NetWare on SPARC/Solaris

Technical White Paper

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Introduction 1

Organizations today utilize a variety of computing resources. Depending upon the requirements, needs, and data processing history of each department, a spectrum of computing platforms may be found, from PCs to UNIX® multiuser systems to mainframes.

As businesses further incorporate computers into their operations, the level of complexity in management of disparate technology increases urgency of accessing and interpreting the information computers provide.

The PC LAN (local area network) emerged in the mid-1980's as a requirement to meet ne need of sharing local resources and information on personal computers, which had begun to complement the centralized computing facilities of companies. The degree of integration proved limited, however, providing terminal emulation (to the mainframe) or file transfer at best.

As PCs emerged, some computing market segments began to take advantage of UNIX workstations. Like PCs, they brought computational power right to the user's desktop. However unlike PCs, workstations were designed to be networked, with the inclusion of Ethernet directly on the CPU board.

UNIX workstations and servers have also been a key catalyst in redefining computing in the last 10 years. Concepts like *distributed processing*, *client-server computing*, *rightsizing*, and *open systems* are a result of the power and capabilities that UNIX provides.

Sun Microsystems® developed the first volume computing platform based on UNIX. With a founding philosophy of open systems, Sun sought to create a computing environment where an entire organization could share resources and information, without being locked into a proprietary solution.

As part of the logical evolution of this strategy, Sun's SPARCserver™ systems are the established leaders in distributed computing, providing the highest transaction per second (TPS) database benchmark of any systems in their class[1]. With NetWare® SunLink®, the proven capabilities of UNIX and the performance of SPARC are now accessible to Novell® LAN users.

People with departmental needs beyond what traditional PC LAN servers provide (such as large databases), can now take advantage of high-performance SPARCserver systems, as well as gain connectivity to the computing resources of their companies.

This whitepaper is intended for technical staff and managers interested in Novell networks and the use of SPARCserver systems as a vehicle for client-server applications, back-end processing, and as a gateway to enterprise computing. End-users and developers already familiar with NetWare will appreciate the architectural considerations of the NetWare SunLink environment and how it can enhance an existing NetWare network. Initial sections describe the NetWare SunLink environment as an implementation of NetWare for UNIX, and discuss how it compares with native NetWare. The use of NetWare on SPARCserver systems is then examined, including several applications scenarios. The latter sections discuss the specific services and facilities of the NetWare SunLink environment.

1.1 Local Area Networking

A local area network (LAN) is generally defined as a communication network used by a single organization over a limited distance, which permits users to share information and resources. This general definition, while stating the basic nature and purpose of a local area network, is incomplete because LANs can span very large areas through gateways and routers, and because advanced applications are increasingly available that not only permit but encourage interdepartmental usage of the same LAN.

1. Transaction Processing Council, Benchmark A, March 6,1992

PC LAN manufacturers are generally restricted in the architecture of their approaches because they are based upon the DOS® operating system. DOS, as a single-user, single-tasking environment, is not optimized for the multiple processes that LAN connectivity permits. Hence these vendors have developed specialized protocols, hardware, utilities, servers, and network application program interfaces (APIs).

According to the International Data Corporation, a computer industry research company, over 18 million PCs were installed on local area networks as of 1990. Novell has been the most successful in selling PC LAN solutions. Although its roots lie in the PC market, Novell has been quick to realize the significance of the UNIX market, particularly in delivering true client-server computing.

Novell's NetWare for UNIX provides a powerful and stable platform for applications on a Novell network. NetWare for UNIX, the principal thrust of Novell's platform-independent NetWare marketing program, has already garnered commitments from most industry leaders in workstations, including Sun Microsystems.

The NetWare SunLink environment provides the same basic facilities on Solaris® UNIX-based workstations and servers as it does on Intel-based PCs. Further, the NetWare SunLink environment interconnects and operates transparently with NetWare networks, while providing the power of UNIX platforms and applications to PC users.

SPARC/Solaris: A Distributed Computing Platform

Together with the ONC™ distributed computing environment, NetWare SunLink environment provides a complete solution to the growing needs of organizations wishing to unite and leverage their computing resources.

Sun had its roots in UNIX, and this commitment has grown to become a major force in open systems today. UNIX is the result of 20 years of development from thousands of people in hundreds of companies, and represents a stable platform for development of distributed computing applications. And UNIX is open - it is available on virtually every computer architecture from PCs to mainframes and supercomputers.

The Solaris 2.0 operating environment incorporates UNIX System V Release 4, the ONC distributed computing capabilities, as well as the TCP/IP network protocols - the de facto standard for Ethernet networks. SVR4 unites over 80% of the UNIX market, providing a platform for open, distributed computing.

The NetWare environment and UNIX collectively provide a flexible vehicle for the migration to client-server computing as well as extending local area networks to effectively connect with the enterprise network. As an open operating system, UNIX has become the platform of choice for distributed heterogeneous applications. By combining UNIX with NetWare connectivity, users gain greater flexibility in their computing environments.

1.2 Networking in the Solaris Operating System Environment

The Solaris ONC environment is a modular, scalable set of networking protocols and services that allows distributed computing across multivendor networks. The ONC environment is made up of a core platform of interprocess communication protocols upon which a variety of services are built. One such service, NFS®, is the best known of ONC components, and provides transparent remote and local file sharing between heterogenous systems. The success of the ONC environment is evidenced by over 110 independent implementations and more that one million installed nodes.

Sun's SPARCserver systems, the Solaris operating system, and the ONC environment and its family of SunLink communication products provide a broad solution to enterprise connectivity. With NetWare SunLink, PC LANs can also benefit from access to enterprise computing resources and information. Figure 1.2.1 shows enterprise computing and PC LANs with NetWare SunLink.

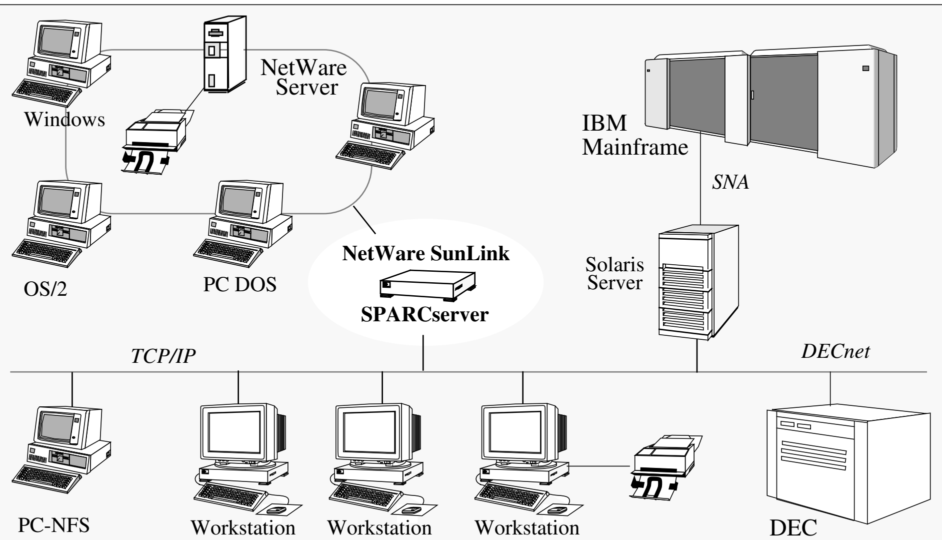


Figure 1.2.1 Enterprise Computing

NetWare SunLink 2

This chapter provides a brief introduction to NetWare and the Sun Microsystem's implementation, NetWare SunLink. As a complete implementation of Novell's NetWare for UNIX, NetWare SunLink provides the same NetWare environment traditional NetWare users are familiar with, plus integration into the Solaris operating environment, which includes ONC connectivity and support on powerful SPARCservers.

2.1 Client-Server Computing

Client-server computing refers to an architecture in which applications or systems obtain resources from other applications or systems through a request mechanism. A database application may request records from a database running on a remotely located database server. A workstation or personal computer may obtain physical file systems from a file server connected to the same network.

NetWare service protocols are built upon a model of remote procedure execution, based upon the client-server model. In a NetWare network, personal computer workstations (clients) are granted access to NetWare resources (disk, printing, etc.) through the NetWare server, which runs the NetWare Real-time Operating System. The clients, running the MS-DOS, OS/2® and MicrosoftWindows®, systems become knowledgable of the network by running one or more utility programs after booting their operating system.

Additional utility programs become available to each NetWare node when its operating system `PATH` variable includes the network drive F:, which is mapped to one or more directories on the NetWare server. Users may utilize these directories and their programs, provided they have appropriate access rights to them.

Sun's powerful desktop, deskside, and datacenter SPARCserver systems provide a flexible and scalable complement to existing Novell networks. A SPARCserver system can be selected to meet any requirement, whether it is large database access, application back-end support, or enterprise connectivity.

The NetWare SunLink environment enables a SPARCserver to appear to a NetWare PC like any other NetWare server. NetWare nodescan access and execute applications running on the SPARCserver system just as they would with other NetWare servers. The NetWare SunLink environment provides a means of effectively integrating NetWare LANs into an enterprise computing environment, enabling personal computers to leverage the wide range of applications and services of UNIX systems and the minicomputer and mainframe environments to which they may connect.

2.2 NetWare SunLink: NetWare on SPARC

The NetWare SunLink environment is Sun's optimized version of NetWare for UNIX running on the Solaris operating system.

Novell's NetWare for UNIX provides NetWare services on the UNIX operating systems, where it runs as a set of application programs and privileged processes called daemons. Systems running NetWare for UNIX programs can run multiuser applications as well as function as a NetWare server.

NetWare for UNIX enables the host system to provide file and print services to the network desktop client. Customers who purchase the NetWare SunLink environment can take advantage of facilities of both the NetWare and Solaris UNIX environments, including applications running native on high-performance SPARCserver systems.

The NetWare SunLink environment provides the same Host/PC network integration as native NetWare. Desktop PC users, whether on DOS, OS/2, or Microsoft Windows systems, have the added benefit of simply and easily accessing data and applications on the SPARCserver system.

In the NetWare SunLink environment, users see files displayed in their workstation's native format, whether they access the PC network or the SPARCserver host. All computer environments appear just as the PC user would expect.

The Netware SunLink environment adds the capability of combined security, utilizing the security of NetWare plus the security of the Solaris UNIX operating system. Users can have accounts in one environment or in both.

The NetWare SunLink environment provides the enhanced backup capabilities of the SPARCserver system withthe Solaris operationg environment, including automated on-line backup. Some of NetWare's own backup utilities are also supported.

Support is also transparent for print services, where users on PC networks can easily print on printers connected to SPARC systems. NetWare print queues automatically deliver print requests directly to the SPARCserver system's local or remote print spooler.

The NetWare SunLinkenvironment is certified by Novell to be compatible with all versions of NetWare v2.x and v3.11, including other vendors host implementations.

2.3 Comparing the NetWare SunLink and Native NetWare Environments

The fundamental architectural difference betweenthe native NetWare and NetWare SunLink environments is in the hardware interface. The NetWare environment provides two basic functions: *NetWare services* and a *real-time operating system*. The NetWare SunLinkenvironment provides just the NetWare services and uses the Solaris operating environment to gain access to hardware resources. The NetWare SunLink environment runs as an application process on top of the Solaris operating system. Whereas native NetWare directly controls the computer's hardware (through the real-time operating system), the NetWare SunLink environment runs in conjunction with the Solaris operating system and uses the Solaris UNIX file system, memory management, and scheduling resources. Figure 2.3.1 illustrates the essential differences between native NetWare and NetWare SunLink environments.

