CHAPTER 1

Introduction to NetWare 6

"The only way round is through." — Robert Frost

NetWare is still one of the world's most popular network operating systems. With NetWare 6, Novell has incorporated all the advantages of previous versions of NetWare and has added new features that build on its foundation to provide a distributed computing infrastructure. NetWare 6 increases productivity, reduces costs, and simplifies installing and maintaining your network.

Key to NetWare 6 is Novell Directory Services (NDS), now referred to as NDS eDirectory (we'll use NDS and eDirectory interchangeably throughout this book), which is a special-purpose name service that enables you to find and use network resources and data as a single integrated system. NDS provides this powerful operating system with the same speed and reliability that you've come to expect with NetWare 3, NetWare 4, and NetWare 5. NDS eDirectory reaches across all major platforms to provide a distributed directory service. No other directory can operate on as many platforms as NDS eDirectory. With the introduction of NetWare 6, you now have the ability to fully manage storage resources, security, and mixed-client environments with greater flexibility and scalability. NetWare 6 provides a reliable and secure foundation necessary for the eBusiness world.

Many corporations over the years have embraced and implemented NetWare as an integral part of everyday business computing solutions. Today, local and wide area networks are running business-critical applications once considered the sole domain of mainframe computers. More and more businesses are finding that they can operate more efficiently and cost-effectively on NetWare networks and still receive the same security and administrative benefits of larger systems.

With the advent of NetWare 6, NetWare has become even more powerful, scalable, and flexible, widening its lead over any other directory-based network operating system available. NetWare 6 is still the same powerful network operating system that NetWare has always been, but it has new features and services that make it more than just a local area network. For example, the need to connect remote and disparate devices to the network has increased dramatically over the past two years. The need for additional storage has also increased dramatically as more users need access to corporate information. Novell has met these challenges with the release of NetWare 6.

This book focuses on NetWare 6, but also includes information on NDS eDirectory, which is the backbone of NetWare 6. NDS eDirectory reaches across all major platforms to provide client integration, security, and scalability. Novell has even made huge strides lately in the file system with its introduction of iFolder, which enables you to synchronize, back up, and access your files and applications anywhere and at any time.

The following paragraphs summarize the essence of what NetWare 6 is and what it can do for you. But, you'll want to read subsequent chapters for more detailed information about this new, powerful operating system.

Non-Stop Access to Your Files

With NetWare 6 there is no longer a need to be near your data files in order to access them. New to NetWare 6, *iFolder* provides the capability to synchronize, back up, and access your files and applications anywhere and at any time.

Printing Via the Internet

Novell has always been a leader in providing networked printing capability. NetWare 6 brings even greater functionality to printing by utilizing Internet printing using the Internet printing protocol (IPP). Any printer can be transformed into an IPP printer and users can utilize the Web server aspects of the software to access any printer on the network. A user can also send a print job via HTTP and SSL encryption in a secure and safe manner.

Greater Storage Capability

Novell's Storage Area Network (SAN) technology provides high-speed storage performance for NetWare servers. SAN technology allows you to dramatically expand the storage capability of your network. NetWare 6 includes free cluster software for up to two systems. Up to 32 NetWare servers may be formed into a cluster. These clusters can all be managed by the NetWare 6 operating system.

Novell Storage Services allows for unlimited disk volumes that can be up to 8TB (terabytes) in size. NSS uses a 64-bit interface and can keep track of huge numbers of objects in your network. The NSS file system keeps track of volumes, partitions, and the files differently and uses more server memory than before.

Easy Network Management

NetWare 6 improves upon such tools as ConsoleOne and other java-based utilities to allow an administrator to easily manage any size network. Adding NetWare Remote Manager gives administrators greater flexibility for manager servers across an entire enterprise.

Directory Services for Security and Management

eDirectory continues to evolve with greater scalability and greater management features, which makes its use in enterprise environments and e-business easier and

more completely possible. Much will be discussed in this book with regards to eDirectory, its design, its installation, and its maintenance.

eDirectory provides management and security for network resources as well as a strong foundation for eBusiness.

Before understanding what NetWare 6 is, it helps to understand the purpose and function of a network operating system. From this starting point, we will begin a comprehensive look at the NetWare 6 operating system and its many features.

Network Operating Systems

A network consists of resources, such as servers, workstations, printers, bridges, routers, gateways, and other peripheral computer equipment (CD-ROMs or jukeboxes, modems, and so on).

The network operating system (NOS) is software that communicates with each of these devices to form an integrated system. Some of the resources tied together by NDS eDirectory are shown in Figure 1.1.

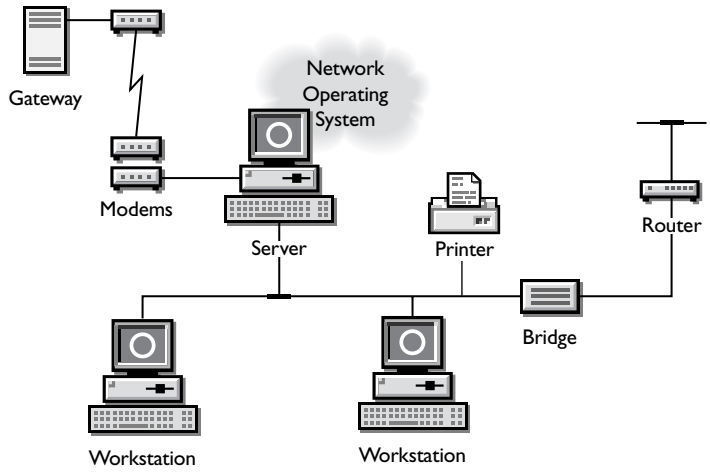


FIGURE 1.1: *NDS eDirectory and the NetWare 6 OS tie together network resources from devices called servers.*

The primary role of the NOS and all the other resources on the network is to build an infrastructure that distributes information among all the network devices. The network components are the server and the client, and now include external storage

and other mobile computing devices. The architecture that distributes the processing between these machines is called *distributed processing*. The following sections describe the server, the client, and how processing can be distributed between each.

Servers

The *server* is the primary component in the distributed processing model. The server is the physical hardware device that runs the network operating system. In turn, the network operating system (NOS) is the software program that enables the local resources of the server to be shared among the network users. The NOS controls the following resources of the server:

- Memory
- File system (disk drives)
- CPU scheduling
- Input/output to shared network devices (CD-ROM, modems, and so on)
- Workstation connectivity and access to file system resources
- Loading and distributing application programs (including NDS eDirectory)

Figure 1.2 shows the local server resources that are managed by the NOS.

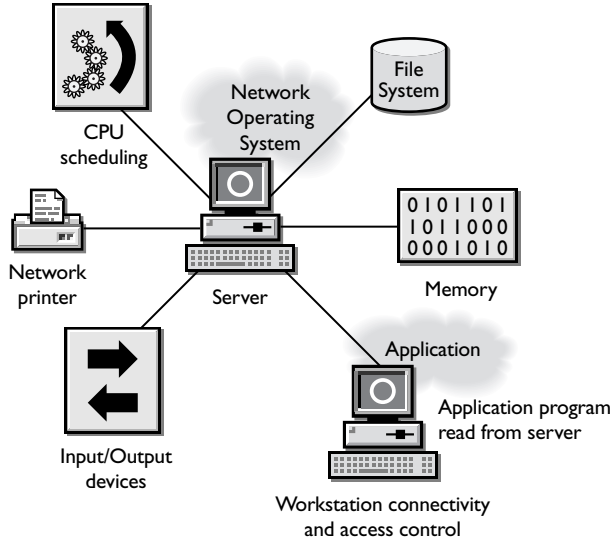


FIGURE 1.2: *The NOS manages the sharing of the server's local resources and coordinates directory synchronization.*

The NOS software either runs as a dedicated machine or can be distributed equally across all nodes on the network. A NOS that makes use of workstation-to-workstation communications in a peer-to-peer environment is an example of a *distributed NOS*. A NOS whose primary software runs on a dedicated hardware platform is a *centralized NOS*. NetWare 6 is an example of a centralized NOS in which the central node is called the server.

Clients

The portion of the NOS that connects the workstations to the server is called the *client software*. The client software runs on the workstations and is the consumer of services provided by the NetWare server. It also enables the workstation to load applications or share resources from the server. Figure 1.3 illustrates the relationship between the NOS running at the server and the client software running at the workstation.

Workstations that load the client portion of the network operating system are often referred to as clients. NetWare 6 has greatly expanded on the concept of a client connecting to a server. As covered in this book, you can access information through various forms of a client or use no client at all. A Web browser can be used as a client. Also, the Apple iMac requires no client but connects to a NetWare 6 server out of the box through native protocols. NDS servers also act as clients of other NDS servers in the tree but not in the same way as a workstation. An NDS server may communicate with other NDS servers during login or when searching for a particular piece of directory information.

