NetWare®/IP

A Novell White Paper

NetWare/IP: A Novell White Paper

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What is NetWare/IP?

NetWare/IP is a set of NetWare Loadable Modules™ (NLMs) and client software that enables existing NetWare 3.1x or 4.01 servers to use the Defense Advanced Research Projects Agency (DARPA) Transmission Control Protocol/Internetwork Protocol (TCP/IP) as their transport protocol instead of — or in addition to — Novell's Internetwork Packet Exchange™ (IPX). The same protocol used to link tens of thousands of nodes on the worldwide TCP/IP-based Internet is now available as a protocol option for NetWare servers and clients. NetWare/IP transparently extends the vast array of NetWare and third-party network services to TCP/IP-based DOS and MS* Windows clients.

In addition to the server components, NetWare/IP includes the market-leading LAN WorkPlace® for DOS TCP/IP transport components at the workstation — making NetWare/IP an ideal solution for MIS departments that use TCP/IP as their standard transport protocol.

Novell's NetWare, UnixWare™ and AppWare™ families of products provide matched system software components for global information systems, making it easier for users to store, process, move and view information. NetWare provides enterprise networking services; UnixWare provides a powerful server platform for running business critical applications; and AppWare simplifies the development of network applications. Novell's goal is to provide seamless integration between these environments. NetWare/IP fits into this strategy by providing customers with the ability to tightly integrate NetWare services into their TCP/IP environments.

NetWare/IP Customer Benefits

NetWare/IP delivers a variety of benefits to NetWare customers who wish to use TCP/IP:

NetWare/IP provides customers with the option of running NetWare on an IP-only infrastructure. Corporate MIS environments that have standardized on TCP/IP and NetWare can seamlessly and effortlessly integrate the power of NetWare services with their protocol of choice.

Enables existing NetWare applications to run over TCP/IP. Customers can continue using NetWare 3.1x and 4.01 applications which employ Novell's standard application programming interfaces (APIs) on the workstation and server. These applications run unmodified on a NetWare/IP node.

Reduces costs. MIS departments that have standardized on TCP/IP and NetWare have an opportunity to lower the cost of managing their networks by reducing the number of network protocols running on their communications backbones and departmental LANs.

Allows NetWare and NetWare/IP networks to seamlessly coexist. A NetWare/IP feature, called the NetWare/IP gateway, transparently connects native NetWare and NetWare/IP networks. The gateway allows IPX-based NetWare clients to access resources on NetWare/IP servers while giving NetWare/IP clients access to resources on native NetWare servers.

Eases migration to NetWare/IP. Customers can gradually migrate their NetWare servers to NetWare/IP using the NetWare/IP gateway. The NetWare/IP gateway provides seamless connectivity between native NetWare and NetWare/IP networks.

Provides alternative management console for added flexibility. NetWare/IP includes an application, XCONSOLE, that turns an X Window System* or DEC VT100/220* terminal into a console from which NetWare/IP can be managed. By running XCONSOLE on a NetWare/IP server, UNIX® systems administrators working at an X Window station such as a Sun workstation running the Open Look® graphical user interface or a UnixWare computer running MOTIF can access the NetWare server's console to manage NetWare/IP. The same can be done from a DEC VT100/220 terminal that is able to connect to the NetWare/IP server using Telnet.

Example Configurations

NetWare/IP provides customers with the flexibility of deploying a total IP network solution or a mixed solution of IP and IPX networks. The following examples show two of the many different ways that NetWare/IP can be used within an organization.

There are some large organizations such as companies in the Fortune 500 and universities that have standardized on the TCP/IP network protocol for transporting information across their network backbones. However, these same organizations will allow other protocols (e.g., IPX) to be used locally if they are not put on the backbone. They often cite the reduced cost of network management, the proven capability of TCP/IP as a WAN protocol, and the availability of TCP/IP across a wide variety of systems as their reasons for wanting to standardize on the TCP/IP protocol for their backbone. However, for organizations that are already using NetWare based on IPX and like the services (e.g., messaging, communication, filing, printing) provided by NetWare in addition to the ease of IPX administration and configuration, NetWare/IP provides a way for these organizations to maintain IPX locally while using TCP/IP to route data across their network backbone.

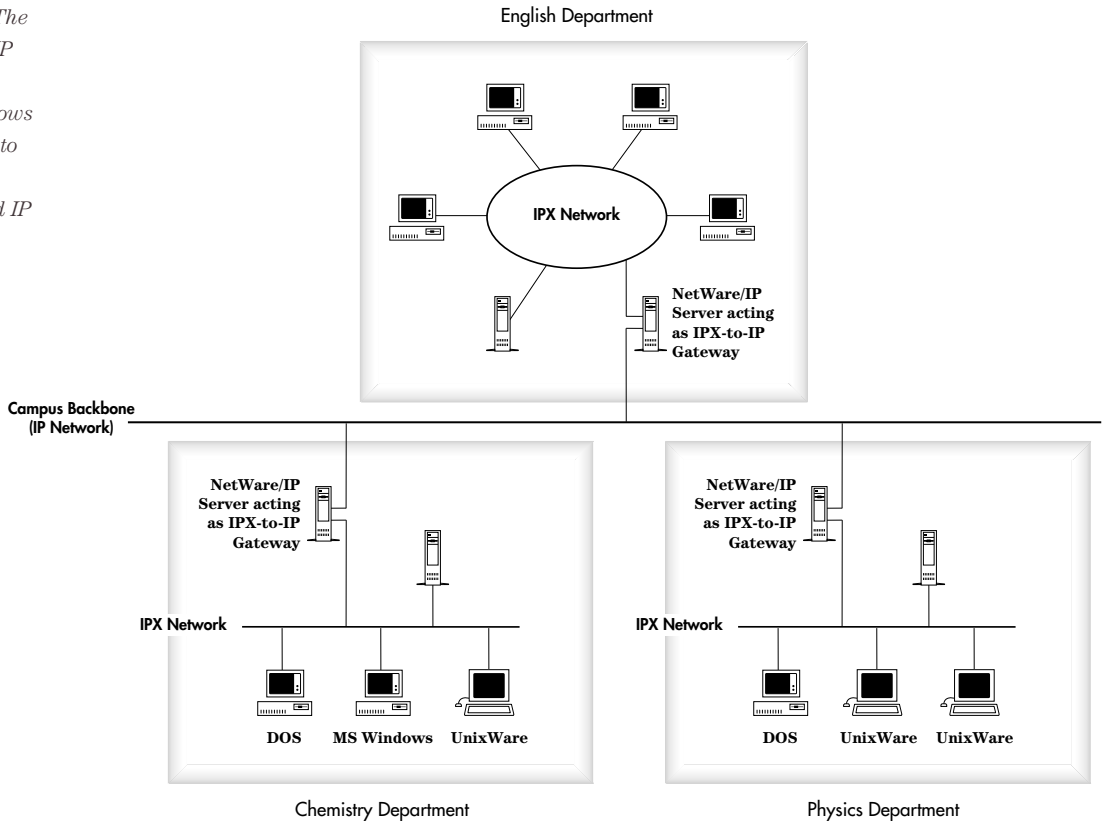


Figure 1: The NetWare/IP gateway feature allows customers to use IPX locally and IP on their backbone.

Figure 1 shows a network configuration that is typical of a college campus environment but could just as easily be found among various departments within a Fortune 500 company. In this example, NetWare/IP's ability to route traffic between IPX networks and NetWare/IP networks is being used to link the English, Chemistry, and Physics departments on a college campus. This setup allows users to continue using their IPX-based services locally and gives them the ability to access servers in other departments across the IP backbone, while satisfying the requirement that IP is the only protocol allowed on the backbone.

Additionally, using NetWare/IP in this manner gives organizations a migration path when converting from a NetWare environment based on IPX to one based on IP. Organizations can migrate their NetWare servers to IP as needed until the entire network is converted. Using this example, the NetWare servers within each university department could be migrated one at a time until all of the servers were converted to NetWare/IP. Once all of the servers within a department were converted to NetWare/IP, it would make sense to configure the client workstations as NetWare/IP nodes. At this point, the server within each department acting as the NetWare/IP gateway could be configured to route network traffic across the IP backbone (i.e., configured as an IP router) since all nodes within the department would be using TCP/IP.

Figure 2. NetWare/IP gives branch offices in San Francisco, Los Angeles and Chicago full access to resources located at corporate headquarters in New York and throughout the entire organization.