From a client user's perspective, native NetWare and the NetWare SunLink environment provide the same basic features and services. Because of the access to the Solaris UNIX operating system, some features of NetWare, such as security, system backup and restore, "system fault tolerant" capabilities (that is, disk mirroring and dual porting), and some aspects of printing and administration are provided through the host operating system rather than NetWare. Discussion of these facilities is provided in later sections of this document.

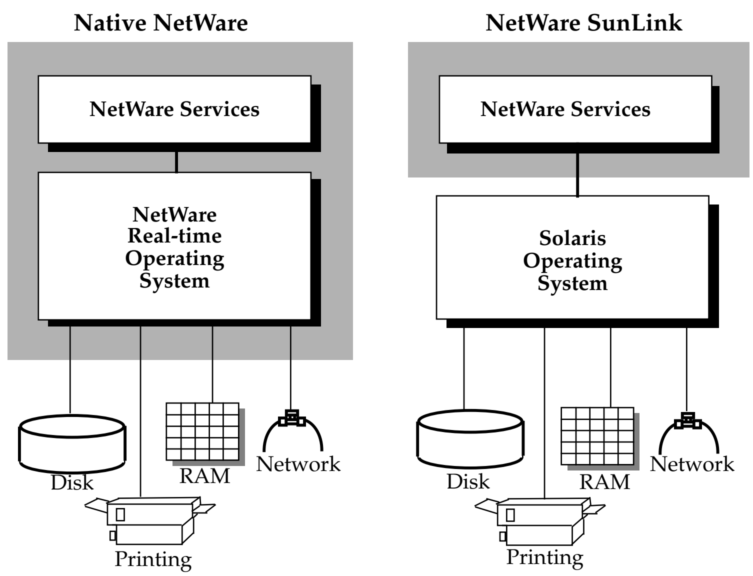


Figure 2.3.1 Native NetWare compared to NetWare SunLink Architecture

NetWare on SPARC 3

With the addition of NetWare SunLink, SPARCserver systems provide PC LANs high connectivity, as well as bridging into the enterprise computing networks accessible from Sun's ONC platform. SPARCservers running the NetWare SunLink environment also address larger systems requirements for applications processing and scalability than their native NetWare equivalent and all under a stable, secure, and open operating system: Solaris. The range of SPARCserver configurations insures that as the needs of the NetWare network grow, the SPARCserver system can adapt, in processing performance, disk capacity, and network connectivity. Figure 3.0.1 illustrates a range of SPARCserver systems running the NetWare SunLink environment.

PC clients can read and write files on the SPARCserver system through the NetWare SunLink environment. SPARCstation clients can read and write files on an Intel-based NetWare server with Novell's NFS NetWare Loadable Module (NLM). And bidirectional printing is possible with any printer on the network accessible through the NetWare SunLink environment and Novell's NFS NLM.

3.1 Components of a NetWare SunLink Network

The NetWare SunLink environment requires a Sun-4 or SPARCserver system with a minimum of 16 MBytes of memory and 40 MBytes of available disk. Additional memory and disk are desirable, particularly for networks of 10 nodes or more. To install the NetWare SunLink environment, the server must be accessible from another Sun network node (via `rlogin`) or have either a terminal or graphics monitor directly attached to the SPARCserver system. If the server utilizes a graphics monitor, the administrator has the option of running NetWare installation programs using Sun's OpenWindows™ graphical user interface version of the installation program. The NetWare SunLink environment

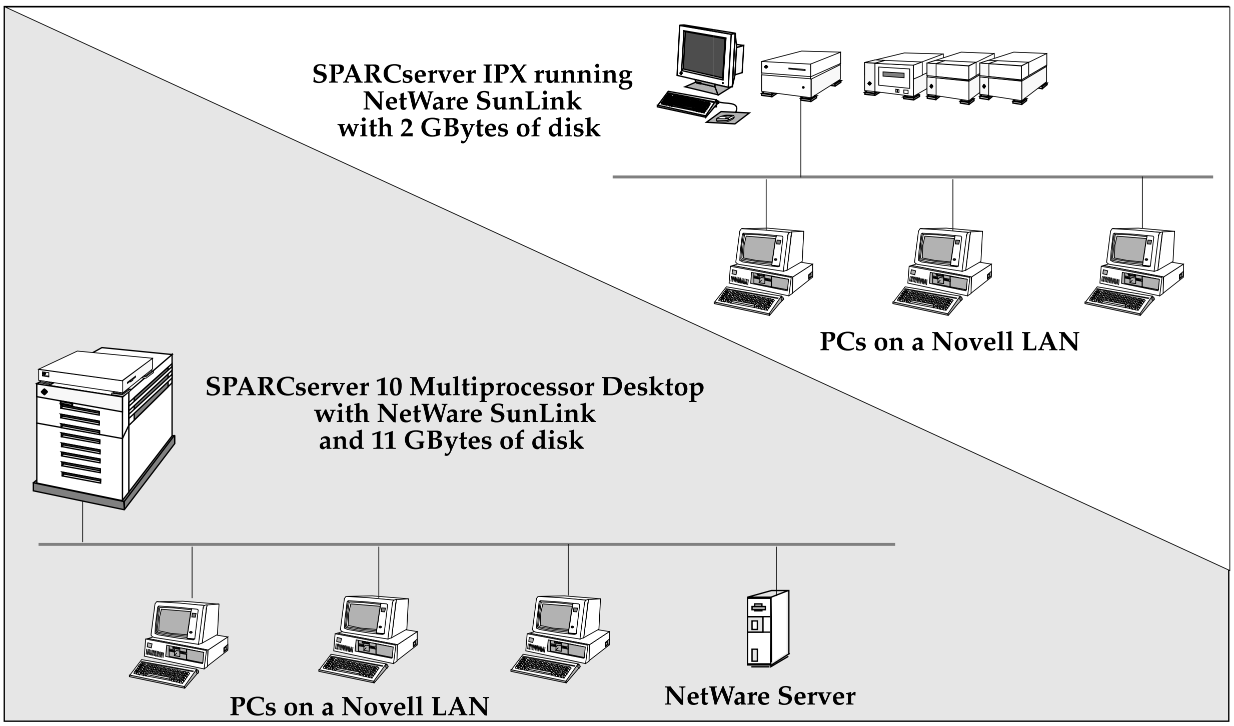


Figure 3.0.1 Examples of SPARCserver systems with the Netware SunLink environment

also requires Solaris 1.0 (SunOS 4.1.x).

NetWare SunLink software is distributed on CD-ROM. A CD-ROM drive must be available to the Sun server on which NetWare is to be installed.

Printers supported on the Sun network are available to PCs connected to the NetWare network. The Sun printers may be attached to either the NetWare SunLink server or to other Sun workstations.

The NetWare SunLinkenvironment supports two principal network topologies: Ethernet and 4/16 Mbps token ring. Networks running NetWare are most commonly based upon these two topologies.

Users wishing to install a NetWare SunLink system in an existing Ethernet network would require no additional network interfaces since all SPARCstation and SPARCserver systems are shipped standard with Ethernet interfaces.

Users who wish to place a SPARCserver system into their existing NetWare token ring network can acquire a token ring interface card from Sun.

Figure 3.1.1 illustrates the minimum components of a NetWare SunLink network. In the following sections, additional examples of NetWare SunLink configurations are shown.

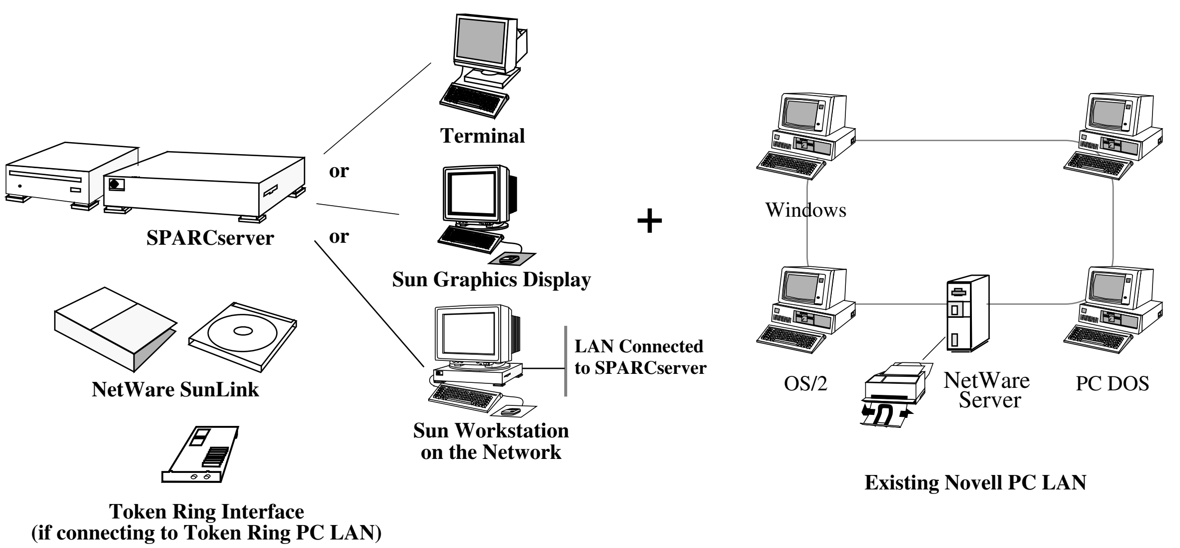


Figure 3.1.1 Components of a NetWare SunLink Network

3.2 Applications and NetWare Sunlink

While the NetWare SunLink environment brings the majority of features of native NetWare running on Intel microprocessor systems to the SPARC RISC environment, it also incorporates SPARC/Solaris into PC LAN networks, extending the flexibility and connectivity for NetWare users and their applications.

Multiuser character-based applications under Solaris can be accessed with the Novell Virtual Terminal (NVT) facility, as a terminal login session to the SPARCserver host. The SPARCserver system could be running a database, spreadsheet and word processing applications, as well as a range of vertical market applications that can utilize a terminal interface.

Client-server applications, including powerful database management systems, could be utilized through the SQL requests sent from the client application running on a NetWare client to the NetWare SunLink server. In this case, the back-end of the application (the database) can take complete advantage of the performance and scalability available from the SPARCserver, delivering as much as 3 to 4 times better transaction performance than PC-based servers.

ONC/NFS Gateway

Using NFS with the NetWare SunLink environment further extends the flexibility of the SPARC-based solution. NFS supports mounting of any remote NFS file system for access by other nodes on the network. The NetWare SunLink environment may be used as a gateway to these remote NFS systems, by permitting access to local as well as virtual NFS mounts. In this way, NetWare clients can access applications and files that reside on the NetWare SunLink server as well as applications and files that reside on the Sun ONC/NFS network.

Bridging Sun and PC Networks

Sun's ONC networking model can be found in a wide range of computing environments, from factory floor to marketing department, and from engineering to finance. Given the size and disparate computing technology used by large institutions, it is common for the need to arise to bridge existing Sun and PC LANs.