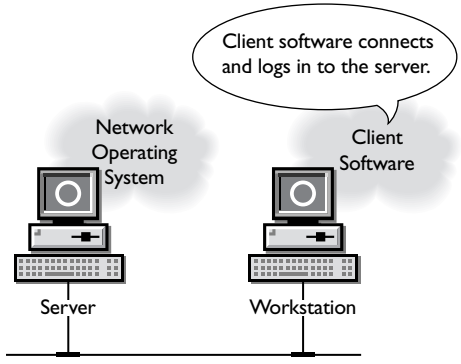
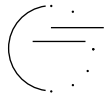


FIGURE 1.3: *Client software loads on the workstation and enables it to connect to the server.*


NOTE

In this book, we will use the terms *workstation* and *client* interchangeably. Technically, though, only the workstations that load the client software and make use of the services provided by the servers should be called clients.

Distributed Processing

Distributed processing occurs when the NOS coordinates the processing in a decentralized fashion. Applications running on the network are a type of distributed processing. For example, each workstation requests its own copy of an application from the operating system. The application is then loaded and run entirely on the workstation. The workstation runs the application independently, and the network operating system simply coordinates access to the shared resources. In the network, application processing can be distributed (client-based) or centralized (server-based) or both (client/server-based). Each of these methods offers advantages and disadvantages that make them right for certain applications and wrong for others.

Client-Based Applications

The types of applications that run entirely on the workstation are called *client-based applications*. For example, all the clients may use the same word processing application, but separate copies of the application are executed in each workstation. A copy of the application is transmitted from the server to the client but is executed at the client workstation. In general, applications that are keyboard and display intensive with minimal disk I/O are well suited for the client.

Spreadsheets and word processing programs are examples of client-based applications because they are heavy users of the display and keyboard with infrequent disk or file access. There is no benefit in running any part of these applications outside the workstation once the program has been loaded into workstation memory from the server. Figure 1.4 illustrates client-based application processing in which the application is loaded from the server.

Server-Based Applications

Applications that do all the processing locally at the server are known as *server-based applications*. These applications are usually specialized applications that execute only on the server. For example, backup/restore software needs to read the file system and write it to the local tape device (on the server) and may not need

to transfer data across the network. Other types of backup software run as clients on a server and transfer files from other servers. Another example is network management software that controls or monitors the operation of the operating system. In addition, NetWare Loadable Modules are primarily server-based applications, although some have a client counterpart that does some of the processing. Figure 1.5 illustrates server-based application processing.

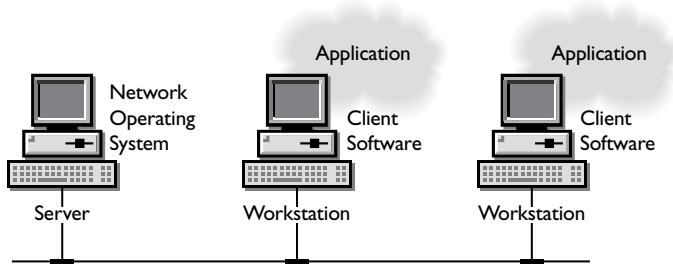


FIGURE 1.4: *Client-based application processing. The application is loaded from the server.*

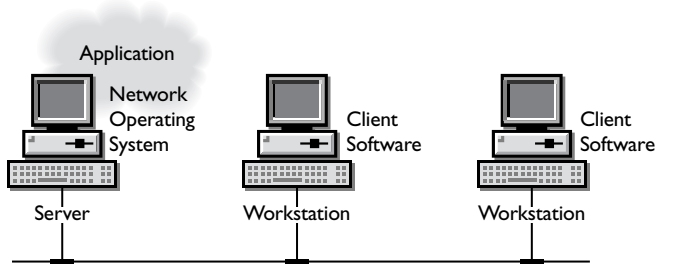


FIGURE 1.5: *Server-based application processing*

Client/Server-Based Applications

Client/server-based applications split the responsibility of the processing between the client and the server. The client and server work together to execute the application even though it is running on different machines. The fact that the parts

of the application are running on different machines is entirely transparent to the user. The software that runs on the server is called the *back end* and manages the shared information. The client portion of the application is called the *front end* and allows communication and access to the server (or back end). Figure 1.6 illustrates client/server application processing.

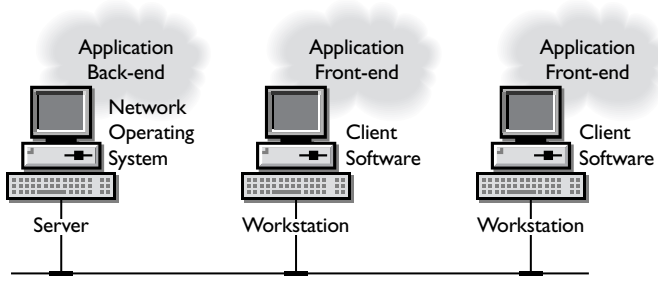


FIGURE 1.6: *Client/server application processing*

An example of a newer client/server-based application is Novell's iFolder application. It consists of three components that work together. The first component, the iFolder client, allows access to current files on a personal computer. The iFolder client performs synchronization whenever it's connected to the network to keep all files up to date. The second component, the iFolder browser plug-in, provides secure authentication links to a central iFolder server. And the third component, the iFolder server, provides the necessary infrastructure for secure file synchronization and access. For more information on installing and configuring this product, refer to Chapter 20.

What Is NetWare 6?

NetWare 6 offers the widest range of distributed applications or network services in the industry. In Figure 1.7, you can see that NetWare 6 provides file, print, directory service, database, communication (includes host connectivity), messaging, network management, software distribution, imaging, Web services, and telephony.

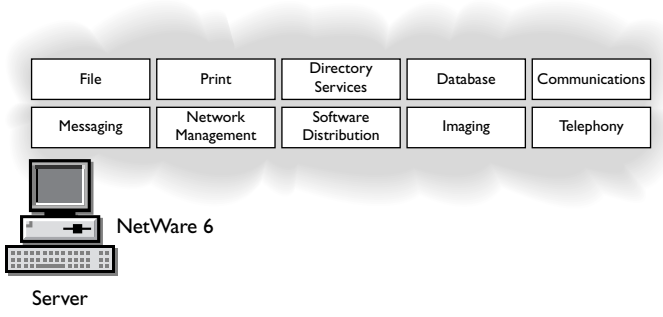


FIGURE 1.7: *NetWare 6 is defined as a complete range of network services.*

These network services are provided to users regardless of their type of desktop. The goal of NetWare has always been to tie different users running Windows, OS/2, Macintosh, UNIX, or Windows NT/Windows 2000 into a distributed information system, as shown in Figure 1.8.

NetWare 6 enables these diverse workstations to access NetWare services and perform distributed processing in their native environments. Figure 1.9 shows how users can choose the desktop system that best fits their needs and still share services and information with other network users using different platforms.

In addition to the integration of desktops, NetWare 6 also integrates larger host computers from vendors such as IBM, Digital, and Hewlett-Packard. Regardless of where information is located on the network, users can access host-based resources and information from their desktops.

Applications that can benefit from client/server-based implementation are database, communications, and transactional applications that require frequent access to disk storage. Consider a database that searches, sorts, generates reports, and so forth. The database will perform better if you place the database engine on the server (where disk I/O is intensive) and process the data entry and user interface at the client. The client simply passes the data request to the database engine, which performs the action and responds accordingly.

Another example would be an e-mail system in which the user reads and composes mail messages at the client and then passes the responsibility for delivery to a server process. Thus, while the server is delivering the messages to the other mail users, the client (or sender) can continue other activities.