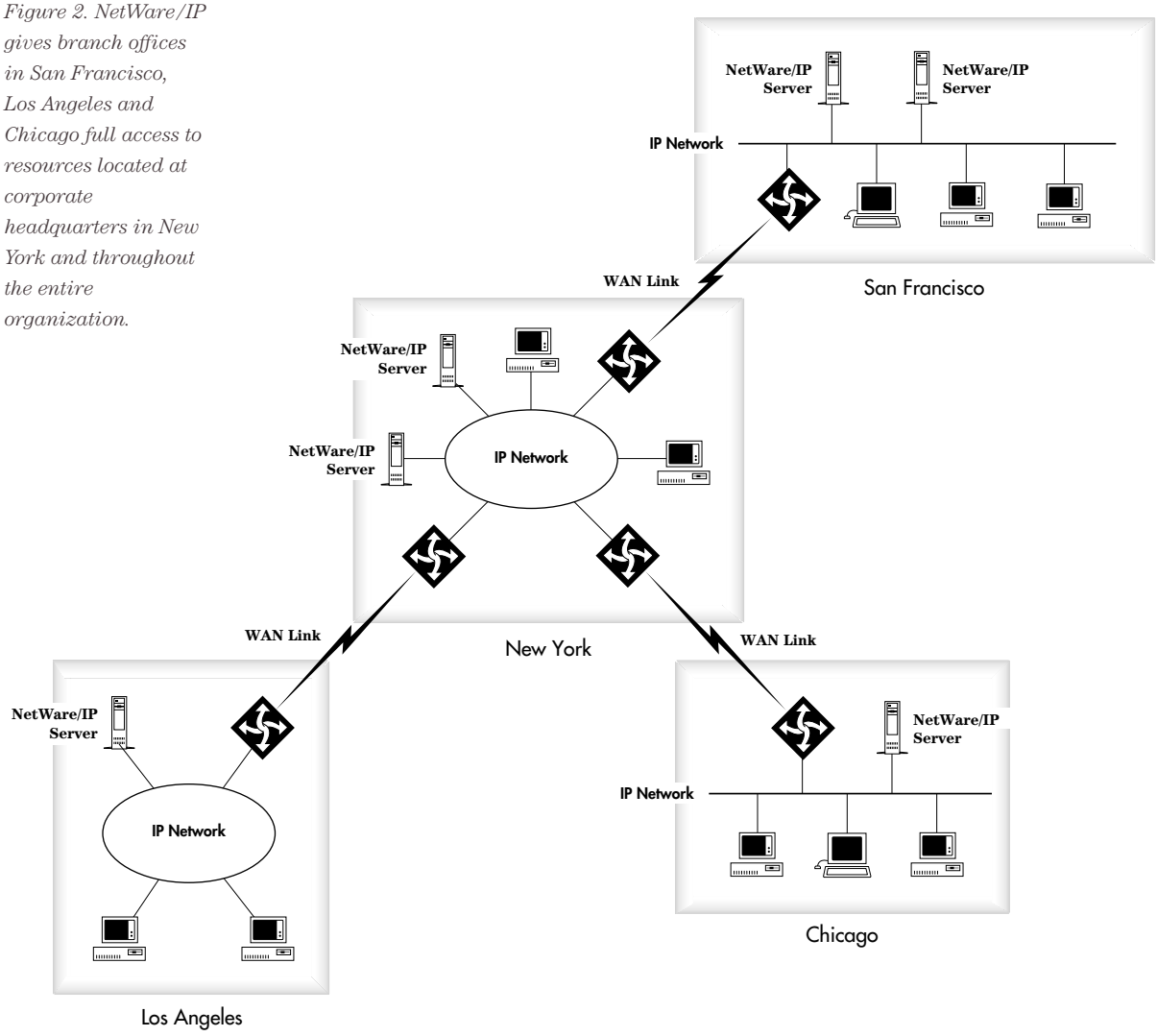


Figure 2 shows an IP-only network. This configuration would be typical for an organization such as a Fortune 500 company which has a need to link offices throughout the world. In this example, the organization has business-critical data located on NetWare/IP servers at corporate headquarters in New York which must be accessible to the satellite offices in San Francisco, Los Angeles, and Chicago. Using NetWare/IP, each of these offices has access to the data from their NetWare/IP client workstations using the TCP/IP protocol — a protocol which has been proven as an excellent networking protocol for traversing wide area links as would be required by this setup. The advantage that this configuration has over the previous example is that each NetWare/IP client in the various satellite offices has direct access to the data at corporate headquarters in New York as well as to the other NetWare/IP servers throughout the entire organization.

The remainder of this document describes the NetWare/IP system architecture, each NetWare/IP system component, and gives an example which explains how to configure a NetWare/IP client and server.

NetWare/IP System Description

NetWare/IP consists of several independent, cooperating client and server components. These components consist of one or more NetWare/IP clients and servers, Domain Name System (DNS) servers and Domain SAP Servers (DSS).

The NetWare/IP client is a workstation which has been configured with the appropriate network hardware, Netware/IP client software, and has the ability to access NetWare/IP servers. In brief, the NetWare/IP client software consists of a TCP/IP stack, TCPIP.EXE, a module called NWIP.EXE, and either NETX.EXE or the NetWare DOS Requestor Virtual Loadable Module™ (VLM) as the NetWare shell.

A NetWare/IP server is a server which has either NetWare 3.1x or 4.01 loaded in conjunction with the NetWare/IP software. NetWare applications which previously used IPX can run on a NetWare/IP server using IP.

The Domain Name System (DNS) server is a distributed look-up service which allows systems administrators to centralize host name-to-IP address information in addition to providing a flexible way for NetWare/IP clients and servers to locate Domain SAP Servers (DSS).

DSS servers maintain a database used for storing and disseminating IPX SAP information to NetWare/IP clients and servers.

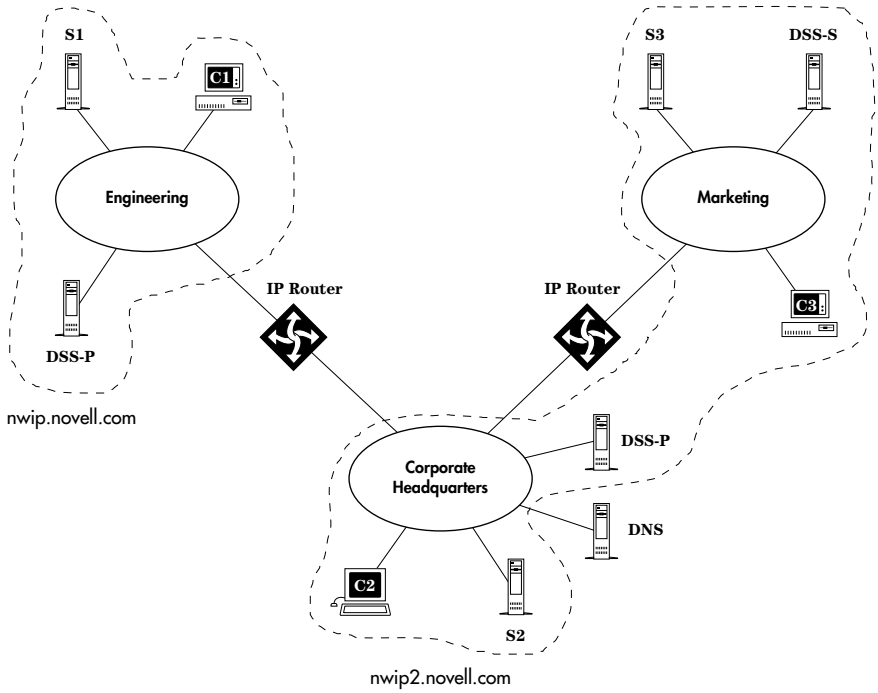


Figure 3: Internetworks can be partitioned into NetWare/IP domains, giving network managers maximum flexibility in setting up a network configuration.

Figure 3 shows a typical NetWare/IP internetwork. Three IP subnetworks Engineering, Corporate Headquarters and Marketing are connected via IP routers. The Engineering subnetwork has one NetWare/IP client labeled C1, a NetWare/IP server labeled S1 and one primary DSS labeled DSS-P. The other subnetworks contain various NetWare/IP components.

NetWare/IP networks are logically partitioned into NetWare/IP domains. There will often be as few as one NetWare/IP domain that contains all NetWare/IP clients, servers and Domain Service Advertising Protocol servers (DSS) on the internetwork, or the network can be partitioned into multiple NetWare/IP domains. Partitioning the network into multiple NetWare/IP domains is one way to limit the amount of SAP information which must be maintained by DSS servers within a domain — reducing the load on the DSS server CPU and its memory requirements. However, in general it is better to increase the efficiency of DSS servers by spreading the load across multiple secondary DSS servers deployed throughout the network rather than by partitioning the network into multiple NetWare/IP domains.