For example, suppose a company's Drafting department wants to share resources and drawings with Manufacturing and Marketing at that location. The Drafting department might use AutoCAD and several other powerful workstation applications for producing drawings and calculating material usage and costs. Typically, the Drafting department would complete its drawings and send paper copies to Manufacturing and Marketing.

Marketing might use the drawings for production of itsbrochures, as well as for figures in product documentation. The drawings from Drafting are scanned into its PC systems, and incorporated into the group's documents as bitmap images.

Manufacturing would normally obtain a copy of the AutoCAD drawing file on floppy disk, which it would load onto its PC for production of numerical control (NC) tape, used to drive the automated milling machines. Often changes are made to the AutoCAD drawing because of design limitations or other restrictions of the manufacturing process.

The company could use an existing NetWare LAN, connecting the marketing organization to other groups. Engineering and Drafting would chose SPARCstation systems for CPU and graphics performance as well as image quality. And they would determine that by streamlining the process of moving drawings to other departments, they can save several days per month in product schedules.

After reviewing the cost benefits of connecting the Sun ONC and NetWare LANs, the NetWare SunLink environment and a SPARCserver system would be added to the network. Figure 3.2.1 illustrates the network layout after the LANs were interconnected.

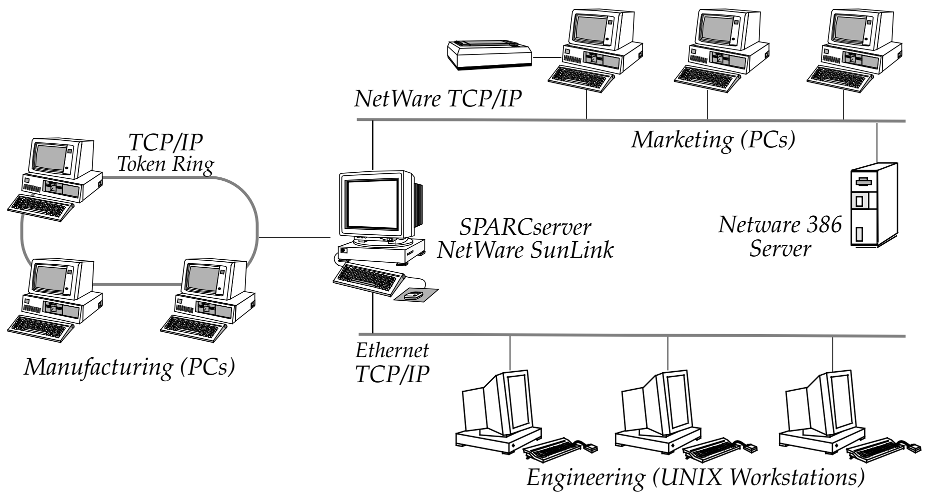


Figure 3.2.1 Example: Bridging Sun and NetWare LANs

As a result of using the NetWare SunLinkenvironment, Marketing was able to obtain drawings from Drafting in their native data format, without the need to scan the images into a PC and so image quality as well as time were saved.

Manufacturing, running a token ring network, reads and modifies the drawings directly on the NetWare SunLink server. Drafting could transparently access these drawings electronically.

Applications Server on a NetWare Network

Sun SPARCserver systems provide a number of significant advantages to NetWare LANs, including superior database and application performance, a stable, secure, and powerful operating system environment, and a high performance RISC-based computing platform.

Solaris provides a robust environment for the development and deployment of business-critical applications. Solaris offers many powerful features of UNIX, including premptive multiuser and multitasking capabilities, virtual memory, and SPARC multiprocessing. The SPARC/Solaris computing environment also includes over 4000 software solutions, including excellent software development tools, for building distributed applications.

The leading database management software has been optimized for the SPARC/Solaris environment, and provides a compelling architecture for implementing a rightsizing strategy for growing PC LANs.

For example, consider a situation where a company providing information services on health care is discovers that the NetWare file server supporting its large network of NetWare-based PCs is increasingly unable to manage the database transactions required to service its telephone operators. As it grows into more and more metropolitan areas and faces increased competition, the company decides to reevaluate its data processing plans.

With a significant investment in PCs and NetWare networks the company cannot abandon the existing systems; nor can it bear the costs associated with retraining the many operators. But the native NetWare servers are simply not able to support the database transactions required to sustain growth.

After due consideration, the company might decide that adding SPARCserver systems with the NetWare SunLink environment is the best alternative, in terms of both cost and performance. This approach would allow the database management system to be moved to a SPARCserver system where it would provide substantially higher performance.

Scalability is also a selling point, because as the demands on performance grow, the company could select additional SPARCserver systems or add multiprocessing SPARCserver 600MP systems for additional performance. And as the database grows, the company can feel comfortable that the SPARCserver will meet their needs with the capability of supporting over 26 Gbytes of storage on a desktop server and even more on Sun's data center servers. Figure 3.2.2 illustrates the example described above.

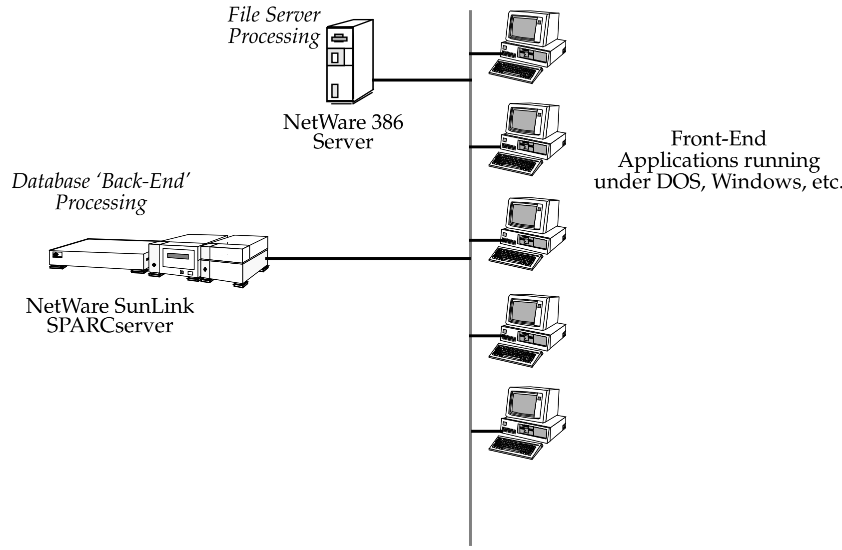


Figure 3.2.2 Example: SPARCserver and NetWare SunLink as an Application Server

Enterprise Connectivity

One of the most compelling strengths of the NetWare SunLink solution lies in providing an opportunity for enterprise connectivity for users of a NetWare LAN. Through NFS, SunLink Communications products and many third party solutions, SPARC systems can bridge the spectrum from mainframe and minicomputers to the desktop.

As an example of where enterprise computing is a factor consider a well-established insurance company with thousands of PCs, hundreds of workstations, and numerous mainframes: it faces the recurrent dilemma of connecting its widely varied computing resources. The personal productivity software available for PCs make them an integral part of the computing solution. And the mainframe systems could provide the necessary services to support their many field locations and agents.

The company is committed to distributed client-server computing and is seriously considering the eventual replacement of its mainframes with departmental solutions on a wide-area network. In the meantime, the demands for sharing information and resources have to be met.

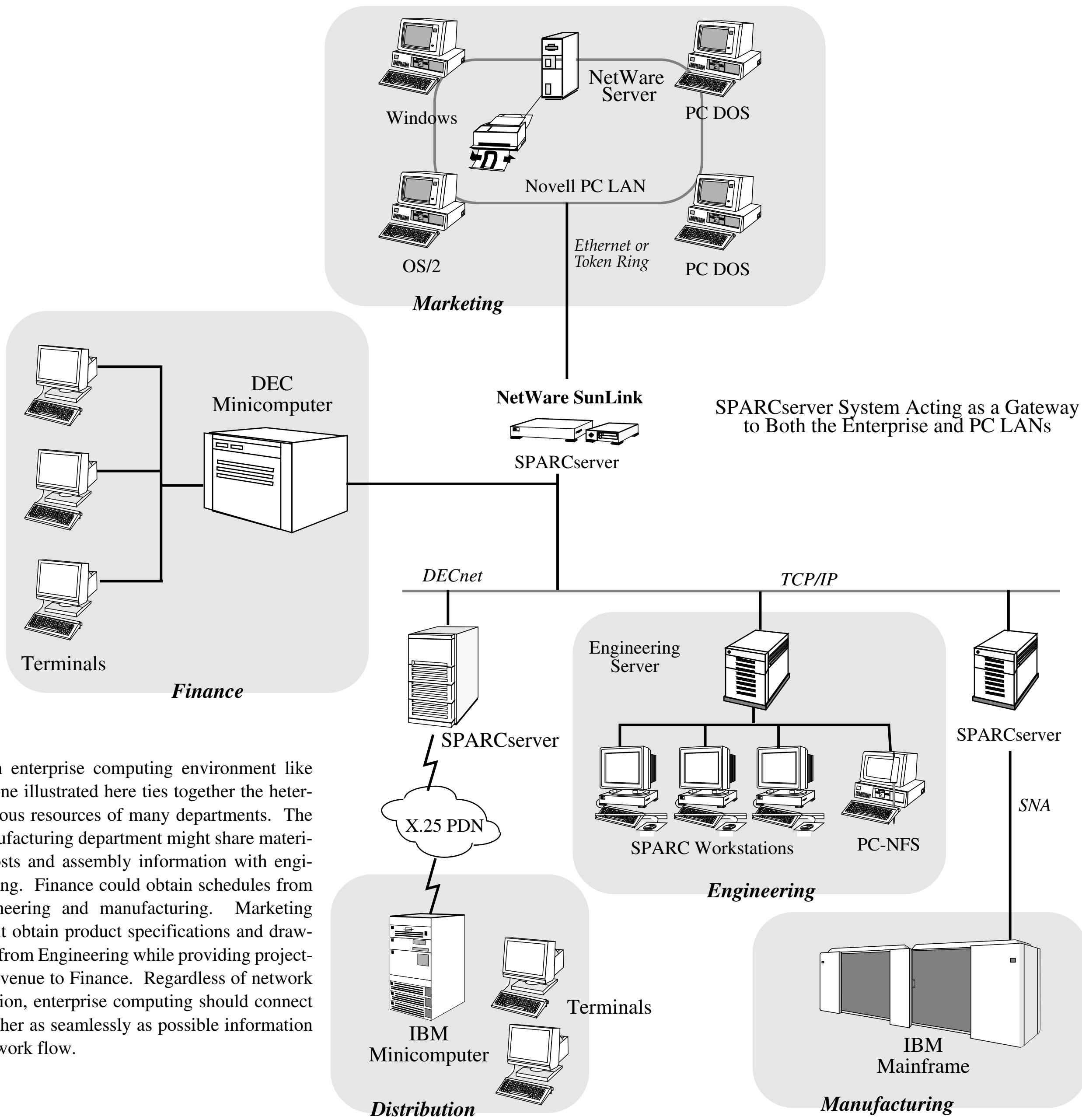
A sound solution for integrating the PCs, workstations, and mainframes, includes the use of the NetWare SunLink environment. Adding the NetWare SunLinkenvironment to an existing SPARCserver system permits it to become a file and print gateway to the existing NetWare LAN. Through ONC and SunLink communications products, the company would have the means for file sharing, terminal emulation, and distributed computing between all of the various computing platforms it uses. Figure 3.2.3 illustrates enterprise connectivity of NetWare SunLink and other SunLink and third party products.