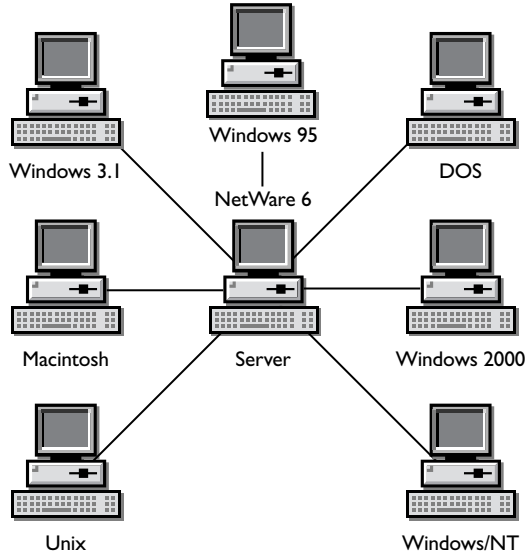


FIGURE 1.8: *NetWare 6 connects desktops running Windows, OS/2, Macintosh, UNIX, and Windows NT/Windows 2000 operating systems.*

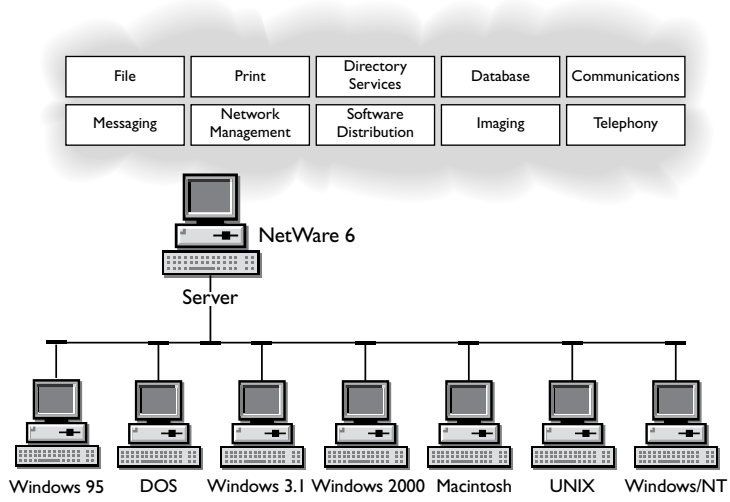


FIGURE 1.9: *NetWare 6 offers distributed processing among workstations running the DOS, Windows, OS/2, Macintosh, UNIX, and Windows NT/Windows2000 operating systems.*

Novell Directory Services eDirectory

Novell Directory Services (also referred to as NDS eDirectory) is an ongoing effort from the company to provide a more scalable directory with greater functionality in each subsequent release. NDS eDirectory is currently on Release 8.6 and is on a different release schedule than that of the NetWare operating system. As a NetWare administrator you will at times be doing an upgrade of NDS eDirectory on the same platform of NetWare. NDS eDirectory is an information name service (database comes to mind) that organizes network resources — users, groups, printers, servers, volumes, and other physical network devices — into a hierarchical tree structure. Figure 1.10 illustrates the structure of an NDS tree. We will use many examples of NDS eDirectory trees in this book.

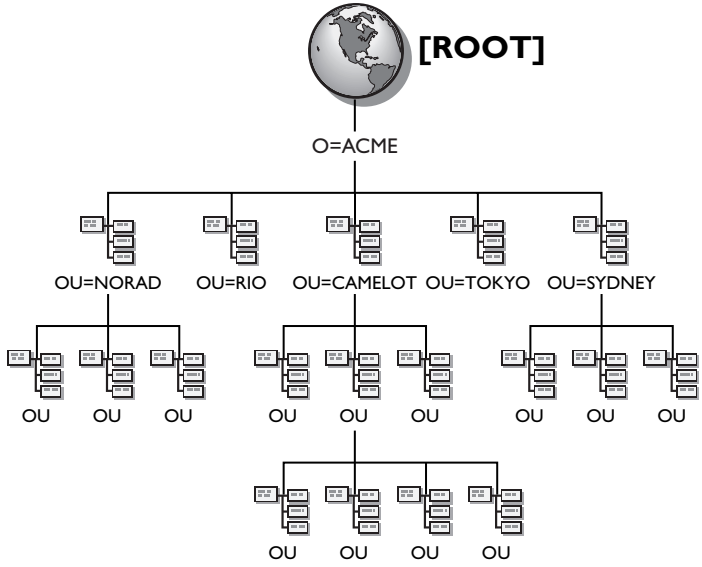


FIGURE 1.10: *The structure of an NDS tree*

The NDS tree, also known as the eDirectory tree, enables resources to be managed and displayed as a single enterprise view. By contrast, NetWare 3 provided only a server-centric view. You can manage the tree including objects and their various

properties by providing varying degrees of security access, giving your network enormous flexibility as it expands and changes.

NDS eDirectory replaces the bindery found in NetWare 3 networks. A major difference between the two methods is that the Directory is distributed and can be replicated on multiple servers for increased fault tolerance and performance. The bindery in NetWare 3 is a flat structure in which resources belong to a single server. Compatibility with the bindery is still available in NetWare 6 for applications requiring bindery services.

For a detailed description of the newest features of eDirectory, see Chapter 10.

NDS Provides a Single Point of Login

Users log into the network once using one username and password to access all authorized network resources. This means that users log into the network, and NDS will process other connections to NetWare 3 and NetWare 6 servers if the username and password are the same.

By contrast, NetWare 3 bindery users had to log into each network server individually with a username and password. This could mean that the users would have to provide a different ID and password for each additional server connection. Single-user login also makes your job easier as an administrator. You create each user account only once for all NetWare 6 servers in the Directory tree. Multiple user accounts on multiple servers are no longer needed in NetWare 6. This feature alone can save you hours of work. As you will see, NDS eDirectory serves as the central point of management, eliminating tedious duplication and increased administrative costs.

The addition of Novell's Single Sign-On to NetWare 5 and NetWare 6 has improved these versions over their predecessors. Novell's Single Sign-On allows users to only log in once and has NDS provide the login and authentication to other devices such as host systems and other platforms. For more information on Single Sign-On, refer to Chapter 17.

NDS Provides Easy Administration

NetWare 6 consolidates most NDS administrative functions into easy-to-use utilities with graphical interfaces that greatly reduce the time you spend on network administration. The main Novell utility for administration is ConsoleOne. ConsoleOne is a Java-based utility that provides the same functionality as NWADMIN and considerably more.

While still used for some administration, NWADMIN is Novell's older utility that enables you to make changes to the Directory with an easy point and click of a mouse.

This object-oriented view of the NDS tree is what lets you perform many routine administrative functions easily. NDS objects, files, directories, and server functions can be controlled through the NWADMIN or ConsoleOne utilities. When users change departments, for example, you simply drag and drop the users to a new location to give them appropriate directory rights, or move users with the move command. Adding file system directory rights for a user in versions prior to NetWare 4 required a multilayered menu and a somewhat tedious process of adding each new user. With NetWare 5 and NetWare 6, all that is required to add directory rights is to drag the user's icon to the specific directory or object; the NWADMIN utility will ask you for a confirmation prior to completing the request.

NDS eDirectory Is Scalable

NDS eDirectory is an object hierarchy that can be divided into smaller sections to be distributed to any number of network servers. We say it is "scalable" because one server can, but does not need to, contain all Directory information. With NDS eDirectory, the information can be distributed and also replicated on multiple servers to provide increased accessibility and reliability. Figure 1.11 shows how NDS eDirectory can be distributed across the servers in the network. Novell has demonstrated massive scalability of the directory by building a billion object tree. Although no organization will probably need to build a tree of that size, you can be assured that your directory has the capability to grow to any size needed. For more information on the scalability of the directory and design recommendations, see Chapter 5.

The process that divides the directory hierarchy into smaller pieces and makes eDirectory scale is called *partitioning*. Another process, known as *replication,* is the mechanism that makes the partition redundant. The partitions and replicas are completely transparent to users and can be scattered across multiple NetWare 6 servers. These features make NDS eDirectory a powerful facility for storing, accessing, managing, and using information about the network resources, regardless of where they are physically located. This means that your NDS tree can easily grow to meet the demands of your environment. Another benefit is that your NDS tree design can be easily modified to reflect both organizational and functional changes in your company.

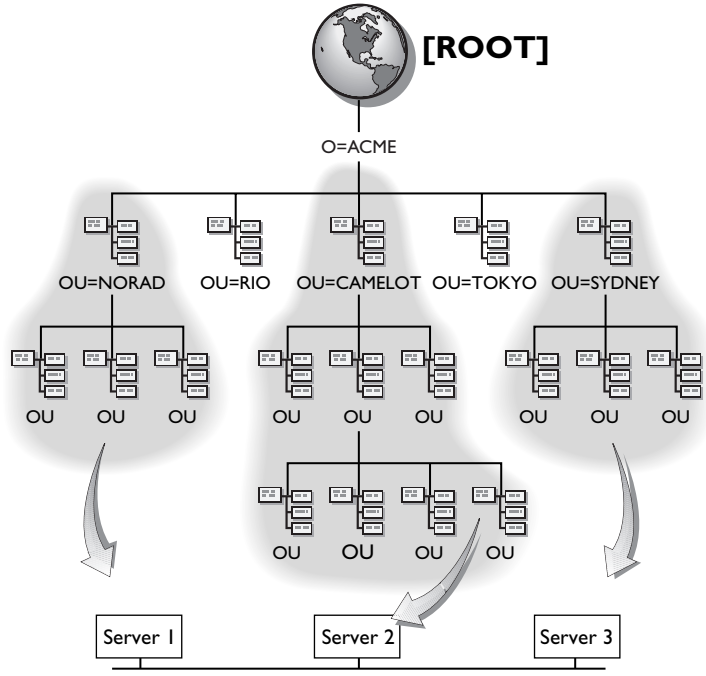


FIGURE 1.11: *NDS provides distribution of the information across the network servers.*

NetWare 6 Features

NetWare 6 is the next generation of the NetWare operating system. Therefore, it inherits features from previous versions, namely those from NetWare 4.*x* and NetWare 5.*x* and even some from NetWare 3. This section examines the new and enhanced features of NetWare 6. The descriptions given in this chapter are brief, presenting only introductory information about each feature. Later chapters offer more in-depth information. The NetWare 6 features are categorized into the following sections:

- Operating system
- File and print systems
- Novell Directory Services (NDS)
- Network services

- Security
- Installation and upgrade
- Developer support
- Third-party add-ons
- Workstation/client support

Changes to the NetWare Operating System

NetWare 6 offers many new changes to the core NetWare operating system. NetWare 6 is aimed at large enterprises that serve customers with 1,000 or more employees. The trend for these types of companies is toward large, centralized data centers known as server farms. With server farms comes the use of symmetric multiprocessing (SMP) server hardware. Most SMP servers use two CPUs to distribute the workload, but they can use as many as 32 processors in one server. Novell has designed NetWare 6 to make use of SMP.