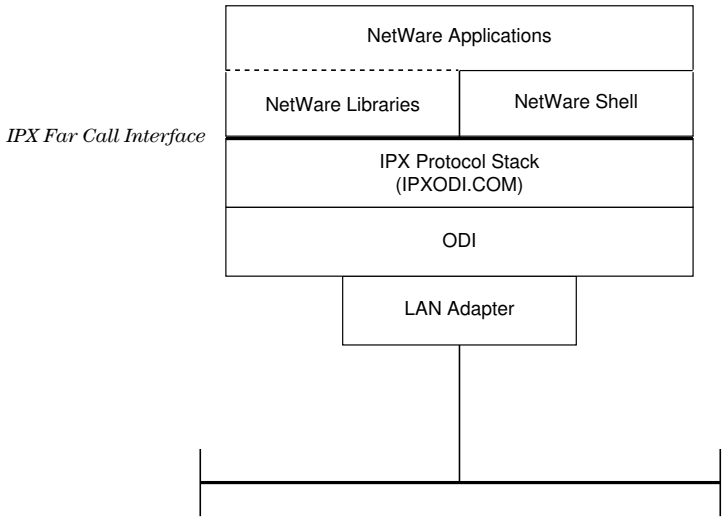
NetWare/IP clients in a given NetWare/IP domain have access to servers and resources in their same NetWare/IP domain. If a NetWare/IP client needs to access servers outside of their NetWare/IP domain, they can do so by using the *nwipmap.exe* utility.

The internetwork shown in Figure 3 is partitioned into two NetWare/IP domains named *nwip.novell.com* and *nwip2.novell.com*. Client C1 in *nwip.novell.com* can access server S1 because both are in the same NetWare/IP domain. In addition, *nwipmap.exe* can be used to map a drive on C1 to server S2 or S3. For instance, to map drive G: to the public directory on S2, the user would issue the following command: nwipmap g:=S2/SYS:\public@nwip2.novell.com.

NetWare/IP Workstation Architecture

The NetWare/IP client architecture is more easily understood by first examining the NetWare client architecture. Figure 4 shows the various layers of software in a NetWare client.

Figure 4: Standard NetWare client architecture



The bottom layer consists of LAN hardware. At this layer, one or more LAN adapters are plugged into the workstation bus. The adapters can support many different types of LANs and access methods, including Ethernet, Token-Ring or FDDI. In fact, any adapter which has an Open Data-Link Interface™ (ODI) software driver can send and receive data on the network.

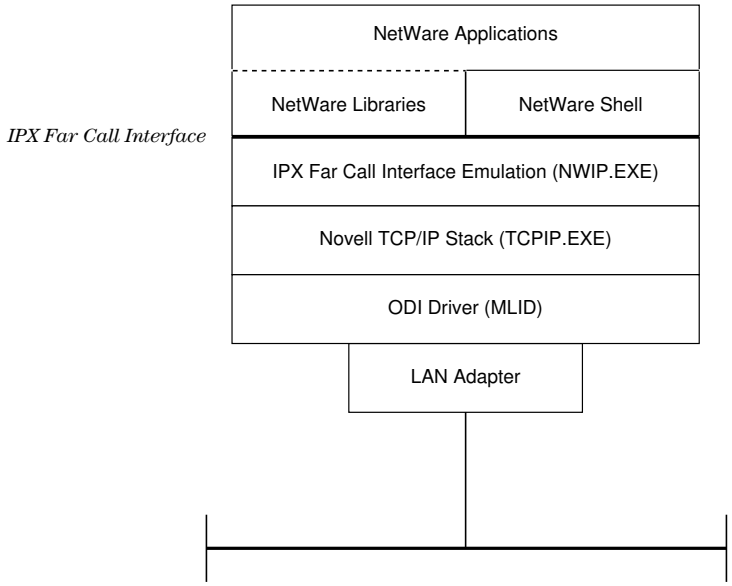
The ODI driver resides in the next layer. The ODI driver communicates with the protocol stack above it and the LAN adapter below it. Drivers written to the ODI specification allow a single implementation of a protocol stack, such as IPX or TCP/IP, to run over many different types of adapters. It also allows multiple protocol stacks to send and receive data over the same or dissimilar adapters simultaneously.

The ODI IPX/SPX protocol stack, IPXODI.COM, functions in the layer above the ODI driver and provides data transport in a NetWare environment. IPXODI.COM is responsible for the end-to-end transport of data between systems. It exports an Application Binary Interface (ABI) called the IPX Far Call Interface that is backward compatible with versions of IPX dating back to the very earliest implementations.

The NetWare libraries, shell and applications are at the highest layer in the NetWare client architecture. They use the IPX layer to transmit data by making function calls into IPXODI.COM using the IPX Far Call Interface.

The key to enabling all existing and future NetWare applications to run over TCP/IP is making the IPX Far Call Interface available to applications over TCP/IP.

Figure 5: NetWare/IP client architecture



The NetWare/IP and NetWare workstation architectures are identical at the hardware, ODI and application layers, but different at the transport layer. Instead of using IPX to transmit information, the NetWare/IP workstation utilizes the User Datagram Protocol (UDP) in TCPIP.EXE, as shown in Figure 5.

Simply replacing IPXODI.COM with TCPIP.EXE will not enable NetWare applications to run over TCP/IP. The explanation is simple — the ABI used by applications to call into TCPIP.EXE is different from the IPX Far Call Interface ABI used by NetWare applications to call into IPXODI.COM. NWIP.EXE sits above TCPIP.EXE and addresses this problem by exporting the IPX Far Call Interface to NetWare applications, libraries and shells above it while making the appropriate calls to TCPIP.EXE below it.

This architecture allows current and future NetWare applications using the IPX Far Call Interface ABI to run unmodified with TCP/IP. In fact, either NETX.EXE or the NetWare DOS Requestor VLM may be used as the NetWare shell. However, there are limitations on IPX-based NetBIOS and other applications which depend on IPX broadcast mechanisms. These applications are limited to their local subnet because IP routers do not forward non-directed UDP broadcasts to other subnetworks.

TCP/IP Transport Features

As a member of the TCP/IP protocol suite, UDP provides end-to-end and process-to-process delivery of data between systems. UDP is implemented as part of the TCPIP.EXE that is distributed with NetWare/IP workstation software. In fact, it is the same TCPIP.EXE found in Novell's market-leading LAN WorkPlace for DOS. It is optimized for DOS and MS Windows

environments and has been field-proven as a high-performance and robust TCP/IP implementation with well over a million nodes of LAN WorkPlace for DOS shipped during the past two years.

The following table lists some of the features of the client TCP/IP Transport included with NetWare/IP:

- Support for the most common APIs for running TCP/IP-based applications in DOS and MS Windows. This includes the LAN WorkPlace Socket Libraries for DOS and MS Windows, as well as the Windows Sockets Interface v1.1 (also known as "WinSock")
- Support for up to 64 TCP and 32 UDP sockets
- Support for IP communications on up to four ODI interfaces
- Support for up to three "default routers" on each interface (for fault tolerance)
- Duplicate IP address prevention (uses ARP to verify that the IP address that it's about to use is not in use elsewhere on the network)
- Support for various types of network media via ODI drivers including: Ethernet, Token-Ring, FDDI, ARCNet, IBM Broadband and asynchronous serial lines using SLIP or PPP.
- IP configuration via: ASCII text file, BOOTP or RARP
- Miscellaneous utilities for testing IP network connectivity including SNMP
- Supports NetBIOS over TCP/IP (an enhanced "B-node" implementation of RFCs 1001 and 1002)

The Internetwork Domain Name System

NetWare/IP includes an implementation of the Domain Name System (DNS) server. A distributed look-up service widely used in UNIX and TCP/IP environments, DNS allows TCP/IP systems administrators to centralize host name-to-IP address information.

On a TCP/IP internetwork, each node is assigned a unique IP address. This address is a 4-byte value that is usually written in a format called dotted decimal notation. Using dot notation, a 4-byte IP address is written in sequence, starting with the most significant byte (MSB) and proceeding to the least significant byte (LSB) with a period or dot character separator.