NetWare SunLink Performance

A consideration in configuring SPARCserver systems within an existing Novell NetWare LAN concerns performance of non-native NetWare versus native NetWare. Native NetWare-based servers will always provide the *maximum* possible file server performance to NetWare nodes, due to the implementation of NetWare as a real-time operating system.

In contrast, the NetWare SunLink environment, and any other non-native NetWare implementation will have slightly degraded performance in managing file serving to nodes because it must translate read/write requests to the native UNIX operating system.

NetWare SunLink performance advantages are derived in the same fashion. Having a native UNIX operating system provides improved security, robustness, connectivity, and better applications performance.



An enterprise computing environment like the one illustrated here ties together the heterogenous resources of many departments. The Manufacturing department might share material costs and assembly information with engineering. Finance could obtain schedules from engineering and manufacturing. Marketing might obtain product specifications and drawings from Engineering while providing projected revenue to Finance. Regardless of network location, enterprise computing should connect together as seamlessly as possible information and work flow.

Figure 3.2.3 Example: Enterprise Computing

Features of NetWare SunLink on the SPARCserver System 4

The NetWare SunLink implementation of NetWare services includes most of the basic native NetWare facilities, including:

- Volumes and file systems
- NetWare SunLink users
- Client connection services
- File services
- Printing services
- Network management and administration
- Internetwork services
- Terminal services

The following sections describe these facilities and their operation.

4.1 Volumes and File Systems

NetWare SunLink provides the same volume and file system facilities familiar to native NetWare users with the added advantage of mapping those file system resources to the Solaris operating system. Additional capabilities of the SPARC/Solaris environment add value to a NetWare network, and include a variety of features beyond native NetWare.

In native NetWare, you create a NetWare partition on each hard disk. From the pool of NetWare partitions, you create volumes. A volume consists of volume segments; different segments of a volume can be stored on one or more hard disks. NetWare maintains the volume definition tables that map the segments on the hard disk to the volume. The data is stored on the disks in a proprietary format known only to NetWare.

With the NetWare SunLink environment, volumes are logical entities and appear as volumes only to NetWare users. To the Solaris operating system, a NetWare volume is a point in the directory system to which an application, NetWare, has been granted all rights. You create NetWare volumes by specifying the path in the `NWConfig` file.

The NetWare SunLink environment handles all the differences in references between the Solaris operating system and NetWare. NetWare files are virtually mapped atop the Solaris file system NetWare directories are actually Solaris directories, and NetWare file objects are actually Solaris file objects. Any data within the files themselves is unchanged between NetWare and Solaris.

Files and directories have the same trustee rights, inherited rights masks, and attributes as they do in native NetWare. The NetWare SunLink environment also enforces the same synchronization rules that govern file access when more than one NetWare user accesses the same file.

NetWare salvageable files is the only file system feature that has not been implemented directly under the NetWare SunLink environment. This function is not conceptually the same under a UNIX operating system as it is under DOS. Under DOS, salvageable files can sometimes be recovered if their file allocation table (FAT) entry is still intact. UNIX provides for maintaining file system integrity and internally guards against inadvertent file destruction, but once a file is deleted, it cannot be recovered

4.2 NetWare SunLink Users

In both native NetWare and NetWare SunLink environments, the NetWare user SUPERVISOR uses the same utilities to set up user accounts, groups, workgroup managers, and security. However, in native NetWare, there is only one type of user, a NetWare user. In the NetWare SunLink environment, three types of users are possible: a NetWare user, a Solaris (UNIX) user, and a hybrid user.

- A *NetWare user* is a user who has a user account on the NetWare server but who does not have a Solaris user account.

- A *UNIX user* is a user who has a user account under the Solaris operating system but does not have a user account on NetWare.
- A *hybrid user* is a user who has a user account on the NetWare server as well as under the Solaris operating system. This user wants to maintain a mapping of file rights between the two systems.

To understand the need for this mapping, suppose a user creates a file as a NetWare user, then logs out of NetWare, and logs in to his or her Solaris user account. Usually, the user would lose rights to the NetWare file because, by default, files created by NetWare users are seen by the Solaris operating system as being created by a single user, *nwuser*.

Since NetWare runs as a root process, NetWare has the right to set the file's owner, and by default all NetWare files are given the same owner. The *nwuser* account is an administrative account rather than a user account, and the name of the account is configurable in the `NWConfig` file. This file also sets up the default permissions that will be granted to all files and directories created by user *nwuser*. The default permissions allow only the owner of the file to access the file.

Thus, when the user logs in to the Solaris user account, Solaris will deny the user access to the NetWare files because the files are owned by another user, *nwuser*. The hybrid user concept allows users who create files in NetWare to maintain those rights when logged in as a Solaris user.

The hybrid utility creates a NetWare bindery property for the hybrid user, and the system administrator then sets its value to the user's Solaris UNIX *uid* (user ID).When the user creates a NetWare file, the NetWare SunLink File System gives the user's uid to UNIX as the owner and creator of the file. When the user then logs in to the Solaris operating system as a Solaris user, Solaris grants the user rights to the file because the file's uid matches the user's uid.

4.3 Client Connection Services

NetWare SunLink supports the MS-DOS, Microsoft Windows 3.x and OS/2 clients.

Client connection services refers to the transparent access to disk, print, and application program resources on a NetWare network. In essence, an MS-DOS, Windows, or OS/2 user would see the NetWare environment and appropriate resources (such as disk volumes, directories, and files) as part of their local environment. To a Windows and OS/2 user, these resources would appear as screen icons within the user interface.

Native NetWare and NetWare SunLink environments use the same client software to support DOS, Windows, and OS/2 clients. The NetWare SunLink environment can communicate with any version of NetWare: NetWare 286 (v2.2), NetWare 386 (v.311), as well as the various ELS versions. Figure 4.3.1 illustrates NetWare SunLink client support.

Since the NetWare SunLink environment is already running on a system supporting UNIX, the system administrator only needs to set up file permissions to the NetWare directories to allow Solaris UNIX clients to access NetWare files.

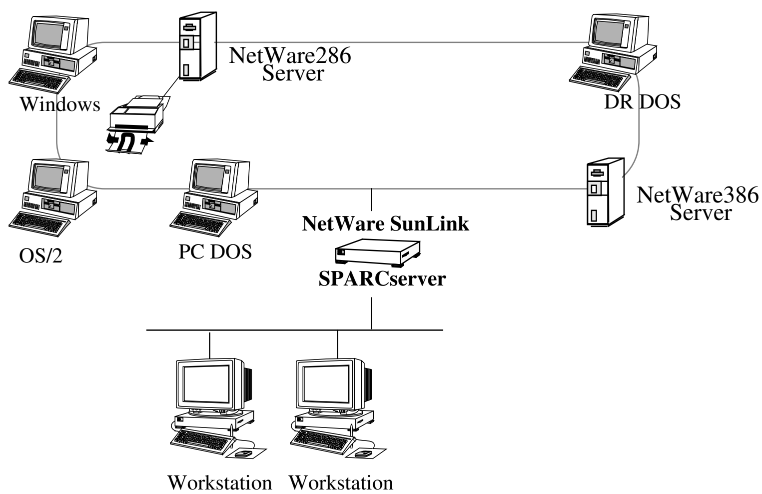


Figure 4.3.1 NetWare SunLink Client Support

4.4 File Services

NetWare employs a file system specifically designed to serve multiple types of clients in a heterogenous network environment. NetWare adapts its file system to various operating systems by providing multiple name spaces for file and directory references. For example, the MS-DOS operating system restricts file names to 8 characters plus up to 3 characters for a file name extension. DOS files names are specifically restricted to ASCII characters. On the other hand, UNIX file names may be limited to 255 characters.

NetWare's multiple name space feature maps names for files (and directories) to alternatives for each operating system accessing them in effect, a file has more than one name. Figure 4.4.1 illustrates the NetWare multiple name space.

Name Space	NetWare	Solaris	Other Name Spaces (e.g. DOS, OS/2)
Volume	SYS:	sys	. . .
Directory	FREDDIR	freddir	. . .
File	FREDFILE.FIL	fredfilefil	. . .

Figure 4.4.1 NetWare Multiple Name Spaces

NetWare employs demand binding of file names, which takes place when the file is actually accessed, rather than creating entries for each name space when the file is created.

NetWare uses an inode method of file and directory allocation, similar to UNIX's. Typically, UNIX's inode information includes a description of the disk layout of the file along with other information such as file owner, access permissions, and access times. Because NetWare does not have direct control of the physical media on a SPARC system, its inodes are instead maintained in a control file. Inode information kept in the file includes the path to the host directory that the file resides in, the NetWare owner ID, modification time, access time, and other information.

Because NetWare's file structure is built on top of the native Solaris file system, Solaris users and applications can also access those directories. Figure 4.4.2 illustrates the directory hierarchy of NetWare in comparison with Solaris.

Sun’s NFS further extends access to NetWare files. Because the NetWare directories are accessible from Solaris, they may also be exported (published) for mounting by other NFS workstations and servers. In this fashion, data files available to NetWare applications may also be accessible to applications that are not running under NetWare.

Similarly, NFS directories exported by other servers and workstations can be mapped into the NetWare environment, where they may be accessed by NetWare PC clients. In this way, PC clients can transparently access files throughout an organization and across a complex set of networks.

	NetWare	Solaris
Volume	VOL1:	/usr/netware/vol1
Directory	VOL1:ACCOUNTS	/usr/netware/vol1/accounts
Sub-directory	VOL1:ACCOUNTS\LARRY	/usr/netware/vol1/accounts/larry
File	VOL1:ACCOUNTS\LARRY\MYFILE	/usr/netware/vol1/accounts/larry/myfile

Figure 4.4.2 NetWare and Solaris Directory Hierarchies

4.5 *Printing Services*

Under native NetWare, the PCONSOLE utility is used to configure the print server. The PSERVER.NLM is then used to initialize printing services on the NetWare server. NetWare SunLink follows these same basic steps. First, PCONSOLE is used to configure a print server, followed by initialization of the PSERVER daemon via the SCONSOLE utility.

In the native NetWare environment, the PSERVER.NLM network-loadable module can be configured to use local printers cabled to the NetWare server and remote printers cabled to DOS workstations, each running the RPRINTER.EXE program (as a local process).

The NetWare SunLink environment uses the remote printing interface to allow the RPRINTER daemon to spool print jobs from NetWare print queues to the print queues of the Solaris operating system. The Solaris operating system then spools the print jobs to the printers that are attached to those queues. Thus, the actual printers may not be physically remote from the NetWare SunLink server; they could be cabled to the same computer that runs NetWare SunLink environment.

And both daemons, PSERVER and RPRINTER, can be running on that same computer. This is different from native NetWare because the PSERVER.NLM and the RPRINTER.EXE are never loaded on the same computer. Figure 4.3.1 shows the typical path of a print job from a NetWare client to a NetWare SunLink server.

NetWare SunLink printing has been designed to use the printers that are servicing the queues of the Solaris operating system. However, all elements of NetWare SunLink printing are compatible with the native versions. NetWare SunLink permits the servicing of print queues by any version of the NetWare

PSERVER (including those of other NetWare servers), the attachment of up to eight NetWare servers and the ability to service their jobs, and the capability of the RPRINTER daemon to attach to any version of the NetWare PSERVER.