The NetWare 6 Multiprocessor Kernel

The core of the NetWare 6 operating system is a new kernel that supports multiple processors out of the box. This effort was actually started at the release of NetWare 5, but it has been expanded upon in NetWare 6. The new NetWare 6 kernel is called the NetWare multiprocessor kernel (MPK). The obvious benefit of having a multiprocessor kernel is that it automatically supports machines that have more than one processor. In fact, it supports single and multiple processors from the same kernel. This means that you can make better use of existing processors in your servers or add processors as needed to help speed up specific services.

The NetWare MPK can support a machine with as many as 32 processors. During installation, NetWare 6 automatically detects the number of processors by reading the multiple processor table in the machine's BIOS. It then determines which of the NetWare 6 Platform Support Modules (PSMs) match the hardware platform. A PSM is a hardware abstraction layer or interface that NetWare 6 uses to support different hardware dependencies.

In addition, the new multiprocessor kernel provides many new services and offers support for Java applications. The NetWare 6 operating system kernel adds these functions: memory protection, virtual memory, preemption, and application prioritization. Novell has included an enhanced version of NetWare 6 Cluster Services, which enables you to create clusters with up to 32 nodes for fault tolerance. An enhanced version of Novell Storage Services (NSS) is included with this release. NSS provides an object-oriented storage with 64-bit internal and external interfaces. Without NSS, the NetWare file system supports a 32-bit interface that limits files to

2GB, directory entries to 16 million per volume, and volumes per server to 64. For more information about NSS, see Chapter 10.

Although the server operating systems of NetWare 5 and NetWare 5.1 included some core components that were SMP enabled, not all components were SMP enabled. For example NetWare 5 provided SMP capability for C-Library (CLIB), RSA encryption, routing functions, and Multiple Link Interface Drivers (MLIDs).

NetWare 6 adds to the core set of functions that are already SMP-enabled. This includes MP-enabled versions of the IP stack, the NetWare Core Protocol (NCP) engine, Web and search engines, NDS eDirectory, and NSS.

Memory Protection

The memory protection in NetWare 6 enables you to load any server applications in their own protected address spaces. The applications are then shielded from other applications and the operating system itself. The result is that failure of one application does not affect any of the other applications or processing of the operating system. You can use protected address spaces to run untried or troublesome applications. Any program or module loaded into a protected address space cannot corrupt the operating system or cause server abends (abnormal ends). The protected address space provides a safe place to run applications. All protected address spaces use virtual memory.

As mentioned, each application can be loaded into its own protected address space. A protected address space is a portion of cache server memory that has controlled communication with the server operating system. The protected address space is only a portion of cache memory that can be set aside, sometimes called user address spaces or ring 3. In contrast, the NetWare operating system does not run in a protected address space. The operating system address space is sometimes called ring 0 or the kernel address space.

In the first release of NetWare 5, only a few NetWare Loadable Modules (NLMs) or applications could be loaded into the protected memory space. NetWare 6 loads Java-based applications in protected mode by default. In addition, you can optionally load GroupWise 5.5, Lotus Notes (except for the debugging module), and Oracle 8. However, certain types of modules and programs cannot run in protected addresses. The protected address spaces run in ring 3; others must be loaded at ring 0 instead. Here is a list of common NLM programs and executables that cannot be loaded into a protected address space:

- SERVER.EXE
- LAN drivers
- Disk drivers
- MONITOR.NLM

Virtual Memory

Virtual memory is a memory management scheme that provides the NetWare 6 operating system with the capability to allocate more than the actual physical memory of the server machine. It does this by using the disk as an extension of memory and by swapping code and data between physical memory and disk as necessary. When the data on disk is needed again, it is moved back into the physical memory. Because data is swapped on and off of the disk, the available memory can be used for a larger amount of data than its actual physical capacity would allow. Virtual memory provides NetWare 6 with a more efficient use of memory and lessens the likelihood that low memory conditions will cause an abend condition.

NetWare 6 moves the data out of physical memory to swap files on the hard drive if the data has been used infrequently. More specifically, the available memory is assessed to see which data items have been used less recently than the rest. How recently data has been used is determined by a bit in each field of the translation table that indicates whether the address space has been used since the last time it was checked. Data that has not been used for some time can be moved from memory to disk, thus, freeing memory for other uses.

As mentioned earlier, protected memory uses virtual memory. The reason is the memory management subsystem can allocate to each process a unique protected virtual address available to run the threads of the process. Thus, each process has a separate address space, so a thread in one process cannot view or modify the memory of another process. This architecture provides the protected memory for NetWare 6.

NetWare 6 loads a few applications or modules into virtual memory by default. One of these applications is the Java Virtual Machine (JVM). Any other modules that are loaded by the JVM will run in virtual memory. On the other hand, any modules and programs that cannot run in virtual memory can also not use protected memory because protected memory uses virtual memory. Here is a list of common NLM programs and executables that cannot be loaded into virtual memory:

- SERVER.EXE
- LAN drivers
- Disk drivers
- MONITOR.NLM
- Novell Storage Services (NSS)

As an example, the server operating system (SERVER.EXE) cannot run in virtual memory because it must always be resident in memory and cannot be swapped to disk. The same condition exists for all the other modules.

Preemption

The NetWare 6 kernel has also been developed to support preemption, just like previous version of NetWare. *Preemption* eliminates the problems associated with applications running on the server as NLMs that have been written poorly and that monopolize the processor. In order to take advantage of preemption in NetWare 6, the application must be explicitly written or enabled by the developers to support the kernel's preemption.

Application Prioritization

As previously mentioned, MPK enables you to support *application prioritization* or *load balancing,* which ensures optimal application distribution among processors. Application prioritization is implemented as part of the new NetWare 6 kernel, and the system administrator decides how to prioritize the applications running on your servers. You can specify the level of processor usage that you want to dedicate to each application.

By adjusting the amount of processor time dedicated to each application, you can tune the quality of service provided. In addition, both single-processor and multiple-processor machines can benefit from the flexibility of application prioritization. Thus, if a single processor machine has multiple applications, you can allow one application to have more CPU cycles than the others.

The NetWare 6 GUI Console (ConsoleOne)

NetWare 6 enables the server console to appear in a graphical user interface (GUI) environment. Its appearance and operation are similar to those for programs in the X Window environment found on UNIX platforms. A GUI server environment permits use of a graphical interface to programs such as installation and Java applications at the server console. To use ConsoleOne, the server must have a VGA or higher video adapter board and a VGA or higher display monitor, along with a mouse.


NOTE

The GUI environment requires additional server RAM. It is not recommended to run the GUI environment on servers with less than 64MB of RAM.

Hot Plug PCI

Just like NetWare 5 and NetWare 5.1, NetWare 6 supports the capability to upgrade or replace network interface cards while the server is running, easing server expansion and providing longer server uptime.

I20 Support

I20 (Intelligent I/O) improves I/O throughput and server performance by relieving the CPU of interrupt-intensive tasks such as memory calls and system interrupts. I20 is an industry-driven software specification designed to provide a standards-based solution to offload input/output traffic from the central processing unit, and it enables hardware vendors to develop a single driver to work with all networking platforms. NetWare 6 provides I2O support for Ethernet- and SCSI-class devices and block storage, making server management easier while increasing application processing efficiency.

Changes to the File and Print Systems

In addition to the changes that have been made to the operating system in NetWare 6, the file system has had some significant additions. This section describes the changes made to the file system, including those to the Novell Storage Services (NSS) and Storage Management Services (SMS).

Novell Storage Services

Novell Storage Services (NSS) was new to the NetWare 5 file system and was designed to mount large server volumes in seconds, virtually eliminating the limits on the number or size of files that can be stored in volumes and directories. You can use NSS to quickly open and update large files, such as those found in databases.