For example, a host might have an IP address of 132.34.6.1. Although this sequence of numbers is simpler to recall than the single 4-byte value of an address — such as 2216822273 decimal in the case of 132.34.6.1 — it is more convenient for TCP/IP-based computers to have proper names that are easily remembered.

Most computers that support TCP/IP maintain a special database that supports mnemonic naming of host devices. On the UNIX operating system, this file is usually called */etc/hosts*. The host's file format is shown in Figure 6.

Figure 6: The /etc/hosts *file used by the UNIX operating system allows host addresses to be named mnemonically.*

```
# Example /etc/hosts file
#
127.0.0.1       localhost
45.12.4.2       salmon
45.15.54.76     lobster  crustacean  thermadore
45.87.34.12     kipper
```

Figure 6 shows three hosts that are mnemonically named. The first host is "salmon" whose IP address is 45.12.4.2, the second host is "lobster" whose address is 45.15.54.76 and last host is "kipper" whose address is 45.87.34.12. Note that the host named "lobster" can also be referred to using the aliases "crustacean" or "thermadore."

The diagram also shows an entry for the special loopback TCP/IP address 127.0.0.1. This is a special IP address that allows client application programs to communicate with server programs running on the same host. With this host database in place, the mnemonic names can be used in place of TCP/IP addresses when a user employs TCP/IP client utilities to communicate with remote devices. For example, a client can use "telnet lobster" instead of "telnet 45.15.54.76" to engage in communication with remote devices.

Although it is convenient to name all TCP/IP nodes on a network, it can be an arduous, time-consuming task to update the myriad host databases for each TCP/IP device. If a network supports 5,000 TCP/IP hosts, it would be difficult to keep a single host's database current across all devices on the enterprise-wide system. Even if the task was simple, the host's database would be extremely large and waste a great deal of disk space when replicated everywhere.

There are additional challenges regarding the maintenance and configuration of hosts in large, complex networks. In most Fortune 1000 organizations, several people are assigned to administer computer systems for certain departments. It is difficult for these administrators to keep in constant contact with one another to maintain a single, global host database. Furthermore, it is difficult for an administrator of one section to notify other administrators in a timely manner about new hosts or obtain quick authorization to bring a new host online.

The Internet DNS was developed to overcome these obstacles. It stores and maintains information tables that map readable host names to TCP/IP addresses on a central computer. The centrally stored information can be queried by other TCP/IP nodes on the network to identify IP addresses and their corresponding nodes. A computer that can provide TCP/IP hostname and address information to the network is call a Domain Name Server.

To simplify and organize the various internetwork sections that are managed by different systems administrators, DNS divides networks into domains (not to be confused with NetWare/IP domains). With DNS, each domain is administered separately, eliminating the need for centralized allocation of IP addresses and host names.

DNS domains are organized into a hierarchical tree structure. At the base is the root domain, which is usually denoted by a period — "." All other domains are subdomains of the root. Because there are no arbitrary limits to the depth of the hierarchy, systems administrators can create any number of domains and subdomains. The only current restriction imposed by the DNS specification is a 255-character-length limitation for fully qualified host domain names within the tree.

Figure 7: DNS domains are organized into a hierarchical tree structure. When a systems administrator modifies a subdomain, the change is consolidated and updated throughout the hierarchy.

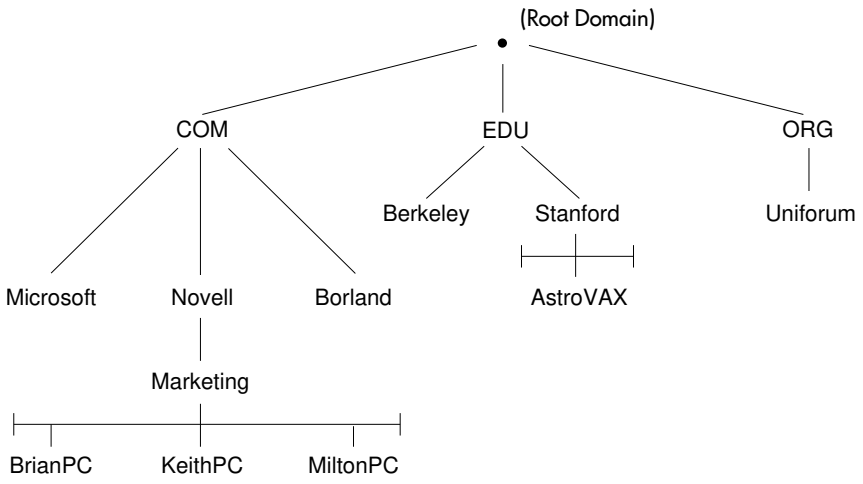


Figure 7 shows a simple domain hierarchy. Subdomains *com* (for commercial groups), *edu* (for educational institutions) and *org* (for non-profit organizations) extend from the root domain. Below the *com* subdomain is the subdomain *novell*, and beneath that is the *marketing* subdomain. The complete subdomain name is written by starting at lowest subdomain and attaching each proceeding subdomain name — separated by a period — until the root is reached. For example, the fully qualified name of the marketing subdomain is *marketing.novell.com*.

This organization of domains is called a domain tree. Although a DNS server is not required in each domain, it is common to have one or more within the domains they serve. In Figure 7, a designated computer would normally act as a DNS server for the root domain. The *com, novell.com* and *marketing.novell.com* subdomains would each have their own dedicated DNS servers as well.

Hosts within each domain can query their local DNS server to identify TCP/IP addressing information for any other TCP/IP host within the domain tree. In Figure 7, the node *keithpc.marketing.novell.com* could query the DNS server in the *marketing.novell.com* subdomain to find the node address of *astrovax.stanford.edu*.

Each systems administrator can be assigned to a specific subdomain within the domain tree. Within their respective subdomains, they can configure the names and IP addresses of every host into the DNS server software. If a domain has subdomains, it is not necessary to teach the DNS server about the various hosts within the subdomains. Only the addresses of the subdomain's DNS servers require configuration. Each DNS server must also know the IP address of its adjacent parent DNS server.

NetWare/IP Domains and DNS

As mentioned earlier in the section entitled "NetWare/IP System Description," NetWare/IP networks usually consist of one NetWare/IP domain but can be partitioned into multiple NetWare/IP domains. NetWare/IP domains are logical groupings of NetWare/IP clients, servers and DSS servers.

A NetWare/IP domain is defined by creating a DNS subdomain with the following properties:

1. It is a subdomain of an existing DNS domain.

2. It does not have subdomains.

After the NetWare/IP domain name is created in DNS, all NetWare/IP components (client, server and DSS) which are members of that domain, must be configured with the NetWare/IP domain name.

For example, suppose Novell wanted to partition its NetWare/IP network into two NetWare/IP domains and it had the authority to create DNS subdomains in *novell.com*. Additionally, assume that there were two pre-existing subdomains of *novell.com* called *utah.novell.com* and *california.novell.com*. One possibility would be to partition the network based upon geographic location by defining two NetWare/IP domains called *nwip.utah.novell.com* and *nwip.california.novell.com*. This means that two new DNS subdomains would have to be created with the same names, *nwip.utah.novell.com* and *nwip.california.novell.com*. Additionally, all NetWare/IP nodes and DSS servers in Utah and California would have to be

configured with the *nwip.utah.novell.com* and *nwip.california.novell.com* NetWare/IP domain names respectively. For more information on the configuration of NetWare/IP nodes and DSS servers, please refer to "NetWare/IP System Configuration — An Example" later in this document.

NetWare/IP Domain SAP Server

Another major component of the NetWare/IP architecture is the Domain SAP Server. The DSS holds one logical database which stores and disseminates IPX SAP information to NetWare/IP servers. The DSS database can be physically replicated on multiple servers for reliability, fault tolerance and better performance across slow WAN links.

There is only one primary DSS within each different NetWare/IP domain and optionally one or more secondary DSS databases. Each DSS maintains SAP information for a single NetWare/IP domain.

Updating the DSS with SAP Information

NetWare services, such as a file, print and directory services, advertise themselves via the Service Advertising Protocol (SAP). Every 60 seconds these services broadcast a SAP packet which lists their name, service-type and address information. The packets are sent out on every network interface to which IPX is bound on the NetWare server that supports these services. This is how NetWare 3.1x servers and clients discover the location of services on an IPX internetwork.

When a NetWare server boots, it sends a SAP broadcast throughout the rest of the network. Similarly, when a NetWare/IP server boots, it advertises itself to the rest of the network by sending a SAP record directly to its nearest DSS using the User Datagram Protocol (UDP).