From the user’s perspective, printing under the NetWare SunLink environment is just like printing under native NetWare, with a number of added advantages. NetWare SunLink integration with the Solaris operating system provides access to additional capabilities associated with Sun’s NeWSprint™ printing technology.

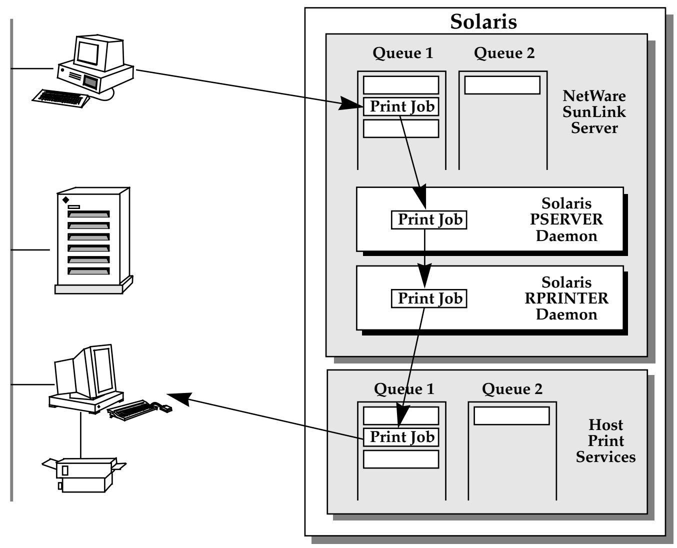


Figure 4.3.1 NetWare SunLink Printing

Sun’s NeWSprint product further extends NetWare printing by providing PostScript® rasterization on the SPARC host supporting the local and remote printers. If an application on a NetWare node (such as a MS-DOS, OS/2 or Windows) generates PostScript output, the file may be printed on a non-PostScript printer if the printer has been configured for NeWSprint support. NeWSprint automatically *sees* different formats of print files, and handles PostScript files automatically.

Coupled with NeWSprint, Sun’s SPARCprinter™ printer adds powerful printing capabilities to a SPARCserver system running the NetWare SunLink environment. The SPARCprinter is a high-speed laser printer providing 400 dots-per-inch resolution, 57 F3 hinted fonts, and up to 12 pages per minute performance.

4.6 Network Management and Administration

As described in the introductory sections, NetWare SunLink supports a specialized user known as the SUPERVISOR, who in general, has absolute access and control over the NetWare environment. The SUPERVISOR user is designed for system setup and administration of a NetWare-based system.

Under NetWare, user accounts are setup by the SUPERVISOR user through the `SYSCON` utility. `SYSCON` is used for a number of NetWare administrative functions including managing user accounts and their restrictions, file and director access restrictions, group assignments, and security equivalence rights.

NetWare uses the term *trustee rights* to refer to those rights that have been assigned to a given user or group. A user or group that has been assigned rights to work in a directory of file is known as a *trustee* of that directory or file.

The *inherited rights mask* (IRM) is a method of controlling the default rights which users can inherit. An IRM is given to each file or directory when it is created. Changes can be made to an IRM by a user with the appropriate privileges.

Because NetWare is perceived by the Solaris operating system as a user, Solaris UNIX file and directory permissions further restrict any rights assigned by NetWare. This additional protection insures that NetWare files are secure and cannot be damaged or destroyed by unauthorized users or errant programs.

NetWare User Access Rights

NetWare SunLink supports the same NetWare user access rights familiar to users of native NetWare. Under NetWare SunLink, a total of eight rights may be granted: *access control*, *create*, *erase*, *file scan*, *modify*, *read*, *supervisory* and *write*. The table 4.6.1 for a list of the NetWare SunLink access rights.

Access Right	Description
Access Control	Allows users to modify trustee assignments and inherited rights masks
Create	Allows the user to create directories and files
Erase	Allows users to delete directories and files
File Scan	Allows users to see files (i.e. see them as a directory entry, but not necessarily read their contents)
Modify	Allows the user to change the directory and file attributes, and to rename directories and files
Read	Allows the user to open and read files
Supervisory	Grants all rights to a directory or file

Table 4.6.1 NetWare SunLink Access Rights

All of the access rights have directory-level equivalents. If a right has been granted at the directory level, the user can perform the appropriate operation on the directory itself.

Under Solaris, NetWare SunLink runs as a set of daemons and processes. As a result, the Solaris UNIX `superuser` has ultimate control over the host system under which NetWare SunLink is running.

Security

NetWare SunLink gives the same protections as native NetWare. Security under the NetWare SunLink environment is achieved through control of information at three levels: `login`, `rights`, and `attributes`. NetWare uses the `SYSCON` utility to determine who can access the network, what resources (directories and files) users can access, what users do with those resources, and who can perform tasks at the file server console.

Login security is achieved by *user name* and *password* control. NetWare maintains a password file that is set up when NetWare is installed. The NetWare administrator can force additional controls on the creation and use of passwords, including minimum password lengths, password time limits, requirements for uniqueness, and limited incorrect login attempts. Additionally, NetWare security can limit access to the NetWare server by dictating restrictions on where a user may login from (which network nodes), time restrictions on access, and account restrictions that limit the amount of time that a user may be logged in.

Rights security refers to the access rights associated with files and directories, as described above.

Attribute security assigns special properties to individual directories or files. Attribute security overrides the rights granted with trustee assignments and can prevent tasks that effective rights would otherwise allow. Attribute rights can prevent users performing such operations as deleting, copying, viewing, or writing files and directories. Attributes may also control whether files may be shared, mark files as modified so that backup utilities can selectively back them up, and protect files from data corruption.

Sun Security Enhancements

In addition to the login and file/directory security facilities provided by NetWare, Solaris/ONC provides additional security capabilities to NetWare users of SPARCserver systems and the NetWare SunLink environment.

The ONC network file system adds *export lists* of available file systems from each server or workstation supporting NFS. The systems administrator can alter the export list to limit access for NFS mounted files to include only specific users (or groups), as well as read-only versus read/write permission.

NetWare SunLink, as a process under Solaris UNIX, yields to the file locking security defined by Solaris. Hence, files used by applications under both Solaris and NetWare, may be locked at the Solaris level as well as through NetWare.

Accounting

The NetWare Sunlink environment implements a portion of the standard NetWare accounting facility through the `SYSCON` utility. Once accounting is installed on the NetWare server, it allows for selection of accounting of user usage of individual services such as printing, disk usage, gateway access usage, and file server usage. NetWare permits the tracking of more than one service for each user, and allows the SUPERVISOR to assign individual values for charges for usage of them.

NetWare SunLink accounting features are user usage administration (including computation of charges for NetWare services such as file access,) and the setting of CPU time limits, login attempts, and account balances.

NetWare accounting facilities under NetWare SunLink do not allow for setting usage limits on disk files or for tracking total disk space used by individual users. These limits are the result of NetWare obtaining file services from the Solaris operating system, which *sees* only a single NetWare user (NetWare itself), rather than all NetWare users.

When the SUPERVISOR sets up accounting, he or she assigns an account balance for each service to be controlled and audited. The account balance controls the amount of service each user may use (not including disk totals). When the user approaches a specific limit, NetWare will warn the user and request that they log out. Additional NetWare options exist which grant a grace usage beyond the assigned limit.

Disk File Backup and Restore

Backup capabilities are provided as part of the Solaris UNIX operating system through *dump* and *restore*. Dump and restore permit selective backup and restore of individual disks and directories. Using NFS, dump and restore can perform backup and restoration of multiple NFS server files. Many third party backup utilities are also available. They are described in Sun's Catalyst catalog of third party solutions.

Sun provides an unbundled product called Backup Copilot™, which provides on-line backup of mounted active file systems. Backup Copilot includes a tape-librarian mechanism that enables system administrators to easily manage their backup tapes. When equipped with a multitape backup system (such as an 8mm tape stacking changer), Backup Copilot can automatically perform tape changes without operator intervention.

In addition to Sun products, there are numerous third party backup solutions that can simultaneously handle PC, Macintosh, and UNIX environments. Generally speaking, backup utilities under UNIX run as root-level processes, executable only by the Solaris superuser. This security feature insures that unauthorized users do not backup file systems they are not permitted access to.

Users wishing to backup only NetWare partitions may utilize NetWare's backup and restore facility, `NBACKUP`. `NBACKUP` is designed to support selective backup by individual users (or the SUPERVISOR) of files and directories for which they have File Scan and Read rights. `NBACKUP` will backup files on both a NetWare server and on local disk drives. Under Solaris, individual users may backup files using the UNIX `tar` utility.

4.7 Internetwork Services

Internetwork services refers to the use of a server as a router or gateway between multiple LANs, including those of different topologies. The SPARCserver system can act as a gateway/router between multiple Ethernet, FDDI, and token ring LANs.

An additional capability associated with SPARCserver systems is the ability to integrate NFS support onto NetWare networks. For example, the NetWare SunLink environment may define additional volumes for PC node access, which are mapped through NFS to disk partitions or directories on the SPARCserver system. These partitions may in fact be mounted from another NFS server. Figure 4.7.1 illustrates internetworking with the NetWare SunLink environment.

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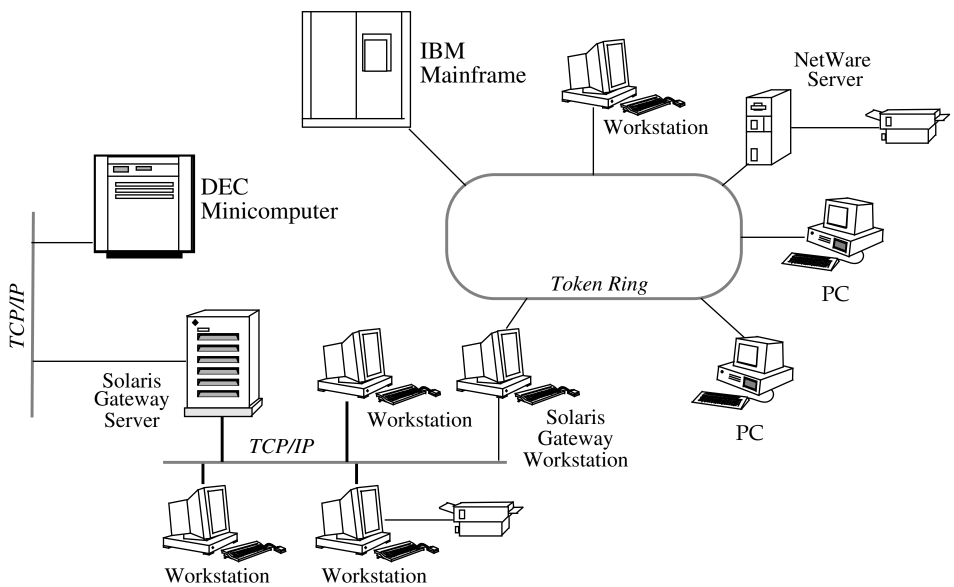

Figure 4.7.1 Internetworking with NetWare SunLink and Solaris

4.8 Terminal Services

Terminal services provided by NetWare SunLink permit NetWare nodes to become terminals of the NetWare server. Using terminal emulation, PCs may access thousands of robust, sophisticated UNIX applications, running native on high-performance SPARCservers.