NSS version 3.0 now supports SYS: volumes in addition to the data volumes that all previous versions of NSS support. NSS also supports file compression, as well as user and directory quotas. NetWare 6 can compress NSS files that are infrequently used or not used at all. You can limit the space a user consumes on an NSS directory and the space a directory consumes on an NSS volume. NSS 3.0 also supports the Transaction Tracking System (TTS).

NSS is a 64-bit indexed storage system that allows for billions of volumes and directories. It allows up to 8-terabyte file sizes and 64-bit addressing with an extremely small memory footprint. Even more spectacular is the speed at which a volume can be remounted. Virtually any size volume can be mounted in seconds.

Novell Storage Services (NSS) eliminates several limitations that currently exist in the NetWare file system. NSS provides object-oriented storage with 64-bit internal and external interfaces. Without NSS, the NetWare file system only supports a 32-bit interface that limits file sizes to 2GB, maximum directory entries per volume to 16 million, and volumes per server to 64. With NSS, the NetWare file system can host a single 8TB (terabyte) file. This would be extremely useful for database applications. In addition, the NSS file system can support virtually unlimited directory entries (or number of files) per volume. During testing, a volume with 1 billion files was successfully created with three name spaces loaded. This demonstrates that the file system can support 3 billion directory entries on a single NetWare volume. Thousands of volumes can be created per server; however, the current NCP interface only supports 127 volumes per server.

In addition to larger volumes and more files, NSS supports much faster volume mount times. A normal NSS volume mounts in less than one second, regardless of size or number of files stored. If the NetWare 6 server crashes and a volume is not dismounted cleanly, when the server is brought back up, the volume will be restored and mounted in 15 seconds to one minute. This is the case for all NSS volumes on the server. By contrast, the older FAT-based file system is organized so that volume mount time increases with number and size of files.

These NSS features are available with NetWare 6:

- Up to 8-terabyte file sizes (a terabyte is equivalent to 8,192 gigabytes)
- Capability to create and access trillions of files in a single directory
- Faster volume mounting and repair
- Lower server memory requirements for mounting any size volume

NSS does not fully replace the default NetWare file system because of some current limitations. Future releases of NSS will address these issues. For example, NSS currently does not have the capability to create its own SYS: volume and does not support the Transaction Tracking System (TTS), disk striping, disk mirroring, Hierarchical Storage Management (HSM), or Real Time Data Migration (RTDM).

NSS 3.0 is compatible with the traditional NetWare file system. NSS still only requires 32MB of RAM to mount, and you can migrate your data at your own pace.

Storage Management Services (SMS)

Novell Storage Management Services (SMS) lets you back up, restore, and verify data stored on the network and on network clients. NetWare 6 SMS includes Enhanced SBACKUP, ensuring regular and complete backups of all the data on your network, including the NDS database, bindery data, GroupWise data, and client and server file systems.

An Improved Backup Utility

NetWare 6 introduces a new GUI-based backup utility that allows for multiple and repetitive scheduling. This new backup utility is a replacement version of the SBACKUP utility. Using this utility, network administrators can perform backups across the network.

Novell Distributed Print Services (NDPS)

Novell Distributed Print Services (NDPS) was released in NetWare 5, and NetWare 6 continues to enhance printing with support of the Internet Printing Protocol (IPP). NDPS is designed to simplify access and administration of network print services. NDPS is a distributed service that consists of client, server, and connectivity software components to seamlessly connect the applications to the network printers.

NDPS provides bidirectional communication between users and printers by downloading drivers for plug-and-print installation of new devices. NDPS enables users to easily locate network printers and can provide information such as printer and job status.

In the past, the Novell Distributed Print Services product has been offered as an add-on product that could be integrated into existing NetWare 4 networks. In NetWare 5 and NetWare 6, NDPS is included as the regular print services for the operating system. If you are satisfied with your current NetWare printing infrastructure, however, NetWare 6 will continue to support it. Then you can incrementally deploy NDPS at your own pace to gain the features and benefits.

NDPS gives users and administrators greater control over their printing. Features such as bidirectional feedback, print job status, automatic driver downloading, and event notification for printer status help simplify and streamline the usability and administration of network printing. NDPS provides the following major benefits, features, and printing capabilities:

- NDPS enables the network administrator to centrally manage printing services from a single location.
- Users submit print jobs directly to the printers; no print queues need to be created.
- NDPS supports bidirectional communications with the printers.
- Administrators can move, copy, delete, prioritize, and pause print jobs.
- Network administrators are able to monitor and control print jobs, and they can receive print alerts or event notifications through e-mail, pop-up windows, event logs, and other methods, such as beepers and faxes.

- Users can determine whether a printer is available or busy and can copy or move print jobs between network printers as necessary.
- A plug-and-print option enables you to quickly install printers that can be immediately used by everyone with setup rights.
- NDPS reduces the network traffic associated with Service Advertising Protocol (SAP) broadcast because direct-connect printer devices no longer require SAP.
- Any NDPS printer can be managed through a standard SNMP console using the standard printer management information base (MIB).
- NDPS supports the current NetWare queue-based printing environment. Therefore, it enables you to upgrade to NDPS as quickly or slowly as necessary.

Novell Directory Services eDirectory

The latest version of NDS eDirectory includes the usual transitive synchronization, transitive vector, caching the replica changes, multiple objects per packet, randomized replica lists, distributive reference links, and WAN Traffic Manager. But its latest Version 8.6 is cross platform and platform independent. This means that NDS can be run on platforms other than NetWare, including the following:

- IBM AIX
- Linux
- Microsoft Windows 2000 Professional, Server, and Advanced Server
- Novell NetWare 5.*x*
- Novell NetWare 6
- Sun Solaris
- eDirectory 8.6 provides the following features. For a more complete description of eDirectory 8.6, see Chapter 5.
- Increased scalability and replication performance
- Hot-continuous backup
- Greater support of LDAP auxiliary classes
- Persistent searches
- Dynamic group management
- Novell Modular Authentication Services to support MD5 and SHA-1 passwords on top of the existing RSA PKI

Transitive Synchronization and Transitive Vectors

The *transitive vector* is a newer structure that has been added to the partition root object for each partition. It is essentially a group of modification timestamps representing the values held by each replica. Each replica has one transitive vector. The transitive vector differs from the synchronized up to property in that it holds a group of timestamps for each replica, where synchronized up to only holds one value for each replica in the partition. Another major difference between the transitive vector and the synchronized up to property is that the transitive vector is synchronized between servers where synchronized up to is not synchronized.

Replica synchronization in NetWare 6 uses *transitive synchronization,* which is the method of using transitive vectors while synchronizing two NetWare 6 servers. Transitive synchronization uses the transitive vector instead of the synchronized up to property that was used in NetWare 4.

With NetWare 6, server replication no longer happens within a replica ring or list as it has in the past. Transitive synchronization works through the transitive vector. If a source server's transitive vector is more recent than a target server's vector, the source server does not need to synchronize with that target server. This procedure reduces synchronization traffic, freeing up bandwidth. It employs either the IPX or IP protocol.

Each time that replica synchronization is scheduled to run on the NetWare 6 server, transitive synchronization reads the transitive vector to determine which replicas it needs to synchronize with. Because each NetWare 6 server has a transitive vector, the process can immediately determine how up to date each of the other replicas are. Using transitive synchronization, a specific server does not have to contact each of the other servers in the partition to complete replica synchronization. After a successful synchronization, the target or destination server merges the transitive vector with that of the source server. In addition, the changes are guaranteed to converge across all replicas of a partition over time.

The Replica Ring Is Randomized

After replica synchronization starts in NetWare 4, the replicas in the replica ring are contacted and updated in a sequential order. Therefore, the first replica in the replica ring is updated first, followed by the second one, and so on. Because the replica ring is identical on all the servers holding copies of this partition, the synchronization process updates all the replicas for each partition in the same order. This may have an undesirable effect if multiple servers are trying to synchronize with the same replica on the same server simultaneously. Because only one inbound synchronization is supported per partition (not per server), one of the

synchronization processes will have to back off and attempt again at a later time. This situation only arises if synchronization tends to execute at approximately the same time on multiple servers.

To help alleviate this situation, NetWare 6 changes the sequence in which replicas are processed by randomizing the replica ring list before attempting to contact the first server. This greatly reduces the possibility that one of the servers will have to back off and attempt to resynchronize with a replica. By randomizing which replica receives the first update, transitive synchronization more quickly converges the data for each partition. As previously mentioned, transitive synchronization can converge the NDS data among all the replicas of a partition without having each replica talk to every other replica.

Cache Object Changes

A new feature that caches changes to the NDS objects enhances the performance of replica synchronization. Remember that the changes or updates that affect the NDS objects include adding, deleting, moving, or renaming an object, as well as changing the properties or attributes of the object.