Subsequently, the NetWare/IP server refreshes its SAP information every 5 minutes (configurable) by resending it to the DSS. This refresh is necessary because the DSS monitors when SAP records are received and discards old ones if they have not been validated within a certain time interval.

Other processes on the NetWare/IP server, such as print servers and NetWare Directory Services™ (NDS), advertise themselves using SAP broadcasts. These broadcast packets are also sent by the NetWare/IP server directly to the DSS using UDP. This method of direct forwarding prevents SAP packets from being sent through every network interface, thereby reducing network traffic generated by such broadcast protocols. This makes NetWare/IP well-suited for deployment in large enterprise networking environments.

Updating the NetWare/IP Server with SAP Information

In a native NetWare environment, NetWare servers listen to SAP broadcasts by other servers and store this information in their bindery and cache memory. This allows NetWare applications to locate network resources by looking in the NetWare server bindery.

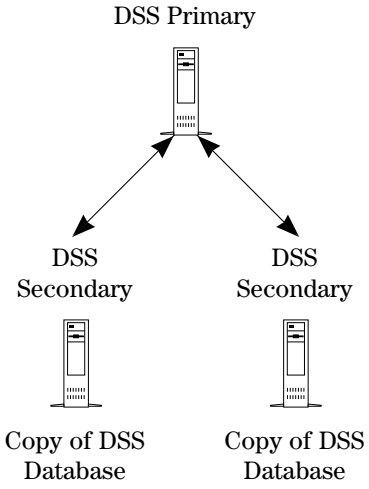
Because applications must be able to locate objects in the bindery, NetWare/IP servers keep the bindery up-to-date with the latest SAP information. This is accomplished by periodically downloading SAP information from the DSS to server cache memory and storing it in the bindery. By default, downloading occurs every five minutes (configurable) to keep SAP information in the bindery current.

DSS Database Replication

One of the design goals of the DSS architecture was to ensure that its database was highly available to the network. This goal is achieved by allowing DSS database replication on a large number of NetWare/IP servers on an internetwork. If a DSS is unavailable because it is too busy to acknowledge packets sent by a NetWare/IP server or it is "down" the NetWare/IP client or server will attempt to contact an alternate DSS for the information it needs.

Additionally, DSS database replication can be used to improve performance on a large internetwork connected by slow WAN links. Since NetWare/IP nodes contact the DSS that is nearest to them, performance can be improved by placing secondary DSS servers on each subnetwork connected by the WAN. This ensures that the NetWare/IP nodes query the secondary DSS located on their local subnetwork thereby eliminating the need for it to query a DSS which may be located on the other side of a slow WAN link.

Figure 8: Secondary servers maintain replicas of the DSS database, providing reliability, fault tolerance, and better performance.



As mentioned earlier, there is one primary DSS and optionally one or more secondary DSS servers in a NetWare/IP domain. The primary DSS holds a database master copy while secondary DSS servers hold Read/Write replicas, as shown in Figure 8.

Because SAP updates occur independently at the primary and secondary DSS, their databases can become out of synch. To correct this, each secondary DSS contacts the primary DSS and initiates a database synchronization process. Three instances may prompt a secondary DSS to contact a primary DSS for synchronization:

- Based on configurable parameters, the secondary DSS will periodically contact the primary to determine whether their databases are out of sync. If the databases are out of sync, they will begin synchronization.
- If connectivity between the primary DSS and a secondary DSS is lost, the secondary DSS will periodically attempt to contact the primary. When connectivity is restored, the secondary initiates synchronization.
- When a secondary DSS comes up after being down, it initiates synchronization with the primary.

To facilitate the database synchronization process, each DSS maintains database version numbers that change incrementally when updated with new SAP records. In the first step of the synchronization process, each DSS compares these version numbers to instantly determine if their databases are out of sync. If out of sync, the secondary DSS will upload to the primary all new records received since the last synchronization. The secondary DSS also downloads from the primary all records not in its database. Notice that only the records which are changed, deleted or new are exchanged, not the contents of the entire database. This saves bandwidth and CPU cycles while bringing the primary and secondary databases to a current and cohesive state.

NetWare/IP Gateway

Another feature of NetWare/IP is its ability to bridge the gap between NetWare/IP networks and IPX-based NetWare networks by acting as a gateway. When configured as a gateway, NetWare/IP gives IPX-based NetWare clients access to NetWare/IP servers, and NetWare/IP clients access to IPX-based NetWare servers. The NetWare/IP gateway provides both a migration path for IPX-based networks that are being converted to NetWare/IP as well as the ability to use IPX-based NetWare locally and use NetWare/IP on a TCP/IP backbone or WAN link, to link widely-dispersed IPX-based NetWare LANs.

NetWare/IP Performance

NetWare/IP's performance compares very favorably to native NetWare. Benchmarks show only a small difference in performance due to the processing overhead associated with the additional NetWare/IP software which must be run on the client and server. For example, a test was performed using a Novell benchmarking tool. When run on more than one client station against the same server, the tool does file transfers between the server and clients and records the throughput measured in kilobytes per second.

The first part of the test consisted of running the tool on four IPX-based NetWare clients against a server running NetWare 4.01. The second part of the test consisted of running the tool on the same hardware but using the NetWare/IP client and server software pieces. It was determined that NetWare/IP's average throughput was only 8% less than the throughput measured when running the IPX network protocol.

Although there is a slight difference in performance as measured in the test lab, it is important to note that NetWare/IP users don't perceive a performance difference when running server resident applications or using NetWare utilities such as SYSCON and PCONSOLE.

NetWare/IP Memory Requirements

The NetWare/IP workstation components, TCPIP.EXE and NWIP.EXE, have RAM footprints of 17.2KB and 15.1KB respectively using DOS 5.0. Either or both of these components can be loaded into an upper memory block using the appropriate DOS memory manager. Approximately 2MB (DOS) or 3.2MB (MS Windows) of free disk space is required on each workstation.

The amount of memory required on the NetWare/IP server depends upon which components are started and how many NetWare/IP servers are in its NetWare/IP domain. The memory requirement can be calculated using the following formulas:

Service	Memory required (bytes)
NetWare/IP	(n * 380) + 75,000
DSS on NetWare 3.1x	(n * 440) + 450,000
DSS on NetWare 4.01	(n * 440) + 710,000

* n denotes the number of NetWare/IP servers in the NetWare/IP domain

Installing NetWare/IP requires at least 2MB of free disk space on the server's SYS: volume.

NetWare/IP System Configuration — An Example

This section shows an example of how a simple NetWare/IP network consisting of one NetWare/IP client and one NetWare/IP server named *sjf-mktg-nwip.novell.com* would be configured in the *nwip.novell.com* NetWare/IP domain shown in Figure 3. In this example, the other NetWare/IP components, namely the primary DSS and DNS server, will be configured to run on the same NetWare/IP server.

NetWare/IP Workstation Configuration

Figure 9 shows a screen shot of the NetWare/IP workstation installation program. The installation program prompts the user for all configuration parameters, which must be set to load the NetWare/IP workstation software. The program installs TCPIP.EXE, NWIP.EXE, necessary ODI drivers and the NetWare DOS Requestor VLMs. If desired, it also updates AUTOEXEC.BAT, CONFIG.SYS, RESOLV.CFG and NET.CFG with the appropriate information, as well as any desired MS Windows files.

Figure 9: The NetWare/IP installation program allows the user to set workstation configuration parameters.

```
NetWare/IP Client Install  v1.10          Monday  October 18, 1993  11:14 am

STEP 6. Provide the following information for configuring TCP/IP.

        TCP/IP Directory:           C:\NET
        Using Boot Protocol?        No
        Client IP Address:          128.32.134.4
        Subnetwork Mask:            255.255.255.0
        Default Router Address:     128.32.134.2
        DNS Domain:                 NOVELL.COM
        Name Server Address:        128.32.134.5
        Name Server Address:        <none assigned>
        Name Server Address:        <none assigned>

STEP 7. Configure this host to access NetWare/IP service.

        NetWare/IP Domain:          NWIP.NOVELL.COM_

STEP 8. Press <Enter> to install.

Esc-previous screen  Enter-select  Alt F10-exit
```

The following parameters must be set for a properly configured workstation:

1. **TCP/IP Directory.** NetWare/IP program files are copied to this location during workstation installation.
2. **Using Boot Protocol.** If this field is set to *No* (the default), then the *Client IP Address, Subnetwork Mask, Default Router Address, DNS Domain,* and *Name Server Address* fields must be set during installation or configured manually after installation.

