PC-NFS™.

2.3.1 TOPS

The TOPS product line allows file access between personal computers (such as the Apple Macintosh® and the IBM PC®) and

Sun workstations, as well as a wide variety of other services. It includes TOPS/Macintosh, TOPS/DOS, TOPS FlashCard™, TOPS NetPrint™, TOPS/Sun workstation™, TOPS Terminal™, TOPS Repeater™, and TOPS TeleConnector™.

2.3.1.1 TOPS/Macintosh

TOPS/Macintosh is software that allows Apple Macintosh systems to share files, disks, and peripherals with other networked computers. It is a distributed fileserver local-area network available for Macintoshes. TOPS works with the Macintosh 512K, the Macintosh Plus, the Macintosh SE, and the Macintosh II.

TOPS/Macintosh includes a print spooler and a file translating utility. TOPS Spool allows a Macintosh to continue work while documents print in the background. TOPS Translators translates text and data file formats between many Macintosh and DOS applications.

2.3.1.2 TOPS/DOS

TOPS/DOS is software that allows IBM PCs and compatibles to share files, disks and peripherals with other networked computers. TOPS/DOS requires a network interface card - such as TOPS FlashCard, Hercules Network Card Plus, or an AppleTalk®-PC card from Apple or Tangent - to connect a PC to the TOPS AppleTalk network. TOPS FlashCard allows PCs with TOPS/DOS to communicate at a 770 Kbps.

2.3.1.3 TOPS FlashCard

TOPS FlashCard, a half-length network card that connects a PC to an AppleTalk network, maximizes the performance of TOPS/DOS by allowing it to use a high-speed PC-to-PC architecture called *FlashTalk.* FlashTalk is a combination of TOPS/DOS software drivers and a dual-speed clocking mechanism on a TOPS FlashCard. FlashTalk allows PCs to alternate between AppleTalk speed (236 Kbps) for PC-to-Macintosh communications and at high speed (770 Kbps) for PC-to-PC communications.

2.3.1.4 TOPS NetPrint

TOPS NetPrint is software that allows DOS users to print directly to an Apple Laser Writer™ or other Postscript-compatible printer from within their DOS applications. DOS users can print with a full IBM character set, all Laser Writer Plus fonts, and any downloadable fonts.

TOPS/Sun workstation is software that allows Sun workstations to act as TOPS network fileservers, giving Macintoshes and PCs access to large capacity disk storage, high-volume backup functions, and the UNIX security system. The connection between a Sun Workstation® and the TOPS Network is a Kinetics FastPath or a direct internal Ethernet card.

TOPS also works with other UNIX systems, including DEC VAX machines and systems from Pyramid Technologies.

2.3.1.5 TOPS Terminal

TOPS Terminal is an AppleTalk link to TCP/IP-based networks and allows Macintosh users to access the applications and file storage of any of networked host computers simultaneously. TOPS Terminal allows communications at 7200 to 9600 bps.

2.3.1.6 TOPS Repeater

TOPS Repeater is a hardware product that regenerates the electrical signals in an AppleTalk or compatible network. Users can extend the maximum length of their networks and change the bus configuration of their networks by adding branches or daisy chains.

2.3.1.7 TOPS TeleConnector

TOPS TeleConnector is a small hardware device that links desktop computers and other peripherals to AppleTalk networks. TOPS TeleConnector works with FlashTalk. Network cables attach to the TOPS TeleConnector via a standard RJ11 modular phone plug.

2.3.2 PC-NFS

Sun's PC-NFS integrates IBM PCs and 100% compatible systems into local area networks, allowing them to share information and resources with high-performance workstations, minicomputers, super-minicomputers, and other personal computers. Without PC-NFS, PCs are restricted to single vendor, PC-only local area networks.

PC-NFS is an implementation of Sun's Network File System (NFS), the industry standard for transparent file access among different hardware architectures and operating systems. PC-NFS bridges the gap between systems running MS-DOS®, SunOS, ULTRIX, BSD, and System V UNIX, VMS, and other systems. PCs can take advantage of the file, compute, printer, and mass storage resources of a network. With the PC-NFS Programmer's Toolkit, developers can distribute their applications across multiple, heterogeneous computers. PC-NFS LifeLine™ Mail and Backup provide PC-NFS users with electronic mail and network backup applications.

PC-NFS networking uses DoD-standard Internet protocols including a complete TCP/IP package for personal computers. PC-NFS provides FTP file transfer, TELNET (with VT100 emulation) remote login, and rsh (remote shell execution).

2.4 Future Directions

Sun is committed to Systems for Open Computing™. In other words, a completely distributed system that allows users to mix Sun workstations, PCs, minicomputers, and mainframes - with the hardware and software of thousands of other companies. Sun will continue to increase network transparency, offer additional network services, and enhance heterogeneous environment interoperability.

Sun will extend transparent access to network resources by allowing clients to find remote resources independent of location. Clients will be able to locate a resource based on selected characteristics of the resource. For example, a client may want to locate PostScript that only printers use.

Additional network services will make the network easier to use and administer and make more effective use of network resources. Heterogeneous environment interoperability will be enhanced by further support for OSI.

New products will enable a smooth migration from TCP/IP to OSI, allowing ONC to run on top of an ISO transport, and will comply with key OSI profiles such as TOPS 3.0.