Using NetWare 4, NDS sequentially searched the entire object file, comparing timestamps to find the objects that have been updated since the last successful synchronization. Sequential searching effectively limited the size of the NDS partitions. When describing implementation of the NDS tree in NetWare 4 in previous versions of this book, we gave you a practical recommendation of 1,000–1,500 objects. In order to overcome this limitation, NetWare 6 eliminates the sequential search time by caching all changes to the objects. The capability to cache the objects in the NDS database greatly increases the speed of searching for and updating each replica and partition.

The object cache maintains a set of object IDs that have been modified since the last synchronization. The cache is populated by placing object IDs in the cache that have been modified as a result of client requests or inbound synchronization. Each cache entry has the modification time relative to the last synchronization. The cache that NDS maintains is for each partition that is stored on a server. The cache has a start time associated with it that identifies when the cache was built. Changes only need to be sent out if the transitive vector for the remote server is less than or equal to the transitive vector for the local server. The janitor process cleans up the cache periodically by removing the object IDs that have already been sent to all the replicas.

Multiple Objects per Synchronization Packet

In order to help synchronize individual replicas faster, NetWare 6 supports more than one object in each communication packet. Formerly, NetWare 4 only

allowed changes for one object in a single communication packet. By allowing multiple changes to different objects in a single packet, NetWare 6 reduces the total number of packets needed to synchronize replicas. If the number of changes between two replicas is small, all the updates between them can be accomplished in a single packet. Basically, this means that a partition can be synchronized in a minimum of one packet.

Distributed Reference Links

NetWare 6 includes a new method for maintaining external references, called *distributed reference links* (DRLs). These links are more efficient than backlinks for renaming, moving, and deleting external references. The distributed reference links are more efficient because unlike backlinks, they are not tied to a specific NetWare server but instead reference the partition that stores the external reference object. By contrast, when a backlink is created it stores the NetWare server name and object ID for each external reference object.

As mentioned, the major downside to using backlinks is that they are tied to specific NetWare servers and not tied to the external reference object's location in the NDS tree. Backlinks result in each NetWare server's tending to have a connection to every other server in the NDS tree. In order to alleviate this problem, distributed reference links store the partition name and object ID where each external reference object exists. By storing the partition name, the individual NetWare servers can resolve the DRLs by using the NDS tree structure.

Inheritable ACLs

Using the inheritable access control lists (ACLs), you can provide role-based assignments by assigning supervisor rights to operators or help desk staff to manage specific types of objects or resources. For example, you can assign rights to a group to manage only the printers, servers, or users. Using the new Password Administrator property, you can specify a help desk group to reset only the user's password.

Another new feature of NetWare 6 is its capability to display all the schema-defined properties in a single list in NWADMIN anywhere in the NDS tree. The properties that are shown are for all the objects in the schema. This gives you the ability to select any property at any level in the NDS tree. For example, you can give a group the rights to manage all users' telephone numbers at the O=Organizational level.

The WAN Traffic Manager

The WAN Traffic Manager (WTM) enables you to manage NDS traffic across WAN links, reducing network costs and increasing performance benefits. The WAN Traffic Manager is a policy-based tool for managing the cost and congestion

of WAN traffic. Its clients (such as NDS) request a policy decision before initiating WAN traffic. WTM, as a policy evaluator, checks administrator-supplied policies and attempts to match input criteria to one of them. If it finds a match, it runs the rest of the policy to see whether to allow the WAN traffic to proceed or to delay it. WTM is a valuable tool for networks that have significant congestion on their WAN links (for example, with ISDN or slow dial-up links), enabling administrators to control and manage bandwidth use and congestion.

Catalog Services

NDS Catalog Services provides a method to store directory data in a non-partitioned format, indexed for rapid access. Directory information stored in catalog or index format is easily customized for searching, sorting, and reporting purposes. Distribution and replication of these indexes enable administrators to quickly access a "snap shot" of the complete network directory as opposed to performing a query across the entire network.

Catalog Services enables the development of applications that need rapid access to directory data in a centralized repository. These applications might include Contextless Login, NDS White Pages, fast lookup for Lightweight Directory Access Protocol (LDAP) gateways, and many others. One of these new Catalog Services applications, called Contextless Login, leverages the NDS catalog and enables users to authenticate from any point on the network simply by typing their login name and password, removing the need to know the location of their user object in the NDS tree.

Catalogs are stored as FLAIM databases within stream attributes in the NDS directory. Catalog databases can be scoped to include data from the entire directory tree or from one or more subtrees. The attributes stored in the catalog can be filtered according to user requirements. Catalog Services includes a dredger that reads the directory to build catalogs; an NWADMIN snap-in that controls the scope, filtering, time interval, and other aspects of catalog creation; and a set of query Application Program Interfaces (APIs) that support development of applications to find catalogs and read data from them.

LDAP

NetWare 6 supports Lightweight Directory Access Protocol (LDAP) version 3, an industry-standard protocol that enables users to easily access X.500-based directories such as NDS. LDAP Services for NDS is a server-based interface between NDS and LDAP-compliant applications running optionally under Secure Sockets Layer (SSL). In NetWare 6, the performance of LDAP access to NDS has also been significantly enhanced, enabling unlimited scalability through NDS's advanced replication and management of back-end directory functions. NDS

eDirectory does not need an LDAP 3 gateway to translate LDAP 3 into NDS. NDS eDirectory has incorporated the LDAP 3 protocol, and it processes the queries natively, providing even greater performance.

Changes to the Network Services

Several new enhancements make the basic network services in NetWare 6 more flexible, manageable, and secure. The new network services included in NetWare 6 are Pure IP, Service Location Protocol (SLP), DNS/DHCP integration, the ZENworks Starter Pack, NetWare Licensing Services, and Internet Connectivity.

Pure IP

New in NetWare 5 was Pure IP, which enabled NetWare to support TCP/IP in a pure sense. It does not encapsulate or tunnel IPX/SPX communications. Pure IP enables servers and clients to make NetWare Core Protocol (NCP) calls directly over the TCP/IP stack to be routed by any IP router on the network. Although NetWare 6 maintains support for IPX/SPX protocols, you now have the option of implementing a pure TCP/IP environment or using IPX/SPX alone or as part of a mixed TCP/IP and IPX/SPX environment. This is advantageous for customers who require a Pure IP environment because it eliminates multiple protocols and frees up valuable network bandwidth, while enabling them to control IP implementation at their own pace.

Novell severed the operating system's dependence on IPX/SPX and rewrote the IPX-only applications and utilities to support TCP/IP. As a result, NetWare 6 servers and workstations can use TCP/IP, IPX/SPX, or both. The major advantages of supporting Pure IP in NetWare are as follows:

- Consolidation to one protocol in your network
- More efficient use of LAN and WAN bandwidth
- A wider range of opportunities for remote user connectivity

Although Pure IP has major advantages, Novell is committed to retain backward compatibility to IPX/SPX. NetWare 6 ships with features that provide a seamless compatibility between IPX and IP-based technologies. NetWare 6's Compatibility Mode enables customers to move to an IP-Only environment without having to replace valuable IPX-based applications and without having to introduce disruptions into their network operations. In addition, NetWare 6 ships an IP Compatibility Mode Migration Gateway that enables you to move to an IP-Only network, incrementally if desired.

In essence, it is your choice whether to use IPX/SPX or TCP/IP as your network protocols. In order to install Pure IP, use the standard NetWare 6 installation program. During installation, select the protocols that you want your server to support. If you enable IPX/SPX, you must select an internal IPX address for the server, as you normally would. If you enable TCP/IP, you must select an IP address for the server.

Service Location Protocol

Service Location Protocol (SLP) provides automatic resource discovery and registration over TCP/IP connections. Network resources such as servers and printers use SLP. SLP is more efficient than Service Advertisement Protocol (SAP) because it creates less ongoing network traffic than SAP. In addition, SLP enables network resources to carry extended description attributes. For example, a printer could be categorized as a "PostScript printer loaded with legal-sized paper used by Consulting."

DNS/DHCP Integration

With NetWare 6 you can store Dynamic Host Configuration Protocol (DHCP) and Domain Name Service (DNS) information in the NDS database and can easily manage IP addresses. This feature provides centralized management of your IP addresses, replication, and fault tolerance of these addresses. You can easily import DNS and DHCP data, automate IP address assignments, and eliminate network problems associated with duplicate IP addresses. Dynamic DNS is also supported.

Domain Name Service (DNS) converts domain names (such as `www.novell.com`) to numerical IP addresses (such as 137.65.2.5). Because NetWare 6 integrates DNS with NDS, each user can automatically be assigned an appropriate DNS server upon login. For example, a mobile user in a distant location might be assigned a DNS server with a faster response time than for a desktop user in a local office.