If the *Using Boot Protocol* field is set to *Yes,* the *Client IP Address, Subnetwork Mask, Default Router Address, DNS Domain,* and *Name Server Address* fields are not displayed because it is assumed that this information will be obtained from a BOOTP server. If this is the case, the TCP/IP stack (TCPIP.EXE) in NetWare/IP will issue a BOOTP query when it is loaded. If a BOOTP server is active, properly configured, and responds to the BOOTP query, TCPIP.EXE will configure itself with the TCP/IP information (e.g., *IP Address, Subnetwork Mask, Default Router Address, DNS Domain,* and *Name Server Addresses*) contained in the BOOTP response from the BOOTP server.

3. **IP addressing information.** When the workstation is not using BOOTP (as shown in Figure 9) the *Client IP Address, Subnetwork Mask,* and *Default Router Address* fields must be set. This information is gathered by the install program and placed in the *Protocol TCPIP* section of the NET.CFG file. The NET.CFG file is a control file stored on the NetWare/IP client workstation that contains section headings and options that deviate from the established defaults of the regular workstation boot process. TCPIP.EXE and NWIP.EXE consult NET.CFG when they are run. The NET.CFG entry generated by the information used in this example is shown below:

   Protocol TCPIP

PATH TCP_CFG	C:\NET\TCP
ip_address	128.32.134.4
ip_netmask	255.255.255.0
ip_router	128.32.134.2

   TCPIP.EXE configures itself by reading this *Protocol TCPIP* section of NET.CFG. The *PATH TCP_CFG* keyword tells TCPIP.EXE where to find other TCP/IP specific configuration files such as the HOSTS, NETWORKS, PROTOCOLS, and RESOLV.CFG files. The other keywords such as *ip_address, ip_netmask*, and *ip_router* are used to set IP addressing parameters when a BOOTP server is not being used as in this example.

4. **DNS Domain and DNS Server Address.** When the workstation is not using BOOTP (as in this example) the *DNS Domain* and *DNS Server Address* fields must be set. This information is gathered by the install program and a RESOLV.CFG file is created with the following contents:

domain	novell.com
nameserver	128.32.134.5

TCPIP.EXE uses this information contained in RESOLV.CFG to set Domain Name System (DNS) parameters. The *domain* keyword denotes the default DNS domain that will be used when querying DNS servers. It is followed by up to three *nameserver* keywords which denote the IP addresses of DNS servers that TCPIP.EXE should contact to resolve DNS domain names.

5. **NetWare/IP Domain.** This field must be set to a valid NetWare/IP domain name. The install program places this information in the *NWIP* section of the NET.CFG file. The NET.CFG entry generated by the information used in this example is shown below:

   NWIP

   NWIP_DOMAIN_NAME nwip.novell.com

   NWIP.EXE configures itself by reading this *NWIP* section of NET.CFG. The *NWIP_DOMAIN_NAME* keyword tells NWIP.EXE the default NetWare/IP domain of the workstation.

NetWare/IP Server Configuration

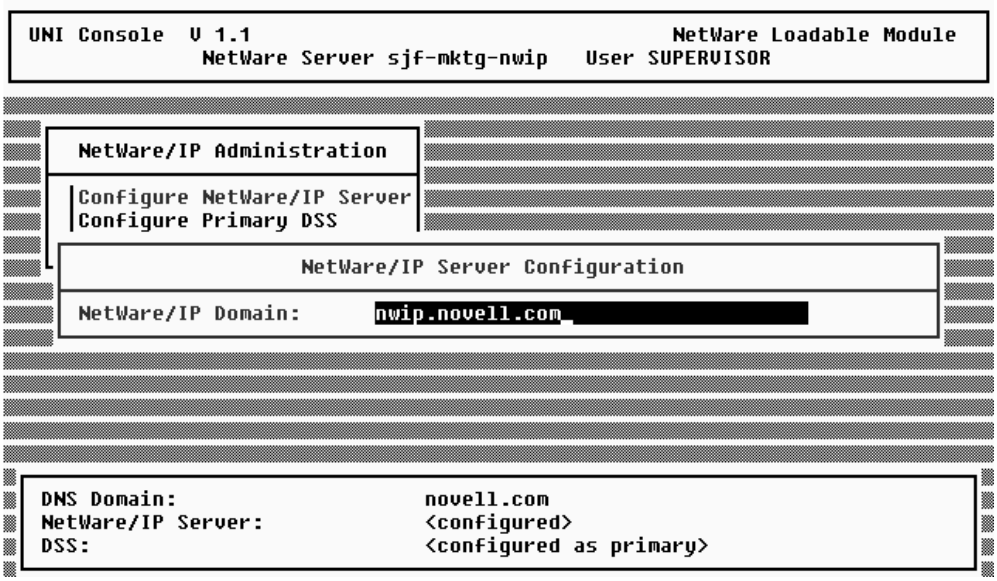


Figure 10: UNICON allows the user to configure the NetWare/IP domain of the server.

All NetWare/IP server components — such as NetWare/IP, the DSS and the DNS server — are configured with the UNICON utility. UNICON is started by typing "LOAD UNICON" at the NetWare 3.1x or 4.01 server console. After the utility loads, a main menu is displayed and lets the user selectively configure NetWare/IP, the DSS or the DNS server. UNICON also offers the ability to start and stop services, add and delete host addresses, control error-reporting levels, and view the audit log.

Figure 10 is a screen shot of the NetWare/IP server configuration screen within UNICON. The following parameters are required:

1. **NetWare/IP domain.** This is the server's NetWare/IP domain. It is called *nwip.novell.com* because in this example, the Engineering subnet is assigned to this domain (see Figure 3).

Configuring a NetWare Server as a Primary DSS

Figure 11: UNICON allows the user to configure the server as a primary or secondary DSS.

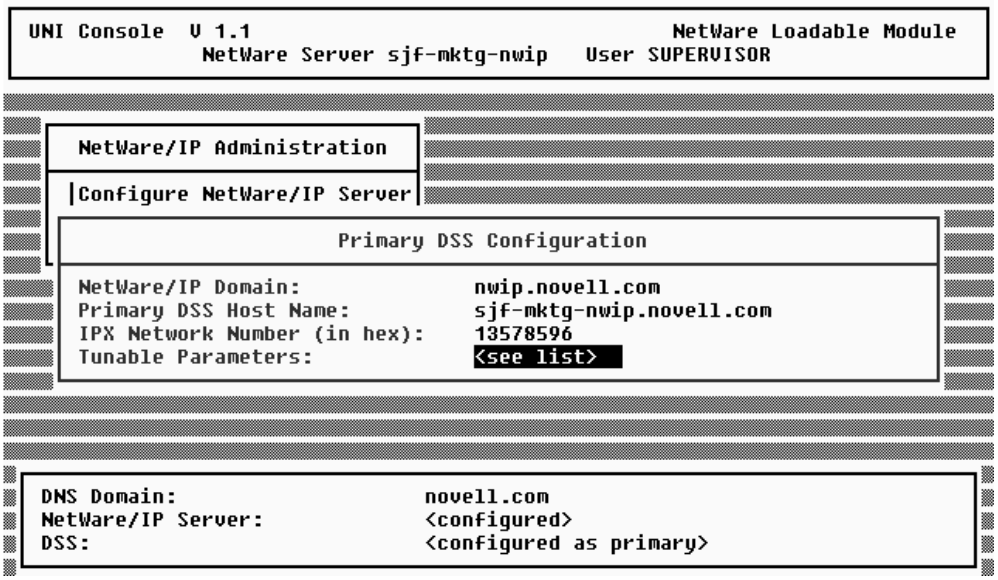


Figure 11 shows the primary DSS configuration screen within UNICON. The primary DSS requires the following information:

1. **NetWare/IP domain.** This is the NetWare/IP domain for which the primary DSS will store SAP information.
2. **Primary DSS host.** This is the name of the host that serves as the primary DSS.
3. **IPX network.** This is the IPX network number assigned to the NetWare/IP domain, *nwip.novell.com*. NetWare/IP domains act as virtual IPX networks and must be assigned a unique IPX network number.