In the scenario described above, users seeking the benefits of distributed computing can take advantage of terminal access to applications on the server today, and migrate over time to the client-server model. Figure 4.8.1 illustrates the two scenarios of terminal emulation and true client-server computing. Applications taking greater advantage of client-server computing could execute a portion of the application, such as a graphical user interface or an SQL generator on the PC, while running the database as a "back-end" on the server.

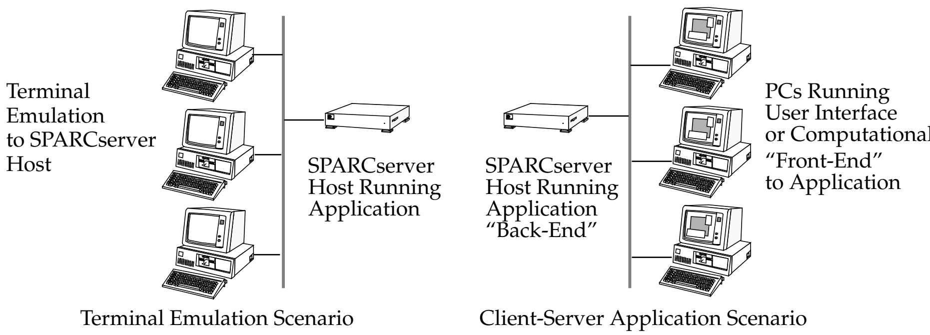

Figure 4.8.1 Terminal and Client-Server Application Scenarios

To provide access from MS-DOS 3.0 (and later) or Microsoft Windows desktop clients to TTY-based applications running on the Solaris system, the Novell Virtual Terminal (NVT) program is provided as part of the NetWare SunLink environment. NVT is a DOS *terminate and stay resident* (TSR) application, which requires a minimum amount of PC memory, making it generally transparent to the user.

NVT allows a network client (such as a PC) to access the host system as a Solaris UNIX terminal. Terminal emulation on PCs is typically limited to data rates between 300 and 9600 bps. NVT over Ethernet provides terminal emulation with data rates of 10 million bps, resulting in extremely fast response.

Data created under NVT remains in the host operating system environment. NetWare users can access data through NVT, or data may be copied into the NetWare SunLink portion of the file system for PC access.

4.9 SunNet License and NetWare SunLink

SunNet™ License is a Sun software product that provides floating license server capability to Sun and third party applications and tools. SunNet License is also integrated into NetWare SunLink to provide a simple means to manage NetWare tiered packaging for the various sizes of NetWare SunLink-based networks.

NetWare users can order NetWare SunLink, which supports a variety of network sizes. A key feature of integrating SunNet License into NetWare SunLink is the provision to support multiple SPARCserver systems without the requirement for purchasing a larger number of NetWare SunLink licenses than are required. If a NetWare SunLink network has 50 users, with 2 SPARCserver systems, only a single NetWare SunLink 50-license package is required, rather than2 separate NetWare SunLink packages. This permits greater flexibility in using NetWare without the additional cost of superfluous NetWare licenses.

4.10 Unique NetWare SunLink Features

The NetWare SunLink environment is an enhanced version of Novell's portable NetWare for UNIX product. The NetWare SunLink environment provides consistent integration with Solaris and SPARC through a number of unique enhancements. These facilities include installation, network support, and network-based licensing, NFS support, file system utilities, and a variety of other features. Table 4.9.1 describes the NetWare SunLink enhancements.

NetWare Feature	Description
Installation	• Includes both OpenWindows (GUI) and TTY(terminal) automated installation • Creates a NetWare DOS ODI boot diskette for the user • Configures the system so most users do not need to do any other configuration prior to bootup • Creates an InstallNotes file that contains customized printer configuration step-by-step instructions • Allows upgrades to new versions of product and reinstallation • `nwremove` and `nwreboot` utilities added to aid deinstallation and reinitialization (after installation/upgrade)
Network Support	• Supports up to 2 Ethernet interfaces and 1 token ring interface
Network Licensing	• NetWare SunLink offers a floating client licensing mechanism, via SunNet License. This allows the sharing of client licenses across multiple servers and upgrading the number of client users without reinstalling NetWare SunLink software • `nwlit, nwttylit` utilities are provided to allow adding additional licenses without reinstalling NetWare
NFS Support	• Allows the user to mount file systems that are not on the NetWare SunLink server, but are actually remotely mounted via NFS • The file system can also handle remote file systems that temporarily go away and come back
Symbolic Links	• Allows files that are symbolic links to be visible
File System Utilities	• User-level `nwfsck` provided to check and repair internal file system `NWinode` consistency • User-level `volcheck` provided to check for access permission problems for NetWare and hybrid users
Other Utilities	• Additional administrative server utilities provided, including: `volinfo, servinfo and stopptr`
Documentation	• Express Installation Guide that gives the user a very easy path to and running • Utilities manuals that can be viewed on-line by the client

Table 4.9.1 NetWare SunLink Enhancements

NetWare SunLink at Work 5

NetWare SunLink provides the same basic services as the native NetWare environment. Multiple NetWare servers and clients can cooperatively coexist on Ethernet and token ring networks with ONC-based SPARCserver systems and workstations. A number of services provided with NetWare are similar to those in the Solaris operating system. Those services may be mapped from NetWare SunLink to Solaris for greater flexibility and performance.

This section describes the underlying architecture and protocols of NetWare SunLink.

5.1 Architecture

NetWare SunLink corresponds to the services available in NetWare v3.11. These services are what most users recognize as NetWare. Table 5.1.1 describes the basic NetWare services.

In the NetWare environment, a user with special privileges, known as the SUPERVISOR, has access to files and facilities not generally available to the typical user. The SUPERVISOR has access to all of NetWare utility programs, such as `SYSCON` (system configuration), which is used for accounting, user and group account setup, establishing system defaults, and setting system restrictions.

Many other utilities under NetWare are accessible by normal users, but are limited to the information that is viewable or to the modifications the user can make.

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Service	Description
Bindery Services	Providing login authentication, intruder detection, password, and station and time restrictions
File Services	Supporting directory and file trustee rights, inherited rights masks, and attributes
Queue Management Services	For management of local and remote print queues
Printing Services	Providing print facilities to any NetWare server
Accounting Services	For user disk usage data collection and administration
Connection Services	Providing support for DOS, OS/2, and Windows clients
Synchronization Services	For multiple access to the same file
Management Utilities	For user and group account, file server, and SUPERVISOR management

Table 5.1.1 NetWare Services

Initialization

On an Intel-based NetWare server, NetWare is loaded by booting DOS and then executing `SERVER.EXE`, which reads two configuration files: `STARTUP.NCF` and `AUTOEXEC.NCF`.

The NetWare SunLink environment has a similar initialization process in that first Solaris is booted, and then NetWare SunLink is started. However, instead of one executable file that reads configuration files and initializes NetWare, NetWare SunLink uses daemons. A daemon is a process that runs in the background with little, or no, user intervention. The Solaris operating system schedules the daemon’s CPU time.

The NetWare SunLink environment uses two daemons. The *NPS daemon* initializes the transports, and the *NetWare daemon* initializes the NetWare services. Each daemon has its own configuration file. Figure 5.1.2 illustrates the initialization process. Under Solaris, NetWare start-up is typically automated and installed as part of the normal boot process.

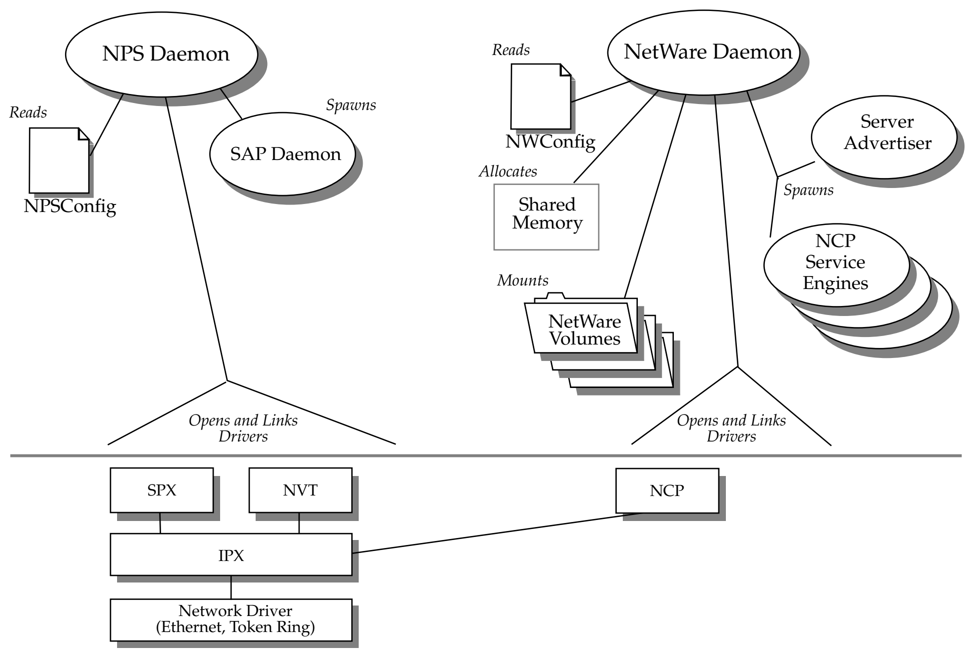

Figure 5.1.2 NetWare SunLink Initialization

NPS Daemon

The NPS (NetWare Protocol Stack) daemon reads the `NPSConfig` file to determine which drivers to configure for transport services. The NPS Daemon must configure two drivers, IPX and the LAN driver, to support standard NetWare services.

NetWare SunLink can be configured to use multiple network board drivers (and thus becomes a router). The NetWare SunLink environment supports both Ethernet and Token Ring topologies. For these topologies, NetWare SunLink supports all the frame (packet) types that native NetWare supports: `ETHERNET_802.3`, `ETHERNET_II`, `ETHERNET_802.2`, `ETHERNET_SNAP`, `TOKEN_RING`, and `TOKEN-RING_SNAP`. The default frame type supported by NetWare SunLink is `ETHERNET_802.3`. A parameter in the `NPSConfig` file allows the NPS daemon to configure the driver for the appropriate frame type.

In the NetWare SunLink environment, the transports (the communication protocols initialized by NPS daemon) can run independently of the NetWare services (the modules initialized by the NetWare daemon). Application developers can access the transport modules using TLI (transport layer interface) calls. TLI is a communications layer provided with Solaris 1.0 and 2.0 and is a standard part of UNIX System V Release 4. TLI provides a protocol-independent platform for distributed computing applications, utilities, and high-level protocols, and may be mapped to any number of lower-level protocols such as TCP/IP, IPX, or OSI.

Figure 5.1.3 illustrates how an application would access the modules with the TLI interface.