Dynamic Host Configuration Protocol (DHCP) provides unique IP addresses upon request to users and network devices. Because NetWare 6 uses NDS to help automate DHCP services, you can store IP address in NDS. When a user logs into the network, DHCP consults NDS and provides an appropriate IP address for that user. DHCP eliminates the older methods of manually tracking and assigning IP addresses, and NDS ensures that DHCP provides managed IP addresses throughout the enterprise.

The ZENworks Starter Pack

NetWare 6 ships with the ZENworks Starter Pack, which includes Novell Application Launcher (NAL) and Workstation Manager as part of the NetWare 6

installation. NAL delivers applications to the user's desktop via NDS. Workstation Manager enables you to remotely manage and upgrade Windows 3.1, Windows 95/98, and Windows NT/Windows2000 workstations. ZENworks, which stands for Zero Effort Networking, is a bundle of management utilities that assists you in managing individual workstations in an enterprise.

The components of ZENworks enable administrators to solve a user's workstation problems without visiting the user's workstation. By adding workstation objects and workstation group objects to the NDS tree, administrators can manage the desktop configuration, distribute applications, and perform maintenance on the workstation through NDS.

With ZENworks installed, workstations are registered with NDS each time a user logs into the network. Registration enables administrators to look at a workstation object's details and centrally manage workstations through NDS.

Features Available in the Full ZENworks Product Additional ZENworks functionality can be obtained by purchasing the full-featured product. Once you install ZENworks and the Novell Client provided on the ZENworks CD-ROM, you can take advantage of these additional features:

- **The Help Requester —** This application lets users send a message about a workstation problem to the administrator or Help Desk. The message automatically includes the workstation object's details stored in NDS. You can use the message and the workstation object in NWAdmin to solve the problem. This saves time and effort, especially when problem workstations are located on a WAN.
- **Workstation inventory —** ZENworks enables you to easily inventory and track all the configuration data for Windows workstations on the network.
- **Remote control of workstations —** By enabling remote control access on the network's workstations, you can connect to a workstation remotely and navigate the desktop to troubleshoot workstation problems without having to visit the workstation.

The full ZENworks product requires an additional purchase. For pricing and details, check out the ZENworks Web page at the following location:

```
www.novell.com/products/zenworks
```

Both the starter pack and the full version of the ZENworks product are discussed in detail in Chapter 19.

NetWare Licensing Services

These two services simplify installation and licensing of new Novell products. Each works on the server to reduce the time and effort you must spend on installing and licensing. Common utilities and interfaces now standardize each of these tasks. NLS provides a single utility you can use to license all future NetWare products; ensures consistent, efficient, and rapid licensing for NetWare products; and permits licensing for all products conforming to NLS requirements.

Internet Connectivity

NetWare 6 ships with the Novell Internet Access Server (NIAS) 4.1. NIAS provides routing between local and remote LANs, remote access to all company network resources (including e-mail and Internet access) through a modem or other connection, and remote service management of all connectivity services and servers from your workstation.

Changes to Security

Several new security features come with NetWare 6, which builds upon the NetWare 4 and NetWare 5 existing security features. The new features have been integrated with Novell Directory Services (NDS) and help simplify administration of each new feature. They also provide security for improved Internet data integrity and privacy across public networks. The new security features include Public Key Infrastructure Services (PKIS), Novell International Cryptographic Infrastructure (NICI), Secure Authentication Services (SAS), and the audit system. This section discusses these new features, explains why they are important, and explains how they provide NetWare 6 with advanced security services.

Public Key Infrastructure Services (PKIS)

NetWare 6 includes PKIS, which supports public key cryptography and digital certificates in a NetWare 6 environment. Digital certificates provide a method for checking the authenticity of keys used in a public key cryptographic session. In NetWare 6, PKIS enables you either to act as your own certificate authority or to use the services of third-party certificate authorities. Through PKIS, you can generate and sign various types of digital certificates and store and manage these certificates within NDS.

PKIS enables any designated NetWare 6 administrators to establish a Certificate Authority (CA) management domain within NDS. PKIS allows administrators to manage certificates and keys for Secure Sockets Layer (SSL) security for LDAP servers.

Certificate management includes services such as establishment of a CA local to your organization, certificate renewal, simplified certificate revocation with

certificate suspension (without complex certificate revocation lists), creation of certificate signing requests (for use with external CAs), unlimited certificate minting services for applications, and using SSL in the NetWare environment (such as Novell LDAP Services for NDS).

Using PKIS, you can control the costs associated with obtaining key pairs and managing public key certificates. PKIS helps you create a local CA based on NDS that signs certificates for other services on the network. With PKIS you can also generate unlimited key pairs and issue unlimited public key certificates through the local CA at no charge.

NDS stores all keys and certificates that are generated by PKIS or obtained from external CAs. NDS's trusted directory features mean that public keys can be openly published while private keys are securely protected.

Novell International Cryptographic Infrastructure (NICI)

NetWare 6 includes cryptographic services named Novell International Cryptographic Infrastructure (NICI). NICI enables developers to use the Controlled Cryptography Service (CCS) API to integrate cryptographic schemes with their applications. NICI also enables developers to write a single application that can be used in several countries, regardless of the differences in countries' cryptographic laws. For example, a developer could write a single application that uses 128-bit cryptographic keys when used within the United States and 40-bit cryptographic keys when used within countries that allow only keys of that length.

NICI is an infrastructure of network cryptographic services for worldwide consumption that supports strong cryptography and multiple cryptographic technologies. The NICI infrastructure has been developed in response to customer and internal Novell needs while complying with various national policies on the shipment and use of cryptography. Cryptography services on the NetWare platform provide fundamental security features such as confidentiality, integrity, authentication, and nonrepudiation.

The services are modular in nature, which enables new cryptographic engines, libraries, and policy managers to be dynamically added. The infrastructure is also tightly controlled, enforced through an integral OS loader that verifies modules before loading and controls access to modules only via standardized interfaces. A Novell SDK provides available cryptographic services.

NICI is the foundation for future network cryptographic services. It ensures that your product complies with international cryptography import and export laws through enforced region-specific cryptographic policies. NICI also provides for single, worldwide commodity vendor products and supports extensible, application-specific cryptographic libraries and interchangeable cryptographic technologies.

Secure Authentication Services

NetWare 6 includes Secure Authentication Services (SAS), an infrastructure for supporting both existing and emerging authentication mechanisms, such as biometric and token-authentication systems. Through SAS, NetWare 6 also supports SSL version 3. Developers can use the SAS API to write applications that can establish encrypted SSL connections. (Developers can then use NICI to ensure that these SSL connections conform to the laws of each country in which the applications are used.)

Authentication is a fundamental component of a robust network service — it is how you identify yourself. Without authentication, you cannot secure a network. Novell's Secure Authentication Services (SAS) provides next generation authentication services, as well as an evolving industry authentication mechanism for the future. In NetWare 6, SAS provides Secure Sockets Layer (SSL) support. Server applications use the SAS API set to establish encrypted SSL connections.

SAS is built entirely on NICI. This means that the SAS service itself is based on a single executable file. Because no cryptography is included in the SAS NLM, you can ship a single NLM worldwide for easy administrator management and tracking. Also, any applications written to the SAS API can also be based on a single executable file.

In addition, applications written to the SAS application can go through a one-time and usually expedited export approval process. Novell has already received export approval for SAS and NICI. This means that application developers benefit from expedited export procedures.

PKIS also provides key management for the SSL services. Any application written to the SAS interface inherits the capability to have PKIS manage its certificates. NDS access control lists (ACLs) manage access to the private key that enables SSL. Because SAS is a network service, it has its own network identity. ACLs are set up on the SSL key object in such a way that only the SAS identity can read the private key. This guarantees that nonauthorized entities such as users, other server applications, and even the application built on top of SAS cannot gain access to and expose or subvert the private key.

Auditing Services

NetWare 6 includes auditing services, which enable administrators to monitor users' access to an organization's network and to record this monitoring information in audit log files. You can create NDS objects to represent audit log files, and you can then manage these objects just as you manage other objects in the NDS tree. You can also grant rights to the NDS objects representing audit log files, just as you grant rights to other objects in the NDS tree. As a result, you can assign administrators to view and manage audit log files.

The audit system now takes advantage of exposed NDS audit services in the following ways:

- Audit log files are represented and managed as NDS objects.
- Access to the audit information and configuration is controlled by the standard NDS rights.
- Auditing is configured at the container and volume levels.
- The audit policy for a container or volume specifies what is audited within the volume or container and which users are audited.

The audit system is an essential element of the total NetWare security environment. You must have network audit integrity to ensure that the network is secure. Additionally, some industries, such as banking, require auditing to be done as part of business operations. The NetWare auditing system can monitor and record every relevant network transaction, which user performed the transaction, and when the transaction occurred.