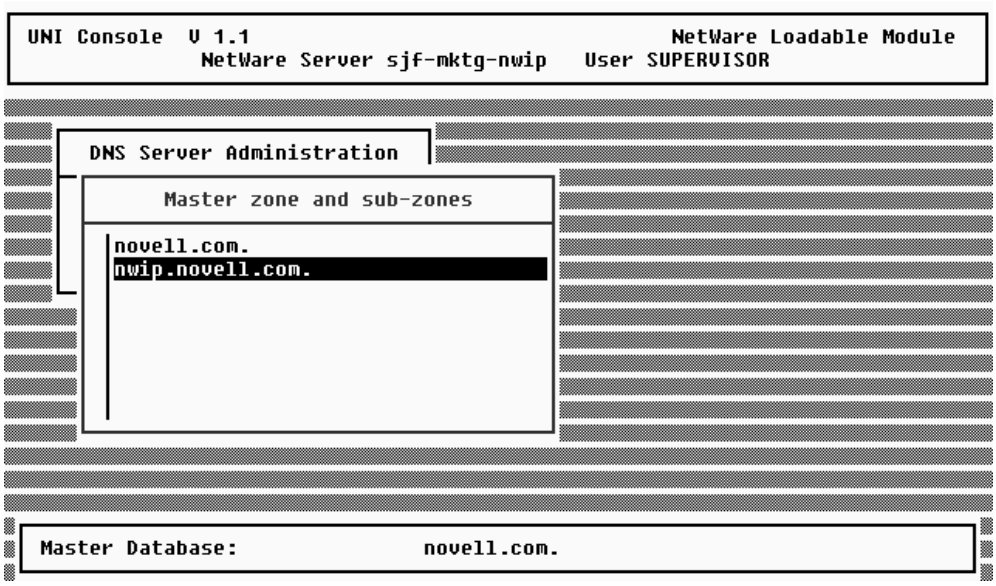
Configuring a NetWare Server as a DNS Server

Figure 12 shows the minimum number of domains which must be entered into the DNS database. Each of these domains, *novell.com* and *nwip.novell.com*, have a Name Server (NS) record associated with them (not shown) which specifies the name of the host that should be contacted for information about these domains and any of their sub-domains. (For

more information on NetWare/IP domains and DNS, see the section entitled, “NetWare/IP Domains and DNS.”)

In this example, the value of the NS record for *novell.com* is *sjf-mktg-nwip.novell.com* (the name of the local machine) since the NetWare/IP server is configured to act as a DNS server for *novell.com*.

Figure 12: UNICON allows the user to create DNS domains.



The value of the NS record for *nwip.novell.com* is *sjf-mktg-nwip.novell.com* (the name of the local machine) since the NetWare/IP server is also configured as a primary DSS for the *nwip.novell.com* NetWare/IP domain.

Notice that *novell.com* and *nwip.novell.com* have identical NS records. The records refer to the same NetWare/IP server, *sjf-mktg-nwip.novell.com*, but for different reasons. The NS record for *novell.com* refers to *sjf-mktg-nwip.novell.com* because it is acting as a DNS server for the *novell.com* DNS domain, while the NS record for *nwip.novell.com* refers to *sjf-mktg-nwip.novell.com* because it is acting as a DSS server for the *nwip.novell.com* NetWare/IP domain. It is assumed that NS records for NetWare/IP domains (e.g., *nwip.novell.com*) only refer to a primary or secondary DSS server, not to a DNS server.

NetWare/IP nodes locate DSS servers by querying DNS for NS records associated with their NetWare/IP domain. Using this example, a NetWare/IP node wishing to contact a DSS for the *nwip.novell.com* NetWare/IP domain, could query the DNS server for the NS records associated with *nwip.novell.com*. The DNS server would respond by sending *sjf-mktg-nwip.novell.com* as the name of the server that should be contacted for the *nwip.novell.com* domain. The NetWare/IP node assumes *sjf-mktg-nwip.novell.com* is the name of a DSS server (as

opposed to a DNS server) since it is listed in the DNS database as a Name Server for the *nwip.novell.com* NetWare/IP domain.

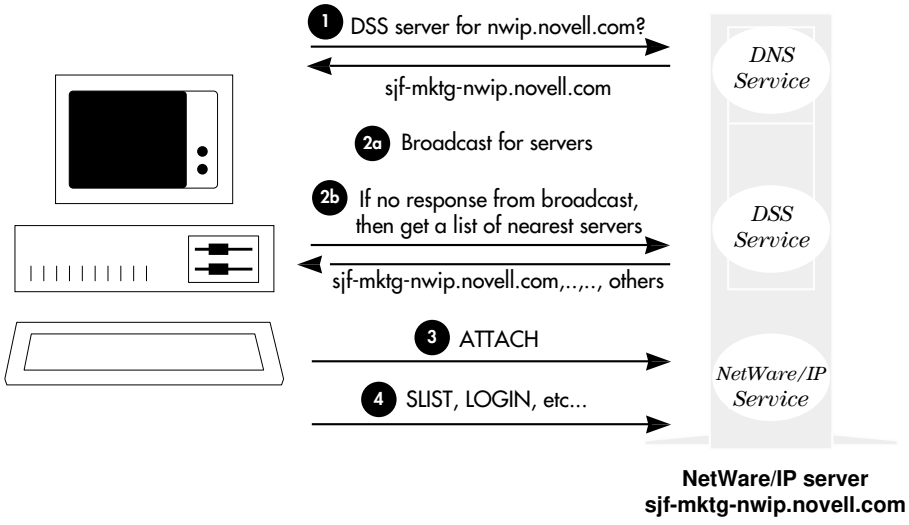
Bootstrapping a NetWare/IP Client

When all NetWare/IP components are properly configured, as shown in the section above, it is possible to boot a NetWare/IP client and have it attach to a NetWare/IP server. This is called "bootstrapping." Figure 13 shows the communications sequence that occurs among NetWare/IP components before a workstation attaches to a NetWare/IP server.

The loading sequence of NetWare/IP workstation software is:

1. LSL.COM	(ODI link support layer)
2. XXXX.COM	(ODI driver specific to network LAN adapter, such as NE2000.COM)
3. TCPIP.EXE	(TCP/IP protocol stack)
4. NWIP.EXE	(NetWare/IP IPX Far Call Interface Emulator)
5. VLM.EXE or NETX.EXE	(NetWare shell which is used for attaching to a NetWare/IP server)

Figure 13: After loading the NetWare shell, the NetWare/IP workstation attaches to a NetWare/IP server.



Loading the NWIP.EXE module causes the NetWare/IP workstation to contact its DNS server using the information in RESOLV.CFG as shown in Figure 13. It queries the DNS server for the names of each DSS in its NetWare/IP domain. The system is operational if the DNS server responds with one or more DSS host names. At least one DSS must be available on a

properly configured NetWare/IP network. If there are none, NWIP.EXE will display an error message and will not load.

After NWIP.EXE loads, the NetWare client software loads and causes NWIP.EXE to issue a UDP broadcast on its local subnet looking for NetWare/IP servers. (In this example, the NetWare/IP server, *sjf-mktg-nwip.novell.com* would have responded to the NetWare/IP client's broadcast for a NetWare/IP server.) If no servers respond to the broadcast or if the NSQ_BROADCAST keyword in NET.CFG is set to *off*, the DSS is queried for the location of the nearest NetWare/IP servers. The DSS then sends back up to five NetWare/IP server names and addresses.

All NetWare/IP server IP addresses are sorted according to their distance from the NetWare/IP client. NetWare/IP server addresses with the same subnetwork number are considered nearest. Next are those with the same network number, followed by server addresses that do not meet either test.

After obtaining a list of servers from the DSS or as a result of the UDP broadcast, the NetWare/IP client will attach to the nearest one. Once the NetWare/IP workstation is attached, the user can run the usual programs kept in the server's LOGIN directory, such as SLIST, LOGIN and others.

Summary

NetWare/IP is a software option that seamlessly integrates the NetWare and TCP/IP environments by enabling customers to run NetWare and its services over the Internet Protocol (IP). NetWare/IP gives users the choice of running NetWare and its services over Novell's traditional IPX protocol or the widely-deployed TCP/IP protocol.

Novell's NetWare, UnixWare and AppWare families of products provide customers with the ability to rightsize their network environments within multivendor network computing environments. Novell's goal is to provide seamless integration between these environments while allowing customers the freedom to choose the computer components that best fit their needs. NetWare/IP reinforces that goal by providing customers with the option to choose the network protocol that works best for them, giving them a flexible way to integrate NetWare into TCP/IP networks.

Questions and Answers

Q: When will NetWare/IP be available for purchase?

A: NetWare/IP is available now through a Novell Gold, Platinum or UNIX Master Reseller.

Q: Does this announcement indicate our desire to replace IPX with IP?