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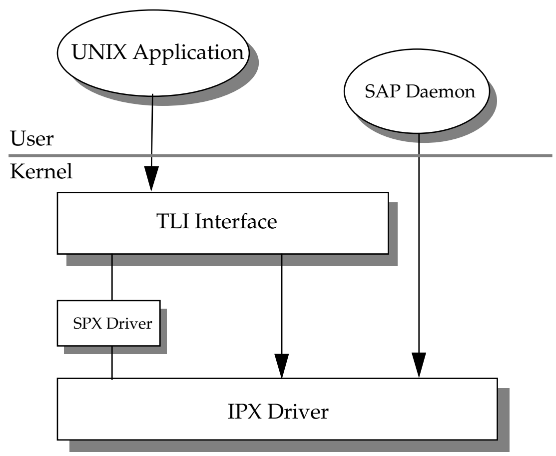

Figure 5.1.3 UNIX Applications and the TLI Interface

NetWare Daemon

The NetWare daemon initializes the NCP MUX (NetWare Core Protocol Multiplexor) driver and starts the NetWare server processes. It reads the NetWare server name from the `NWConfig` file and begins advertising itself on the network as a NetWare server. Once it has finished its initialization process, users can log in, query the bindery for servers on the network, access files and directories, and use the standard NetWare directories: `SYS:LOGIN`, `SYS:PUBLIC`, `SYS:MAIL`, and `SYS:SYSTEM`. The Solaris UNIX user would see these directories as mapped to UNIX (`/usr/netware/sys/login`, `/usr/netware/sys/public`, `/usr/netware/sys /mail`, and `/usr/netware/sys/system`).

The strength of the NetWare SunLink environment lies in the fact that the NetWare SunLink server seems like any other NetWare server to users. The packets of a NetWare SunLink server and those of a native NetWare server appear identical. Below the user interface, however, NetWare SunLink handles many things quite differently than native NetWare.

5.2 NetWare Protocols

NetWare utilizes a set of protocols performing similar functions to those of traditional network schemes such as TCP/IP, but which may run concurrently with them on the same media. Existing Ethernet networks can thus run several network protocols simultaneously.

Within the context of the Open System Interconnection (OSI) reference model, NetWare performs functions at all but the bottom two levels (data link and physical), where it relies on an Ethernet LAN driver and an associated network interface controller. Figure 5.2.1 illustrates the NetWare architecture as related to the OSI model.

The NetWare protocol stack provides routing, transport, and advertising services. The modules in this stack can be run on the host system independent of the NetWare service modules.

The NetWare protocol stack consists of the two daemons (NPS and SAP), various drivers, and protocol specific modules. Only four of the modules in the stack are required to run NetWare services: the LAN driver, IPX, NPS daemon, and the SAP daemon. In addition to these four modules, NetWare SunLink implements SPX (connection and sequence oriented) and NVT (for terminal emulation). The NetWare SunLink daemons and protocols are described in Table 5.2.2.

NCP, SAP, and NVT originated with Novell and are specific to NetWare. The IPX, SPX, and RIP are NetWare adaptations of the Xerox Network System (XNS) protocols

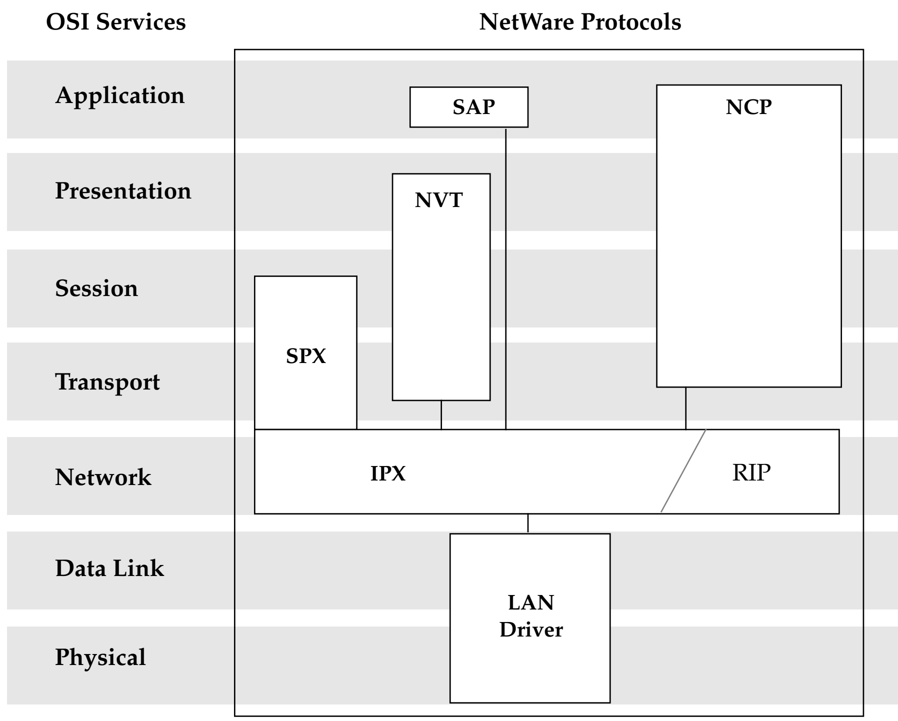

Figure 5.2.1 NetWare Protocols and the OSI Reference Model

Upon initiation of NetWare, the NPS daemon opens and links modules in the NetWare protocol stack. First, the NPS daemon reads the `NPSConfig` configuration file to determine which modules to open and link. Then the NPS daemon opens IPX. For each LAN driver specified in the configuration file, NPS opens the driver and links it to IPX.

NPS then spawns the SAP daemon. The SAP daemon provides a mechanism for service nodes, such as file servers, printers and gateway servers, to register their services and addresses in server information tables. Clients may query these tables for available services and their IPX addresses.

NPS completes its initialization by linking other drivers specified in `NPSConfig` file to IPX, such as SPX and NVT. Once it has completed initialization, the NPS daemon sleeps, maintaining the stack open until shutdown.

Daemons and Protocols	Function
NPS (NetWare Protocol Stack) Daemon	Starts the NetWare protocol stack
SAP (Service Advertising Protocol) Daemon	Broadcasts names and locations of services through the network
IPX (Internet Packet Exchange)	Provides datagram delivery services
NVT (Novell Virtual Terminal)	Provides connection-oriented delivery for terminal emulation
SPX (Sequenced Packet Exchange)	Connection-oriented protocol providing guaranteed delivery of messages in correct packet order
NCP (NetWare Core Protocol)	Manages response to NetWare service requests from clients
Packet Burst Protocol	Provides high-performance reads/writes using 64-Kbyte blocks
RIP (Routing Information Protocol)	Manages routing tables for packet routing and delivery

Table 5.2.2 NetWare SunLink Daemons and Protocols and Their Function

Packet Burst Protocol

The Packet Burst Protocol is an enhanced protocol provided with the NetWare SunLink environment. It is a high-performance connection-oriented protocol that is built on top of IPX. The Packet Burst Protocol offers a number of advantages over other NetWare protocols, including:

- A single request packet can result in the server reading or writing large blocks of data that comprise multiple packets.
- The client can adjust the rate at which packets are sent from the server or the number of packets contained in a message or burst.

The Packet Burst Protocol is especially useful in environments where large block size transfers are common. For example, some database transactions can result in significant data transfer between the database and the client application. Large networks, or those with traffic, will also benefit from using the Packet Burst Protocol.

Netware SunLink Compared to Native Netware A

The following list compares the features of NetWare SunLink with native NetWare. Numerical limits reflect the capabilities of the NetWare environment rather than physical limitations of the underlying platform.

Operating System Specifications	**NetWare SunLink**	**Native NetWare**
Maximum number of users	Tiered Licensing up to 250	10, 20, 100, 250
Concurrent open files	100,000**	100,000
Maximum number of volumes	64	64*
Maximum number of hard drives	1024*	1024*
Directory entries per volume	65,000**	32,000
Maximum file size (file can span hard disks)	4GBytes+	4GBytes*
Maximum addressable RAM memory	Virtual	4GBytes*
Maximum volume size	32TBytes*	32TBytes
Maximum total disk storage	32TBytes*	32TBytes*
Dynamic cache buffers	Yes	Yes
Full DOS and OS/2 services	Yes	Yes

+ NetWare software limit. NetWare SunLink on SPARC/Solaris limit is 2GB.

* NetWare software limitation. Physical hardware limitation is significantly less.

** NetWare SunLink software limitation. Operating system limitation may be less.

Operating System Specifications	NetWare SunLink	Native NetWare
Dynamic server memory allocation	Yes	Yes
Use of paged virtual memory	Yes	No
Maximum shared printers per server	16	16
Multi-tasking	Yes	No
Internal routing of TCP/IP	Included	Included
File Services		
Volume segments	Not Applicable	Yes
NetWare Loadable Modules	UNIX Applications*	Yes
Drivers and daemons	Yes	No
Security		
Security equivalences	Yes	Yes
Set account expiration date	Yes	Yes
Set time and date restrictions	Yes	Yes
Lock account after multiple failed passwords	Yes	Yes
Designate intruder detections threshold	Yes	Yes
Mandatory password changes	Yes	Yes
Limit concurrent connections	Yes	Yes
Set minimum password length	Yes	Yes
Require unique passwords	Yes	Yes
Restrict users to specific workstations	Yes	Yes
Network Management Services		
Workgroup manager (SYSCON)	Yes	Yes
Client management utilities	Yes	Yes
Remote network administration	Yes	Yes
Integrated Host Environment		
Hybrid user	Yes	No
Host utilities	Yes	No

* Applications under the Solaris operating system frequently provide the same capabilities as NetWare Loadable Modules under native NetWare. Such applications include third party application solutions and administration utilities, as well as Sun products such as SunNet License.

Internetworking Services	NetWare SunLink	Native NetWare
NetWare external bridge software	Included	Included
Internal routing of IPX	Yes	Yes
Internal routing of AFP	Available	Available
Internal routing of TCP/IP	Included	Included
Terminal Services	SunLink	NetWare
NetWare Virtual Terminal	Yes	No
Developer Interfaces		
NetWare Services APIs	Available	Yes
IPX/SPX APIs	Available	Yes
Accounting		
Limit disk space for accounts	No	Yes
Track user space in use	No	Yes
Charge users for services	Yes	Yes
Vary rates by date and time	Yes	Yes
Set user account balances	Yes	Yes
Set user credit line	Yes	Yes
Log out users exceeding credit limit	Yes	Yes
E-MAIL		
Email support	SMTP	MHS
SMTP to MHS Gateway	3rd Party	Optional
Archival Services		
1-step backup/restore server disks (with security)	Yes	Yes
On-line backup of account files	Yes	Yes
Alert Services		
Drive full/almost full	No	Yes
Excessive errors	No	Yes
Intruder alert	Yes	Yes
Printer problem alert	Yes*	Yes

Print Services	NetWare SunLink	Native NetWare
Multiple queues serviced by one printer	Yes	Yes
Multiple printers servicing one queue	Yes	Yes
Multiple queues serviced by multiple printers	Yes	Yes
Set queue priority level	Yes	Yes
Remote Printers		
Connection Services	Yes	Yes
DOS client shell and management utility	Yes	Yes
OS/2 client requestor and management utility	Yes	Yes
Macintosh client management	Available in Version 2.0	Yes
327X remote gateway	Client only	Yes
Asynchronous gateway	Client only	Yes
Bridging		
Support for remote workstations	Yes	Yes
Support for remote servers	Yes	Yes
Fault Tolerance		
UPS monitoring	3rd-Party	Yes
Disk mirroring/duplexing	Online: DiskSuite™	Yes
Split seeks	Yes (Solaris)	Yes
Read after write verification	Yes (Solaris)	Yes
Transaction tracking	No	Yes
Supervisor Utilities		
`SYSCON`	Yes	Yes
`FILER`	Yes	Yes
`MONITOR/ INSTALL`	Provided by `SCONSOLE`	Yes
`SCONSOLE`	Yes	No

Network Terminology B

Bindery NetWare's database of information on users, groups, printers, and other network information.