NetWare provides audit data granularity. This includes which events are audited, control of audit configuration, and access to audit data.

Changes to Installation and Upgrades

Several changes to the installation or upgrade utilities are available in NetWare 6. In addition, improved utilities are available to help you upgrade your clients. These new installation and upgrade tools enable you to chose the option that best reflects your organization's network structure or design.

The NetWare 6 Installation Program (NWCONFIG.EXE and .NLM)

The NetWare 6 installation program is used either to install a new NetWare 6 server or to upgrade an existing NetWare 5 server to NetWare 6. Upgrading an existing NetWare 5 server to NetWare 6 is often called an *in-place upgrade*.

Novell also provides the NWDEPLOY.EXE utility to prepare your servers before beginning a migration to NetWare 6. NWDEPLOY can be run during the beginning a NetWare 6 install through the install screen when running an installation of NetWare 6. For more information about NWDEPLOY.EXE see Chapter 10.

The Novell Upgrade Wizard

NetWare 6 still provides the Novell Upgrade Wizard, which moves the NetWare 3 source server's bindery (including print information) and file system to a destination NetWare 6 server. The utility is a wizard-based interface, which ensures ease of use for across-the-wire upgrades. The wizard can also detect potential conflicts and provide options to resolve them before the upgrade begins.

Automatic Client Update

The Automatic Client Update (ACU) ships with NetWare 6. This utility is used to upgrade all varieties of NetWare clients. For example, you can upgrade NetWare 3 clients to NetWare 6 clients automatically from a central location.

Changes to Developer Support

NetWare 6 caters to network developers by providing the world's fastest Java Virtual Machine (JVM) for running server-based Java applications and services. Following are several additional enhancements made to the NetWare 6 system.

Java Support in NetWare 6

NetWare 6 supports Java applications running on the server. Java Virtual Machine (JVM), which is part of the NetWare 6 kernel, enables a wide range of Java-developed applications to serve your network and users. You can now develop Java-based applications for the Internet using Java and Java scripting.

This means that the Java support on NetWare 6 enables you to run Java applets on the server console, display Java applications in X Window–style formats — with full mouse and graphic support — and run multiple Java applications on the server while the server performs other tasks.

Java support in NetWare 6 is provided by JAVA.NLM. This NLM starts the Java engine, which enables Java applications to run. You can load Java support by calling JAVA.NLM at the server console prompt, and you can run Java applications using the APPLET console command.

Scripting

NetWare 6 scripting and component services offer you choice, compatibility, and speed. NetWare 6 supports the major scripting languages available, including Perl 5, NetBasic, and JavaScript. In addition, NetWare 6 also ships with and supports the Common Object Request Broker Architecture (CORBA), ORB, JavaBeans for NetWare, and JavaScript.

Third-Party Add-Ons

Several third-party products are included at no cost in NetWare 6. Novell includes these third-party products as part of the NetWare 6 package software in order to integrate them with NDS and take advantage of the security and services of NetWare 6. Some of the third-party products are listed in the sections that follow.

IBM Websphere Web Server

The IBM WebSphere Application Server is a Java-based application environment that enables you to build, deploy, and manage Internet and intranet applications on NetWare. This product provides you with a robust way to deploy Web services on the fast, secure, and stable NetWare environment. The Standard Edition is bundled for free on the *NetWare 6* CD-ROM. There is a charge for the Advanced version of the software

NetScape FastTrack Server

NetWare 6 provides a fully integrated version of the Netscape FastTrack server. This Web server used Netscape Web server code specifically adapted for maximum performance on a NetWare 6 platform along with integration to eDirectory. This integration with eDirectory makes the Web server easier to administer and more secure by restricting who can administer the Web server and what content the user can publish. The Netscape FastTrack server supports eDirectory, LDAP, Common Gateway Interface, CGI, PERL, and NetBasic.

BTRIEVE

Even after years and years of use, the BTRIEVE key-indexed record management system still provides high-performance data handling and improved programming productivity. BTRIEVE enables an application to retrieve, insert, update, or delete records either by key value or by sequential or random access methods.

Changes to Workstation/Client Support

Several new enhancements to the workstation or client appear in NetWare 6. Most notable is the support for Pure IP for each of the new clients that ship with NetWare 6. In addition, Novell's new clients are all based on the new and advanced NetWare Client 32 architecture, which departs from the NetWare DOS Requester software (the VLM-based client). Client 32 enables client software to run in protected mode and, in addition, requires less than 5KB of conventional memory while providing a larger cache. The Client 32 architecture, designed for robust connectivity and easy maintenance, provides the following features:

- Client 32 detects changes in a workstation's network environment and restores connections to the network when the relevant network service is restored. This makes Client 32 the most reliable NetWare client available. And when a computer loses its connection to the network, the computer continues to run without having to reboot.

- Client 32 caches frequently used data, such as file content and network information, resulting in less traffic on the network and faster response times on the client.
- Client 32 supports multiple Directory tree access and complete Novell Directory Services access.

The new clients based on this Client 32 code are NetWare Client 32 for DOS/Windows 3.*x*, NetWare Client 32 for Windows 95/98, NetWare Client 32 for Windows 2000, NetWare Client 32 for Windows NT, and NetWare Client for Macintosh.

NetWare Client 32 for DOS/Windows 3.*x*

In addition to all the benefits of the Client 32 architecture, the NetWare Client 32 for DOS/Windows 3.*x* software provides these capabilities:

- The familiar graphical NetWare User Tools utility is available in Windows to enable network users to manage their network environment.
- Support for Novell's 32-bit Pure IP transport is included.
- The same Target Service Agent used to enable backup and restore on workstations using the NetWare DOS Requester software works on workstations using the Client 32 for DOS/Windows 3.*x* software.

NetWare Client 32 for DOS/Windows 3.*x* differs from the NetWare Client 32 for Windows 95/98 software in these ways:

- The core Client 32 component, NIOS, runs as an executable file rather than as a virtual device driver (VXD).
- NIOS uses a text configuration file (NET.CFG) rather than the registry.
- There is no graphical interface for changing configuration parameters. You have to edit the NET.CFG file manually and restart the client software to implement the changes.

NetWare Client 32 for Windows 95/98

NetWare Client 32 for Windows 95/98 differs from the NetWare DOS Requester and the NetWare Client32 for DOS/Windows 3.*x* software in these ways:

- The core Client 32 component, NIOS, runs as a virtual device driver (VXD) rather than as an executable file.
- There is usually no STARTNET.BAT file. Windows 95/98 loads the client at startup.

- There is no NET.CFG file. Configuration settings are saved in the Windows 95/98 registry. Because configuration settings are saved in the registry, you can manage Client 32 parameters using the Windows 95/98 System Policies Editor.
- You can upgrade Windows 3.1*x* workstations to Windows 95/98 and NetWare Client 32 for Windows 95/98 in one installation process, called the *Batch Install*.
- Client 32 for Windows 95/98 is fully integrated into the Explorer and Network Neighborhood utilities. In addition, you can log into NetWare networks and run login scripts from the Windows 95 desktop environment.
- Client 32 for Windows 95/98 supports long filenames.
- Client 32 for Windows 95/98 supports the following industry standard protocols:
  - Windows 95/98 implementations of TCP/IP, Winsock, Named Pipes, and NetBIOS
  - The Windows 95/98 WSOCK32.DLL (supported by the Client 32 IPX protocol stack)
  - Simple Network Management Protocol (SNMP)
  - The Microsoft Client for Microsoft Networks

NetWare Client 32 for Windows NT and Windows 2000

The NetWare Client for Windows NT brings the full power, ease of use, manageability, and security of NetWare 4, intraNetWare, and NetWare 6 to Windows NT workstations. It enables organizations to get the most from their NetWare networks through NT workstations.

With the NetWare Client for Windows NT, you can take full advantage of NetWare services, such as NDS, and realize the performance of the NetWare Core Protocols (NCPs).

NetWare Client for Macintosh

The NetWare Client for Macintosh does not ship directly on the NetWare CD-ROMs. A third-party vendor provides the NetWare Client for Macintosh for NetWare.

The newer iMac can connect directly out of the box without any client software to a NetWare 6 server by utilizing the Novell NetWare Native file system software.

For detailed information about each of the NetWare clients and their installation and configuration instructions, please see Chapter 17.

Summary

This chapter has provided you with brief descriptions of the features of NetWare 6, including the many new features that greatly enhance NetWare 6. NetWare 6 is scalable and enables you to add up to 32 CPUs for each SMP server. You can also link multiple NetWare 6 servers together in what is known as a cluster. NetWare 6 also provides enhanced storage services through NSS 3.0 and NetWare 6 is more flexible for large enterprises while offering the most secure and cost-effective network operating system available. For installation and configuration information, refer to the rest of the chapters in this book.