A: No. NetWare/IP is not a replacement for NetWare. Both the TCP/IP and IPX/SPX protocols are key to Novell's strategic direction and product offerings. Novell will continue to enhance its popular IPX/SPX based protocols as evidenced by recent developments such as NetWare Directory Services (NDS), NetWare Link Services Protocol (NLSP), and SPX II. Additionally, we have created the Novell Network Registry which helps customers keep network traffic running smoothly and reliably by eliminating name and address conflicts among interconnected NetWare networks. With NetWare/IP, Novell provides customers with the freedom to choose the network protocols that best fit their requirements for building their network infrastructure.

Q: Will NetWare/IP run on NetWare 3.1x and 4.01?

A: Yes. NetWare/IP runs on both NetWare 3.1x and 4.01 servers.

Q: What customers need NetWare/IP 1.1?

A: 1) Organizations that have standardized on TCP/IP as a protocol of choice and prefer NetWare for their networking services. Also, customers who wish to reduce the number of protocols on their network are likely candidates for NetWare/IP.

2) Large Fortune 500 companies, and technical-oriented organizations such as universities and research labs.

3) Customers with large, multivendor networks that span several geographic sites.

Q: How does NetWare/IP 1.1 differ from NetWare 3.1x and 4.01?

A: NetWare/IP 1.1 is add-on software to NetWare 3.1x and 4.01 that enables customers to run their NetWare applications and services over the Internet Protocol (IP). It provides network administrators with the freedom to choose their networking protocols. It frees end users and the application developers from having to worry about the underlying protocol since all applications built to IPX run without modification in the IP environment.

Q) Will NetWare Directory Services (NDS) work on NetWare/IP?

A) Yes. NDS works on a NetWare/IP server the same way it works on NetWare 4.01 servers.

Q) How will NetWare/IP be packaged?

A) NetWare/IP will be available as an add-on product to NetWare 3.1x and 4.01 and distributed on 3.5-inch and 5.25-inch diskettes. It will be stratified in the same user levels as NetWare 4.0x — 5-, 10-, 25-, 50-, 100-, 250-, 1000-user levels. The stratification level of NetWare/IP must be equal to or greater than the stratification level of the NetWare 3.1X or 4.01 server on which it is being installed. The 25-user version of NetWare/IP works on a 20-user version of NetWare 3.11.

Q: How does NetWare/IP work with existing NetWare networks?

A: NetWare/IP gives network administrators the freedom to choose their network protocol. Two typical configurations are as follows:

- Some customers may choose to convert their complete IPX network to an IP-only network. NetWare/IP eases the task of migrating users to the TCP/IP environment.
- Other customers may configure their network to benefit from the strengths of both environments — IPX for ease of use and setup, and IP for its wide use in heterogeneous enterprise networking — by using TCP/IP over their Wide Area Network (WAN) and IPX/SPX over their Local Area Network (LAN). In this case, NetWare/IP supports the IPX and IP network protocols simultaneously by acting as a gateway between NetWare/IP and traditional NetWare IPX networks.

Q: Will existing IPX applications run over NetWare/IP?

A: Absolutely. Most existing NetWare applications which are based on IPX/SPX work without modification on NetWare/IP. For example, NetWare for SAA™, LAN WorkGroup™, NetWare NFS, the NetWare NFS Gateway and other Novell products all operate correctly when running over IP.

End users can continue to use their applications without having to worry about the underlying network protocol — whether it is IPX or IP. Likewise, application developers can build their applications knowing that they'll operate correctly, whether running over IPX or IP.

Q) Is there any software that will not run on NetWare/IP?

A) In general, any software that runs on NetWare 3.1x and 4.01 will also run on NetWare/IP. However, NetBIOS and other applications that depend on IPX broadcasts can run only on their local subnet because of UDP broadcast limitations.

Q) Can a NetWare/IP client use NETX instead of the NetWare DOS Requester?

A) Yes. In the NetWare 3.1x environment, you can use NETX instead of the NetWare DOS Requester. However, the NetWare DOS Requester is required to give NetWare/IP clients access to NetWare 4.01 services.

Q) How much server memory is needed to run NetWare/IP?

A) At least 8MB of server memory is required to run NetWare/IP.

Q) How much workstation memory is needed to run NetWare/IP?

A) Specific NetWare/IP components, namely TCPIP.EXE and NWIP.EXE, need at least 32.3KB of memory. This is in addition to the memory required for either NetWare 3.x or NetWare 4.01 client software. TCPIP.EXE and NWIP.EXE can be loaded into upper memory using the appropriate DOS memory manager.

Q) How much disk space is needed on the server to run NetWare/IP?

A) Approximately 2MB.

Q) How much disk space is needed on the workstation to run NetWare/IP?

A) Approximately 2MB (DOS) or 3.2MB (MS Windows).

Q) What additional services are included with NetWare/IP?

A) NetWare/IP includes the XCONSOLE utility which allows anyone running TCP/IP with either a VT100/220 terminal or X Windows to manage the NetWare/IP file server. Similar to the RCONSOLE utility, XCONSOLE uses TCP/IP instead of IPX/SPX.

Q) Will customers need to convert their LAN drivers to ODI drivers?

A) Yes. Customers must convert their LAN drivers to ODI drivers if they have not already done so. This is necessary because the NetWare/IP workstation TCP/IP protocol stack requires an ODI driver.

Q: Which desktop operating systems are supported by NetWare/IP?

A: The DOS and MS Windows desktops are supported by NetWare/IP 1.1. Clearly, this level of integration between NetWare and UNIX is important; our customers are demanding increasingly sophisticated solutions to help them integrate these two environments. Although we don't make a habit of discussing unannounced products, you can expect to see other popular desktops, including UnixWare, supported by NetWare/IP in future versions.

Q) Does NetWare/IP include a BOOTP server?

A) No, NetWare/IP does not include a BOOTP server but the NetWare/IP client software can use BOOTP to ease the task of network administration.

Q: Can other common TCP/IP applications, such as FTP and Telnet, run using NetWare/IP?

A: Yes. Any of these applications can run on a NetWare/IP client as long as they are written to either the Novell LAN WorkPlace for DOS BSD socket interface or to the WinSock v1.1 interface. All of this functionality and more is available by purchasing Novell's LAN WorkPlace for DOS 4.1.

Q: Is it possible to use DOS/MS Windows TCP/IP stacks from other vendors on the NetWare/IP workstation?

A: No. It is necessary to use the TCP/IP stack packaged with the NetWare/IP client software.

Q: Is the TCP/IP in NetWare/IP "RFC Compliant"?

A: RFCs exist to provide basic guidelines for companies implementing their specifications. The TCP/IP portion of NetWare/IP complies with over 30 RFCs. See the *LAN WorkPlace for DOS* Spec Sheet (Novell part number 489-000014-005) for a list of these RFCs.

Q) Will users notice any difference in the way the NetWare/IP network operates?

A: Most users will not notice the difference between a NetWare/IP network and a NetWare network. However, users might need to learn about NetWare/IP's new drive-mapping utility, *nwipmap.exe*, which provides access to NetWare/IP servers outside their NetWare/IP domain.

The performance of NetWare/IP compares very favorably with the performance of native NetWare. On average, the overhead associated with NetWare/IP is only about 8%. The difference is so imperceptible that end users experience no change in performance after NetWare/IP is installed.

Q) What additional training is recommended for systems administrators who will use NetWare/IP?

A) Systems administrators should have a firm understanding of TCP/IP and DNS before installing NetWare/IP. Courses #605: NetWare TCP/IP Transport and #630: NetWare/IP are recommended for learning how to install and configure NetWare/IP. Call 800-233-EDUC or 801-429-5508 for more information.

Q: Does NetWare/IP include all of the TCP/IP applications found in LAN WorkPlace for DOS?

A: No. Although the NetWare/IP client software includes the same TCP/IP transport found in LAN WorkPlace for DOS, it does not include its applications. These applications, such as Telnet, FTP, and an SNMP agent and manager, are part of the LAN WorkPlace product.

Customers may also choose LAN WorkGroup since it offers all the functionality and ease-of-use enjoyed by LAN WorkPlace for DOS users, while easing the installation, configuration and maintenance tasks of network administrators. LAN WorkPlace and LAN WorkGroup are fully interoperable with the NetWare/IP client software.

Q) Does NetWare/IP support Packet Burst™ Mode IPX and Large Internet Packet Exchange (LIPX)?

A) Yes. NetWare/IP supports both Packet Burst Mode IPX and Large Internet Packet Exchange for improved performance over wide area networks and slow links.

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