Bridge A device connecting different LANs of the same topology so that a node on one LAN can communicate with a node on another. Packets are routed at the data link layer level.

CCITT The International Telephone and Telegraph Consultative Committee, an arm of the International Telecommunications Union (a United Nations agency).

Circuit Switching The exclusive allocation of a specific channel for the duration of the connection. Each individual link in the circuit is dedicated to the connection.

CSMA/CD Carrier Sense Multiple Access Collision Detection, a scheme for network control where a carrier signal (sent by more than one node) is detected and data is subsequently re-sent at a randomly selected time delta.

CSMA/CR Carrier Sense Multiple Access Collision Resolution, a scheme for network control where data (sent by more than one node) is detected, and upon collision, is re-sent. This scheme is utilized on the passive bus defined as part of the ISDN Layer 1 characteristics.

Data link layer Layer 2 of the OSI Reference Model, providing framing, error detection, and other services.

Gateway A device acting as a translator between networks that use different transport protocols. A gateway permits a workstation using one protocol, such as NetWare's NCP, to communicate with another running a different protocol, such as SNA.

HDLC High-Level Data Link Control. A family of communications protocols defined by the ISO.

Internetwork Two or more physical networks connected to one another via a bridge, gateway, or router.

IP Internet Protocol. A protocol developed by the Defense Advanced Research Projects Agency (DARPA) for the reliable transfer of data to the correct node. IP is a lower-level connection-less datagram protocol, upon which other connection-oriented protocols are built.

IPX Internetwork Packet Exchange. One of two data transmission protocols user by NetWare, the other protocol being Sequenced Packet Exchange (SPX). IPX permits the transmission of message packets or requests between the file server and workstations.

ISO International Organization for Standardization, an international group defining standards in a variety of technology areas, including computing and communications.

MHS Mail Handling System. Defined by ISO as a set of standards (X.400) for interoperability in the exchange of electronic mail.

NCP NetWare Core Protocol. NetWare's service protocol allowing clients and servers to transport packets using either a session (SPX) or datagram (IPX) protocol.

NetBIOS A communication protocol used by IBM's PC LAN system. Applications may be specifically written for the NetBIOS environment.

Network layer Layer 3 of the OSI Reference Model, responsible for routing data through a communication network.

NFS A distributed file system permitting the sharing of data regardless of operating system, workstation type (processor architecture), or the protocols used.

NIC Network Interface Controller is a hardware component of workstations and servers that permits them to connect and communicate on the network.

NLM Network Loadable Module. A program that runs as though it is part of the NetWare 386 operating system. NLMs may be written by Novell, third-party vendors, or end-users. NLMs, as a feature of NetWare 386, replace Value-Added Processing (VAPs) of NetWare 286.

Node An intelligent, active device on the network, such as a workstation, server, printer, bridge or other device with a unique network address.

NPS — NetWare Protocol Stack Daemon. During NetWare initialization, the NPS Daemon opens and links modules in the NetWare protocol stack.

NVT — Novell Virtual Terminal. A high-level connection-oriented protocol which manages network-based terminal emulation sessions between workstation nodes and a NetWare SunLink server.

OSI — Open Systems Interconnection, a activity of the ISO for standardization of communications.

Packet — A discrete unit of data transmitted over a network in an encoded format generally containing address information, error control information and data.

Packet switching — A communications architecture in which data is transferred across the network in variable-length packets using a scheme called store and forward.

RIP — Routing Information Protocol. A scheme adapted from the Xerox Network System (XNS) for maintaining routing information utilized by IPX for obtaining an efficient route for transfer of information from source to destination on a NetWare network.

Router — A device connecting different LANs of different topologies or packet types. Packets are routed at the network layer level.

SAP — Service Advertising Protocol. SAP provides a mechanism for service nodes, such as file servers, printers and gateway servers, to register their services and addresses in server information tables. Clients may query these tables for available services and their IPX addresses.

SDLC — Synchronous Data Link Control. A subset of the HDLC protocol used by IBM computers running under SNA.

SNA — Systems Network Architecture. A proprietary communications protocol employed on IBM's minicomputer and mainframe networks.

SPX — Sequenced Packet Exchange. One of two transmission protocols used by NetWare, the other being IPX. SPX provides guaranteed delivery of packets for printing.

TCP — Transmission Control Protocol. A connection-oriented communications protocol usually implemented on top of IP.

TCP/IP — Transmission Control Protocol/Internet Protocol. A DARPA defined network protocol suite featuring a connection-less network layer.

TLI Transport layer interface. The communications layer provided as part of UNIX System V Release 4, providing a protocol-independent platform for distributed computing applications, utilities, and high-level protocols. TLI may be mapped to any number of lower-level protocols such as TCP/IP, IPX, or OSI. TLI is also supported under UNIX System 3 and the Solaris 1.x release.

Token ring A network topology relying on the passing of a exclusive access flag known as a token. A node that gains access to the token may send a message, and when complete, releases the token.

Topology The basic network layout scheme determining the way in which network nodes are connected. Common network topologies include bus, ring and star.

TTS Transaction Tracking System. A feature on native NetWare 386, where transactions, such as groups of reads and writes, may be arranged in blocks that if not completed may be reversed or "rolled back". TTS provides a reliable method of maintaining database integrity in the event of system or network failure.

X.400 The CCITT standard for electronic message handling, known as electronic mail (email). X.400 is also frequently referred to as MHS.

SunLink Communications

C

SunLink products address both proprietary and industry standard connectivity, including support for IBM and DEC networking schemes as well as terminal emulation, electronic mail standards, and wide area networking. In addition to NetWare Sunlink, Sun Microsystems provides the following communications products:

- SunLink MHS
  Supports X.400 mail interchange with multi-vendor networks.
- SunLink OSI
  Provides support for OSI's MAP and TOP protocols.
- SunLink X.25
  Provides connectivity to public and private X.25 networks.
- SunLink DDN
  Supports the packet-switched Defense Data Network (DDN).
- SunLink IR
  Connects Ethernet-based local area networks over a wide area.
- SunLink DNI/SunLink TE320
  DECnet network support, DEC VT320/220/100 terminal emulation.
- SunLink Channel Gateway
  Combined hardware and software product connecting SPARCserver systems to IBM's mainframe block multiplexor channel.

- SunLink Local 3270
  Provides 3270 sessions via IBM SNA or Bisync protocols. Supports 3278 and 3279 terminal emulation and 3287 printer emulation.
- SunLink SNA 3270
  Provides IBM cluster controller emulation on any Solaris workstation using SDLC or token ring.
- SunLink CG3270
  Performs IBM 3270 color graphics terminal emulation.
- SunLink SNA Peer-to-Peer
  Supporting IBM's SNA environment over Token Ring or via SDLC.
- SunLink TRI/S
  4 and 16 Mbps IEEE 802.5 Token Ring network support.
- PC-NFS®
  Provides the industry-standard NFS distributed file system to PCs, with terminal emulation and Windows 3.x support.

SunLink communications provide the infrastructure for enterprise-wide computing from the mainframe and supercomputer to the minicomputer and desktop workstation. Sun's PC-NFS product extends that coverage to include PCs wishing to share disk resources and which may benefit from terminal emulation to UNIX hosts.

The NetWare SunLink environment completes the enterprise computing model by integrating NetWare servers and clients into the ONC and SunLink infrastructure. Existing NetWare LANs can interconnect with SPARC systems that are in turn bridged to mainframe and minicomputers. System-wide sharing of information, distributed applications, and transparent access to printing and compute resources has become possible.

NetWare SunLink System Requirements D

NetWare SunLink 1.0 is a SunOS 4.1.x SPARC port of NetWare for UNIX v3.11. It is supported on Solaris 1.0.1 (SunOS 4.1.1, 4.1.2, and Solaris 1.1 SMCC Version A).

NetWare SunLink 1.0 will run an any SPARC-based Sun-4, Sun4c, or Sun-4m system. The system must have:

- 16 MBytes of memory
- 40 MBytes of disk space
- A graphics display monitor or a terminal attached to the SPARCserver system or remote login access from another Solaris-based workstation via the network. If a graphics display monitor is present, you may wish to also run OpenWindows 2.0 or 3.0.
- A CD-ROM drive (either local or remote), for installation of NetWare SunLink

16 MBytes of memory will service a 10-node or smaller network. For more than 10 nodes, it is recommended that 32 MBytes be configured. Please refer to the NetWare SunLink documentation for more details.

To use NetWare SunLink, it is recommended that at least 100 MBytes of free disk space be available, as well as two times the physical memory size for swap area (for example, with a 16 MByte system, reserve 32 MByte of swap).

NetWare and UNIX Environments E

Native NetWare and UNIX (Solaris) have a number of parallels when examined side-by-side. The following chart illustrates a rough mapping of functionality between them.

Native NetWare	Unix (Solaris)	Description of Function
SPX	TCP	Connection-oriented protocol for reliable packet delivery
IPX	IP	Connection-less datagram protocol, acting as a transmission base for higher-level connection-oriented protocols
SAP	NIS, Portmapper	Service advertising mechanism for broadcasting names and locations of services throughout the network
NCP	NFS	A core set of services providing file system access, independent of underlying transport protocols
SUPERVISOR	root (superuser)	Login name for the qualified user with overall administrative access to all files, directories, and programs
Trustee Rights	Permissions	Assignable access privileges to files, directories, and programs. Trustee right is a parallel mechanism with broader capabilities and flexibility than UNIX permissions
PSERVER	LPD	Provides routing and management of printing and print queues
RIP	RIP	Routing information protocol, providing an efficient route for transfer of information between routers

References F

Computer Communications: Architectures, Protocols and Standards, William Stallings, IEEE Computer Society, 1991
Computer Networks, Protocols, Standards and Interfaces, U. Black, Prentice-Hall, 1987
Inside NetWare for Unix v3.11: A Novell Research Report, Novel, Inc., 1992
Inside Novell NetWare, Debra Niedermiller-Chaffins, New Riders Publishing, 1991
International Organization for Standardization, Basic Reference Model for OpenSystems Interconnection, ISO 7498, 1984
Local Area Networking with Novell Software, Michael Palmer & Alvin Rains, ‘ Boyd & Fraser, 1991
Local Area Networks: The Next Generation, Thomas Madron, John Wiley and Sons, 1990
NetWare for Unix v3.11: User Documentation, Novell Part # 183-000416-001, Novell, Inc., 1992
NetWare SunLink Reference Manuals, Sun Microsystems Part # 814-1050-10, Sun Microsystems, Inc., 1992
Novell NetWare Companion, Phil Croucher, Sigma Press, 1990
Open Systems Interconnection, IBM Systems Journal Numbers 3 & 4, J. Aschenbrenner, 1986
Understanding Local Area Networks, Stan Schatt, Sams & Company, 1990
Using Novell NetWare, Bill Lawrence, Que Corporation, 1990
X.400: The Messaging and Interconnection Medium for the Future, P. Chilton, NCC Publications, 1990

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